Speeding the uptake of electric vehicles in Australia: social attitudes to electric vehicle purchase and recommendations for government intervention to address market failures

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Speeding the uptake of electric vehicles in Australia:
social attitudes to electric vehicle purchase and recommendations for government intervention to address market failures

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Thesis dissertation sheet, abstract and declaration

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Abstract (350 words maximum):
Personal motorised transport overwhelmingly relies on oil based fuels that generate significant global greenhouse gas (GHG) emissions, thus contributing to global warming and exacerbating climate change. Recent models of electric vehicles (EVs) are suitable alternatives to conventional internal combustion engine vehicles (ICVs). Using Australian electricity as an energy source, EVs are capable of reducing transport related emissions and other negative externalities. Potentially, EVs could further reduce pollution as the renewable energy component of electricity generation increases.

To recommend possible actions for Australian governments that could advance EV uptake two research streams were undertaken: 1) analysis of government actions in the more successful markets to identify international best practice; 2) original research, using online questionnaires, to identify social attitudes to EVs for motorists with pro-environmental tendencies to determine significant perceived barriers to uptake, and incentives that might enhance EV acceptance in Australia.

Analysis of international best practice showed governments who provide financial and other soft incentives are more likely to stimulate EV uptake than those who did not, or who implement incentives poorly. To date Australian government action to foster EV acceptance has been minimal, as have Australian EV sales. The sample cohort had many attitudes in common with overseas ICV drivers unfamiliar with EVs. The main concerns were vehicle price, vehicle range and recharging away from home. An experimental component found providing relevant information could enhance positive attitudes towards EVs, increasing the likelihood that car customers, especially women and those buying new cars would next purchase an EV.

Assuming near term EV purchase price comparability to ICVs, best government practice to speed up EV adoption includes: enacting appropriate legislation, supporting the installation and maintenance of an adequate public recharger network, procuring EVs for government fleets and investing in public information programs. These practices, together with conclusions from this original research, point to recommendations that if adopted by Australian governments could allay motorists' concerns and encourage them to make the transition from ICVs to EVs, thereby accelerating the transition away from transport's age of oil and driving to a new energy future.

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Abstract

Speeding the uptake of electric vehicles in Australia: social attitudes to electric vehicle purchase and recommendations for government action

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Publications arising from this thesis

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List of Abbreviations

Abbreviation	Meaning
ACI	Aggregated carbon intensity
AUD	Australian dollar
BEV	Battery electric vehicle (only uses mains electricity as energy source)
CO_2	Carbon dioxide
DC	Direct current
EU	European Union
EV	Electric vehicle
Gg	Gigagrams
GHG	Greenhouse gas
HEV	Hybrid electric vehicle (uses oil products in vehicle as energy source)
HOV	High occupancy vehicle
ICV	Internal combustion engine vehicle
km	kilometre
kW	kilowatt
LCA	Life cycle analysis
ML	mega Litre
NGO	Non-government organisation
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
PHEV	Plug-in hybrid electric vehicle
RFID	Radio Frequency Identification
UK	United Kingdom of Great Britain
UN	United Nations
US	United States of America
VAT	Value added tax
WAR	Weighted average response

Chapter 1 Introduction

1.1 Problem statement

Anthropogenic climate change is considered an existential threat to the future health of the planet (UNFCCC, 2010). By releasing greenhouse gas (GHG) emissions, burning fossil fuels for energy plays a pivotal role in global warming, which if left unchecked could lead to catastrophic climate change. Since the early 20th Century the use of oil as an energy source has increased rapidly, particularly post World War II (US EIA, 2013). Not only does oil consumed for transport via internal combustion engine vehicles (ICVs) result in GHG emissions, a wide range of other negative externalities also impact on the environment, the economy and society (Table 1.1, p4). Expeditiously reducing oil consumption would be prudent to mitigate and ameliorate the consequences of these externalities. Reducing car dependency by increasing public and active transport is one means to reduce harm arising from cars used for personal mobility. However, not all car journeys can conveniently be replaced by these modes. Encouraging car owners to replace their use of ICVs with innovative technologies such as electric vehicles (EVs) can be a crucial path to rapidly reduce transport-related oil consumption.

1.2 Background to the problem

The following sub-sections provide contextual background information that may assist in understanding the importance of this research into EVs, and help explain the underlying premise for the research. Following that, Section 1.3 defines the Terms and Scope of the research. Section 1.4 summarises actions that have been taken to reduce oil consumption from transport and research contributing to understanding processes involved in the transition away from the age of oil, including Australian research. Section 1.5 outlines gaps in the research and explains the importance of this research. Section 1.6 describes the aims, objectives, research questions, and significance of the research. Finally, Section 1.7 overviews the content of the thesis.

1.2.1 Transport related Green House Gas emissions

Burning fossil fuels results in GHG emissions and other forms of pollution (Clean Energy Ministerial, 2016). As climate change is recognised as one of the key challenges of the 21st Century (UNFCCC, 2010), limiting global warming and climate change by leaving fossil fuels in the ground is a key strategy to reduce such emissions (McGlade and Ekins, 2015). Some governments have been more active than others in addressing this global problem (UN Climate Change Conference COP 21, 2015); initiatives by many governments to facilitate their country's transition from oil fuelled conventional ICVs to EVs (Section 4.3) sit within this context of GHG emissions mitigation. As an example, a recent announcement by the French government signals the end of new ICV sales in France by 2040 to reduce air pollution and GHG emissions (BBC News Europe, 2017). Similarly, Norway has signalled it wants all new cars to be zero emissions vehicles by 2025 (Avinor Jernbaneverket Kystverket Statens Vegvesen, 2016) and China recently announced it is working towards a timetable to end production and sales of ICVs (Bloomberg News, 2017).

Fossil fuelled transport is a significant source of GHG emissions (Table 1.1). In 2010, transport accounted for 23% of total energy related CO_2 emissions (UN Climate Summit, 2014). Globally, passenger cars use 64% of transport energy (IEA, 2015a). In Australia, 17% of total GHG emissions arise from the transport sector, with light vehicles[1] contributing 10% of all emissions (DoE, 2015). The costs of its consumption are borne by all, not just car users, as the price paid by customers for fossil fuels does not fully cover the resulting negative externalities (Struben and Sterman, 2008). This burden could be minimised by shifting to low carbon transport sooner rather than later; including through government intervention, thus simultaneously increasing domestic manufacturing and /or jobs and reducing oil import bills (Crist 2012). A shift away from a reliance on oil for transport can reduce costs to subsidise its use (Coady et al., 2015), which indirectly contribute to the continued popularity of ICVs.

Fossil fuel extraction, use and waste disposal and the costs and benefits of using various alternative energy sources fall within the field of environmental economics, including the relationship between the economy and the environment, and associated risks. Central to this field, is the concept of market failure, where markets inefficiently allocate resources and, thus, do not generate the greatest social welfare (Hanley et al., 2001) (Sections 2.2 and 3.2.2). Relatedly, "in the medium term, improving the efficiency of road passenger transport using existing technologies is one of the lowest cost emissions reduction opportunities in the Australian economy" (CCA, 2015). Stern (2016, p 408) has stated that risk models "generally omit the potentially huge costs of air pollution from fossil fuels, which are saved if alternative fuels are used". Furthermore, he argued that such models "struggle to describe developments in alternative energy"; a statement that is relevant to

[1] Light vehicles: all road vehicles in Australia under 3.5 tonnes gross vehicle mass, including passenger vehicles, sports utility vehicles (SUVs) and light commercial vehicles, but excluding motorcycles.

the technological advances that have "allowed solar-photo voltaic and onshore-wind technologies to become competitive with natural gas and coal in several locations, even without emissions taxation" (Stern 2016, p 408). He also contended that emerging new networks where electric vehicles and energy storage are integrated into smart grids are an example of development that economists ought to consider, especially when undertaking cost benefit analyses into fossil fuel consumption and energy generation, including risks.

1.2.2 Negative externalities arising from using fossil fuels for transportation

Markets are imperfect and commonly have failures (Section 3.2.2) including a wide range of negative externalities (Hanley et al., 2001). Petrol and diesel fuelled ICVs dominate the Australian motor vehicle fleet; with 11.9 million petrol and 1.3 million diesel passenger cars in 2015, accounting for 97.7% of all passenger cars (73.5% of the total vehicle fleet) (Australian Bureau of Statistics, 2016a). Table 1.1 outlines the main negative externalities arising from fossil fuelled transportation in Australia.

Table 1.1 Negative externalities arising from fossil fuelled transportation in Australia

Externality	Negative impacts
Greenhouse gas emissions (GHG)	In 2013-14, transport generated 17% of Australia's total GHG emissions, 46% of which was from private road transport (DoE, 2015). The National Greenhouse Gas Inventory, 2014, showed domestic transport annual emissions increased from 32,112 Gg to 45,597 Gg (1990-2014) (AGEIS, 2015). These contribute to global warming and hence climate change, a significant global environmental problem with noticeable impact (Australian Academy of Science, 2015).
Toxic air pollution	Production of air pollution especially particulate matter. Diesel produces Class 1 carcinogens (IARC 2012). Even low levels of air pollution result in health impacts (Kjellstrom *et al*. 2002; Nawrot *et al*. 2011).
Noise	Noise results in significant but often unrecognised health impacts (DenBoer & Schroten 2007; Passchier-Vermeer & Passchier 2000).
Fuel security	Australia imports 90% of its oil, and is almost entirely dependent on imported oil for road transport resulting in very low fuel security as stockpiles are low (Blackburn, 2014) with only 23 day's supply in stock (DoEE, 2017, Table 7). The bulk of automotive gasoline is imported from South Korea and Singapore (DoEE, 2017, Table 4B), which has implications in a geopolitical context.
Balance of trade	In 2014, Australia's fourth highest value import was Crude Petroleum (AUD14.7 billion) (DFAT, 2015); Refined Petroleum imports were third highest (AUD18.1 billion). Combined value of AUD32.8 billion resulted in considerable balance of trade deficits, exceeding the highest ranked (AUD24.3 billion for personal travel).
Loss of jobs	Transport energy sourced from overseas means employment is outsourced; generating renewable energy locally for transport would create Australian jobs.
Waste heat	Waste heat from conventional cars contributes to the heat island effect in urban areas thus increasing the use of air conditioning in buildings in summer (C. Li et al., 2015). Buildings located near heavily trafficked roads have high air and noise pollution levels, reducing the use of windows for building ventilation and placing additional demand on air conditioning and electricity use.
Financial leakage	Due to repatriation of funds by foreign owned oil and electricity providers, financial leakage could be reduced if individuals use home generated renewable electricity to charge their EVs.

Further, as the importation of automotive gasoline grows it exacerbates problems associated with GHG emissions, fuel security and financial leakage; Australian imports increased two and a half times in six years, increasing from 2,642.8 ML (2010-11) to 6,638.0 ML (2015-16) (Office of the Chief Economist, 2016, Table 4). Thus, reducing oil consumption would make good commercial sense. Any entity, whether household or organisation, which changes to EVs not only helps reduce fuel imports and financial leakage but saves on their transport energy bills as EVs are cheaper to run than ICVs. Furthermore, if such entities generate their own renewable energy they can cut transport energy costs to zero once their electricity generation costs have been amortised.

Despite the negative externalities that directly impact the environment and human health, the Australian federal government appears reluctant to reduce transport based fossil fuel consumption (Ottley, 2016). However, this reluctance may not stem from direct transport costs incurred by the government sector in Australia, which bought 3% of all new vehicles sold in 2015 (FCAI, 2017), but rather the financial rewards from fuel taxation income. In 2015-16, fuel excise revenue collected by the Australian federal government was estimated to be AUD17.9 billion, or approximately 4.4% of total revenue (AUD405.4b) (Australian Government 2015). A compilation of OECD retail fuel prices (DoEE, 2017, Table 8B) shows that in December, 2016, Australia had the fourth lowest petrol prices and seventh lowest automotive diesel prices (including the tax components) of the 32 OECD countries. Low taxing regimes result in lower petrol/diesel prices for consumers, and likely do little to encourage a move away from oil based transport energy consumption in Australia. Such low fuel prices for motorists highlights one of the difficulties affecting attempts to reduce the country's transport related GHG emissions. If Australia is to make a greater contribution to global efforts to combat climate change, this relatively low taxing regime is one avenue that could benefit from closer analysis. Economic modelling could find a better balance for the tax component of Australian fuel prices to more fully cover the cost of damage arising from using oil for transport. In tandem, undertaking action to encourage use of suitable alternatives for ICVs, such as EVs could help reduce oil consumption. This research investigates some suitable actions that could facilitate such changes.

1.2.3 Fuel sources for passenger cars

Since the advent of motorised passenger cars, various fuels have been used as the energy source for propulsion. Conventional ICVs use various petroleum products including: petrol (automotive gasoline), diesel, liquefied natural gas and compressed natural gas. Hybrid vehicles (HEV), such as the *Prius*, have an electric motor but use petrol or diesel as the energy source. Due to diminishing oil reserves, the possibility that peak oil may have passed (Nashawi et al., 2010) and because using fossil fuels results in significant harm (Table 1.1) various alternative fuelled vehicles have been further developed to make them more attractive as alternatives to ICVs.

Some of these alternative fuelled vehicles include:

1.2.3.1 Hydrogen Fuel Cell vehicles

Developed by several manufacturers, the major advantage of hydrogen fuel cell vehicles is that they can be refuelled as quickly as petrol cars and have the same travel range (Dowling, 2015). The major disadvantage is that hydrogen production is very expensive and environmental or societal benefits are insignificant; emissions can vary widely depending on hydrogen production method (Shaheen and Lipman, 2007). As water hydrolysis is extremely expensive, 95% of hydrogen is derived from methane (Cox, 2014). Due to GHG emissions from the natural gas reformation process (to obtain methane) and methane leakage from methane production, use of hydrogen for cars is worse for the environment than using gasoline (Romm, 2014). Using renewably produced electricity to obtain hydrogen is not the best use of that resource and Hydrogen Fuel Cell vehicles are expensive even compared to BEVs (Romm, 2014). The cost of hydrogen fuel production and distribution would be expensive whereas electricity networks are almost ubiquitous and relatively easy to tap into.

1.2.3.2 Biofuel vehicles

Some cars can use biofuels, such as biodiesel (largely from oilseeds) and ethanol (mainly from sugarcane). Ethanol-only vehicles were made in Brazil but numbers are declining; there were over two million vehicles in 2006 but by 2013 there were fewer than one million and no longer produced, although flex vehicles, using both ethanol and petroleum, remain popular despite environmental concerns (UNICA, 2016). Fuel from microalgae may prove to be a useful replacement for petroleum products but there are large gaps in understanding large scale production outcomes (Usher et al., 2014). While beneficial from a GHG emissions perspective compared to gasoline, the evidence suggests the use of biofuels should be treated with caution as “changes in agricultural land use have a dominant impact on the evaluation of biofuel pathways” and, in particular, tropical rainforest deforestation should be prevented (TIAX LLC 2007, p ES -18).

1.2.3.3 Electric vehicles

The batteries of EVs are recharged from mains electricity. There are two main types: 1) Fully (Battery) electric vehicles (BEVs) only use mains electricity, and 2) Plug-in Hybrids (PHEVs) use mains electricity to recharge smaller batteries providing a shorter range on electric drive, but can extend their range using petrol or diesel to recharge the batteries or for direct drive. Barriers to BEV purchase, previously identified by research, include: battery capacity, and hence vehicle range, and recharging station locations (Wallace et al., 2011). In 2015, the range for most BEVs was about 150 km; projected battery technology improvements should mean the range will increase (IEA, 2016a). For most people day to day driving seldom exceeds 50 km as evidenced in Europe and Australia: 1) in Europe, drivers only have occasional need to recharge away from home as average driving distances are 40-80 km per day in 2-3 trips (A. R. T. and McKinsey & Co, 2014); and 2) in Australia, the daily average for passenger vehicles is 35km (Australian Bureau of Statistics, 2017) with 50% of drivers travelling short distances each day, accounting for only 20% of road use, and the top 20% of motorists undertaking 50% of the driving (Gargett, 2014).

Despite the many innovative technologies developed as alternatives to ICVs, evidence suggests that not all options are equally able to reduce GHG emissions. EVs may be regarded as less damaging to the environment than other alternatives because of lower emissions per kilometre of travel (as further elucidated in Section 2.2.2), lower electricity distribution infrastructure costs, and less need to remove forests and use agricultural land for crops for fuel. For these reasons this thesis focuses on EVs as the preferred replacement for ICVs for personal motorised transport.

1.3 Terms and scope

This thesis focuses on analysing and understanding measures that can facilitate the transition of cars from ICVs to EVs, in particular factors that affect private car customer buying decisions. Many customers may have a positive attitude to EVs in principle but for a variety of reasons do not choose to buy one. The research examines some of the critical barriers to purchase and incentives that, if implemented, could encourage uptake. This research targeted private car customers, as in Australia they are the largest sector of the light vehicle market, which is the most significant contributor to transport-related GHG emissions.

EVs, for the purposes of this study, will include passenger cars that use energy stored in an on-board battery that is fully rechargeable using mains electricity. Their range varies from about 100 km to 400 km between charges. Fully electric cars are also called Battery Electric Vehicles (BEVs). Plug-in hybrid electric vehicles (PHEVs) work in two modes: 1) using fully electric mode for 15 -50 km, then, 2) when the on-board battery is depleted, using petrol or diesel as the energy source, engaging an internal combustion engine to re-charge the battery, or by direct drive, giving a total range of some 6-800 km. Range extended EVs are considered to be PHEVs. A car, for the purposes of this study, is typically a four-wheeled, self-powered motorised vehicle used on roads for transportation, principally of people rather than goods.

1.4 Action to reduce transport related emissions

Burning fossil fuels generates GHG emissions, and transport-related oil consumption is a significant component. Thus, reducing anthropogenic GHG emissions via the substitution of suitable alternatives for ICVs, such as EVs, has become a concern for many countries, with governments undertaking action to implement policies to enhance the popularity of EVs among car buyers (Chapter 4). Prior research showed that some markets had higher EV sales and more success than others in encouraging EV adoption in the private car market (Pontes, 2017). Analysis of the strategies employed by many industrialised markets demonstrates that government action is essential to encourage most individuals to buy EVs (Mersky et al., 2016). Such actions are thought to correct market failures and to facilitate the diffusion of such a technological and behavioural innovation (Chapter 3).

EVs are more expensive to produce than ICVs, and evidence suggests subsidies to equalise the cost price to buyers has been an important strategy to encourage purchase (Bjerkan et al., 2016). However, further research has demonstrated that ensuring the provision of market co-conditions, in particular recharging infrastructure, is essential and that cheaper car purchase prices alone will not guarantee success (Lieven, 2015). There is a growing body of literature (Chapter 4) suggesting that for most car customers these two factors – price and driving range – are probably the most important, acting as significant barriers to uptake. However, as discussed in Chapter 4, governments may also need to consider that any measures to encourage EV uptake are implemented in a timely and effective manner to avoid potential pitfalls. To convince customers to make the transition from ICVs to EVs motorists' needs ought to be kept in mind when designing programs. Overseas research has shown that people with EV owning friends are more likely to buy an EV (Chapter 4) indicating the importance of information flows to inform potential buyers. However, in contrast to the other industrialised countries investigated, in Australia there has been a shrinking market for EVs in the last three years (FCAI, 2017). Previous Australian research (Gardner et al., 2011) had found that Australians who were urban, younger, better educated and of higher socio-economic status and were more concerned about the environment were more likely to be inclined to buy an EV than others; although as will be discussed, this inclination has not necessarily translated into sales. This thesis seeks to understand what can be done to reduce the barriers to uptake and incentivise customers to buy electric vehicles, whether or not they are motivated to reduce emissions from car travel.

1.5 Research gap and importance of the proposed research

Australian government action to date to facilitate the transition to EVs has been very limited (Ottley, 2016) and uptake is negligible and falling (FCAI, 2017). Due to the high proportion of GHG emissions resulting from personal passenger car transport (Section 1.2.2) there is a large untapped potential for EVs to minimise overall transport emissions.

Previous Australian research (Gardner et al., 2011) identified characteristics of people most likely to have a positive attitude to purchasing EVs and those more likely to be early adopters of the innovation. However, there is evidence of an attitude-action gap (Lane and Potter, 2007) – those with positive attitudes towards a particular action do not necessarily carry it out. In a market where Australians have little or no exposure to EV technology and there is minimal infrastructure, identifying actions relevant to particular Australian circumstances is an important aspect of this research and relevant for Australian policy makers. It may be argued that there is a need to understand what government actions could be helpful in Australia to bridge the attitude-action gap for those who express willingness to consider uptake but unable to take it.

1.6 Research aims, objectives, research questions and significance

The overall aim of the research is to identify and recommend suitable measures that if adopted could increase EV uptake in Australia. By investigating factors that may impact on the purchasing decisions of Australian car customers who might consider buying an EV, and identifying barriers and suitable incentives, this research attempts to identify measures that if addressed, could turn positive attitude into sales. However, even among those with a pre-disposition to act sustainably, having a positive attitude does not always lead to consumer action; there can be an attitude - action gap (Section 2.3.2). To underpin potential actions, this research sought to identify factors influencing EV purchasing decisions. If government is willing to act, identifying measures that could maximise return on investment may encourage policy makers to formulate suitable strategies to adopt.

The research objectives were to answer the following research questions (Table 1.2), using a variety of methods to provide sufficient evidence to underpin recommendations for interventions in the Australian car market.

Table 1.2 Research questions and methodology

Research Questions	Methodology
1. a. What policies and strategies have been most useful in encouraging Electric Vehicle uptake in countries with higher levels of EV adoption and what are some pitfalls that should be avoided? b. What is the Australian EV scenario and how does it compare to more successful markets?	Literature review
2. What are some important barriers and incentives that could influence the likelihood of customers to buy EVs in Australia?	Consumer surveys
3. Does the provision of up to date information about EVs influence the likelihood of customers to buy EVs in Australia?	Experimental component of consumer survey
4. What are some potential interventions that could be recommended to policy makers to increase the rate of uptake of EVs in Australia?	Literature review and research outcomes to inform recommendations

To answer Research Question 3 the experimental component tests the following:

Null hypothesis: There is no relationship between provision of information and likelihood to buy an EV: those who receive information about current model EVs are no more likely to buy an EV than those who do not receive information.

Alternative hypothesis: There is a relationship between provision of information about current model EVs and likelihood to buy; people who receive information are more likely to buy an EV than those who do not.

This research is significant because it identifies potential means to address a substantial market failure: the negative externalities (including GHG emissions) arising from burning fossil fuels for private person motorised transport (see Table 1.1). If Australia is to reduce its GHG emissions and meet its international commitment targets (DoEE, 2015) it would be prudent to adopt measures to reduce the use of ICVs as conveniently and soon as possible. Substituting EVs for ICVs would be one pathway to achieve GHG emissions reductions. Due to social inertia and the expense and longevity of cars the transition period from ICVs to EVs would necessarily be long and yet Australia, to date, has not adopted any meaningful action to make such a transition. Policy makers need evidence to support their work and hence one objective of this research is to provide that evidence.

1.7 Outline of the thesis

Chapter 1 overviews the problem and provides background material to help explain why the problem ought to be addressed. It also provides the terms and scope of the research, the aims, objectives and research questions and explains the importance of the research.

Chapter 2 reviews the literature including some background to vehicle and infrastructure technology. It also demonstrates the ability of EVs to reduce transport emissions regardless of electricity supply, except in two countries, and then reviews research into factors affecting consumer choice. It also contains a section reviewing research into governance and government action to encourage EV uptake.

Chapter 3 provides the methodological framework and describes the main theories informing the research and how their interaction with government actions affects markets and individuals. It then describes the methods used to answer the research questions.

Chapters 4, 5 and 6 discuss the results by research theme. Chapter 4 answers Research Question 1 by investigating international best practice, the actions taken by the most successful countries and some potential pitfalls as shown through a case study. It also provides information about the status of the Australian EV market. Chapter 5 answers Research Question 2, by discussing the results of the two consumer surveys. These were implemented to find the most important barriers to EV uptake for Australian drivers and incentives that could encourage adoption. Chapter 6 focuses on the experimental component of the first questionnaire to answer Research Question 3. It tests the null hypothesis and alternative hypothesis; half the respondents were randomly placed in a Test group and given information about EVs, the remaining Control group were given no additional information. Finally, in Chapter 7 conclusions are drawn from the research and provide recommendations for policy makers that if implemented could increase EV sales in Australia. The Appendices contain copies of the questionnaires, related materials and results.

Chapter 2 Literature review

2.1 Introduction

This thesis sought to understand social attitudes to electric cars (EVs) in Australia to suggest policy actions governments can take to encourage uptake of EVs. Chapter 1 highlighted the research problem and provided background material, including evidence suggesting why EVs are a suitable alternative to ICVs. This chapter includes information about EV technology and its introduction into the market, which informed the construction of the questionnaires and analysis of the results. The following literature review uncovers some of the hurdles EVs consumers face and highlights information motorists need when making car purchase decisions. Governments also need such information to help decision making regarding their commitment of taxpayer dollars to assist customers' transition from ICVs to EVs.

Section 2.2 begins with a review of EV development since the 19th Century. It sets out technological developments and their relationship to environmental sustainability to provide an understanding of why society may wish to make the transition from fossil fuelled transport to that powered by electricity. This section also identifies problems of introducing EVs to the mass market and co-conditions necessary for success. The identification of these problems helps explain why factors affecting consumer convenience constitute barriers to uptake.

Thereafter, Section 2.3 explores factors affecting consumer attitudes to EVs, particularly in countries with greater EV market penetration than Australia. It explains consumer concerns revealed in previous studies and provides a theoretical background of behaviours displayed by people who may show concern for the environment but fail to carry out actions that could mitigate harm. (Chapter 3 further examines theories explaining personal choice involved in transitioning towards new technologies and market factors affecting decision making.)

Section 2.4 outlines the role of governments in assisting market formation when transitioning from old to new technologies. Section 2.5 sets out previous research conducted in Australia including understanding barriers to uptake, characteristics of those more likely to buy an EV, and the ability for EVs to satisfy day to day driving for Victorian motorists. Finally, this Chapter summarise research gaps, in the Australian context, laying the foundation for the arguments that follow in Chapters 4, 5 and 6 to reveal suitable measures that governments could undertake to increase uptake of EVs in Australia.

2.2 Background to EVs

2.2.1 Early electric vehicles

Early experimental EVs have existed since the early decades of the 19th Century and appeared in a number of countries including the United States of America (US), United Kingdom (UK) and The Netherlands (Hoyer, 2008). Following the invention of rechargeable batteries combined with more powerful and efficient engines developed by 1870, by the turn of the 20th Century, EVs constituted 38% of the US car market (Guarnieri, 2012; US DoE, 2014). Despite this success, EVs were pushed from the mainstream market and internal combustion engine motor vehicles (ICV) eventually came to dominate, particularly as the introduction of the Model T Ford made gasoline cars less than half the price of electric cars (US DoE, 2014). Other factors also contributed to this shift including: the discovery of large oil deposits that became increasingly cheap to extract and distribute, the development of ICVs that were capable of long range trips between refuelling (Struben and Sterman, 2008), improved intercity roads and the limited availability of electricity outside of major cities (US DoE, 2014). As the 20th Century progressed, a mass market for private passenger cars developed affecting how cities grew, family lifestyle choices and even holiday options. This growth in personal car use, however, led to measureable negative impacts on people, the economy and the environment (see Section 1.3). The result of burning petroleum to fuel these cars has become a key source of pollutants, and are the cause of significant negative externalities and yet, petroleum products have continued to be cheaper than might otherwise be. As Coady *et al.* (2015, p2) reported, “post-tax energy subsidies are dramatically higher than previously estimated and are projected to remain high”. Further, they noted that subsidies arise when “consumer prices are below supply costs plus a tax to reflect environmental damage and an additional tax applied to all consumption goods to raise government revenues”.

EVs, as with any new technology, take time to diffuse into the market (Section 3.2) and Struben & Sterman (2008) suggested that such alternatives, even if equivalent to ICVs, would have a difficult transition. They argued that efforts to reduce the dominance of ICVs would need to be sustained for decades due to the long life of cars and to overcome customer resistance to perceived issues.

2.2.2 EVs as a more sustainable technology

Over the course of the 20^{th} Century problems associated with the use of fossil fuels have become apparent (Section 1.3 and Table 1.1) and reducing the use of fossil fuels for transport would be a major contribution to reducing GHG emissions in Australia (National Greenhouse Gas Inventory, 2013). Replacing ICVs with EVs is one pathway to foster reduction of fossil fuel emissions related to transport (CCA, 2015) and to reduce other negative externalities.

The benefits of using EVs compared to ICVs are many. There is clear evidence that BEVs, which use only mains electricity, can be a useful alternative to ICVs as they have fewer moving parts, require less maintenance, are more reliable and are cheaper to drive per kilometre (Idaho National Laboratory, n.d.). Typically petrol ICVs are 15% energy efficient and diesel ICVs are about 20% efficient when driven, with most of the energy lost as heat (California Energy Commission, 2016) whereas BEVs are about 60% efficient (US DoE, n.d.). The Climate Change Authority (2014) noted that "when powered by the current average Australian grid [2014], the fully electric vehicles currently available in Australia are less emissions-intensive that the average light car, which is the most efficient class of light vehicle".

Vehicle fuel consumption and GHG emissions are affected markedly by vehicle mass, whereas air pollution is more dependent on vehicle technology and type of emission control system used (Beer et al., 2004). BEVs are less polluting than ICVs although BEVs used for urban driving are less polluting per kilometre than for highway driving (Karabasoglu & Michalek, 2013). However, as urban drivers have been found to be more likely to buy an EV than those from out of town (Higgins and Paevere, 2011) this factor may not significantly affect the benefits accruing from EV uptake in urban areas compared to driving long distances on highways. By contrast, assessing the benefits of plug-in hybrid electric vehicles (PHEVs) compared to BEVs is more difficult as individual driving habits impact on the ratio of electricity to petroleum used in any vehicle (Lin and Greene, 2011).

2.2.2.1 Emissions reductions potential of BEVs and ICVs

Recent research (Broadbent, 2017) demonstrates that compared to driving ICVs, using BEVs reduces GHG emissions on a per kilometre basis, regardless of the electricity grid mix, in all but two countries: Iraq and South Africa (see Appendix H, which includes the formulae and results). Results are calculated for emissions from driving EVs in five countries (including Australia), those with the highest aggregated carbon intensity (the most polluting electricity generation), and a further six countries to provide examples with decreasing aggregated carbon intensity. The examples used (US EPA, 2017) in Table H.1 demonstrate that even in the five countries with the highest Aggregated Carbon Intensity (ACI) for their electricity production (Iraq, South Africa, Poland, India, Australia), the smaller BEV used as an example had lower emissions per kilometre than the ICV models selected. Only in Iraq and South Africa did the larger more powerful Tesla have slightly higher emissions than at least one of the smaller ICVs selected. For all other countries, which have lower ACI values (Ang and Su, 2016), the selected BEVs produced fewer emissions than the selected ICVs.

However, it should be noted that Tietge *et al*. (2016) have compared real world data with type approval values for car emissions and found increasing divergence. They showed, based on European Environment Agency data, type approval values (EU averages) for ICV CO_2 emissions went from 170g/km in 2001 to 120g/km in 2015, a decrease of 30%. However, their evidence (n=134,000) demonstrated there is an increasing divergence between laboratory results and real world performance of new cars: real world data (based on EU averages) suggests that new European cars actually went from 183 g CO_2 /km in 2001 to 167g CO_2 /km in 2015, a decrease of less than 10%. If this discrepancy is applied it may be expected that the emissions benefits of using BEVs are even higher than calculated above. Other research shows that different countries would achieve different total emissions from their fleets depending on several factors such as: the numbers of vehicles, the types of vehicles favoured by drivers and the design rules. For example, in Australia in 2013, the national average carbon emissions from new passenger cars and light commercial vehicles was 192 g CO_2 /km, ranging from 144 g CO_2 /km for the smallest passenger vehicles to the highest of 288 g CO_2 /km for the largest SUVs (National Transport Commission, 2014). In 2015 the average figure dropped to 188g CO2/km (DIRD, 2017a) where the standard adopted is based on the Euro 5 standard (DIRD, 2017b), however in Europe the standard has already been tightened to Euro 6 (Euro-Lex, 2007).

Additional calculations from other research demonstrate the efficacy of BEVs compared to ICVs. Renault (2011) conducted a Life Cycle Analysis (LCA), for company purposes, of its *Fluence* vehicle in its two motorisations – the ICV (in both forms – petrol and diesel) and fully electric vehicle (BEV). Calculations for electricity used British and French data separately. While production of EVs results in higher GHG emissions than ICVs due to the batteries, operationally the BEV outperformed the ICVs, even with the grid mix of that time, due to BEVs' global efficiency and lower primary energy needs for driving (Renault, 2011).

Including production inputs, when using French electricity the *Fluence* EV had lower total GHG emissions compared to the *Fluence* ICEVs after only about 2 years average use, whereas using British electricity (of that time) it was after about 4 years (Renault, 2011). As a country's electricity transitions to renewables, pollution and emissions reductions are said to improve. For example by transitioning to less polluting electricity for Beijing, a coal rich region of China, Ke *et al.*, (2017) demonstrated that as electricity production shifts away from coal there are clear environmental and health benefits for BEVs over ICVs. Hawkins *et al.* (2012) conducted LCAs and calculated that if a BEV was driven, using average European electricity for 150,000 km, emissions were reduced by 10% compared to diesel vehicles, and a 24% improvement over petrol vehicles. However, they noted other aspects of EVs supply chain resulted in other forms of pollution. Continuing improvements in battery technology, production and recycling techniques may reduce such pollutants.

2.2.2.2 EVs and sustainability advantages

Further evidence into the sustainability of EVs demonstrated by Needell *et al.*, (2016) showed that EVs used for personal travel are capable of meeting current US policy targets for transport emissions reductions of 26-28% of 2005 levels by 2025. The authors determined that EV models available in 2013, even with the prevailing US electric grid mix, were capable of meeting the target. Emissions from electricity have been falling as the proportion of coal used to produce electricity in the US has reduced over time, in 2016 coal contributed 30% of fuel to generate electricity (US EIA, 2017a) indicating that using EVs will also produce less emissions over time.

As Simpson (2009) has pointed out, using sustainable renewable energy instead of fossil fuels has the potential to further reduce total GHG emissions from EVs. However, even in countries with high fossil fuelled electricity production such as Australia or India, EVs can still produce lower GHG emissions per kilometre than ICVs because EVs are inherently much more efficient to operate, (Renault 2011; California Energy Commission 2016) and they are cheaper to drive (Idaho National Laboratory, n.d.). In an analysis of external costs of EVs, Jochem *et al.* (2016) found that EVs were advantageous compared to ICVs for reducing oil dependency and providing benefits to climate change, local air pollutants and noise, especially in congested inner cities, but other benefits were dependent on the local grid mix and recharging strategies of individual EV owners.

Electricity production methods impact on levels of pollution emanating from electricity consumed by EVs (Tessum *et al.* 2014; Sims *et al*. 2011). For example, burning coal for electricity is a major source of CO_2 and releases toxic air pollutants, especially particulate matter (Weng et al., 2012), which have significant human and environmental health impacts (Diniz da Costa and Pagan, 2006). Calculations of the global warming potential of various types of electricity generation, with assessments attempting to cover full life costs including extraction, construction, operation and waste management have been published. Coal is clearly the most polluting of all electricity sources with solar, hydro and wind generating far less CO_2 than coal, gas or biomass, while rooftop solar, due to cheaper distribution costs, had lower emissions overall than utility scale solar (Schlömer *et al*. 2014; Krey *et al*. 2014). As these researchers have evidenced, even if electricity is from a poor grid mix it is still worthwhile beginning the transition to EVs in almost all countries. As each country moves towards decarbonising its electricity supply and increasing renewable generation, the emissions and other pollutants resulting from the operation of EVs can only reduce.

2.2.3 Market co-conditions: recharging infrastructure, interoperability and harmonisation

This section summarises evidence from prior research to support the argument that for a market to operate successfully a product may require the presence of co-conditions. In the case of EVs, the availability of a publicly accessible recharge network is a market co-condition. Further explanation of market failures, which can include the absence of such co-conditions, can be found in Section 3.2.2. This section also explains how introducing standards and regulations around the use of the recharge network (Section 2.2.3.2) and improving interoperability, especially regarding payment systems (Section 2.2.3.3), enhances the user experience encouraging more drivers to buy EVs.

2.2.3.1 Recharger network

Most EV (BEV and PHEV) owners recharge at home most of the time (Figenbaum and Kolbenstvedt, 2016a). Over time new owners become more comfortable with changing their recharging behaviour and prefer home recharging rather than filling up an ICV at a petrol station (Bunce et al., 2014). However, due to the limited capacity of the batteries and hence range, for BEV drivers to make long trips away from home an adequate recharging network appears essential to attract BEV customers, regardless of how many kilometres motorists actually drive on a daily basis (Lieven, 2015). Low availability of public recharge stations combined with range anxiety can make consumers reluctant to buy BEVs (Struben & Sterman 2008; Egbue & Long 2012), and prospective owners demand better infrastructure based on perceived need (Cluzel *et al*., 2013; Deloitte, 2011). A network of rapid[2] chargers was proposed as being the most efficient way to complement overnight charging at home (Cluzel et al., 2013). To illustrate this point, an analysis of some households and public recharge infrastructure usage across the whole island of Ireland was undertaken by Morrisey *et al* (2016). Their results showed: EV users prefer to recharge at home in the peak evening period; car parks were the most favoured public location; and fast chargers (with a nominal output of 43kW or 50kW using DC and three phase electric power), which were primarily located at service centres on major highways, received the highest usage frequencies.

Comparing international evidence, it would appear early EV adopters are not as price sensitive as others, but they are more likely to be concerned about lack of recharging opportunities especially on long trips away from home. Though governments may perceive recharge infrastructure as an expensive investment, recent modelling of investment in recharge station deployment found it was three times more effective than subsidising the purchase of EVs, due to indirect network effects on the demand and supply side of a market (Yu et al., 2016). Adding weight to this argument are the results of a recent survey that pointed out that British drivers (mainly of ICVs) appeared to be more concerned about availability of rechargers, including in their local area, and vehicle range than they were about purchasing costs (UK DfT, 2016).

The absence of adequate recharging networks can act as a market failure (see Section 3.2.2) and may partly explain low EV uptake in many countries. Government financial support for publicly accessible rechargers is commonplace in countries promoting the roll out of EVs (OECD 2015). For example, at December 2015, the Netherlands had 465 fast chargers and 17,788 publicly accessible Level 2 chargers (RVO, 2016). Japan has favoured fast chargers with 6469 publicly installed, compared to 3028 in Europe, and only 1686 fast chargers in the US (McCurry, 2016). In recent research using British real world data Serradilla *et al.*, (2017) recommended government support for rapid rechargers on major highways, as their evidence suggested that investment is financially viable.

Adequate country wide distribution of a recharger network can be regarded as critical to ensure that motorists can readily travel long distances and hence overcome a key deficiency of BEVs over ICVs. In this regard, Estonia is the first country considered to have nationwide coverage of fast chargers (Gerdes, 2013), with a network that has recharge stations located approximately every 50 km on all major roads and in towns with

[2] Cars may be recharged, depending on brand and model, using AC or DC electricity delivered at four possible rates (level 1, 2, fast or rapid).

populations higher than 5000 (ELMO, 2014). Meanwhile, the US has favoured Level 2 chargers with approximately 13,537 public EV recharging stations with 33,259 charging outlets (McCurry, 2016), although distribution of rechargers is not uniform across the country (US DoE, 2017a). To assist motorists, reliable and readily accessible information about the location of recharge stations must be available. For example some countries have introduced internet applications (examples: Next Green Car2015a; PlugShare 2016; HK Gov EPD 2016; US DoE 2016a). However, there is room for improvement as some countries, for instance Belgium, fail to centralise collection of information about recharger locations, or internet applications may be out of date or inaccurate (IEA 2016, p 153).

2.2.3.2 Standardisation and regulation

EV customers want convenient recharging when away from home; drivers want to be able to easily locate a recharge station, determine availability and the price of the electricity, and to plug in (EV Connect, 2013). However, a comparison of markets suggests EV drivers are prevented from accessing all available recharge stations:

1. There may be many network providers and a driver may have to join individual networks to access proprietary rechargers when making a long trip, particularly in relation to billing protocols.
2. The hardware to enable a car to be plugged in may be incompatible with that provided by an individual network and car brands.

Evidence suggests fragmented recharge networks, and missing standards and regulations can inhibit larger market penetration (Steinhilber *et al*. 2013; Brown *et al*. 2010). The situation is very complex and the number of rechargers available to any EV owner in most countries is limited by various factors (Bakker, 2013) including:

1. The multiplicity of plug designs and charging modes that the charger and connector could be rated for (US DoE, 2016a).
2. Lack of standardisation: not all types of rechargers can be used on specific cars and use of some types may invalidate car warranties (Next Green Car 2015).
3. Wide array of payment methods: identification and billing systems often can only be accessed with membership cards via annual subscriptions to a large number of national or regional recharge network companies (Bakker, 2013). The UK is a case in point with complex and inconvenient payment systems; there are seven national and 10 regional members-only recharge networks, hence the actual number of

rechargers available to any one driver at a reasonable cost is limited (Next Green Car 2016). As one BEV owner commented:

> *"Having been a Leaf owner for 2-1/2 months, and having friends in the US who've had one for 4-1/2 years, I'm absolutely flabbergasted at the appalling mess of the UK public charging network in comparison to California. In the US, you simply swipe your credit card. No messing around with pre-registering and pre-paying on multiple different networks. Charge points WORK* [sic]" (Next Green Car, 2015b).

Additionally, Wittenberg (2016) noted the lack of co-operation among car makers to develop a single plug type particularly for fast charging, manufacturers assuming that car buyers do not consider this inconvenience as a problem, if they consider it at all, when they buy an EV. The aforementioned precludes recharge networks being used to their full potential, limiting motorists' mobility, including across borders.

2.2.3.3 Interoperability and regulation

Convenience for users is an important aspect when introducing a new technology. To facilitate easy payment for recharging an EV, improvements in interoperability – the ability of a car's recharge technology system to communicate and operate with that of the recharge station and its billing system – are needed (Bakker, 2013). The State of California is a leading example of good practice in interoperability; through Executive Orders it fosters zero emission vehicle uptake including recharger access (Governor E. G. Brown, 2012) and passed the *Interoperability Electric Vehicle Charging Stations Open Access Act* (California Senate, 2013) thus assisting a more streamlined roll out of EV charging stations and enhancing user friendliness. EVs can be recharged at any publicly accessible recharge station using a credit card to pay rather than requiring network membership. Additional legislation (California Assembly, 2014) has enabled 40% of Californians who are tenants in multi-household housing complexes, as well as business tenants, to install a recharger in their building (Shahan, 2014). Legislation goes hand in hand with technological developments that enable electricity consumed by rechargers installed in multi-tenanted buildings to be billed separately (Simpson, 2015). The former has made Californian cities among the leading US cities adopting EVs (Lutsey et al., 2015).

In summary, initial steps towards interoperability, harmonisation and standardisation of recharge fittings are underway (AVERE, 2013; European Commission 2013), though it may take time as non-standard fittings are gradually replaced (Bakker and Jacob Trip, 2013). Adding to government initiatives in many countries the private sector has stepped in. For example, in each of their markets, including Australia, car brand Tesla has installed a 'supercharger highway' and provides software supported information to make recharging simple, as an exclusive benefit to support Tesla customers (Tesla Motors, 2016) thus ensuring that their EV customers are provided with the necessary co-conditions to ensure market success, particularly where adequate government support is lacking.

2.3 EV Consumers

2.3.1 Consumer concerns about EVs

While many potential customers may be willing to change from ICVs to EVs, there are technical, financial and institutional barriers to purchase (Dunstan et al., 2011). Struben & Sterman (2008) posit that customers' willingness to consider an alternative is shaped by multiple factors including direct exposure and product attractiveness. Survey results, including those conducted when EV technology was less developed and with fewer EV models available, indicate potential consumers have numerous concerns including: vehicle range, access to rechargers, charge time, price premium, purchase price, fuel price and fuel efficiency, brand and segment supply as well as consumer receptiveness to change (Deloitte 2011; Cluzel *et al*. 2013). Key concerns for potential EV customers were identified as: vehicle price (for example, Graham-Rowe *et al*. 2012) and recharging aspects (for example, Mock & Yang, 2014; Krupa *et al*., 2014). Jensen *et al*. (2013) identified that for single vehicle Danish households EV range was critical, but in multi-vehicle households this was less important because ICVs could be relied on for long distance trips. Further research concluded that car customers tended to value purchase price more highly than future fuel prices (Allcott and Wozny, 2014), although fuel prices may increase over time thus increasing total operating costs. While fuel price and fuel efficiency may be of concern to car customers, a study on the impact of vehicle fuel costs on household budgets (Turrentine and Kurani, 2007) found that householders do not systematically track fuel expenditure, nor do they consider it specifically in their budgets. The authors identified that people generally had a sense of fuel prices, but a lack of specific information meant that fuel cost estimates were largely erroneous when buying vehicles, so rational decision making was difficult. This finding suggests consumers often lack hard evidence about ongoing ICV operating costs making it difficult to compare with the value that EVs could provide.

Customers' attitudes to EVs and buying decision processes are complex and multi-factorial (Section 2.3.2; 2.3.3; Chapter 3). Carley *et al* (2013) has ascertained that in the US EV interest was largely affected by customer perceptions of disadvantages associated with EVs, whereas from a German consumer perspective, "perceived compatibility with daily life is the most important predictor for the willingness to purchase an EV" (Peters & Dütschke 2014, p375). In another German stated choice study, Rudolph (2016) argued that incentives encourage some people to increase their preference for EVs. However, he maintained it was mainly those already displaying low emissions travel behaviour, for example those frequently riding bicycles and /or using public transport, who were more likely to prefer EVs, while those who predominantly used cars for daily travel needs were more unwilling to change. More recent research (Degirmenci and Breitner, 2017, p 250), surveying mainly young male German university students with limited experience of EVs, showed that "environmental performance of EVs is a stronger predictor of attitude and thus purchase intention" than is price or vehicle range. However, these young students may not be intending to buy a car in the near future, perhaps influencing their stated choices in the survey. As discussed in Section 2.3.2, it is likely that such positive attitudes towards EVs and declaring an intention to buy does not necessarily lead to sales.

Additional evidence points to other factors, not just positive attitude, affecting customer attitudes. In Norway, the country with the highest penetration of EVs in the new car market (Figure 4.3, p59), ICV owners continue to hold concerns about EVs that owners are much less worried about (Figenbaum et al., 2014). Their analysis of a revealed choice survey showed that ICV owners continue to express the opinion that vehicle range, access to charging stations, and time to charge were the primary concerns, with ICV owners being about three times more concerned about these issues than EV owners. This finding signals that those familiar with a technology have fewer concerns than those lacking exposure. Further, Figenbaum, Kolbenstvedt and Elvebakk (2014) found Norwegians considering the purchase of an EV next time more frequently reported having EV owning friends than people who would not consider buying an EV on their next car purchase. Consistent with these findings, "those who do not consider EVs an option show a lower level of knowledge of the technology" (Figenbaum *et al*. 2014, p 92) giving hope that more knowledge may turn parts of the non-owning group around. More recently, to further understand consumer motivation, Danish experimental research (Cherchi, 2017) found informational conformity (where individuals accept others' information as factual), and social conformity (where individuals yield to group pressures) were highly significant mechanisms influencing individual decision making. Another study (Hardman et al., 2016) comparing high-end and low-end adopters established that while overall satisfaction with BEVs was good, owners of high-end vehicles were much more likely to definitely buy another BEV next time compared to low-end adopters. Vehicle attributes relating to recharging time, environmental impacts and running costs were considered significant factors in willingness to continue BEV ownership for low end adopters whereas for high-end adopters running costs followed by time to recharge were the most significant factors affecting future purchase decisions (Hardman et al., 2016)].

Despite peoples' perceptions of EVs, Needell *et al*. (2016) undertook research that pointed out current model EVs were sufficiently advanced that the cars could suit many people, even in car dependent cities. This US study into BEV range capabilities and adoption potential measured against US driving patterns showed the energy requirements of 87% of vehicle-days could be met by a 2013 affordable model EV without top-up recharging during the day. The authors compared driving patterns in New York (the US city with highest public transport usage and lowest personal vehicle use) with those of Houston (the US's most car dependent city). They demonstrated the percentages of vehicle-days served by existing BEV technology were strikingly similar and concluded both cities showed substantial BEV adoption potential. Such research, as illustrated above, indicates that consumer concerns, especially vehicle purchase price and aspects relating to recharging, can act as barriers to EV uptake, especially for people with lower knowledge about EVs. Evidence suggests that EVs could be suitable for many drivers and relevant action could overcome customer resistance.

2.3.2 Attitude – action gap and willingness to pay

EVs are usually regarded as an eco-friendly innovation to reduce air pollution and fossil fuel consumption used for transportation (Section 2.2.2). An issue for surveys investigating EV interest is that potential customer preferences can be expressed as *willingness to pay,* which may be different from *ability to pay* (Skerlos and Winebrake, 2010). Furthermore, there is often an *attitude-action gap* indicating people may have certain attitudes but fail to carry out the action (Lane and Potter, 2007).

The attitude-action gap describes the behaviour observed in many people who have generally positive attitudes towards taking actions to reduce environmental impacts but limit undertaking of such actions. Kollmuss & Agyeman (2002) reviewed numerous theoretical frameworks and determined that no definitive interpretation had yet been found to explain this gap. Rather, a range of factors with complex relationships shape pro-environmental behaviours. Factors include: demographic factors, particularly gender and years of education; external factors such as culture and economics; and internal factors such as knowledge, values and priorities. The authors maintain that people's values are negotiated, transitory and sometimes contradictory and that strong environmental concerns can be outweighed by stronger desires and needs, such as alternative priorities for household budgets. As an example, Krupa *et al*. (2014) identified that even those most willing to buy a PHEV generally were reluctant to pay more than a few thousand dollars extra for it. Due to the complexities of human behaviour, Kollmuss & Agyeman (2002) suggested that policy makers look to social marketing techniques to find useful strategies to encourage pro-environmentalists to actually change behaviour.

Gender is one factor influencing pro-environmental and other human behaviour. For example, McCright, (2010) showed women had greater knowledge of and showed more concern about climate change than men, independent of cultural factors. Further, Zelezny, Chua and Aldrich, (2000) demonstrated that females had stronger pro-environmental attitudes than males, and their pro-environmental behaviours were even more pronounced. A considerable body of literature (e.g. Byrnes, Miller and Schafer 1999) exists to explain such gender differences. Understanding the underlying basis for such differences may be useful background information for other fields of research, including into factors affecting EV adoption. One explanation for gender differences can be found in the field of evolutionary psychology (for example, Buss 1999) and signalling theory[3]. These explanations for gender differences may help understanding differences in attitudes to car buying and preferences for various car attributes, a topic explored in this research in Chapters 5 and 6.

Prior research on the attitude-action gap (Mairesse *et al* 2012), focusing on environmental attitudes towards car purchasing, demonstrated that a preference for superior environmental performance in car models was generally outweighed by other attributes (for example, cost, quality). Although public and active transport trips would produce better environmental outcomes, consumers interviewed preferred cars as the primary means of transport due to the convenience and independence afforded. The attitude-action gap was explained through Information Integration Theory; that is "thought and action are determined by the joint effect of multiple determinants" (Mairesse *et al*. 2012, p

[3] Evolutionary psychology explains that males can potentially increase their evolutionary fitness, including their ability to survive and pass on genes, by having sex frequently with multiple partners; whereas females have limited opportunities to reproduce over a lifetime and must take fewer risks in selecting a partner. One suggestion is that high quality males can afford to take risks more often as they are less likely to fail than low quality males (Wilke et al., 2006). By contrast, females are less likely than males to be risky and more likely to weigh up evidence to ascertain whether to undertake a particular action, which can be explained in terms of evolutionary biology and signalling theory. This theory argues that men undertake attention seeking activities to signal their superiority in order to gain sexual partners and allies, and as a cue for male rivals; costly signals are undertaken to increase the chances of a desirable outcome for the signaller (Zahavi, 1975). For example risky behaviours and acquiring status symbols are forms of signalling, and the signaller's ability to bear the cost of that activity is a way to reveal superiority (Hawkes and Bird, 2002). Men with high status were found to be preferred by women as a means to satisfactorily acquire resources (Buss 1999, p 111).

549). The authors further clarified it by proposing that when making car buying decisions, consumers average the impacts of attributes with differing levels of importance. Mairesse *et al*. (2012) further argued that associating environmental attributes with financial aspects could be a sensible pathway for policy formulation: taxation according to a car's environmental performance is an effective approach to promote vehicles with lower environmental impact, rewarding green car purchases and penalising high polluting vehicles. However, they did caution that this may not always be effective as vehicle quality is an important attribute for car buyers, and environmental friendliness is not necessarily seen as a marker of quality.

France is an example of a country that has adopted policy to link vehicle environmental impact with financial arrangement. France adopted a bonus-malus purchase subsidy scheme where a bonus is paid for low CO_2 emitting vehicles and high emission vehicles are penalised (Appendix D). However, France was ninth in the ranking for EV adoption (Figure 4.1, p52) with a relatively low adoption rate of 1.45% in 2016, indicating that it is not necessarily a guaranteed method for attracting buyers; other factors must also be important. Tran *et al*. (2012) also noted the discrepancy between survey respondents stated preference to buy EVs and actual willingness to pay, they argued that many people were unwilling to pay a price premium therefore information about fuel economy and the link to GHG emissions and cost savings needed to be presented, and before customers reached a car showroom (further discussed in Section 2.3.3). They argued that much of the literature assumes a homogenous market, but car manufacturers demonstrate that the market is very heterogeneous.

The discussion above of research related to attitudes to purchase indicates that people who express a positive attitude towards the environment may wish to undertake appropriate action, but for a complex range of reasons may not be able to undertake such action. For example, an inability to pay the price premium may make EV's ticket price prohibitive for many consumers.

2.3.3 Vehicle price and other factors affecting purchase decisions

Research indicates customers are primarily concerned about purchase price (for example, Mersky *et al*. 2016) but it is not the sole determinant when choosing a car. Consumer decision making is complex and prior research evidences that a range of incentives and other actions need to be adopted to address the range of consumer concerns. For instance, Hahnel *et al*. (2014) noted price had a strong impact on consumers, though lowering price can signal a lowering of quality and reduce demand for a product. They argued that consumers purchasing intentions were malleable and that activation of environmental values could motivate willingness to pay more for EVs but not necessarily guarantee increased demand; consumers may shun EVs regardless of price and any 'environmental' marketing signals, hence making the case for activating behavioural change, even among those tending to act environmentally. Additional research from Norway by Nayum & Klockner (2014) corresponds with such views, it detailed how consumers held perceptions that owning fuel efficient cars involved a trade off with other attributes, thus, provision of information and personal experience together could help overcome consumer fear and doubt about the technical performance and practical aspects of EVs. As a result, Nayum and Klockner (2014) recommended that incentive structures and policy decisions consider consumers' multifaceted purchase motivations, to allow a higher level of policy success in the long term. In another consumer survey in Manitoba, Canada, Larson *et al*. (2014) found people were reluctant to pay large premiums for EVs, even if given information on future fuel savings. However, a quarter of those consumers with experience or exposure to EVs were willing to pay a premium.

Appropriate information can help consumers to weigh purchase price against lower operating costs. A consumer stated preference survey in metropolitan US (Dumortier et al., 2015) found overall that ranking vehicles by response to vehicle labels, consumers were unaffected by *five year* fuel cost *expenditure* labels, however when information was provided about *total cost of ownership per month*, statistically significant results showed respondents ranked PHEVs and BEVs higher for small/mid - sized cars, but not SUVs.

Complexity in behaviour needs to be considered to enhance EV uptake. Earlier research by Choo & Mokhtarian (2004) reported that generally the more a vehicle costs the less likely it is chosen by customers; as well, travel attitudes, personality and lifestyle impact on vehicle type choice (for example, a desire for fuel efficient transportation was not strongly associated with those living in dense urban areas, who often chose SUVs). They argued that as travel conditions worsen, for example with traffic congestion, some people compensate with larger and more expensive vehicles rather than reducing travel. Similarly, those who think they do a lot of long distance travel do not buy small cars.

The above factors indicate that purchase-based decision making is complex and potential customers consider a wide range of factors, which should be addressed by policy makers aiming to increase EV uptake in their particular market.

2.4 Governance and government action to incentivise EV uptake

Government actions impact the operation of markets. For a market to function well it requires good governance and that requires state capacity, policy capacity and administrative capacity (Dovers and Hussey, 2013). As one means to encourage uptake of a new technology, governments can implement policies – among these policies those relating to market formation are probably the most important (Gallagher, 2014), and may contribute to higher shares of EV sales (Vergis et al., 2014).

As discussed in Section 2.2.3.1, research shows that action relating to one such market formation investment (recharger infrastructure) could be more cost effective than subsidising EV purchase. Such government spending could be outweighed by savings from other government expenditure such as health costs from air pollution derived from ICVs. A cost benefit analysis for individual markets is research that could help provide evidence to support government investment in a transition away from the use of oil to energise cars.

Policy approaches

Government action to address a problem may take the form of adopting policies and implementing specific programs. Policy approaches can be statutory, market based or information provision (Dovers and Hussey, 2013). Policy interventions are intended to solve problems, to achieve success clearly stated goals should form the basis for implementation, monitoring and review processes (Dovers and Hussey, 2013). For example, in 2007 the US *Energy Independence and Security Act* (Pub.L.110-140) was enacted to reduce the nation's dependence on foreign oil and to increase "energy independence and security and to increase production of clean renewable fuels"(US Government Publishing Office, 2007). Subsequently a raft of federal and state legislation and incentives were introduced with the objective of increasing the EV fleet (Reid and Spence, 2016). Policy setting by European Union (EU) member countries has been driven by the need to meet targets set in a number of directives (European Parliament & the Council of the European Union, 2014).

Policies to encourage EV purchase affect car buying behaviour to varying degrees. Early consumer interest in EVs in Australia, France, Germany and UK (Deloitte 2011) has not necessarily translated into higher rates of EV adoption (Figure 4.1 and Appendix D). Potential environmental benefits of EVs were found to be insufficient to promote a change in consumer behaviour (Lane & Potter, 2007) and ranked behind vehicle cost and performance (Egbue & Long, 2012). Such behaviour conforms to the attitude-action gap previously described (Section 2.3.2) and government incentives have been found to help overcome these barriers to purchase and encourage uptake (see Chapter 4).

Battery costs determine that EVs are still more expensive to produce than ICVs (Nykvist and Nilsson, 2015). Thus incentives, such as direct subsidies, fiscal incentives and fuel cost savings, offered by governments are thought to encourage EV purchase and help overcome customer resistance to higher vehicle prices (Mock & Yang 2014; OECD 2015). However, the form of incentive is as important as its generosity, with research showing tax waivers at time of purchase to be more effective than delayed income tax credits, suggesting that immediacy and ease of application is important and influences consumer behaviour (Gallagher and Muehlegger, 2011). Moreover, prior research (Diamond, 2009) points out that upfront payments are more effective, though such monetary incentives could act as a subsidy for car dealers if these subsidies are factored into their pricing schedules. More recent research (Lévay et al., 2017) indicates different types of financial incentives can favour certain market segments over others; they conclude such incentives are crucial in market formation but that EVs will only become more popular when price competitive with ICVs.

Types of policies

While most policies to incentivise EV uptake have been fiscal, other policies such as direct subsidies, information programs and regulatory changes were also promoted, especially those relating to the provision of recharger networks (OECD, 2015). A multi-national survey demonstrated that installation of a recharger network on freeways was an absolute necessity to attract buyers to adopt EVs and was independent of actual distances driven on a daily basis; in comparison, high purchase subsidies were attractive but not essential (Lieven, 2015). Consistent with this survey, Harrison & Thiel (2017) identified, in the absence of policies to increase recharge infrastructure, very high subsidies alone did not lead to long term EV market success. Furthermore, to encourage transition away from fossil fuelled transportation, they argued that regulations with long term fleet emissions should target vehicle manufacturers. Modelling by Sierzchula *et al.* (2014) showed EV uptake was positively correlated with financial incentives, charging infrastructure and local vehicle production, with the number of charging stations per inhabitant assessed as most important. Similarly an analysis of Norwegian EV sales data assessed that access to BEV recharging infrastructure was the most highly important measured factor linked to sales data (Mersky et al., 2016).

Government action to assist this necessary market co-condition could be considered vital to accelerate EV market formation. For stakeholders "subsidies for the installation, maintenance, and operation to the quick charging infrastructure are seen as the most important contribution by the public sector " (IEA 2016, p73). Lack of support for infrastructure deployment would be worse than doing nothing at all, or only subsidising vehicle purchase. For governments the "most common action is to support their installation through tax exemptions, financial incentives and especially for quick chargers (due to their high cost), direct, partial or full funding" (IEA 2016, p74) and may include purchase and installation. However, despite considerable national government investment, countries like the US evidence that EV deployment is not uniform, with uptake influenced by multiple factors, including: vehicle purchasing subsidies, model availability, city-level awareness promotions and good access to public recharging stations (Lutsey et al., 2015). A stated-choice experimental study in Sweden (Langbroek et al., 2016) established that incentives such as free parking or bus lane access increased the likelihood of EV purchase and could be a useful alternative to expensive purchase price subsidies. They also determined the probability of EV adoption was higher for three different groups: those in advanced stages of behavioural change towards buying EVs; people who believed EVs help reduce current transport related negative externalities; and those whose travel patterns aligned with EV capabilities.

Analysis of EV uptake in Norway (Fearnley et al., 2015) showed that nationally offered incentives of value added tax (VAT) exemption, registration tax exemption and reduced annual tax were more effective than locally or regionally offered incentives. However, local incentives tailored to local conditions were nevertheless demonstrated to have a big impact on uptake, particularly bus lane access, whereas free parking was the least cost-effective policy. Fearnley et al. (2015) highlighted the importance of providing a range of incentives to appeal to differing user needs to speed EV diffusion.

It is noteworthy that in EU countries company cars make up about 50% of new car sales (Naess-Schmit and Winiarczyk, 2010). The authors assessed that the tax system facilitates individuals gaining private access to company cars, thus enabling motorists to obtain more expensive models of cars than they might otherwise be able to afford. In practice people have chosen larger cars using more fuel hence boosting CO_2 emissions. The authors recommend the tax system be urgently reformed to find options that better align with emissions reduction strategies. One such option would be to preference EVs rather than ICVs for company tax benefits.

Concurrent with strategies to encourage EV uptake, many countries set mandatory vehicle emissions reductions targets, which have tightened over the years (European Commission Climate Action, 2016). It is notable that a number of important car manufacturers have been caught cheating on fuel economy tests (Farrell, 2016) while attempting to meet legislated fuel efficiency standards targets. In Europe, car emissions are averaged across a whole brand (European Commission Climate Action, 2016), therefore producing more EVs could be an easier way for a brand to meet its emissions targets. For example, in the wake of the VW emissions scandal, the company announced plans to expand its EV production (Cremer, 2016). Recent modelling (Harrison & Thiel, 2017) indicates that very high purchase subsidies could not lead to market success in the absence of policies to increase recharge infrastructure; and it appears that regulations with long term fleet emissions targets for vehicle manufacturers are essential to encourage transition away from fossil fuelled transportation.

2.5 Previous Australian research and barriers to uptake in Australia

The majority of research discussed so far has been Europe-centric in concert with the high levels of uptake in these markets. However, in the last decade, several Australian studies have also gained insight into potential for EV uptake in Australia that complements this international research on customer attitudes to EVs (Sections 2.3 and 2.4). Research into potential EV uptake in Victoria, Australia, for example, found attitude and perceptual measures were the most important factors for predicting EV purchase, while higher education and lower age also increased likelihood to buy (Gardner et al., 2011). The authors determined "the most important predictors of potential EV uptake were concern about climate change, tendency to take up new technology, positive attitudes to EVs and belief EVs are better for the environment" Gardner *et al*. (2011, p 6). Further, they established that factors such as total cost of ownership, upfront cost of the car, and maintenance costs were important to all potential car buyers; while those with a lower tendency to buy an EV were somewhat more worried about the range of the vehicle, the time taken to recharge and the cost of replacing the batteries than for those who were more likely to buy.

In other research the Victorian state government (2010-14) conducted an electric vehicle trial, to assess the process, timelines and barriers to market development with the aim of providing all levels of Australian governments with issues and opportunities associated with the uptake of EVs (DTPLA 2013, p 7). The study's mid-term report discovered that during the trial, families actually using the vehicles did not have to change anything about how or where they travelled most of the time as compared to average Victorian data (DTPLA 2013, p 38) and that the existing electricity network could accommodate charging the EVs.

Barriers to an Australian uptake of EVs have been reported by several studies. While vehicle cost was the primary obstacle for EV purchasing (DTPLA 2013, p37, p42), another key barrier to uptake was lack of a public charging infrastructure network, although, installing a network commercially was seen as a difficult business proposition. Further, the study also determined that by 2020 EV operating cost advantages would out outweigh purchase price disadvantages with conventional vehicles. These lower operating costs could be considered a possible motivation for EV purchase among ordinary consumers.

A key study by Dunstan *et al*. (2011) investigated barriers to widespread adoption of EVs and suggested policy solutions. Barriers were categorised as technical or institutional. Technical barriers relate to characteristics of the technology and associated costs, including the failure to include the cost of externalities for competing technologies. Institutional barriers related to values, culture and regulatory/legal settings, which are biased against the technology.

Dunstan *et al*. (2011) discussed a wide range of barriers especially lack of information; difficulties for the mainstream population in obtaining sufficient and correct knowledge about new opportunities and changes in the technology as they arise were considered a market failure. Similarly, they discussed the many myths surrounding EVs and PHEVs and, they further noted there was a payback gap for infrastructure providers between supplying rechargers and attracting sufficient custom to pay off the investment.

Compared to the wealth of international research on EVs, these few Australian studies, while useful, indicate there is a dearth of research in the current Australian context. More work is needed to take into account a maturing technology and the ever-increasing urgency for action on climate change and to find solutions relevant for Australia. If applied these solutions could be adopted by Australian governments at all tiers that have thus far lacked interest in stimulating the Australian EV market despite the many benefits at an individual and societal level that EV use provides.

2.6 Summary and gaps in the literature

Compared to earlier models, technological developments of recent EVs have resulted in improved operating efficiencies. Evidence suggests that EVs can be a useful substitute for ICVs and that their use would reduce many associated negative externalities, resulting in positive social outcomes and is more sustainable than using fossil fuels for transport. EVs compared to ICVs are environmentally less damaging, even if the electricity used for recharging is considered highly polluting and applies to all but a few countries, (Section 2.2.2).

This review of the literature demonstrates that for a high proportion of customers in many countries there are common factors that may impede the uptake of EVs. Research points to inadequate recharging infrastructure as the most important barrier to adoption followed by relatively high vehicle price compared to similar ICVs. Government action is a necessary component to increase EV market share, particular in the early phase of market formation. Actions to reduce vehicle price and to encourage the supply of infrastructure, and other consumer benefits have been common in many advanced economies (Section 2.4).

Understanding the potential for uptake of EVs in Australia by researching consumers provides useful background material for more targeted studies, however, previous research exhibits some limitations. While this earlier research identified some barriers to uptake and found who was more likely to have a positive attitude to EVs, as explained in Section 2.3.2, positive attitude does not necessarily translate into actual purchase. Further research is required to understand factors that need to be addressed to help bridge the action-attitude gap. Gardner *et al*. (2011) revealed there were many misconceptions about the characteristics of EVs especially relating to purchase price and running costs, which were consistent with other research (Krause et al., 2013). However, while Gardner *et al*. (2011) investigated some potential barriers to purchase, they did not explore respondent travel patterns, impacts of recharge infrastructure location, the importance of 'rechargability' on long trips, nor incentives that might be popular, possible factors affecting EV uptake.

The Victorian EV trial (DTPLA, 2013) investigated families who used EVs on a day to day basis. However, using the results to understand customer purchasing resistance could be limited as all trial respondents: were enthusiastic; prepared to make behavioural changes needed to plan trips and manage recharging; owned a conventional ICV in addition to using the EV (provided free of capital costs during the trial); had off-street parking with access to electricity and did not pay for a recharge unit; nor were they required to pay a purchase price premium associated with EVs compared to similar ICVs.

Dunstan *et al*. (2011) undertook a search of the literature, government policies and other practical sources of information and reported on an extensive range of technical and institutional barriers to the uptake of EVs. They made more than 50 policy recommendations that could address these barriers. However, they did not investigate customer attitudes such as convenience of ownership or other factors that might encourage uptake such as providing relevant up to date information.

Building on previous work, research into Australian consumer attitudes to EVs is needed to gain a deeper understanding of what policy measures might encourage EV uptake in Australia. Additionally, research of various purchasing incentives to determine those most attractive to customers would assist in finding appropriate actions that could be recommended to governments to accelerate the transition to EVs. Such assistance, if successful in increasing EV uptake, would help mitigate the harm that results from using conventional cars for passenger transport. The aim of this thesis (Section 1.6) is to address some of these knowledge gaps by undertaking further research into potential EV customers as outlined in Chapter 3 Methodology, and ultimately, to use the findings to reveal actions that if implemented well, could allay Australian motorists' concerns thus encouraging acceptance and purchase of EVs.

Chapter 3 Methodology

3.1 Introduction

This chapter discusses the conceptual framework underpinning this research. The exploratory research methods used to collect and analyse data to better understand factors affecting Australian car customers' potential EV purchasing decisions are also described.

First in Section 3.2, the theoretical framework is described to structure the research and provide the philosophical paradigm and approach. Next, in Section 3.3, the framework for data collection is outlined. Section 3.4 describes the data collection techniques employed, with an explicit focus on the methods used for each part of the research. The data analysis techniques are described in Section 3.5. Finally, a summary of the characteristics of the sample used to obtain data contextualises this work (Section 3.6, Table 3.1). Limitations of this research are discussed in Section 3.7. Ethics approval and my positionality statement, underpinning my understanding of the topic, the approach to data and interpretation of the results follow.

Ethics and positionality statement

This research had UNSW ethics approval number 155078. As part of this approval, participation in the questionnaires was voluntary with informed consent and a guarantee of privacy, confidentiality and anonymity was given.

The role of the researcher cannot be overlooked in the direction research takes and the influence of personal experiences on the interpretation of the data collected. I recognise that my personal approach to the data does ultimately influence choices made regardless of how objective I tried to be.

I have worked as a transport policy advisor for the NGO sector as well as government. In both roles public and active transport was the primary focus, because of the benefits that could accrue to society the economy and the environment if car dependency was reduced. However, my approach in this thesis has acknowledged that personal motorised transportation could not be entirely eliminated for a variety of reasons, including people's individual choices. In pursuing such a nuanced understanding of personal car purchasing choices, I recognise many people do drive some of the time, and I advocate that it would be better if the cars were less harmful than might otherwise be the case. After the commencement of this thesis I purchased a PHEV, which is my family's only car. While keeping an open mind, my positionality also influences my overall interpretation of the data. I have tried to recognise and account for my subjectivity through rigour in analytical approach and searching for congruence of my findings with previous studies. My previous studies for the Master of Environmental Management (UNSW 2004) have influenced my acceptance that transport contributes GHG emissions to the atmosphere and hence is a factor involved in climate change.

The original research undertaken as part of this thesis was by questionnaire. This format provided quantitative data and short answer qualitative data (Section 3.3.1 and Appendix C). There was a potential bias in the recruitment process. While respondents chose to answer the survey, the link was distributed via a contact list I constructed, with snowballing occurring from an original list of people more likely to have a pro-environmental bias. However, as the data sought was to generate information about aspects important to people with such views, this may be regarded in a positive light. Thus I was able to judge what would be needed for the motorists potentially easiest to convince to buy an EV next time they bought a car.

3.2 Theoretical framework underpinning consumer purchasing decisions for innovative products

This research is concerned with understanding the barriers and possible incentives to the adoption of a relatively new technology – electric vehicles. Relationships between technology and society are complex, and just because a new technology may have significant positive attributes, as argued is the case with EVs, its acceptance and successful uptake into society is not always assured. Thus, underlying the theoretical framework of this thesis is research that focuses on this relationship between technology and society and how it helps to make sense both of our ability to change the world *and* how we use technology for our own benefit. Transition from one technology to one more innovative has been viewed as a six stage linear process from basic research through to usage, using an integrated constructivist "seamless web" approach to science and technology through a sociological lens (Bijker et al., 1987). It has been hypothesised that studying how technological artefacts are developed and change over time can facilitate greater understanding of problems that may develop from existing and new technologies (Bijker et al., 2012), thus allowing society to use technology to minimise those problems.

However, it is more likely that the adoption of innovation is more complex than described in many theories and involves a wider range of factors. For example, the *Actor Network*

Theory, developed in the mid-1980s by the sociologists Callon, Latour and Law, explored the relational ties within a network of people and things, which were considered on an equal footing (Bijker et al., 1987). They considered that not only do engineers shape objects and their use and hence society, but society influences what problems they solve (Bijker et al., 1987). A rich literature exists covering innovation and transitions, and it evidences the impossibility of understanding change being as described by any one theory; as well prior research has not provided a consensus on how best to explain transitions to new processes and technologies (Garcia and Calantone, 2002).

To make sense of the factors impacting on the uptake of innovations, and in particular those impacting on the adoption of electric vehicles, two concepts were employed: *Diffusion of Innovations Theory* (Rogers 2003) and *Market Failures* (Bator, 1958). These concepts describe and explain factors that appear to be closely linked to consumer choice processes and they are described further in Sections 3.2.1 and 3.2.2. The focus centred on the responses of government to various elements of these two theories as a possible explanation for why new products are not universally adopted despite apparent multi-factorial benefits. The interplay of these two theories with government action (illustrated in Figure 3.1) forms the model used to guide this research to explain factors affecting adoption of innovation, in this case electric vehicles.

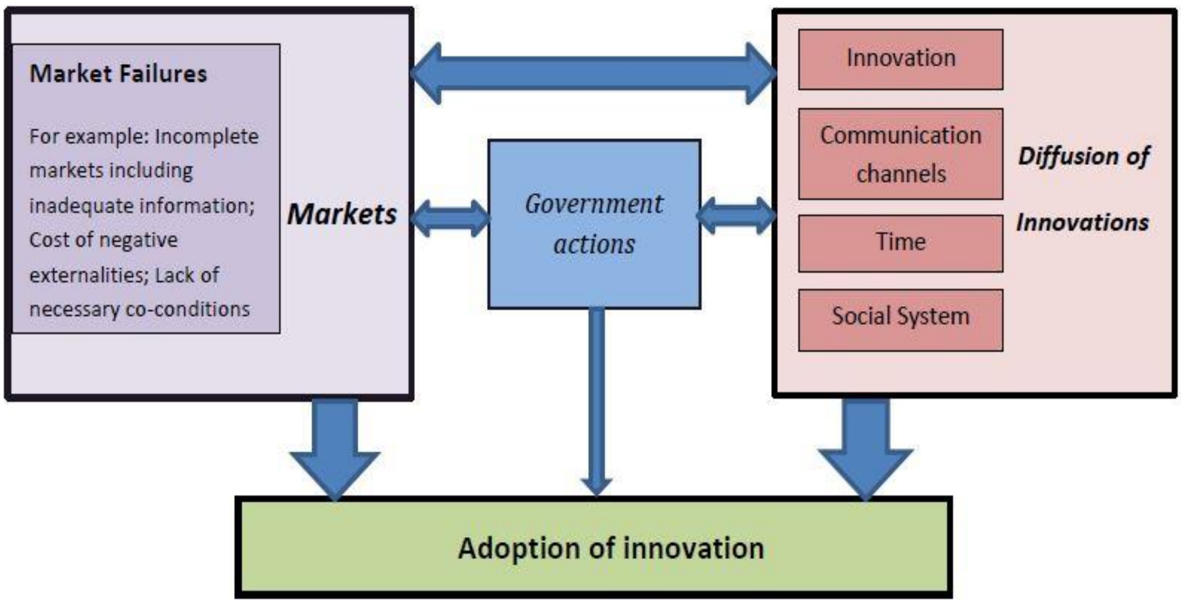


Figure 3.1 Conceptual Framework: adoption of an innovation is affected by the interplay and influence of government actions on elements of markets and Diffusion of Innovations. Source: Adapted from Bator (1958) and Rogers (1983).

Consumers are affected by a range of conditions, as described in both theories used in this model. However, government actions, such as the development of new policy, for example adopting new legislation, regulation and / or programs to promote a particular action or infrastructure, impact on aspects of these two theories. An example might be the adoption of new legislation that impacts on how a service is delivered – this may impact on the choices consumers can make in the market place, and on customer communications concerned with those choices. Thus, the interplay of these aspects affects the adoption of an innovation. The elements of Diffusion of Innovations Theory as outlined (Section 3.2.1), with market failures (Section 3.2.2) underpin the model developed (Figure 3.1) to inform the research questions investigated in this thesis.

3.2.1 Diffusion of Innovations

Diffusion of Innovations Theory (Rogers, 1983) explains how an innovation is communicated through certain channels, such as person to person, over time and diffused within a society. Rogers (1983) explained that in the early stages of the adoption process, barriers to purchasing innovative products are too high for most people to consider purchasing an innovation, as they are risk averse and require evidence of an innovation's superiority. For example, the higher price of EVs compared to ICVs and the inconveniences of frequent, lengthy recharging compared to infrequent quick refuelling may act as barriers to all but the most enthusiastic adopters of a new technology such as EVs. In Roger's theory, a very small *Innovators* group adopt innovations early and are those prepared to take more risks (Figure 3.2). Often *Innovators* have the financial resources needed to absorb failure should that occur, whereas other groups could be considered to accept lower levels of risk and need more time to evaluate an innovation. *Laggards* are the last group to adopt an innovation; they could be considered to be more conservative and resistant to change than other groups, and are often older and of lower socio-economic status (Figure 3.2).

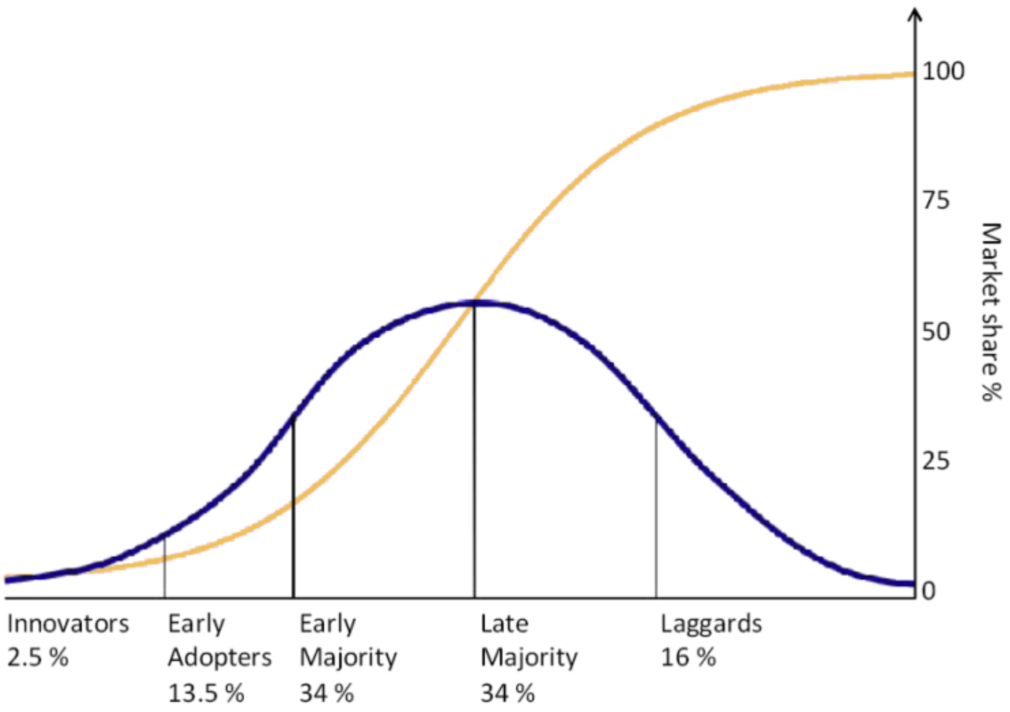


Figure 3.2 Adopter categories based on Rogers' *Diffusion of Innovations Theory*

Source: Rogers (1983, p247)

Rogers (1983) also divided the adoption process for an individual into five separate phases, from knowledge through to confirmation (Figure 3.3). An innovation may be accepted or rejected at any stage in the process, with influence from communication channels possible at any stage.

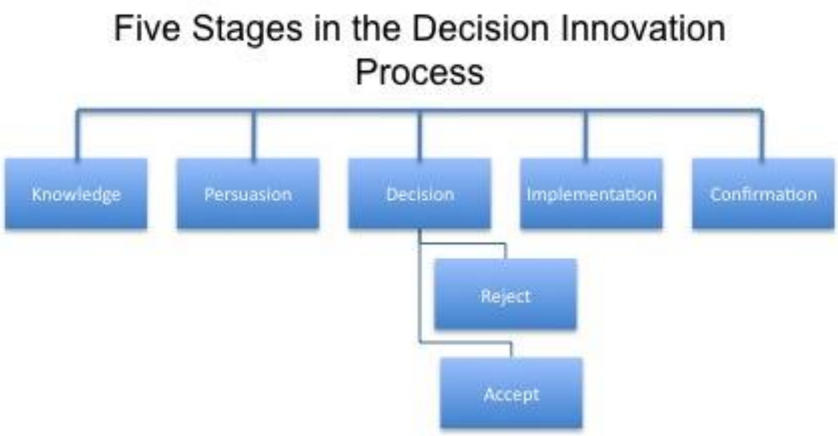


Figure 3.3 *Diffusion of Innovations Theory* Stages in the innovation decision process
Source: Adapted from Rogers (1983, p 165)

Rogers (1983, p233) theorised that for most consumers to decide to accept a product they need evidence that the innovation has:

1. Relative advantage over existing products
2. Consistency with their values, experiences and needs
3. An acceptable level of utility and freedom from complexity
4. The ability to be tried before buying
5. Observable tangible improvements over the incumbent technology.

Rogers (1983) speculated that barriers to purchase can occur when any of these criteria fail to meet expectations. It follows that the so-called critical mass occurs when there are sufficient adopters to ensure the innovation is self-sustaining. He further clarified his argument that while an innovation could be adopted it may be later discontinued, or if initially rejected it may be later adopted.

3.2.2 Market failures

A market failure describes a situation where decisions by individuals prove to be incorrect, in a collective capacity, making the community worse off because the price mechanism fails to account for all costs and benefits necessary to provide and consume a good (Boundless, 2016). The concept of market failure (Bator, 1958) helps explain aspects of markets that can act as barriers to purchasing innovative goods that would provide community benefit compared to incumbent technology, and could also help explain why individual customers may reject new products as theorised by Rogers (2003) (Section 3.2.1).

Market failures for EVs can result from a range of factors, including: incomplete markets where customers may have inadequate information; the market has failed to take into account the costs of negative externalities such as GHG emissions and health costs of toxic air pollutants and noise, where third parties suffer; and where markets can struggle to form because of a lack of the necessary co-conditions (Boundless, 2016). Governments may intervene in adoption processes to help new markets establish and to influence the rate of an innovation's acceptance. Such responses can include: legislation, direct provision of public goods and / or merit goods, taxation, subsidies, tradeable permits, extension of property rights, information provision, and co-operation with other governments (Boundless, 2016).

However, neither the theory of diffusion of innovations nor market failure individually provided a perfect explanation for human behaviour as decision making processes are complex (Section 2.3). For example, an empirical study of consumer adoption of Hybrid

Electric Vehicles (HEVs) by Ozaki & Sevastyanova (2011) found complexities in customer behaviour not portrayed in prior research; the researchers concluded that these complexities have implications for policy makers and factors such as societal pressure could be useful when designing policy to assist adoption of such an innovation. Trying to understand such behavioural factors affecting acceptance or rejection of an innovation may be helpful for policy makers in deciding on intervention programs.

Thus, the theory of Diffusion of Innovations and market failure, and how government action interacts with both, impacts on the rate of uptake of a new technology such as EVs. This interconnectedness (Figure 3.1, p36) has been used as the underlying framework for this research to make sense of why consumers may or may not adopt such an innovation. To make sense of conditions that apply in the Australian market, specific data was collected and analysed. The following Section 3.3 provides a framework to underpin that data collection.

3.3 Methodological framework of data collection

Data collection as described in this research is post-positivist and is partly deductive and partly inductive (Bryman, 2012). The research paradigm of this thesis is post-positivist in its outlook to bridge the divide between a search for an objective reality and accepting an understanding that socially constructed human values are an important part of the research, where causes probably affect outcomes (Creswell, 2009). Post-positivism does not limit research to qualitative methods (Hall, 2008), it acknowledges that data, evidence and rational considerations shape our understanding and allows that knowledge is conjectural and never absolutely true (Creswell, 2009). The approach taken is also partly deductive, where the research is conducted with reference to predetermined theory/theories (Bryman, 2012) and partly experimental (Chapter 6) in nature; which is needed to fulfil the research aims to understand factors affecting Australian car customers that may influence EV purchasing decisions (see Chapter 1).

Quantitative aspects of the research are deductive, including testing the hypothesis posed in research question 3 (Section 1.6), using numerical data collected from the units of analysis (individual car drivers). This experimental component included two comparison groups: respondents were randomly assigned to Test or Control groups. While not trying to establish causal relationships, it explores if, by providing information about recent EV models, respondents' stated preferences about likelihood to buy an EV are affected. Through analysis of questionnaire data, this research sought to establish trends and relationships between variables. Qualitative aspects are inductive and are used to reveal and interpret the complexities of people's lives (Hay, 2005). Therefore, this research is partly inductive and partly deductive as it used a combination of quantitative and qualitative data enabling different complementary perspectives, thus yielding a richer and fuller analysis of the subject matter (Hall, 2008).

3.3.1 Mixed methods

A mixed methods approach was used to gain a comprehensive understanding of social attitudes towards barriers and incentives that may affect EV purchasing decisions by Australians. Using mixed methods enables cross checking of results using different approaches to the same problem, improving the confidence in the findings and reducing limitations of single designs (Hall, 2008, p 124). This research has an integrated design as findings from parts of the study were used to influence design aspects of other parts of the study (Hall 2008, p122).

This mixed method approach, described in greater detail in Section 3.4, consisted of:

1. *Critical review of the literature*: to answer research question 1 (Section 1.6) the following topics (a-d) were investigated. This research facilitated a better understanding of international best practice for government assistance aiming to increase EV sales in the new car market. This information also enabled a comparison to the Australian scenario. Topics:
    a. EV market share in 2013-16 in selected countries;
    b. Policies and actions in best performing countries;
    c. EVs available in Australia 2016;
    d. Government action in Australia to increase EV purchase.

2. *Consumer market survey*: two online questionnaires were designed and administered ten months apart to gather quantitative data (closed ended responses, graded scales, Likert scales) and qualitative data (open ended short answer responses). Copies of the questionnaires are in Appendices A and B.

Questionnaires were selected in preference to other data gathering techniques, such as focus groups and one-on-one interviews, as they are cheaper and easier to collect and interpret. Data can be spatially broader than might otherwise be practical. For example, the cost of collecting data from areas away from home were prohibitive, thus using online methods enables data collection from right across Australia at minimal expense. The open response questions allowed respondents to provide unprompted answers thus gaining insights that may be missed with closed response questions. However, this short answer technique may miss some of the subtleties provided in face to face interviews. This shortcoming may not be detrimental as broad information was sought about an innovation, with which few Australians have experience, rather than exploring details that may be apparent to EV users. Characteristics of the questionnaires and justification for their use are further elaborated in Appendix C, Table C1.

Questionnaires could be completed by individuals at a time and place convenient to them during the survey period, whereas to conduct focus groups sourcing sufficient respondents to attend at a nominated time and place would be very difficult particularly over a wide geographic area. This research was mostly about car buyers and their concerns as they decide whether to make the transition from ICVs to EVs. Hence, it was decided not to interview key informants from various vested interest groups such as body corporates from apartment buildings. Such a broadening of the participant criteria would have changed the focus of research to being about stakeholder responses to any barriers to EV adoption. The focus was on potential private EV customers and understanding possible barriers and incentives for them. How interest groups might react to any recommendations arising from this research could be an area for future study.

Questions allowing open ended answers are more difficult to analyse but do give unprompted answers, allowing for unexpected responses and more nuanced opinions (Hall, 2008). Making sense of such answers to enable manageable analysis requires individual responses to be categorised, which is a subjective process. Analyst bias, however slight, may affect the categories into which responses are placed. This question type however, gives an opportunity to search for meaning rather than just an identification of behaviour, although both types of data are useful in shedding light on a problem (Winchester, 1996). Online questionnaires have the advantage of being conducted anonymously in a value free setting. Units of analysis were individuals aged 18 years or over as they were able to have a driver licence, are potential car buyers, and for ethical reasons. Appendix C provides further justification for using questionnaires.

To provide a brief overview of the demographics, the sample surveyed in the consumer market survey is summarised and included in Section 3.6. Limitations of the research are briefly discussed in Section 3.7.

3.4 Data collection techniques

Techniques used in this research are described below.

3.4.1 Critical review of the literature

A critical review of relevant literature was undertaken to enhance understanding of four themes, namely: EV market share; policies and actions in best performing countries; EVs available in Australia; and government action in Australia to encourage EV purchase.

3.4.1.1 EV market share in 2013-16 in select countries

EV market share in individual markets was calculated as:

Rate of uptake = (Number of new EVs sold/ new car registrations) x 100

The numbers of new EVs sold, and total new passenger vehicles registered in each country, for years 2013 to 2016 inclusive, were collected from a variety of sources in the grey literature, including: government departments, car manufacturers and car associations (see Appendix D for sources). EV sales figures generally included both BEVs and PHEVs, but inclusions / exclusions were noted.

This step addresses research question 1, and identified 14 countries with the highest rate of EV uptake. Results of 2016 were used to rank countries. Data from Australia, Germany, Japan and Denmark were also collected and included as examples of countries with high rankings on the UN's human development index (Jahan, 2015), but low adoption of EVs, and varying levels of government support to encourage EV purchase (Appendix D).

Measuring the stock of EVs in a particular country does not give a useful measure of marketplace acceptance; for example in 2016, the US had the highest EV stock of all countries, followed by Japan and China (IEA, 2015b), despite modest EV market penetration. Similarly, calculation of EVs per inhabitant may only serve as a measure of a country's wealth rather than as a measure of acceptance by car owners; additionally, places with a small geographic area and good public transport may have low car numbers per capita. Countries with large populations can have many cars numerically, and vehicles can be more numerous in wealthier countries than poorer countries. The ratio of EV sales to the total number of new car registrations in a country, as adopted in this research, is unaffected by the aforementioned factors and it enables EV market share to be measured regardless of population numbers, geographic area and/or country wealth.

3.4.1.2 Policies and actions in best performing countries

A review was made of relevant peer-reviewed journal articles and the grey literature including government, international agency and business reports to identify incentives offered in those countries identified in Section 3.4.1.1 above. Information was obtained from a wide range of mainly English language sources, and where possible, recent changes to incentives offered were noted. Incentives offered by each country are listed in Appendix D, with references.

3.4.1.3 Review of Australian government programs available in 2016 designed to encourage purchase of EVs

A review of the grey literature was undertaken, including government websites and media reports, to find measures Australian state and federal governments had implemented to encourage customers to buy EVs. These measures are reported in the section on Australia in Appendix D.

3.4.1.4 Review of EV car brands and models available in Australia in 2016

Information from the grey literature and results were tabulated (Table 4.1, p71) using the following entries:

- Brands and models of EVs available in Australia in 2016;
- Travel range for each vehicle on one recharge and, for PHEVs, the additional range achievable on the petrol/diesel component;
- Vehicle attributes;
- Approximate selling price (AUD) of each model;
- Annual fuel cost for 14,000km assuming 66% urban driving (as per DIRD (2017);
- Vehicle size (length, width).

3.4.2 Consumer survey

As noted in Section 3.3.1, two questionnaires were conducted as a means to survey the opinions of Australian car drivers about cars and EVs. Both questionnaires were self-reporting and cross sectional. Recruitment was by convenience sampling with contact mainly by email or Facebook. Selected friends, family, colleagues, and many groups with an environmental bias (number and identity of members was unknown) were contacted.

Questionnaire 1 was undertaken in October/ November 2015; it included an independent design component (using systematic variation), with a null hypothesis and an alternative hypothesis (Section 1.6).Sample respondents were separated into Test and Control groups to manipulate one variable: information provision or no information.

Questionnaire 2 was undertaken in August 2016 to obtain greater in-depth understanding of interventions such as the provision of incentives that could assist in overcoming potential barriers to purchase, and to cross check results. Respondents from Questionnaire 2 were a subset of Questionnaire 1 and consisted of those who voluntarily provided contact details and agreed to undertake this second questionnaire.

3.4.2.1 Questionnaire design summary

Survey Monkey (2015) was the online platform used to administer the two questionnaires, to assess factors that might influence a customer's stated preference for likelihood to buy a BEV (fully electric vehicle) or PHEV (plug in hybrid electric vehicle). The first questionnaire included an experimental component to test a hypothesis about the influence of the provision of information on decision making as previous research had revealed that "most consumers are either uninformed or misinformed" about EVs inflating personal cost estimates thus reducing likelihood of buying one (Krause *et al*. 2013, p 439).

The questionnaires were pre-tested as pilot studies to help refine the questions and subsequently modified prior to delivery to reduce risk of question ambiguity (Winchester, 1996). Questionnaire 1 was constructed using information from previous research (for example: Gardner *et al*. 2011) and refined following the pilot study with a group car drivers. Questionnaire 1 also was designed to gather information that could assist in answering research question 3: testing if receiving up to date information about current model EVs increased the likelihood that the respondent would buy an EV. Survey Monkey randomly allocated half the respondents to a Test group, who received a page of information about current EV models, and the other half to a Control group who did not receive the information.

Questionnaire 2 was prepared using a pilot study with the same respondents used for the original pilot study. It was constructed to obtain a deeper understanding of issues revealed to be important by the first questionnaire, and for cross checking. Questionnaire 1 included questions about incentives already used in other international markets that could have a positive impact on EV uptake. In Questionnaire 2 respondents were also asked about incentives, but were asked to assume a new EV was the same price as a similar conventional car as the price of EV batteries has been rapidly declining (Nykvist and Nilsson, 2015).

3.4.2.2 Questionnaire design details

Questionnaire 1

The questionnaire (Appendix A) comprised 6 sections (below) with a total of 42 questions. Questions were ordered in a logical fashion so that respondents, by answering the questions, would be led through concepts relevant to the feasibility of EV purchase by the respondent. These questions would remind respondents of their individual circumstances that could allow/disallow such a purchase, for example they were asked if they had off-street parking and electrical outlet accessibility for recharging an EV. Data was collected from 12 October 2015 to 13 November 2015. The contact email and Facebook page included a covering letter (Appendix E) and consent was tacit in choosing to undertake the questionnaire. Appendix C provides a summary of design features.

The sections were:

1. Project information Statement;
2. Part A General Questions: Physical characteristics: Postcode, gender, age, type of residence, home ownership status, availability of off-street parking and ability to provide electricity socket; socially defined characteristics: education, employment, current study;
3. Part B: Car ownership and use: number of cars, car ownership status, intention to purchase new or used car, cost of next car purchase, size of car, type of car, type of fuel, purpose of car trips, frequency of trips > 100km per day, purpose of long trips;
4. Part C: Knowledge about cars: source of information about cars, interest in cars as a technology, knowledge of car technology, recollections of media about EVs, importance of car features for purchasing, what would encourage BEV purchase, what would encourage PHEV purchase;
5. Information page: Random allocation of respondents to:
    1. Test group: page with information about EVs, or
    2. Control group: no new information
6. Attitudinal questions on: Likelihood to buy BEV or PHEV, two reasons not to buy BEV or PHEV, preferred main place to recharge, other place to recharge, opinions about various factors that may affect EV purchasing decision; opinion about government investment, explanation of opinion; importance of government actions to encourage EV ownership, how the respondent found out about survey, and two optional questions on voting intention.

Two hypotheses were proposed (Section 3.4.2) to answer research question 3 (Chapter 1). An experimental method[4] was used to test if information provided about current model EVs increased the favourability of EVs to questionnaire respondents. The use of “Communication channels” to disseminate information about an innovation, such as EVs, is

[4] Experimental research aims to determine if a specific treatment influences the outcome, the results of one group receiving treatment are compared with the other group from which treatment was withheld (Creswell 2009, p 12)

one of the four main elements of the Diffusion of Innovations theory (Rogers, 1983) described in section 3.2.1. Using information provision as a marketing tool is a well-established practice (Pulizzi, 2013).

Afterwards results of the Test and Control groups were compared and contrasted to seek evidence that could illustrate if provision of relevant information on new products, such as EVs, may be a suitable policy intervention to foster uptake. Random selection of Test group respondents removed any bias by ensuring the effects of other variables not being measured were not systematically related to the variables under investigation. In questions with multiple parts, some statements were worded negatively to provide inaccurate statements, and further avoiding systematic bias; for example "The lithium batteries of electric cars are very polluting compared to lead batteries".

Questionnaire 2 - follow up study

This questionnaire was undertaken to explore the more common barriers to EV purchase, and to increase understanding of the popularity of measures used in other countries to incentivise EV uptake. Results from Questionnaire 1 were used to design questions to ask in Questionnaire 2, using sequential methods (Creswell 2009, p 14). With only 15 questions this second questionnaire was shorter, and more focused on open-ended responses.

The 150 respondents from questionnaire 1 who had volunteered email addresses were requested to participate in the follow up questionnaire. The contact email included a cover letter (Appendix F); consent was tacit in choosing to undertake the questionnaire. A reminder email was sent after one week. Data was collected from 2 August 2016 to 19 August 2016. Responses from 102 respondents were useable.

Questionnaire 2 (Appendix B) comprised 3 sections:

1. Project information Statement
2. Section A: - Information about EVs currently on the Australian market
   - Demographic questions: gender, number of cars owned / leased, whether car was purchased new/ used or if no car was owned, availability of electricity supply for recharging,
   - Attitudinal questions: EV interest since last survey, significance of information sources.
3. Section B: - Questions relating to EVs. Respondents were given information about battery prices and asked to assume that EVs would be the same price as similar conventional cars then asked likelihood of buying a BEV and a PHEV. Respondents

were asked to provide information on what factors would impact on their buying decisions (open ended), and to rank those incentives they found appealing. A final open-ended question (optional) asked respondents to provide any further insights to explain what would encourage or dissuade EV purchase.

3.5 Data analysis techniques

Information obtained from the two questionnaires was analysed to provide information about:

- The independent variables: demographic characteristics of potential car purchasers and car/ house / parking factors, and
- The dependent variables on attitudes to electric vehicles, perceived barriers to purchase and incentives that could encourage purchase.

For closed response questions the percentage of respondents selecting each possible response was calculated. For those questions with interval Likert scaled response options, the weighted means of responses (Weighted Average Response = WAR) were calculated (see box below). By comparing the weighted means, the bigger the differences between weighted means for different groups then the more likely the responses are significant.

Calculating Weighted Means

Weighted mean = $[(1 \times n_1) + (2 \times n_2) + (3 \times n_3) + (4 \times n_4) + (5 \times n_5)] / N$

Where $n_1 + n_2 + n_3 + n_4 + n_5 = N$

N = number of respondents in a particular category e.g. New car buyers

Where n = number of respondents in each of the Likert scale values for that particular value e.g. 1= least likely and 5= most likely.

Analysis of qualitative responses to open questions is more complex and challenging than closed question analysis. Value judgement was required to place individual responses into the appropriate coded categories for each of these questions. Such category coding enables the researcher to find patterns and commonality in the responses (Hay, 2005). This latent content analysis was more appropriate to use than manifest content analysis (visible surface content, for example, tally the number of times certain words or phrases appear) as many words or phrases can relate to the same thing and sometimes a single word can relate to several themes, therefore it depended on context to discern the respondent's intention. Determination of category codes was an iterative process. All answers were read and commonly occurring responses were placed in preliminary categories until more discrete patterns emerged, and final categories could be determined. Percentages of respondents who provided answers in each category were calculated.

3.6 Sample size and demographics

A total of 330 respondents[5] satisfactorily completed Questionnaire 1 providing a total sample of n=330. Two thirds (66%) found out about the survey by email, 17% by word of mouth, 10.5% by Facebook, and almost 7% via sources such as Twitter, school newsletter, and an electric vehicle forum.

Table 3.1 Survey sample demographics

General Demographics			
Gender (%)		**Highest level of education (%)**	
Female	50.3	No formal qual.	0.9
Male	49.7	HSC	4.2
Age (%)		Diploma /Advanced dip.	8.8
18-24	6	Bachelor degree	30.6
25-34	18.5	Grad cert. / Grad dip.	12
35-44	19.4	Post-grad degree /PhD	42
45-54	21.8	**Student status (%)**	
55-64	20.6	Full time tertiary studies	0.6
65-74	10	Part time tertiary studies	8.25
75 +	3.6	None	81.2
Voting intention: House of Reps (%) Optional question (275/330)		**Voting intention: Senate (%) Optional question (272/330)**	
Liberal/National coalition	29	Liberal/National coalition	22
Labor	18	Labor	14
Greens	43	Greens	56
Other (incl. unsure)	10	Other (incl. unsure)	9

[5] Although 352 people undertook Questionnaire 1, two respondents were eliminated as they did not have a drivers licence and did not drive, which were prerequisites. The results of a further 20 respondents were insufficiently complete to be useful. The accepted 330 respondents, as a minimum requirement, completed the questionnaire up to and including Q27.

Residence	
Dwelling Type (%)	**Home ownership status (%)**
Separate house 53.3	Fully owned 35.8
Semi-detached /terrace house/townhouse 16.1	Being purchased (mortgaged) 32.4
Flat/unit/apartment 30.6	Rented 26.4
	Still at home 5.5
Car related demographics	
Number off –street parking spaces (%)	**No. Cars available to drive (%)**
Zero 17.9	Zero 3.3
One 31.8	One 47.3
Two 27.9	Two 36.1
Three + 22.4	Three + 8.5
	Use car share 4.9
Designated parking (%)	**Car ownership status (%)**
Yes 58.2	Own car 85.5
No 23	Lease car 5.5
No off-street parking 18.8	No car but intend to buy within 5 years 5.5
Mains electricity at parking space (%)	Do not intend to own ever 3.6
Yes 62.4	
No 7.6	**New or Used car at purchase (%)**
Unsure 11.5	New 42
No off-street parking 18.5	Used 47
	No future intention to buy a car 11

3.7 Methodological and technical limitations

The questionnaires were limited to self-reported data. Due to the brevity of responses in open ended questions there was a limited ability to capture the full richness of meaning in people's decision-making processes.

The targeted sampling regime used in this research meant that respondents were not representative of the entire Australian population due to differences in education, political affiliation and environmental awareness (see Appendix C, Table C2 for a complete list of the characteristics of the sample, and Appendix C2 for a comparison of this sample with the Australian population). It aimed to gain a better understanding of barriers that affect people more likely to buy an EV than a random selection of the Australian population, and to seek insights into their attitudes to potential government actions that may incentivise EV uptake.

Chapter 4 International best practice and pitfalls for policy makers

4.1 Introduction

This chapter provides a critical review of the literature to answer research question 1:

a. *What policies and strategies have been most useful in encouraging Electric Vehicle uptake in countries with higher levels of EV adoption and what are some pitfalls that should be avoided?*
b. *What is the Australian EV scenario and how does it compare to more successful markets?*

Understanding the contribution that a range of government policies and strategies can make to encourage market success is helpful for countries with low uptake, either to modify existing less successful measures, or when deciding which measures to adopt.

To determine International Best Practice for such government policies, rates of EV adoption in the new car market were calculated as a measure of successful uptake. A comparison of rates in different international markets and measures was undertaken to investigate actions and policies that contributed to enhanced uptake. A discussion of measures that, if implemented poorly or not at all, may contribute to lower uptake is presented. To enable comparison with Australia factors affecting its EV market were investigated. Thus, understanding what drives success and what has contributed to Australia's declining market share could provide pointers to policy measures and strategies that if adopted could encourage EV uptake.

Section 4.2 portrays the data for the top 14 EV markets for the years 2013-2016. Section 4.3 discusses the factors affecting EV sales, including government policies and actions, in the top 4 performing markets (Norway, Hong Kong, The Netherlands and Iceland). Section 4.4 presents the UK as a case study of poorly implemented policies that resulted in stagnating BEV sales, with PHEV sales contributing most growth. Information dissemination is a critical action to foster EV acceptance and is therefore discussed in Section 4.5, along with other considerations in Section 4.6. Using the information outlined, Section 4.7 describes international best practice. The Australian scenario is described in Section 4.8 including EV models available in 2016, and Section 4.9 summarises the overall findings from this chapter.

4.2 Strongest performing EV markets

Rates of EV adoption for the 14 strongest performing markets for the years 2013 – 2016 are shown in Figure 4.1, ranked by 2016 results. Countries were identified through the process described in Section 3.4.1 where rate of EV uptake represents the percentage of EVs sold in the new car market. Appendix D contains the data used to construct this graph and, for each market, lists the incentives offered to encourage car owners to buy electric. The incentives used in the most successful markets are analysed and discussed below. Data collected for some other advanced economies: Japan, Germany, Denmark and Australia, are included in Appendix D as examples of countries with high standards of living (Jahan, 2015), but with lower EV sales rates than other more successful markets included in Figure 4.1.

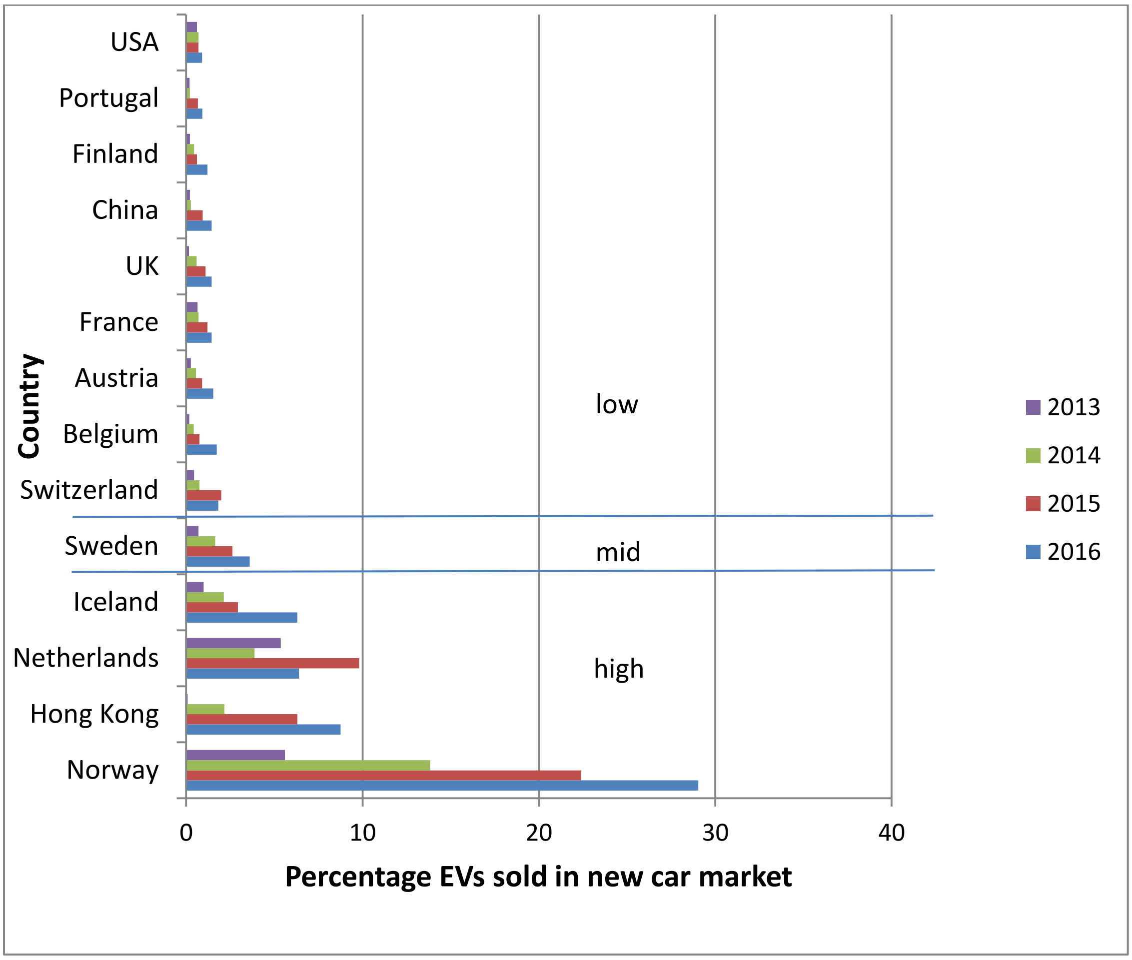


Figure 4.1 Uptake of EVs in selected countries as percentage of new car registrations by market; showing top, mid and low performers

Figure 4.1 shows that EV uptake varies considerably, both temporally within individual markets and geographically. Many countries are still in the early stages of market development when compared to the higher performers. Based on 2016 data there is a cluster of four top performers in terms of EV uptake (Norway, Hong Kong, The Netherlands and Iceland), Sweden is a mid-level performer, while Switzerland, Belgium, Austria, France, UK, China, Finland, Portugal and US make a third cluster with lower EV market shares. Of particular relevance to this thesis is that the percentage of EVs sold in Australia have been so low, and falling, they do not even appear on this graph: in 2016 EVs represented just 0.02% of the new car market, dropping from 0.12% in 2015, 0.13% in 2014 and not even as high as the 2013 rate of 0.03% (see Appendix D). This thesis aims to discover actions that could address and reverse this trend, and useful actions are discussed below.

4.3 Factors affecting rate of EV uptake in the most successful markets

This thesis argues that adoption of suitable government policies and other well implemented measures is necessary to encourage market formation of an innovation such as EVs. These measures, examined in Section 2.3, can assist the diffusion of innovations as well as address market failures, and together can increase the uptake of relatively new products such as BEVs and PHEVs to provide economically, socially and environmentally beneficial outcomes. Policy settings to encourage EV uptake in individual countries have been implemented for a range of reasons (Section 2.4), and as Figure 4.1 (p 52) indicates, some markets have been more successful than others. Discussion follows hereafter on the enabling conditions identified in markets that most successfully encouraged uptake of EVs. The impact of weak instruments on good policy, the role of awareness-raising and the importance of government procurement is also discussed. An analysis of policies in countries where EV sales have declined since 2013/4/5 (Australia, Denmark and the Netherlands) (Appendix D), indicates that adequate support from government is needed to encourage the EV market, especially in the early stages of its development.

4.3.1 Norway

Norway is the most successful market for EV uptake (Figure 4.1) with EVs comprising almost 30% of all new cars registered in 2016. There has been extensive research to understand conditions that have contributed to this success story. BEV adoption has had political support for decades with the implementation of a suite of measures, most importantly by making the cars cheaper and priced similarly to ICVs (Figenbaum *et al*. 2015), shown to be critical for over 80% of BEV owners (Bjerkan et al., 2016). In 1990, BEVs were exempt from purchase tax, and since 2001 were also exempt from high VAT (25 %) (Figenbaum et al., 2015). Initially, exemption from VAT and the initial registration fee was to apply to the first 50,000 BEVs sold, with the policy due to expire in 2018; however, upon reaching the target in April 2015 the government voted to continue providing financial incentives until the end of 2019 (Hockenos, 2017; Milne, 2017).

Soft incentives

In addition to generous financial incentives, the Norwegian government has provided a range of other soft incentives (Appendix D) such as extensive deployment of recharge infrastructure, free battery recharging, free EV parking in public car parks, exemption from road and public ferry tolls and free access to bus lanes for BEVS (Bu, 2015). Norway has the highest number of rechargers per million population (Lutsey, 2015). These incentives were all assessed to have positive impacts on BEV sales (Bjerkan et al., 2016).

Mersky *et al.*, (2016) found access to recharging infrastructure was the most highly important measured factor linked to Norwegian sales data. The authors also showed that toll exemptions and bus lane access were important soft incentives, although of less impact than incentives affecting car price and availability of rechargers; by contrast, they found access to free parking had the least impact. Toll lane access was the most cost effective soft incentive offered (Fearnley et al., 2015). Decision making on some softer incentives has devolved to individual local authorities (Gordon-Bloomfield, 2015). A survey of BEV owners by Figenbaum, Kolbenstvedt and Elvebakk, (2014) found that vehicle price and operating costs were most important, with local incentives playing a role in attracting customers: free ferries were least important nationally but important in some local areas, and free toll roads were very significant for 39% of owners. Active local government procurement policies were also positive actions (Figenbaum *et al*. 2015). These studies indicate that offering a mix of incentives that are tailored to local motorists, while simultaneously ensuring there is an adequate national recharge network, are the most critical factors in explaining Norway's high rates of EV adoption.

Vehicle ownership

Multi-vehicle ownership and higher income may also be factors in Norwegian motorists choosing EVs. A study by Figenbaum & Kolbenstvedt (2016) attributed the higher rate of BEV owners who are in multi-vehicle households (79%) to their higher socio-economic status compared to the national average (49%) of multi-vehicle households; notably 75% of BEV owners also own an ICV or PHEV while 21% of EV owners had only one car. This study also found BEVs were driven for the majority of daily trips, but that ICVs were preferred for longer trips. Another survey of Norwegian EV owners (Haugneland et al., 2016) found that in households with both electric and conventional cars, EVs replaced 82% of ICV use. In 2016, EVs made up almost 30% of the new car market (Figure 4.1) evidencing that EVs are now appealing to Norway's "early majority" as per Rogers (1983) Diffusion of Innovations Theory (Figure 3.2), not just "innovators" and "early adopters" (Section 3.2.1).

BEVS versus PHEVs

Comparing Norway's relatively low uptake of PHEVs rather than BEVs until 2016 (European Commission, 2017) also points to the efficacy of Norway's incentives for BEVs (see Figure 4.2). For many years PHEVs did not attract the generous incentives given to BEVs, however in July 2013 some financial incentives were offered (EV Norway, 2016) and this, along with an increasing variety of PHEV models, could help explain the subsequent rising popularity of PHEVs in the country. In 2013, there were 328 new PHEVs first registered compared to 1678 in 2014, and 7964 in 2015 (OFVAS, 2016), whereas in 2016 the numbers dramatically rose to 20,664 almost equalling the number of BEVs sold (24,224)(Appendix D).

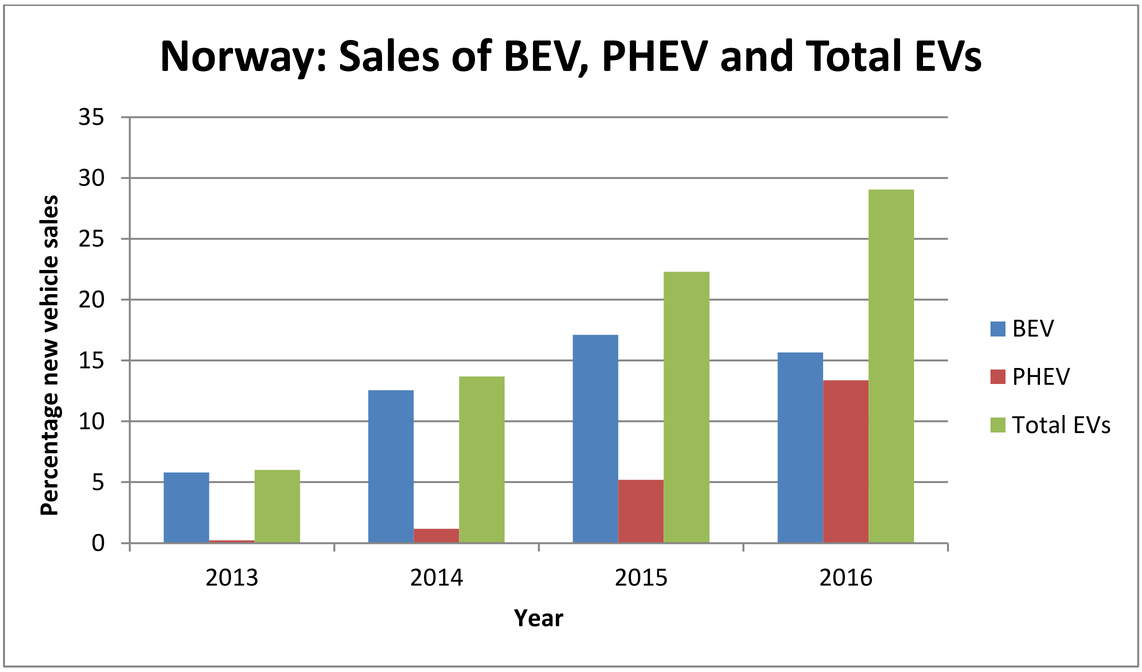


Figure 4.2 Norway: sales of BEVs, PHEVs and Total EVs 2013-2016

Earlier research found that those less likely to buy an EV were more concerned about range than enthusiasts (Gardner et al., 2011). Therefore, the rising sales numbers of PHEVs indicate that this type of EV may be a more appealing option for customers who have some range anxiety or may wish to avoid inconvenient recharging away from home, or perhaps only want one car that can meet all their requirements. Worth noting is that a mid-priced PHEV was Norway's top selling EV in 2016 (the Mitsubishi Outlander PHEV SUV) (European Commission, 2017).

These survey statistics, plus high national EV sales, indicates that Norway is successfully transitioning away from fossil fuelled transport, and many car owners use a mix of vehicle types to provide for their personal transport needs.

4.3.2 Hong Kong

Hong Kong, the second most successful market, introduced financial incentives to enhance EV sales as a means to reduce air pollution (HK Environment Bureau, 2012) by exempting BEVs from the very high first registration tax, which typically almost doubles the price of a new car (Appendix D). This high tax regime, which was introduced to curb car ownership due to traffic congestion concerns (HK Transport Advisory Commitee 2014), has resulted in a relatively low per capita level of car ownership compared to the other markets mentioned. However, the tax exemption policy on BEVs alone was not sufficient to increase sales: it has been only since 2014, with the advent of a larger selection of models that were sufficiently attractive to customers (Blum, 2014), that EVs have become popular. Consistent with this argument, Hardman *et al*. (2016) noted that the 2012 introduction of the Tesla Model S created a new high-end category of EVs: previously EVs were considered low-end and less desirable, despite their relatively high price within any market segment. These new models enabled potential EV owners to overcome the seeming embarrassment of driving earlier model EVs, which were small sized (Graham-Rowe et al., 2012), and possibly incompatible with their lifestyle choices. In 2013, EVs comprised just 0.09% of Hong Kong's new car market, however, uptake rose to 2.17% in 2014, 6.31% in 2015 and to 8.76% in 2016 (Appendix D). Non-financial incentives adopted by the Hong Kong government include installation of a public recharger network (with an ongoing program to upgrade recharger speeds) and provision of information useful to EV owners and potential owners such as a telephone hotline, car dealers' addresses and recharger locations (HK Gov EPD, 2017).

4.3.3 The Netherlands

The Netherlands, the third most successful market in 2016, also offered a range of incentives to encourage buyers, although incentives were changed at the end of 2015 as explained below. EVs represented 9.8% of new cars registered in 2015; however, there was a dramatic reduction in 2016 when EVs dropped to 6.4% of new car sales (Appendix D). Financial incentives, such as income tax credits and exemption from annual car taxes, had applied to cars emitting 50g CO_2 per kilometre or less, thus including BEVs and most PHEVs.

To encourage higher uptake of BEVs, the favourable treatment for PHEVs was reduced at the end of 2015, resulting in high PHEV sales in late 2015 (Irle et al., n.d.), probably bringing forward many sales, which halved in 2016 (European Commission, 2017). BEV sales did increase, though insufficiently to compensate for the drop in PHEV sales, demonstrating the importance of financial incentives in encouraging uptake. BEVs may appeal to a smaller market segment than PHEVs but, to secure a larger market share, the incentives offered for BEVs may have been inadequate to encourage people to choose a BEV.

Notwithstanding the support for recharger installation by the Dutch government, including a relatively high proportion of publicly accessible fast chargers compared to Level 2 rechargers (RVO, 2016), PHEVs have been more popular than BEVs (41,226 PHEVs versus 2543 BEVs sold in 2015) (RVO, 2016), in sharp contrast to Norwegian sales figures (Appendix D and Figure 4.1). Further research would be needed to understand the motivations for PHEV sales compared to BEV sales in The Netherlands.

4.3.4 Iceland

Iceland with its very small population (Appendix D), introduced financial incentives for EVs offering VAT (25.5%) exemption for the first US$47,000 of a car's value (Blanco, 2012). The strategy was aimed, in tandem, to reduce transport GHG emissions and improve macroeconomics by reducing fossil fuel import costs (Althingi 2011). The country is yet to achieve nationwide recharger coverage, although there are limited numbers in the capital Reykjavik and in some tourist areas (PlugShare, 2016), and there are plans to ensure all municipalities have fast chargers (Iceland Monitor, 2016).

PHEVs, especially the mid-priced Mitsubishi Outlander, have become increasingly popular in Iceland, outstripping BEV sales (European Commission 2017), which is not surprising given the current lack of a country-wide network of fast chargers. Furthermore, Iceland has very cheap electricity, 99% of which is renewable (Askja Energy, 2017), thus relatively cheap operating costs may be very appealing in a country with high petrol prices[6].

4.3.5 Further considerations to engender success

Each of these top four markets has implemented policy instruments that have helped address EV market failures, and they illustrate useful strategies for countries considering funding measures to accelerate EV adoption. Making EVs cheaper helps attract customers, as does supporting the installation of an adequate network of rechargers that supplies

[6] http://www.globalpetrolprices.com/ Petrol prices as at 27 Feb 2017: Norway US$1.88/L; Iceland US$1.89/L; United States US$0.68/L; Australia US$1.01/L; Netherlands US$1.68/L

necessary market co-conditions; exemplified by The Netherlands and Norway, which present the highest number of rechargers per million people (Lutsey, 2015). The discussion thus far also indicates that each market is unique with different contextual factors affecting customer decisions. Evidence supplying the contextual factors for Australia is examined in Section 4.8 and Chapters 5 and 6.

Recharge issues

Evidence from the US, additional to the circumstances in Norway described above in 4.3.1, shows that most EV owners drive less than their vehicle range on most days and recharge overnight at home (Needell et al., 2016). However, for longer trips away from home the batteries would need more frequent recharging. Hence, motorists would need convenient access to high speed chargers, especially *en route*, on highways and in country towns, to enable such journeys within a single day. Inspection of recharger maps (PlugShare, 2016) of countries with high EV sales illustrates that well distributed numerous public recharge stations are in place. Recharge time is variable depending on the car's capabilities and the speed of the recharger, and on long trips membership of a one or more charge networks may be needed if there is no legislation in place to require interoperability and easy payment options such as by credit/debit card (Section 2.2.3). Even if battery capacity increases, thus extending vehicle range, individual journeys have unique trajectories requiring recharging at different points. The current frequency and distribution of petrol stations in advanced economies indicates that even for long range ICVs there is a market for conveniently located refuelling stations for these cars, particularly on intercity roads. This would indicate that a well distributed recharge network would be needed to service EVs, especially on long trips, but also to reassure potential owners, a very high proportion of drivers in most countries. As discussed in Section 2.3, EV owners are far less concerned about recharging issues than those unfamiliar with the technology, and motorists who know EV owners are more likely to buy an EV than those who do not. Therefore, until EV drivers are more numerous in any particular place an extensive EV recharging network would be needed to allay the fears of those unfamiliar with EVs' charging needs.

Recharger availability

Another problem relating to recharging occurs in Hong Kong, where future EV market growth may be constrained by the availability of sufficient public rechargers, in addition to the cessation of financial incentives in March 2017. Cheng (2016) highlighted the congestion at public recharge stations because of limited access to home recharging; given that most people in Hong Kong live in apartment blocks and building managers have no obligation to install carpark rechargers, even in new buildings, urgent government action to remedy these problems is warranted. This example emphasises the importance of ensuring ready access to rechargers whether at home or elsewhere to facilitate the transition away from fossil fuel consumption; rechargers could be featured in advertising to attract buyers and/or tenants to buildings with them.

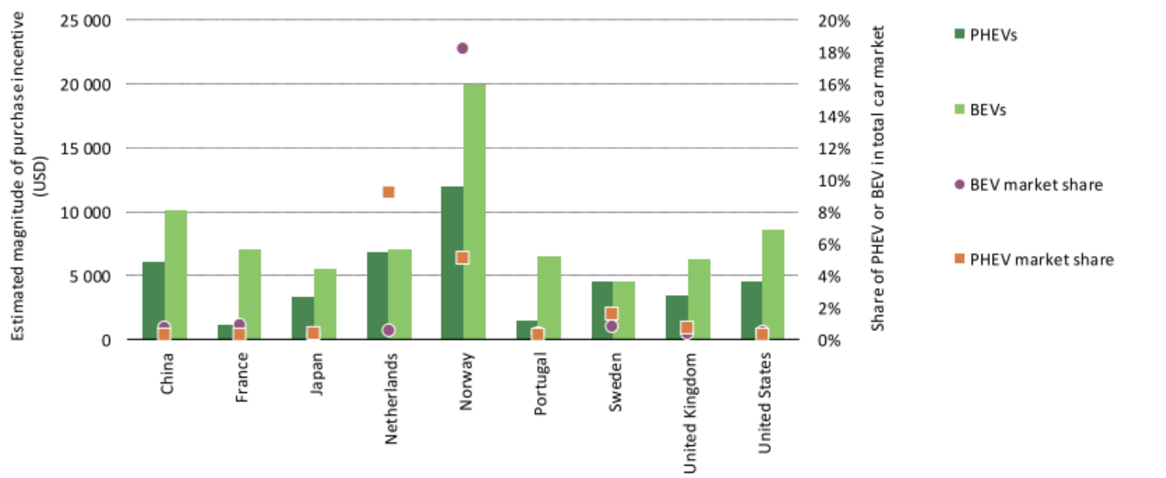
Fuel taxes

The above discussion of countries with relatively high EV uptake also draws attention to the importance of government action to control fuel taxes to support EV market development. As one example, Norway imposes high taxes on oil based fuels for transport (DoEE, 2017, Table 8B) making it cheaper to drive EVs compared to ICVs. By comparison Australia is one of the lowest oil taxing nations (Section 1.2.3) making the operating cost difference for EVs compared to ICVs lower than in high taxing nations. In recent years Australian non-private EV sales have dramatically decreased (FCAI, 2017). Such declines are unsurprising, as media articles have pointed out (O'Kane 2014); EV purchase price compared to ICVs is relatively high and payback time, based on such relatively low operating costs for ICVs, is lengthy. Declining sales figures indicate this is a market failure, particularly for the non-private sector of the EV market that would likely require positive economic signals to justify EV purchase.

Impact of subsidies on market uptake

Denmark also provides evidence of the importance of government support to address market failures via reasonable car purchase prices to enhance EV uptake. In 2015, Denmark was ranked sixth with EVs making 2.39% of all new car sales. However, a policy decision to partially re-imposed the registration tax on EVs (1 January 2016) with full tax by 2020, resulted in high EV uptake in late 2015 as sales were brought forward, and then immediately plummeted (Wenande, 2016), resulting in total EV sales of 0.63% in 2016 (Appendix D). This Danish action resulted in a significant market failure. These two examples, Australia and Denmark, demonstrate that understanding specific market failures is helpful if the aim is to address factors affecting EV uptake.

Despite its importance, upfront vehicle price does not appear to be the critical driver for increasing EV market share. Figure 4.3 (IEA 2016b, p 16) evidences that the magnitude of a purchase incentive is not the only factor encouraging EV buyers.



Note: estimates for the Netherlands are calculated as the difference between the tax paid by a BEV and a PHEV emitting 50 g CO_2/km and the average of the tax paid by a gasoline and a diesel car emitting 130 g CO_2/km. Incentives in Norway are based on an average electric car cost (before VAT) of USD 30 000.

Figure 4.3 Purchase incentives and market shares for BEVs and PHEVs, 2015
Source: IEA 2016b, p 16. © OECD/IEA (2016) *Global EV Outlook 2016 Beyond one million electric cars*, IEA Publishing. Licence: www.iea.org/t&c

Norway offered the highest financial benefit and was the most successful market. However, other countries in 2015 (including China, France and US) offered the same or higher financial incentives per vehicle than the second most successful country, The Netherlands, but lacked Dutch success in encouraging EV uptake.

It may be argued that supplying market co-conditions is more important than purchase subsidies for motorists, regardless of their financial circumstances. A 20 country, five continent study (Lieven, 2015) found that, independent of daily average distances driven, the installation of a charging network on major highways was an absolutely necessary co-condition for EV uptake, and that high financial purchase incentives, while very welcome, were not essential.

Although now causing declines in EV sales, the impact of financial incentives being phased out in the future may not act as a complete brake on sales as might be expected. A systematic review (Nykvist and Nilsson, 2015) of more than 80 sources found that internationally, battery prices have been falling rapidly. Nykvist and Nilsson (2015) demonstrated that most of these sources over-estimated the impact of battery prices on EV costs, and thus the authors estimated that battery prices will drop sooner than most have predicted. Therefore, if EV price compared to ICVs is a key customer concern (Section 2.3), expected cheaper battery costs could result in price parity of EVs compared to conventional cars within a few years, even without government incentives, assuming car sales prices are not artificially kept high by marketers. It is interesting to note that flat tax exemptions favour the larger more expensive EV models, for example Tesla Model S, whereas lump sum subsidies favour cheaper smaller models, for example Nissan Leaf (Lévay et al., 2017). The type of financial support offered has implications for government policy, with careful consideration required for the types of instrument employed (for example, tax exemption).

The four successful EV markets discussed, Norway, Hong Kong, The Netherlands and Iceland, provide evidence that government actions to address market failures have encouraged motorists to continue to buy EVs, including positive feedback from early adopters. However, careful attention to implementation of such actions would be necessary if customers, beyond the initial enthusiasts, are not dissuaded from buying EVs due to negative feedback emanating from dissatisfied owners.

4.4 Pitfalls: Effects of weak instruments on good policy, case study of the UK

Despite the influence of financial policy instruments on EV market share, discussed in Section 4.3, results of this research (Figure 4.1, p 52) show EV uptake is still low, and a much larger proportion of car customers continue to buy ICVs, indicating there are factors at play other than incentives affecting initial purchase price of EVs. A British review found higher up-front capital costs can deter buyers, and tax relief affecting purchase price can have the most direct impact on sales (Gross et al., 2009). However, in the case of the UK, while generous financial incentives are helpful, they have not necessarily encouraged more customers to buy EVs (Figure 4.3). In 2015, EV adoption rate in the UK was 1.1%, that is, less than half of Sweden's 2.5%; and in 2016 UK uptake grew to 1.45% compared to Sweden's 3.6% (see Appendix D for data). For each new EV sold since 2011 the UK government offered grants to a maximum of 5,000 GBP (about USD 6750), higher than those offered in Sweden since 2012 (40,000 SEK, approximately USD 5000) (Mock & Yang 2014, p 7). Despite these financial incentives, uptake is low and the UK government, in its pledge to promote zero emission vehicles, extended the plug-in car grant till March 2018 (UK DfT, 2015).

Recent modelling (Harrison and Thiel, 2017) demonstrated that even very high purchase subsidies were, in isolation, insufficient to ensure long term market success, and adequate infrastructure was strongly tied to the level of success. Furthermore, Langbroek *et al.* (2016), conducted a Swedish stated choice experiment and found that a mix of soft incentives was a useful substitute for price incentives, particularly among those who were more predisposed towards EVs.

Impacts of recharge network factors on rates of uptake

Cluzel *et al*. (2013) argued that subsidising EV purchase was not the most effective means of encouraging uptake. Their research concluded consumers value up-front costs and heavily discount running costs, with substantial subsidies needed to overcome customers' short payback periods, which were typically under 4 years. They contended that EV uptake could be enhanced via other incentives such as consumer awareness and better infrastructure; for example, they calculated that public recharge networks in the UK could be as few as 2000 fast charging sites. However, data collected for this research shows that at 21 March 2016 the UK had 10,508 rechargers in 3856 locations, including 1962 rapid rechargers (Next Green Car, 2015a), about the minimum requirement of rapid chargers predicated by Cluzel *et al*. (2013). Thus, the *number* of rechargers appears not to be the only factor (aside from car price) influencing the UK's poor rate of uptake, as compared to other advanced economies.

It is contended that as a necessary market co-condition, an adequate recharger network should possess numerous charge locations that are well dispersed, adequately maintained, easily accessible to the public, easy to use (for example credit card payment) and well sign posted. Clearly, the deployment of such a network requires careful implementation of policy instruments but would ultimately enhance the popularity of EVs. The UK is a case in point, showing that an inadequate implementation of policies and strategies to increase the recharger network may have, paradoxically, contributed to EV's lower popularity in the UK compared to countries who have offered the same or less as financial incentives, on a per car basis. For example, London's Lord Mayor set an ambitious target of 25,000 recharge points in London by 2015, importantly to cater to the large number of households without off-street parking (Wiederer and Philip, 2010). However, in 2015, up to 40% of public rechargers in London were out of service at any one time, and nationally about 23% of rechargers were unable to be used (Sharman, 2015). Other deterrents to EV uptake identified by Sharman (2015) were:

1) The risk of inactivity of the radio frequency identification (RFID) cards' mechanism to access the electricity once a car is plugged in; and

2) The governance of recharger network maintenance, where the British authorities did not elect to centralise responsibility for recharger maintenance, rather, opting for an inadequate system of multiple actors and contracting out to private providers.

EV owners' bad experiences with recharging may have influenced potential buyers, perhaps dissuading them from making the change. This assumption would align with the contribution that Diffusion of Innovations Theory (Section 3.2.1) makes to understanding successful EV uptake, including the impact of communication channels on potential purchasers. Using British real world data, Serradilla *et al*. (2017) concluded that: 1) there is a business case to support investment in fast chargers on major highways and; 2) it would be beneficial if governments supported such investment not only financially, but in liaising with, and gaining co-operation from, the necessary authorities to ensure speedy roll-out and ongoing timely maintenance.

Supporting the argument that a recharger network needs to be adequate is recent research of Danish drivers (Cherchi, 2017) who showed that informational conformity (where group members are used for guidance) is stronger when information is negative. Cherchi (2017, p103) concluded that "information about poor performance constitutes a strong obstacle to the growth of the EV market". This finding may not only apply to the cars themselves but to other aspects such as recharging. Also research from London (Bennett et al., 2016) lends support to this argument where marketers had not addressed customer concerns about perceived negative aspects of EVs. The authors recommended that to improve current customer messaging, promotional materials should emphasise information about: battery improvements (including longevity), increased trip range, no need for recharging during most journeys plus the increasing availability of recharge points, with links to network maps and trip planner phone 'apps'.

Stagnant BEV growth compared to PHEV sales

A closer analysis of UK market figures (Appendix D) helps illustrate the point about the influence of customer experiences on future sales. While superficially EV growth figures for 2016 look positive, on inspection almost all recent UK growth was in the PHEV market. PHEV sales increased from 0.71% in 2015 to 1.06% of the total market in 2016, while BEVs virtually stagnated, growing from 0.38% in 2015 to 0.39% in 2016. The introduction of a popular PHEV (Mitsubishi Outlander SUV) in 2013 resulted in spectacular sales, becoming the UK's top selling EV, with 36.8% of the 2014 EV market, growing to 41% of the 2015 EV market and settling to 24.2% of the EV market in 2016 as additional models were introduced (European Commission, 2017). Again, these results indicate that consumers are starting to make the transition away from fossil fuelled transport as suitably priced models that meet their everyday needs come onto the market. In particular PHEVs, which require a less extreme behaviour change for recharging in comparison to BEVs, are probably more suitable in a country with an inadequate system of public recharging options (Section 2.2.3.2). Hence, it appears that any government wishing to encourage sales and maximise the benefits that BEVs provide in mitigating negative externalities arising from fossil fuelled transportation, might benefit from the salutary lessons from the British experience. The British government itself only recently, in late 2016, publicly recognised past problems with their public recharging network and may introduce a Modern Transport Bill to address the issue (Grayling, 2016) in addition to allocating a further £35 million to improve EV infrastructure (Western Automation, 2016a).

4.5 Information dissemination

If Rogers' Diffusion of Innovations Theory (Section 3.2.1) helps to explain the mechanisms by which innovation is adopted in a society, then potential customers need information to aid the transition towards new technology. Comparing ICV owners with EV owners, Nayum & Klockner (2014) concluded that offering information and personal experience helped drivers overcome fears and doubts they may have had about technical and practical issues of such fuel efficient cars. For example, there is widespread adoption of EVs in Norway where they have government support and a good recharger network (Section 2.4). However, a Norwegian survey showed that ICV owners were three times more worried than EV owners about the primary concerns of vehicle range, access to charging stations and time to recharge (Figenbaum and Kolbenstvedt, 2016b). It may be argued that even there, many ICV owners have not had sufficient exposure to EVs to convince them of EVs suitability for purchase.

Education programs, field days, friends and the media play an important role in diffusion as customers need to be persuaded to make the change when innovative products, such as EVs, are not directly substitutable for the incumbent technology. Results from Norway (Figenbaum *et al*. 2014, Fig 9.19) show that most EV owners are very satisfied with their cars and report that non-EV owners who have EV owning friends, are more likely to buy an EV for their next car compared to people without EV owning friends. This evidences that Diffusion of Innovation is a mechanism for increasing motorists' knowledge and amenability towards EVs. Thus, supplying information to customers, such as available incentives and location of rechargers, can help address incomplete markets and provides relevant information that spreads through communication channels to assist in the diffusion of innovations and improving adoption rates.

The accuracy of customer perceptions, may influence buying decisions (Krause et al., 2013). Thus, understanding EVs and their attributes is a necessary precondition for potential customers. A series of workshops for Californian motorists to discuss EV ownership revealed that many ICV owners were surprised to learn that EVs were for sale in their area, and developed more positive interest in acquiring an EV after discussing them with EV owners (Kurani et al., 2014). Governments can assist with provision of information about EVs. Norway has had a sustained program to promote EVs for more than 20 years and has had time to build awareness (Cluzel *et al*. 2013; OECD, 2015 p 55); for example, they have had comprehensive media coverage so that 84% of EV owners had already decided to buy an EV before visiting the dealer (Figenbaum et al., 2014). Likewise, the US implemented a wide range of programs to encourage EV ownership; noteworthy is the EV Everywhere program (US DoE, 2012), an umbrella effort to promote and support the adoption of EVs, including US DoE, 2016a; US DoE, 2016b; Buell, 2015. Similarly educating both consumers and car dealers can help diffuse information into the market, for example Plug-in America has a pilot engagement program with 'ride and drive' events (Cahill, 2016).

In Hong Kong, a government website informs potential EV owners where to buy EVs, locations of rechargers, guidelines for installing rechargers for private and car park owners and technical guidelines for new building developers (HK Gov EPD, 2017). Field days enable learning by doing and prolonged advertising campaigns increase awareness (National Research Council, 2015) and these could be useful in providing adequate information for ICV owners to aid the diffusion of innovation process when they are thinking about buying a new car. Formula-e racing, appears to be another means to display the power of EVs, helping promote the technology and drive innovation (FIA, 2016).

Thus, the employment of a variety of channels of information to inform potential EV customers about the benefits and ease of EV ownership appear to be useful strategies to increase their acceptance in the market place. Including programs to increase the familiarity of EV attributes would be a useful strategy for governments to employ to encourage uptake.

4.6 Other factors affecting EV market share

4.6.1 Government procurement, fleet purchasing and the second-hand car market

Government procurement is an important instrument to improve EV uptake. Procurement of EVs stimulates sales, and through turn-over rates relatively quickly creates a second-hand market. Switching to EVs would enable government employees to experience EV driving without having to buy one, thus acting as a means to demonstrate ease of use and potential ownership benefits (Silvia and Krause, 2016) and becomes a means to assist diffusion of this innovative technology. A case in point is the Swedish Association of Local Authorities and Regions, which has had an EV procurement policy since 2010 and turns over its vehicles every 3-5 years (Radio Sweden, 2016) increasing in turn the second-hand market. As well, Norwegian Municipal authorities have procurement policies further boosting uptake (Figenbaum et al., 2015). In Australia, all tiers of governments procured 27,608 (3%) of the new passenger cars bought in 2015 (FCAI, 2017), indicating the potential magnitude of how many employees could experience EVs first-hand and increase diffusion of this innovation.

At the Sydney Global Forum on Sustainable Procurement, Farid Yaker (2016, pers. comm.), a sustainable procurement officer for UN Environment, argued that government procurement officers should be moving their thinking away from acquisition costs and total cost of ownership for their government department and towards global costs for sustainable public procurement. As just one example, the health costs from fossil fuelled transport (Xue et al., 2015), a significant negative externality resulting from ICV use (see Section 1.2.2), could be reduced by making the transition to EVs thus reducing costs not directly associated with car use by a particular government department but affecting whole of government spending.

Businesses operating vehicle fleets provide another potential opportunity for motorists to experience EVs without having to buy. A study of fleet drivers (Lane et al., 2014) found they had sufficient positive experiences when using EVs, although not as high as EV private owner/drivers, that fleets could be considered a potential gateway for EVs into the general car market. A Swedish demonstration project (Wikström et al., 2016) revealed a range of operational measures that businesses fleets could implement to enhance the capacity for fleet drivers to maximise vehicle output; adopting such practices has the potential to improve diffusion of this innovation into the general population via these employees who could positively influence their social networks . As with government fleets, business fleets comprised of EVs would stimulate demand for EVs and increase the second-hand market due to vehicle churn rates of 3-5 years. As an example, in Australia in 2015, 1,155,408 million new cars, SUVs and commercial vehicles were sold, including: 515,683 passenger cars; 408,471 SUVs; 199,070 light commercial; and 32,184 heavy commercial vehicles (Costello, 2016a). Of these, Australian business fleets accounted for 36% (417,939) of all new vehicle sales; rental sales 4.9% (56,938); government sales 3.6% (41,577); with private sales 52.5% (606,770); and other 2.8% (32,184) (Costello, 2016a). This sales data demonstrates the large potential for government and business fleet sales, if they procured EVs, to contribute to positive EV user experiences and to quickly enlarge the second-hand car market, thus ultimately increasing the share of EVs in the country's vehicle fleet.

Due to European countries' taxation policies, another factor that appears to foster EV adoption there, is that customers accessing company cars through leasing arrangements are not required to bear the full up-front purchase costs of cars (Dimitropoulos *et al*. 2016). Such policies facilitate access to relatively more expensive EVs; although such taxation arrangements do divert tax payer funds from government budgets that could be used for other programs (Dimitropoulos et al., 2016). However, while this system may distort the car market by increasing the rate of EV uptake, it does mean that the second-hand EV market can be enlarged sooner, increasing the possibility that those unable to afford a new EV could buy second-hand sooner.

Second-hand cars constitutes an important segment of the car market (for example, most people in the US cannot afford to buy new cars (von Kaenel, 2016)), so action such as changing government procurement policies to favour EVs, business fleet procurement and taxation policies have the potential to enlarge the second-hand EV market enabling more people to make the switch to electric transportation sooner.

4.6.2 Adequacy of EV model availability and sales practices

Another important aspect to increasing the attractiveness of EVs was having diverse models available in any particular market to suit the preferences for different market segments (Cluzel et al., 2013). Fulton *et al*. (2016) reported that close to 100 EV models were available worldwide but very few were sold widely, reflecting different market contexts. In certain US cities, car brands and how they were marketed were important factors in EV uptake and particular models have dominated individual markets (Lutsey *et al*. 2015). Lutsey *et al*. (2015) have shown that while the relationship between EV sales and EV model availability in the US was not linear, generally there were higher numbers of models for sale in cities with higher EV popularity. Lutsey *et al*. (2015, p35) also noted that in the cities they reviewed "the availability of electric vehicle models is also a significant factor in predicting overall electric vehicle shares across the metropolitan areas"; more models increase the range of sizes, prices, styles and manufacturers, broadening customer choice. Although the authors did note that some cities had relatively high sales but relatively few models, such as Seattle; and that in some cities particular marketing programs popularised certain models thus rewarding dealer efforts to sell EVs. They also noted the number of rechargers impacts market uptake.

Importantly, the attitudes of car dealers may act as a barrier to diffusion of EVs in the market place (Cahill et al., 2014). Dealers may not be adequately motivated to sell EVs due to low sales volumes and the need for additional training and experience with EVs (Cahill et al., 2014). In the US, "automakers with established dealer networks are bound by franchise laws to sell all new cars through licensed, fully independent dealers who make their own decisions about which cars they sell and how they are sold" (Cahill *et al*. 2014, p16). Consistent with the theory of diffusion of innovations, Cahill *et al*. (2014) further argued that good experiences by early adopters help promote new technology while unsatisfactory experiences delay it. This standpoint is also consistent with the arguments in Section 4.4 that in the UK poor recharging experiences by EV owners is communicated to others and acts as a deterrent to make the transition to the new technology.

Cahill *et al* (2014) recommended that retailers use their support networks and expertise about the benefits of EVs to help convert customers. By contrast, the highly successful Tesla Motors with no existing dealer network, were undeterred by traditional dealer / manufacturer practices. Cahill *et al*. (2014, p19) further reported that Tesla chose "a direct-sales model in which its vehicles are sold at fixed prices online or through factory-owned stores and service centers", and ran its own "sales network and aggressively deployed its own charging infrastructure", which are "illustrative of its commitment to the 'whole product' experience. Tesla's industry-high satisfaction ratings demonstrate that a much better experience for plug-in customers is achievable". One argument could be that the government could support "dealer days" whereby car companies implement sales staff training days to promote EVs, potentially increasing customer sales.

Increasing drivers' exposure to EVs can assist diffusion of innovations and help reduce market failure. Such promotional mechanisms include: government procurement policies; better sales practices; encouraging business fleets and increasing information availability, such as through field days and other events.

4.6.3 Rechargability

Being able to charge your car quickly and conveniently is a key issue for consumers, especially when away from the regular charging point, usually at home (Section 2.2.3.1). A lack of standards is considered a major obstacle to the introduction of alternatives to ICVs and consumer acceptance (European Commission, 2013) and has implications for governments especially in the early stages of market development. Developing standards for recharge hardware (Section2.2.3.2) is important to maximise network benefits and work is underway to implement directives, particularly in Europe (Euro-Lex, 2014). Standardisation could help remove uncertainties for motorists thus increasing the realisation that EVs are a viable present day option rather than a potential future option, and standardisation would increase production economies of scale for infrastructure manufacturers (Bakker, 2013). If not already undertaken, measures to standardise the hardware before too much has been invested in a recharge network, whether by private investors or government, should be implemented. Lower roll out costs would be incurred if there is uniformity in the recharging hardware; more outlets could be installed for the investment thus enhancing consumer experiences. The cost of converting existing rechargers would be wasteful and a disincentive for existing networks to change. One solution would be to develop adapters (for example, Tesla 2017) but this situation becomes an inconvenience and cost for consumers who may need to carry a range of adapters to suit all available plugs.

Wittenberg (2016) noted that while there is some agreement on standards for slower types of chargers, there is a lack of co-operation among car makers to develop a single plug type for fast charging. He also pointed out that manufacturers assume car buyers may not consider this problematic when they buy EVs, as they believe potential customers are unaware of plug incompatibility and thus is not a purchasing consideration. However, such short sightedness fails to take into account the effect of elements of diffusion of innovations theory (Section 3.2.1) in particular the impact of negative information on future sales. As previously noted (Section 4.4), informational conformity and social conformity have been found highly significant mechanisms influencing individual decision making. Cherchi (2017) also showed informational conformity is stronger for negative information, thus it may be argued that information about the limited availability of compatible fast chargers for drivers away on longer trips would quickly spread to non-owners and may reduce the likelihood of a future EV purchase, particularly BEVs.

4.7 International best practice for government action

As this thesis argues, governments of countries with the highest level of EV uptake have been proactive in supporting EV adoption using a range of policy tools. To remove market failures, whether perceived or actual, measures adopted aimed to address purchasing barriers and attempted to increase customer convenience thereby improving EVs user-friendliness. Incentives to reduce purchase price have been the most effective when combined with support for the roll out of an extensive recharger network, with an adequate highway network for long trips considered essential, regardless of daily distances travelled (Lieven, 2015). However, in the near to medium term, as battery prices continue to decrease, financial incentives to reduce up-front purchase price may become less important while cheaper operating costs of EVs compared to ICVs become more important.

It seems that offering a range of incentives to appeal to different consumers helps drive EV car sales; indeed, theoretical modelling demonstrated that offering mixed incentives were most effective in attracting customers (Silvia and Krause, 2016). Norway, the most successful market, has offered a wide range of incentives including deployment of recharge infrastructure (Section 4.3.1). San Francisco further exemplifies this argument: there, EVs represented almost 6% of new car sales in 2014 (Lutsey et al., 2015) compared to the US national average of 0.7% in 2014 (Appendix D). A range of incentives was offered in addition to Californian legislative policy to facilitate EV adoption (Section 2.2), indicating that success has been fostered by addressing a variety of customer concerns. While some incentives have been more popular than others overall, different customers have different priorities; it may be argued that government support for a wide range of incentives would be crucial to attract more customers.

Not only are direct incentives important to increase uptake but so is streamlining of access to adequate recharge networks – something governments need to consider. One consideration would be to adopt recharger hardware standards to help maximise the efficacy of the recharger network. Measures increasing consumer convenience include:

1) Improving interoperability: facilitating recharge electricity payment including by credit / debit card;

2) Hardware standardisation: ensuring any EV can be recharged at any publicly available recharge outlet regardless of the brand; and

3) Open access to all public rechargers: no requirement for network membership.

The EV markets discussed in this chapter evidence that governments using a multi-pronged approach, aiming to address multivariate consumer concerns, are more likely to engender greater acceptance of EVs, as opposed to governments that either fail to act or implement inadequate measures, or, worse still, create negative feedback loops and cause the market to stagnate or reverse.

4.8 The Australian scenario and comparison to other markets

Data relating to the brands and models in Australia in 2016 are shown in Table 4.1. The Australian scenario is further discussed in Section 4.8.2.

4.8.1 EVs offered in the Australian market 2016

The brands and models offered for sale in Australia in 2016, together with various features of these vehicles are listed in Table 4.1.

Table 4.1 Brands and models of BEVs and PHEVs for sale, in Australia's new car market, 2016

Brand	Model (year of release)	Features	Approx. New Vehicle Price AUDk 2016	Max. Electric Range km	Annual fuel cost[7] AUD	Vehicle size Length(m) Width (m)
BMW	101 i3 (2014)	BEV, 4 door, 4 seat sedan, 2WD (range extended option)	64 (70)	190 (+ 150)	361	4 1.78
Nissan	ZEO Leaf (2012)	BEV, 4 door, 5 seat hatchback, 2WD	40	175	484	4.44 1.77
Tesla	Model S 60 kWh (2015)	BEV, 4 door, 5 seat, hatchback, 2WD	115	408	518	4.98 1.96
	Model S 75 kWh (2014)	BEV, 4 door, 5 seat, hatchback, 4WD	140	490	554	4.98 1.96
	Model S 90 kWh (2015)	BEV, 4 door, 5 seat, hatchback, 4WD	160	557	554	4.98 1.96
Audi	A3 e-tron 17"wheel (2015, non-current,2016)	PHEV, 4 door, 5 seat hatchback, 2WD, 1.4L 4 cylinder turbo, tailpipe 37g/km	69	50	324	4.31 1.79
Mitsubishi	Z J Outlander (2014)	PHEV (petrol), 4 door, 5 seat SUV, 4WD 2L 4 cylinder	47	52	375	4.7 1.8
Volvo	XC90 Excellence (2016)	PHEV (petrol), 4 door, 4 seat SUV, 4WD, 2L, 4 cylinder turbo	150	43	509	4.95 1.94
	XC90 T8 (2016)	PHEV(petrol), 4 door, 7 seat, 4WD, 2L, 4 cylinder supercharged	123	43	509	4.95 1.94

[7] Note: fuel costs for 14,000km /year, with 66% urban driving; as per US EPA (2017)

BMW	F30 330e (2016)	PHEV (petrol), 4 door, 5 seat sedan, 2WD, 2L, 4 cylinder, turbo	79	37	333	4.62 1.81
	I08 i8 (2014)	PHEV (petrol),2 door, 4 seat coupe, 2WD, 1.5L, 3 cylinder, turbo	319	37	333	4.69 1.94
	G11 740e iPerformance (2016)	PHEV (petrol), 4 door, 5 seat sedan, 2WD, 2L, 4 cylinder, turbo	246	44	372	5.10 1.90
Mercedes-Benz	C350e (2016)	PHEV (petrol), 4 door, 5 seat sedan, 2WD , 2L, 4 cylinder, turbo	75	29	324	4.69 1.81
	C350 T e (2016)	PHEV (petrol), 4 door, 5 seat wagon, 2WD , 2L, 4 cylinder, turbo	78	28	333	4.69 1.81
	S500 L e (2016)	PHEV (petrol) 4 door, 5 seat sedan, 2WD, 3L, 6 cylinder, turbo	320	33	378	5.25 1.90
	GLE 500 e (2016)	PHEV (petrol) 4 door, 5 seat wagon, 4WD, 3L, 6 cylinder, turbo	125	30	467	4.82 1.94
BMW	X5 40e (2015)	PHEV (petrol) 4 door, 5 seat wagon, 4WD, 2L, 4 cylinder, turbo	119	31	431	4.89 1.94
Porsche	E2 Cayenne (2015)	PHEV (petrol) 4 door, 5 seat wagon, 4WD 3L, 6 cylinder, turbo	140	36	582	4.86 1.94

Information sourced from: DIRD (2017); Tesla Motors (2016)

4.8.2 The Australian scenario

In Australia to date, EVs have struggled to gain a substantial foothold, particularly in comparison to the top-selling markets detailed above. In fact, since 2013, the market has declined not only in terms of actual numbers of EVs sold annually but in percentage terms as well (Appendix D). As the discussion above demonstrates, appropriate government action to address consumer concerns has been critical to garner consumer support for EVs. By contrast, Australian governments have made very limited attempts to support the market and this is reflected in the extremely low sales (Appendix D). Support and incentive programs vary from state to state with no Federal co-ordination, although there is a Federal program to reduce tax for lower emissions luxury cars. The state of Victoria exempts EVs from a state based annual car tax; however, this exemption is of limited monetary value compared to the cost of buying a relatively expensive EV. Queensland has provided minor support for EV rechargers and now has plans to create an electric vehicle strategy (DEHP, 2017), but elsewhere it has been left to market forces. The Australian Capital Territory government exempts vehicles emitting <130g CO_2/km from registration duty in their Green Vehicles Duty Scheme, but this is not exclusively for EVs. The threshold for the application of the 33% Federal luxury car tax (applying to new cars costing more than AUD63,184) rises to AUD75,375 for cars <7L/100km fuel consumption (ATO, 2016). However, this tax relief does not only apply to EVs and there are few new car buyers in this upper price bracket, about 8% nationally in 2015.

This thesis argues that market failures affecting EV sales in Australia are the result of a combination of factors including: relatively high purchase prices, motorists' lack of exposure to EVs (evidenced by the dearth of EVs on Australian roads), lack of support by the government particularly to support the roll out of an adequate recharge network, continued cheap petrol (Section 1.2.2) , which allows ICVs to continuing having modest operating costs compared to most other advanced markets, and limited availability of EV models (Table 4.1 above). In the US some 33 different models were sold in 2016 (Pontes, 2017), whereas Australia had 8 brands selling about 14 EV models (not including some minor variants); arguably, the range of EVs on sale in Australia is relatively low with insufficient variety and range of features to appeal across the market segments. In total, these factors have failed to promote EVs as an alternative vehicle type for every-day Australians.

As described in Section 4.6.2 above, in the US, even with subsidies, EVs are quite expensive within their market segment (Fulton *et al*. 2016). A similar situation exists in Australia with most EV models in the higher price brackets, and expensive within these brackets, thus this relatively high price puts them out of reach of most Australians. For example, in 2016 the Mitsubishi Outlander PHEV cost about AUD 47,000 (Table 4.1, p 71), about AUD 8,000 more expensive than the same model petrol-only SUV (Suttons Motors, Sydney, Mitsubishi dealership, pers. comm., 2016). By way of comparison, the top selling petrol mid-sized SUV (Mazda CX 5) cost AUD 30,000 new (Stevens, 2016). Yet, despite EVs being cheaper to own over the life of the vehicle due to cheaper operating costs, customers focus their attention on up front purchase prices rather than long term benefits. This high up-front purchase price is likely to be a key reason potential customers are reluctant to buy EVs. As an example, Gass *et al*. (2014) concluded from their research that in Europe, Austrian motorists preferred up front purchase price support rather than tax benefits that apply later.

A number of factors affect the popularity of EVs in Australia. There has been limited government support for EVs, as outlined above, and noted by Climate Works Australia

(2016), and there are no concrete plans to introduce supporting measures at the national level (Ottley, 2016). In Australia, there is a limited public recharger network, although the NRMA (2017) recently announced that it plans to install a members-only network in NSW. Furthermore the information available to EV owners about location and status of public rechargers may be inaccurate. While smart phone applications (for example, PlugShare, 2016) may label many rechargers as "public", many are located at hotels and restaurants for patrons only, are at car dealerships (accessible during office hours), or are suitable for Teslas only. A BEV driver in Australia would be unable to take a trip further than the vehicle range (see Table 4.1, p72), especially out of business hours, without considerable pre-planning. Some local government areas may be planning to introduce rechargers in high visitation locations (for example, Waverley Council, Sydney, pers. comm.) but in these high demand areas if parking spots are designated as exclusively for EVs it may cause public anger, possibly creating negative feedback for EV sales. Further to this, the Victorian Electric Vehicle trial (DTPLA, 2013) noted that infrastructure providers would find it difficult to recoup investments. Thus, government support would be essential in the early market stages to ensure there is an adequate infrastructure network to support early adopters of EVs as well as reassure potential customers. As manufacturing matures and individual recharge units become relatively cheaper such government support could be phased out.

The impact of Australian government inaction is illustrated through the recent decisions of major car manufacturer VW. Following the emissions scandal in September 2015, in an effort to claw back lost global market share VW announced it would be investing heavily in electric vehicle R&D and introducing some 30 new models to its EV line-up within ten years (Howard, 2016). However, while planning to import some EVs to Australia, VW gave no guarantee on future model intentions due to inadequate infrastructure and relatively high EV prices, which VW considered were barriers for potential Australian customers (Costello, 2016b). Due to lack of government support for EVs, VW intend to limit the number of models it will import thus reducing the availability of a wider range of EVs, affecting those Australians who may want to buy one of their models to satisfy their motoring requirements.

Other car manufacturers may also be reluctant to sell EVs in Australia without government support. It is feasible that this lack of Federal government support may be associated with petrol sales: the current receipt of about AUD18 billion per year, about 4% of government income, from fuel sales tax revenue is considerable, despite the tax's low level in Australia (Section 1.2.3) compared to other much higher taxing countries. By contrast Norway, as one of the highest fuel taxing countries, potentially loses relatively more fuel taxes due its promotion of EVs aimed at decreasing transport fuel consumption. Thus Norway's financial and political commitment to transitioning towards fossil free driving could be regarded as substantial (see Section 4.1).

In conclusion, for this section it has been demonstrated that the Australian scenario contrasts with most other advanced economies, in particular those countries that have incentivised the EV market across a range of initiatives. Australia's insignificant and declining EV sales and low market penetration appear to be due to a number of factors including relatively high purchase prices, a poor network of rechargers and cheap petrol. However, there is a lack of understanding of the relative impact of such issues on Australian motorists, and in Chapter 5the results of my consumer surveys will be discussed to answer the second research question.

4.9 Summary

EV sales have been growing year on year in countries where there are specific government policies and strategies designed to encourage car customers to buy EVs instead of ICVs. Consistent with the conceptual framework (Section 3.2) that government actions influence adoption of innovations, countries with a degree of success have adopted measures to address market failures and provided positive influences on the diffusion of innovations. Insufficient attention to the implementation of such measures, as exemplified in the case study of the UK (Section 4.4), may result in slower market growth that fails to meet the potential of incentives offered. Worse still, reversal of successful measures, as demonstrated by the actions of The Netherlands and Denmark, has resulted in rapidly declining sales. Moreover, Australia has not implemented meaningful measures to stimulate demand for EVs (Section 4.8.2). Without suitable government intervention, EVs struggle to attract buyers.

Market forces making EV purchase prohibitive in Australia include:

- High vehicle prices relative to similar ICV models;
- Continuing cheap petrol and the relatively long payback period associated with EV total operating costs resulting in negative feedback loops, affecting business and private customers;
- An inadequate recharge network particularly on highways;
- Lack of useful legislation to regulate standards and payment methods;
- Low numbers of EV models available;

- An almost non-existent second-hand market; and
- Limited information.

Taken together, these factors likely explain Australia's insignificant sales of 2013 (292 EVs from a total new car market of some 900,000 vehicles) and the growth in 2014 (1130 EVs) actually declining in 2015 (1108 EVs), and worse in 2016 (215 EVs). Unless government action is taken to reverse such declines, it is likely that the EV market will stagnate until the purchase price of EVs is equivalent to ICVs due to declining production costs. Even then lack of an effective recharge network could stymie growth despite removal of the price barrier.

It is possible that the market forces, listed above, contribute to EVs being seen as inconvenient for customers, particularly on long trips. The existing scenario most likely has succeeded in driving EV sales down and consequently, with rising total numbers of cars in the Australian fleet (Appendix D), will do little to address the raft of negative externalities arising from fossil fuel consumption (Table 1.1, p4) used for personal motorised transport. The continued dominance of ICVs in the Australian fleet could potentially contribute to Australia's failure to meet its GHG emissions reduction obligations. By contrast, encouraging EV uptake in Australia may be one of the cheapest and quickest ways to meet those targets (CCA, 2015). Having a poor grid mix, as in Australia (Section 2.2.2), is not a reasonable excuse to delay change, it takes time to install an adequate level of infrastructure, cars are durable and there are considerable lag times associated with diffusion of an innovation especially for expensive products such as cars (Section2.2.1). By way of example, car technologies, such as front wheel drive, which require minimal behaviour change for customers, take about 15-20 years to reach maximum market penetration (Davis, 2012). A simultaneous increase in EV uptake combined with electricity grid decarbonisation would reduce emissions and improve other factors such as air quality and traffic noise more quickly than if EVs were introduced after increasing the proportion of renewables in electricity generation.

By contrast EV sales are moving ahead in many other advanced economies, most especially in Norway. It is apparent that in the top selling markets successful adoption of incentives to reduce vehicle purchase price, and other soft incentives, critically an extensive recharge network, have encouraged EV sales.

When considering PHEV sales, while multiple car ownership is not necessarily a factor in uptake, there needs to be some understanding of customer attitudes to the two types of EVs particularly in countries with good recharger networks, and this would be a useful area of research. However, without support for the recharger network, overall EV uptake may be limited, as diffusion of innovations factors (for example, communication channels) and market failures (such as inadequate information) may have influenced all potential EV owners not just those considering a BEV, thus supporting the argument that non-EV owners may generalise information to cover all EVs.

In the next chapter, Chapter 5, factors affecting Australian drivers' preferences for buying EVs, or not are analysed and discussed, as ascertained through this research using surveys to question a sample of motorists. While Australia's EV market is still in its infancy there is still time to implement a range of incentives to overcome consumer resistance and turn around sales. Using the lessons learned from international best practice and preferences of Australian motorists to formulate policy and strategies could successfully overcome the declining EV market here.

Chapter 5 Barriers and incentives to EV uptake for Australian survey respondents

5.1. Introduction

To answer research question 2, this chapter discusses the major themes and trends revealed in the two questionnaires. The results of the questionnaires will enable a better understanding of potential barriers and incentives influencing the likelihood of Australian motorists choosing to buy an EV. The results form the basis of potential strategies for policy makers intending to formulate policies to overcome adversities to EV adoption in Australia. Using convenience sampling (Section 3.4.5), the questionnaires targeted people with pro-environmental tendencies, this was to find factors that contributed to the attitude-action gap (Section 2.3.2) for people who may wish to buy an EV but are unable to do so. Thus, this information was used to make recommend actions that could help bridge that gap.

5.1.1 Analytical framework

The assumption underpinning the analysis was the premise that if people who were more concerned about the environment tended to resist buying EVs, it is likely that other less environmentally inclined people would also be averse to buying them. Voting intentions (Qs 40, 41) were used as a proxy measure for pro-environmental tendencies. Previous Australian research (Gardner et al., 2011) evidenced that Australians who were more willing to buy EVs were more likely to take action on climate change and tended to be better educated than those not predisposed to buy EVs (Section 2.5). This research assumed that voters for the Greens political party[8] had an increased likelihood of having positive attitudes towards taking action on climate change than all Australians. Thus, as respondents were 4-6 times more likely to vote for the Greens party than the population as a whole (Appendix C), the results of these questionnaires are more likely to reflect the views of people who are more pro-environmentally minded than average Australians. Survey respondents were also better educated than Australians on the whole and more likely to dwell in large urban centres (Appendix C). However, a limitation of the research is that questions relating to voting intention (Qs 40, 41) were optional (276 respondents from a total of 330) and it is unknown if those intending to vote for any particular party were more likely to opt in or out of answering those questions. Perhaps the high percentage answering the questions (84%

[8] The Greens political party have a platform that reflects an awareness of the interrelatedness of all ecological, social and economic process and this guides their policies, including taking action to address climate change.

of respondents) indicates that there could be a strong relationship with voting intention and thus the representativeness of answers in comparison to the whole group.

This research investigated incentives used overseas, to find those that are potentially more effective for encouraging uptake in Australia, positing that adoption of these incentives could achieve a higher success rate for EV uptake than using less attractive incentives, or none at all. Thus, understanding car customers' preferences is an important first step in initiating a more mainstream acceptance of EVs in nascent markets.

While researchers from many countries have been investigating the adoption of EVs, the literature review (Chapter 2) cites research of Norwegian EV and ICV owners more often. Norway has had the most success in adopting EVs (Figure 4.1, p 52) and their government has been encouraging EV uptake for more than 20 years (Section 4.2), thus Norwegian research results, especially those with large numbers of respondents with revealed-choice answers (rather than hypothetical stated-choice responses), could be considered as providing reliable evidence to support the use of incentives. Hence, evidence from international research, in particular from Norway, has been used to support the arguments put forward.

In Chapter 3 the methodology employed was detailed, and copies of the surveys are provided in Appendices A and B. A key component of this chapter's analysis focused on the closed questions that used interval Likert scale responses (Section 3.5). In these questions, if respondents chose 1, for example, it represented that this factor was least important to them, whereas 5 represented that the factor was most important. To gauge the average response from the Likert responses, the *Weighted Average Response* (WAR) (Section 3.5) was calculated for the questions, including for any subgroups analysed. This calculation measured the average response for that question and enabled comparison to other questions and / or sub-groups. The larger the difference between WAR scores the more likely the results were significant. The WAR figures were used throughout this chapter. To provide comparative analysis, this sample's demographics were compared to the population of Australia (Appendix C); detailed results from Questionnaires 1 and 2 are provided in Appendix G.

5.1.2 Car attributes as a factor in car choice

While the overall aim of the questionnaires was to understand barriers and incentives affecting EV purchase decisions, Question 26, focusing on car attributes, was included to gain an understanding of the importance of various features when buying *any* car. This data was also useful for comparative purposes as it provided information on the importance of certain attributes regardless of car type. All respondents regarded fuel efficiency (WAR=4.38/5), closely followed by purchase price (WAR=4.36/5), as the most important features they considered when thinking about buying cars; one participant summarised it as: "*Purchase price and running costs*" (Respondent 7, 9 November, 2015, Q27). Car brand (WAR=2.83/5) and country[9] of car manufacture (WAR=2.76/5) were the least important features. Results of Q26 revealed gender differences in the responses. Females valued safety features, fuel efficiency, fuel costs and GHG emissions more than males, whereas men valued aesthetics and car brand more than women. Car performance (WAR=3.06/5) was the third least valued attribute, with males (WAR=3.12/5) valuing performance slightly higher than women (WAR=3.01/5).

Overall, respondents valued fuel efficiency (WAR=4.38/5) more highly than GHG emissions (WAR=3.84/5) despite one being a proxy measure for the other in the case of fossil fuelled cars (Tietge et al., 2016), suggesting that the concept of saving money on fuel was more highly regarded than reducing GHG emissions. This difference is consistent with international evidence showing that environmental concerns were of lower importance than price when buying cars (Section 2.3.1). That women were much more concerned about GHG emissions than men (WAR=4.08/5 v WAR=3.59/5) is probably due to environmental concerns as discussed in Section 5.2.1.1 hereafter.

In the sections that follow further clarification is provided about the results revealed to be the most significant factors linked to respondents' likelihood to buy EVs. The issues are discussed as per the order of variables as they appeared in Questionnaire 1.

5.2 Factors affecting EV uptake: Discussion of results

The most important variables affecting likelihood of this sample cohort to purchase an EV were gender and whether the respondent would buy a new car rather than a used car. Not all factors affected customer purchasing decisions equally. These research results showed that the likelihood of respondents buying an EV was more strongly associated with some variables than with others, and these are discussed in greater detail hereafter. Questionnaire respondents were asked about a range of independent variables, and answers were measured against the dependent variables of how likely they were to buy an EV. Overall, respondents were moderately predisposed to buy a BEV (Q30 WAR=2.94/5) and slightly more likely to prefer a PHEV (Q31 WAR=3.1/5).

[9] Note: From the end of 2017, Australia will no longer manufacture major brand passenger cars.

The results, detailed hereafter in Section 5.2.1, show that the respondents who were more likely to buy an EV (either a BEV or PHEV) were:

- female,
- middle aged,
- those opting for more expensive cars, particularly new cars of a small or medium size, and
- the self-employed.

Other variables, for example, number of cars owned and level of education, had a minor relationship, if any, with likelihood to buy an EV. However, it should be noted this sample was more highly educated than Australians as a whole (Appendix C), which may have influenced results pertaining to that variable. By comparison, a survey of Norwegian car owners (Figenbaum et al., 2014) established that the group of car owners who were most willing to consider an EV for their next car purchase were younger, richer, had higher education levels and higher levels of employment, particularly the self-employed, than those who would not consider buying an EV, and there was a higher share of women among prospective buyers. Consistent with the results here, these Norwegian survey results, also found older people were less likely to express an interest in buying EVs.

To analyse the results, responses about barriers to adopt BEVs or PHEVs were grouped into categories, thus revealing the most commonly held concerns. Respondents were concerned about vehicle purchase price and issues about recharging the cars / acceptable vehicle driving range. Similarly themed issues were revealed as factors that, if addressed, might incentivise EV uptake. The two most popular incentives (Q38) were:

- "*public recharge stations available in every town and on highways*" (WAR = 4.24/5), and,
- A "*subsidy to make the cost of an EV the same as an equivalent ICV*", whether up front (WAR = 3.6/5) or after 10 years (WAR = 3.6/5).

5.2.1 Influence of independent variables on results

The following sections provide more detail about the most important variables revealed as more closely linked to a greater likelihood to buy a BEV or PHEV.

5.2.1.1 Gender

There was a relationship between respondent's gender and likelihood to buy an EV (Q2): females were more likely to buy a BEV (WAR=3/5) than males (WAR=2.8/5) and females also had a greater tendency to want a PHEV (WAR=3.22/5) than males (WAR=2.89/5). Findings from a more recent Australian snap poll (Roy Morgan Research, 2017) where 65% of women compared to 61% of men were willing to spend more to buy an EV are consistent with this survey's results. A possible explanation for women expressing a higher likelihood of buying an EV than men could be that females preferred cars with better environmental credentials. This assertion is based on responses to Q26 on car attributes, which showed that females were more likely than males to nominate 'GHG emissions/km travelled' as an important consideration when buying **any** car (women WAR = 4.08 v men WAR=3.59). As previously discussed (Chapter 2) women appear more likely to care about the environment than men (McCright, 2010) and show stronger pro-environmental behaviours, and thus may be a way females enact protection of themselves and their families (Zelezny et al., 2000); further explanation about gender based behavioural differences is provided in Section 2.3.2.

Despite these results, for the sub-group who participated in Questionnaire 2 (administered 10 months after Questionnaire 1) females were no more likely than men to buy a BEV (Q9: women WAR =3.83/5 v men WAR= 3.82/5) and only marginally more likely to buy a PHEV (women WAR =3.83/5 v men WAR =3.73/5). As both sexes expressed a greater interest in EVs in Questionnaire 2 than in Questionnaire 1 (Q5: WAR=3.5/5) it may explain this difference in results. Those men and women who agreed to participate in Questionnaire 2 might have been similarly more interested in EVs than the typical Questionnaire 1 male and female respondents.

5.2.1.2 Age

People most likely to buy an EV were 45 to 54 years of age (Q3: WAR=3.1/5) or in the age bracket either side of that group (Figure 5.1 below). It is likely these groups have greater interest in purchasing any kind of car than the young, perhaps because of a greater financial capability, with the under-25s being least likely to buy an EV (WAR=2.6/5). That those over 75 years old (WAR=2.67/5) were also less likely to consider a BEV is consistent with Rogers (1983) Theory of Diffusion of Innovations where the 'laggards' tend to be older, more risk averse and least willing to adopt an innovation.

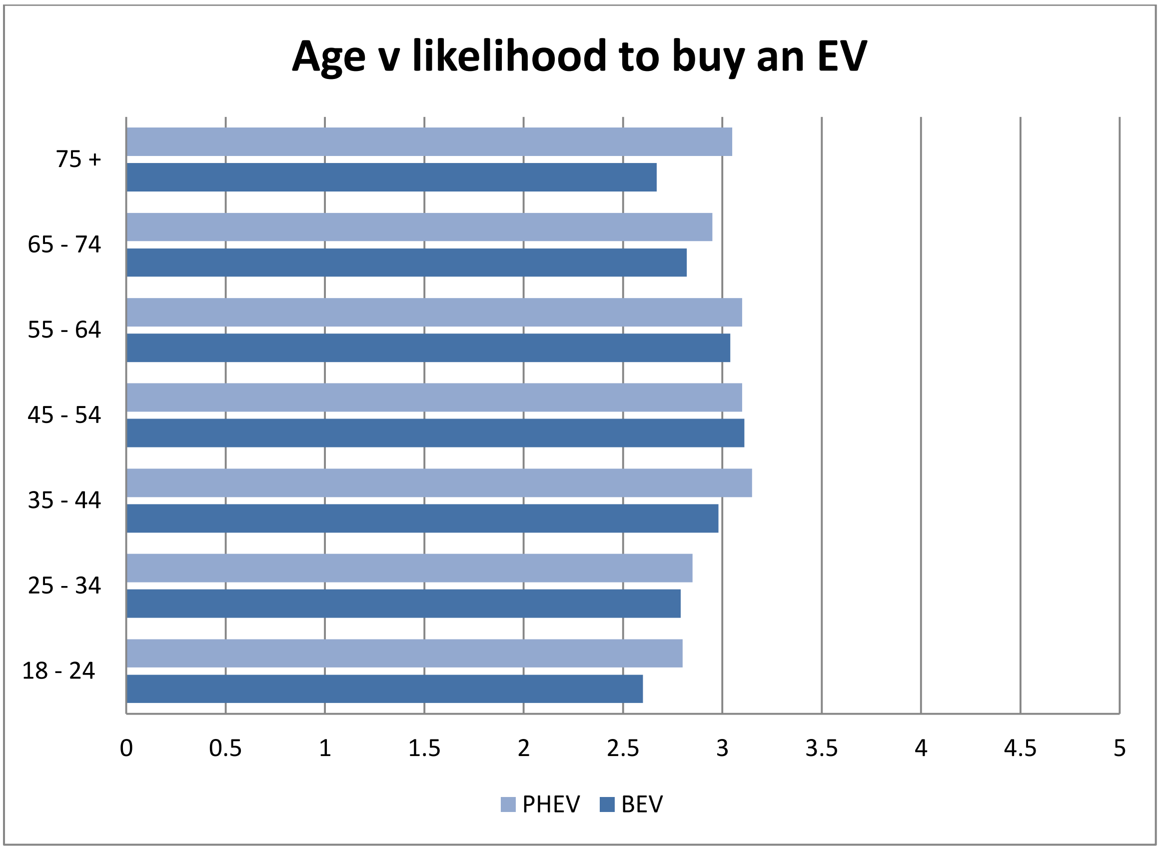


Figure 5.1 Respondent age versus likelihood to buy and EV

This research showed all aged groups sampled were more likely to buy a PHEV than a BEV (Figure 5.1). Surprisingly the oldest aged group 75+ were almost as likely to buy a PHEV (WAR=3.05/5) as the middle-aged groups. This result may reflect the lower behavioural change required to own a PHEV compared to a BEV and due to the reduction in range anxiety. As one participant noted, "[I am] *more likely to buy this kind* [PHEV] *as we run a single car household and want to use the car every now and then for long trips*" (Respondent 69, 24 October, 2015, Q28). Not only can PHEVs be driven long distances without needing a recharge (as the vehicles automatically switch to petrol or diesel driving when the battery is depleted), but they offer cheaper, less polluting driving on a day-to-day basis than ICVs.

That age is a factor related to the likelihood of an EV purchase is supported by the results of a Norwegian study: results showed the average age for a BEV owner is 47, and the average age for PHEV owners is 55 (Figenbaum and Kolbenstvedt, 2016b).

5.2.1.3 Employment status

Employment status (Q5) had little impact on likelihood to buy an EV of either type, except for the self-employed who were much more likely to buy a BEV (WAR=3.32/5) compared to other groups (WAR about 2.9/5). This result may reflect the ability for a car purchase to be used as a business expense thus reducing the overall financial burden of higher priced EVs.

Evidence from Europe supports this assertion; there, EVs are frequently purchased as company cars, although used as private vehicles, making use of the tax system to do so (Section 4.6.1). The self-employed in Norway are also more likely to buy an EV (Figenbaum et al., 2014). By contrast PHEVs were more popular with this survey's respondents than BEVs with all groups, except the self-employed, especially for those not in formal employment (WAR=3.5/5) including retirees (WAR=3.4/5).

5.2.1.4 Number of car spaces

The number of car spaces a person had (Q9) gave surprising results: those with zero car spaces were the most likely to buy a BEV (WAR=3.16/5) or PHEV (WAR=3.28/5). One sub-group, the users of car share schemes, the most likely to want an EV, may also have zero car spaces thus boosting this result. This comment from one respondent who did not have a car space could help explain this group's higher preference for EVs: *"Just need to work out a solution for charging at home with no off-street parking. Once sorted, it will get purchased"* (Respondent 88, 20 October 2015, Q27). People with three or more spaces (WAR=3.04/5) were more likely to buy a BEV than those with two car spaces (WAR=2.78/5) or one car space (WAR=2.88/5). Further research would be required to explore motivations and barriers for people with all car space numbers to determine how significant this factor is for actual EV sales rather than just positive intentions.

5.2.1.5 Numbers of cars, voting intention and EV preferences

The number of cars respondents had available to drive (Q12) had limited bearing on the likelihood to buy an EV. Almost half of the respondents (47%) had only one car to drive and slightly fewer were multi-vehicle owners (45%). Drivers with one car were only slightly more likely to buy a BEV or PHEV than those with two or more cars: (BEV: 1 car WAR=2.94/5 versus 2+cars WAR=2.88/5); (PHEV: 1 car WAR=3.08/5 versus 2+ cars WAR=2.97/5). Two possible reasons may explain this result:

1. The lack of familiarity with the capabilities, including pollution reduction, of EVs by Australian multicar households may have contributed to their slightly lower preference for EVs than single car owners, whereas the single vehicle owners had a greater understanding about the benefits of using EVs including pollution reduction potential.
2. Single vehicle households spend more per car than multi-vehicle households, thus the more costly EVs being more affordable by single vehicle households in Australia where EVs are not subsidised (see Appendix D).

The first explanation is more likely and is supported by Danish evidence (Jensen et al., 2013), which showed that: multi-vehicle owners were more likely to buy an EV after a three month driving trial than single vehicle owners; and secondly, people with higher environmental concerns were more likely to prefer an EV than people without such concerns.

These questionnaire results also showed a relationship between number of cars owned and voting intention (Optional Q40, n=276 /330). Greens voters appeared more likely to own only one vehicle (48%) than either Liberal/National coalition voters (22%), or Labor voters (21%). Also, there was a stronger relationship with voting intention and likelihood to buy an EV. Greens voters appeared more likely to buy a BEV (WAR=3.1/5) compared to Liberal /National coalition voters (WAR=2.8/5) or Labor voters (WAR=2.85/5). Greens voters seemed equally likely to buy a BEV as PHEV (WAR=3.1/5). In contrast, Labor voters appeared more likely to buy a PHEV (WAR=3.15/5) and coalition voters showed marginally more likely to buy a PHEV (WAR=2.9/5) compared to a BEV.

If the proxy measure of voting intention is linked to environmental attitudes, it may be argued that single vehicle respondents are more mindful of environmental harm caused by cars, and consequently more likely to want an EV and also choose to manage with only one car. This rationale has been supported in previous research where Norwegian EV owners were far more likely to belong to an organisation concerned with environmental conservation than ICV owners (Figenbaum et al., 2014).

The second possible explanation, that single vehicle households spend more per vehicle than multi-vehicle households, is not supported by overseas evidence. Norwegian survey results showed single car owners were less likely to consider buying an EV and were more unsure about it than those in multi-vehicle households (Figenbaum *et al*. 2014, p 89). This result is logical as 75% of Norwegian BEV owners also owned at least one ICV or PHEV and can use this other vehicle to do long-distance trips. In Norway, EV owners are predominantly in multivehicle households (79%), compared to 49% of all Norwegian vehicle owners, and are considered to be of higher economic status than average Norwegians (Figenbaum and Kolbenstvedt, 2016b). Furthermore, in Norway new EVs have been highly subsidised to make then more affordable (Appendix D) thus reducing price as a barrier to purchase. Also, as EVs have become more mainstream in Norway, more reasonably priced models have become more popular in recent years (European Commission, 2017), possibly as a reflection of the increased availability of EVs in the lower priced segments, although this factor could apply in any market not just Norway.

5.2.1.6 New or used cars

Buyers of new cars appeared more likely to buy a BEV (WAR=3.09/5) than buyers of used cars (WAR=2.68/5). The likelihood to buy a PHEV was also higher for new car buyers (WAR=3.09/5) than used car buyers (WAR 2.91/5). As there are few used EVs on the Australian market, and new cars are more expensive than used cars this outcome is not surprising if a potential customer is limited by overall cost. For example, one participant stated these factors would encourage purchase of a BEV: "*Size of car [is important]. [It] needs to seat 4 people and have ample boot space. Overall cost of vehicle to purchase, and availability of second hand car*" (Respondent 87, 20 October, 2015, Q27).

5.2.1.7 Market segmentation by vehicle price

Asking for an indication of how much a person is *willing to spend on a car* (Q15) may indicate if they can afford an EV. This question - on willingness to spend - was asked, rather than asking for household income, as it was considered it a better indicator of the importance of cars to the respondent than total income. The group least likely to want to buy an EV (WAR=2.64/5), was willing to spend $20,000 or less on a car, and constituted one third of respondents. Those most likely to nominate future EV purchasing were those willing to spend $40 -50k on a car (WAR= 3.26/5). This result was also unsurprising given the higher price of EVs in Australia compared to similar ICVs (see Table 4.1, p71, for the price of EVs on the Australian market in 2016). Results of this question are consistent with those revealed subsequently in open response questions; price was a primary concern for respondents in car purchase considerations, as one explained "*[the] cost of purchase [is a consideration] (I drive a second-hand car that cost $3,300, 3 years ago)*" (Respondent 170, 15 October, 2015, Q27).

5.2.1.8 Market segmentation by vehicle size

Owners of large cars (Q16) appeared much less likely to buy a BEV (WAR=2.6/5) or PHEV (WAR=2.6/5) than those with other sized cars (Small cars: WAR=3.05/5; Medium cars: WAR=2.9/5). As earlier models of modern EVs were small, it is possible that large cars owners were less likely to consider EVs would suit their needs, despite the introduction of the larger and more powerful Teslas (Table 4.1). This argument is supported by prior research (Roy Morgan Research, 2013): the larger the vehicle class, on average the further travelled, suggesting people consider car size based on distances they regularly travel. For example, one respondent would be encouraged to buy an EV "*if such a vehicle could do long interstate journeys towing a boat or caravan*" (Respondent 230, 14, October, 2015, Q27).

5.2.1.9 Purpose and frequency of trips

Comparing the purpose (Q19, Q21) and frequency of trips (Q20) undertaken by respondents with their preferences for buying EVs yielded unexpected results: those who never drove more than 100km in a day were the least likely to buying a BEV or PHEV in the future; conversely, those whose daily travel distance was only occasionally more than 100km were the most likely to buy a PHEV (Table 5.1, below). This data, and results from other questions, suggests that range anxiety is a critical concern; this issue is discussed further in Section 5.2.2.

The majority of respondents (60% of all respondents) nominated that the most frequent purpose of their trips (Q19) was short and local, for personal reasons. These types of trips also conform to national travel data. Excluding the category of light commercial vehicle, Australian passenger cars (including SUVs) travelled on average, 14,780km per year (average 40.5km/day) in 2012, although this fell to 13,100km (36km/day) in 2016; 53.5% was for personal and other use, the most common reason given (Australian Bureau of Statistics, 2017). These relatively short average daily travel distances indicate that models of EVs available in Australia are suitable for most people's travel on most days, without requiring a top-up recharge. In this study, the main purpose respondents reported for trips over 100km in a day (Q21) was holidays and leisure, mentioned by 63% of respondents; business trips were mentioned by 22.7% of respondents, and visiting friends and relatives by 32.3% (totals do not add to 100% as many respondents included more than one category in their answer).

Table 5.1 Likelihood of buying a BEV or PHEV dependent on frequency of travel >100km /day

Frequency travel > 100km/day	% Respondents (n/328)	Likelihood to buy BEV (WAR)	Likelihood to buy PHEV (WAR)
Most days	1.8% (6/328)	3.17	2.83
Most weeks	13.9% (46/328)	2.80	2.80
Once/twice a month	27.1% (89/328)	2.79	2.82
On occasion during the year	49.7% (163/328)	3.07	3.32
Never	7.3% (24/328)	2.75	2.71

Most BEVs currently on the Australian market can travel further than 100km in a day on one charge (Table 4.1, p71). Very few respondents regularly *travelled further than 100km* in a day (Q20), with only 13.9% people travelling this far most weeks, and this group's likelihood of buying a BEV (WAR=2.8) was the same as their likelihood of purchasing a PHEV (WAR=2.8). Those who only occasionally drove more than 100km a day (49.7% of respondents) expressed a higher likelihood of buying a BEV (WAR=3.07/5), or a PHEV (WAR=3.32/5), than those more frequently driving longer distances. For those 1.8% of respondents who most frequently drove long distances (more than 100km a day, on most days), the likelihood they would buy a BEV (WAR=3.17/5) or PHEV (WAR =2.83/5) could be considered unreliable due to the paucity of data (6/328 respondents). Until there is a better supply of rechargers on major interurban routes and in country towns there will be concerns obviating consumers' desires to buy a BEV as their only car.

This thesis' arguments about preferences for buying an EV compared to travel data, revealing concerns about the capabilities of EVs to undertake the types of trips people do, are supported by similar findings from a Norwegian survey (Figenbaum et al., 2014). The average annual distance driven by Norwegian EV owners was 14,500km (average: 40km/day). They further reported that Norwegian owners of the long-range Tesla Model S vehicles (range more than 350km) drove further than owners of any other type of EV, but about the same distance as ICV owners. These Tesla drivers possibly selected this model specifically to assist with long-distance travel to reduce recharging frequency, and to obtain free electricity when recharging (an incentive offered by Tesla). In Norwegian households with both BEVs and ICVs, BEVs were preferred for shorter trips and replaced 82% of ICV driving (Section 4.2). If the Norwegian uptake of EVs (Section 4.3.1) is to be emulated, more substantial investment in an appropriate recharge networks would be necessary. To further support the argument herein, 61% of Norwegian BEV drivers, in 2014, stated that they never used their BEV for a long vacation trip, whereas by 2016 only 37% never used it for long trips, with the change in travel habits perhaps demonstrating an increasing acceptance of BEVs as a vehicle type (Figenbaum and Kolbenstvedt, 2016b) and increasing familiarity with the capabilities of BEVs. The data may also reflect the increasing availability of rechargers (European Commission, 2017), which may be an important consideration for administrators planning locations for rechargers as part of a network and the importance of an adequate infrastructure network to encourage consumers to adopt EVs.

5.2.2 Barriers

Research respondents were provided with a number of opportunities to identify barriers hindering their acceptance of EVs. In Questionnaire 1, two barriers dominated: 1) that EVs were expensive and 2) EV recharging. When specifically asked for two reasons they would NOT choose to buy an EV (Q32), price was nominated by 44% of respondents as the primary reason discouraging EV purchase (either BEV or PHEV). One respondent summed up several issues of concern to the sample:

> "*Ease of recharge, e.g. at current residence not possible; public recharge options; if the electricity is produced via renewable means - otherwise what is the point; rebates/costs so not too much more expensive than other cars*" (Respondent 19, 2 November 2015, Q27).

However, some respondents did not provide a specific answer; 1% of respondents were not discouraged, responding they wanted to buy an EV, and 2.7% were just not interested at all. The importance of car price as a barrier to EV uptake is unsurprising given the low proportion of respondents willing to spend high sums on a car (Q15); more than half the of respondents (57%) were willing to spend $30,000 or less on a car and the cheapest new EV in Australia (Nissan Leaf) cost $40,000 (Section 4.1.2, Table 4.1, p71). For example, purchase would be encouraged if there were "*government subsidies on purchase of green vehicles like they have in the USA*" (Respondent 14, 5 November 2015 Q27).

The next most common main concern, for 11% of respondents, pertained to recharging, succinctly expressed by one participant as a "*lack of public recharging stations*" (Respondent 32, 28 October, 2015, Q27). Although at home recharging also presented problems, another respondent noted "*I need to make sure my apartment complex will allow charging to be wired up in the car park*" (Respondent 14, 5 November 2015 Q27). Recharging time was mentioned specifically by a few respondents; for example, "*not much [would encourage purchase] but probably if recharging was as quick as buying petrol*" (Respondent 10, 5 November 2015, Q27). Worry about the recharge network was part of overall doubt about reaching a destination; accounting for the distance travelled, the battery's capacity to get there and how recharging is part of that journey. Thus, range anxiety was likely to be a factor influencing respondent's stated choice about buying EVs, articulated by one respondent as:

> "*Fear of the car running out of energy before one could get to an electricity source for recharging particularly in busy traffic and /or on a motorway, harbour tunnel or harbour bridge where there are hefty fines for running out of 'juice'. On the positive side having a car that did not require carcinogenic fuels and non-sustainable fuel sources is very appealing*" (Respondent 21, 11 August, 2016, Question 10, Survey 2).

It may be argued that this anxiety is unfounded for most trips and likely related to respondents' lack of familiarity with EVs but also to the fact that most day-to-day trips undertaken by the survey respondents, and the Australian public more generally, fall within the range capable of most EVs on the market. For example, one participant noted that they "*would only consider electric if I needed a vehicle solely for local use*" (Respondent 48, 27 October, 2015, Q27). This thesis' assertion is also supported by American research (Needell et al., 2016), which found BEVs could satisfy 87% of daily trips without a top-up charge, even in car dependent Houston (Section 2.3.1). However, the role of range anxiety in decisions regarding EV purpose should not be understated, even if they are unfounded, when considering these short local trips. This research evidences that those respondents who never drove more than 100km a day were the least likely to buy either a BEV (WAR=2.75/5) or PHEV (WAR=2.71/5).

For single car households the range anxiety was not entirely misplaced when undertaking long journeys. This reasoning relates to:

- BEV drivers would not have ready access to ICVs to provide an alternative vehicle to enable long trips to be undertaken with minimal inconvenience, especially relating to vehicle range (due to battery capacity) and hence recharging frequency;
- Lengthy recharge time when the battery is fully depleted (only relevant if the trip is longer than vehicle range and for BEVs not able to utilise superchargers); and, the lack of an adequate network of rechargers to support long journeys, even if the car could be recharged at the destination. This point is explained in greater detail in Section 2.2.3.1 and supported by international research.

For example, one respondent was concerned about the ability to do longer trips and would only be encouraged to buy an EV with "*[the] guarantee that it will travel the given distance – I won't be stuck outside Grenfell* [in regional NSW] *with no fuel and no way of recharging the thing*" (Respondent 262, 13 October 2015, Q27).

There was further opportunity in Q35 to gather information about respondents' concerns about electric car ownership, for example, total cost of ownership. When asked their opinion on each statement provided, the statement that they were concerned about lack of recharge infrastructure on long trips (WAR=4.24/5) displayed the highest level of agreement, followed by the statement pertaining to difficulties in finding recharge stations (WAR=3.85/5). These concerns were exemplified by one respondent wanting a "*fully established network of fast charging stations*" (Respondent 12, 5 November, 2015, Q27) and another who would be encouraged by the "*easy availability of electrical outlets and fast recharging*" (Respondent 104, 19 October 2015, Q27). Other research supports these findings. For example, Lieven (2015) identified in a 20 country, five continent study that a recharge network particularly on major highways was a must have for EV uptake, whereas a reasonable price was seen as nice to have. The next most worrying factor, speed and acceleration of EVs (WAR 3.54/5), was as problematic as EVs being too expensive (WAR 3.53/5). For example, one participant succinctly responded "*Sportiness/performance. Cost and lifetime of battery* [would encourage BEV purchase]" (Respondent 324, 13 October, 2015, Q27); while another said *"I'd love to* [buy a BEV] *but until now it's been out of our budget. We won't be in the market for a new car for another 5 years at least but at that time we'll definitely be considering an electric car*" (Respondent 55, 27 October, 2015, Q27). Regarding speed and acceleration, research has shown that consumers are frequently ill informed or misinformed about current model EVs (Krause et al., 2013). It is possible that as a whole, the respondents were poorly informed about the capabilities of modern EVs, which now have better acceleration than most ICVs. As one participant noted "*Equivalent performance to a petrol car*" would increase the desirability of BEVs (Respondent 206, 14 October, 2015, Q27).

To eliminate the bias of high purchase price as a barrier, Questionnaire 2 respondents were asked to assume a new EV was equivalent in price to ICVs. This assumption was predicated on recent research that demonstrated the price of batteries has been falling more quickly than previously thought (Nykvist and Nilsson, 2015) and that EVs would cost the same as ICVs by about 2020. Thus, in Questionnaire 2 the main barrier to EV uptake (Q10) for close to half of respondents (42%) was vehicle range; as one respondent answered, "*Lower range of distance that can be travelled*" (Respondent 52, 3 August, 2016, Q10). Access to recharge stations was the next most concerning issue for 27% of respondents, including "*Availability of charging stations*" (Respondent 3, 19 August, 2016, Q10). The most important secondary barriers (Q11) revealed by the second questionnaire were also related to range (for 23%) and recharge network concerns (another 23%).

When asked for problems with PHEVs (Q12), range was still concerning for 16% of respondents, for example, "*Range of travel on charge*" (Respondent 93, 2 August, 2016, Q12). This result was apparent despite PHEVs functioning on petrol /diesel when the battery is depleted enabling long-distance travel without stopping to recharge or refuel. The availability of a recharge network was a concern for 14% of respondents, and not just on major routes, for example, "*Convenience of recharging throughout Australia*" (Respondent 30, 9 August, 2017, Q12). However, other issues including environment and car design were of concern. For example, 17% of responses mentioned the environment including "*Climate change mitigation*" (Respondent 85, 2 August, 2016, Q12), while car models and related features were more important for 29% of respondents, for example, "*design and appearance of cars, ease of servicing*" (Respondent 43, 6 August, 2016, Q12).

Question 15 provided the opportunity to express overall concerns about EVs. A sample of comments includes:

"*Car customers would buy EVs if they had a large range, as it is a typical argument against them*" (Respondent 8, 10 August, 2016, Q15),

"*I would consider purchasing an EV if recharging facilities were widely available*" (Respondent 9, 10 August, 2016, Q15), and,

"*More people would buy EVs if there were clearer signals of support for infrastructure from government instead of the recent zig-zagging on renewables and other climate change related policy*" (Respondent 102, 22 August, 2016, Q15).

Gender-based analysis of Questionnaire 2 results found that responses about important barriers showed marked differences when cross tabulated against gender. Additionally, Section 5.2.1.1 provides additional gender related data. Confirming the gender preferences revealed in Questionnaire 1, the data from Q10 (Questionnaire 2) demonstrated:

1. The availability of a recharge network was especially important for females (33%) compared to males (20%);
2. Women were more likely to list environmental concerns as a factor influencing car purchase than men (11% versus 7.3%) and for recharge time (4% versus 0%);
3. Women were not concerned about running costs (0%) compared to men (7.3%); but
4. Men were more mindful of car model features such as performance, aesthetics and storage capacity (21.8%) than women (17%), although few mentioned performance specifically.

The aforementioned new information from Australian motorists enhances the understanding that males and females have different attitudes to individual barriers. Such information could help in social-marketing campaigns, for example to refine the messages targeted at specific audiences and increase the likelihood the messages are heeded.

5.2.3 Incentives

In addition to investigating barriers, the questionnaires sought respondents' opinions on preferred incentives. The most nominated incentives were: lower vehicle price, better recharging opportunities, and a greater number of models in the market.

In Questionnaire 1, Q27 (open response with multiple reasons allowed), showed that:

- A reasonable price would encourage BEV purchase for more than half of all respondents (56%), for example, "*if the price comes down*" (Respondent 50, 27 October, 2015, Q27).
- A greater level of recharging convenience would encourage 54% of all respondents (combining 28% who wanted better infrastructure and 26% improved driving range) such as "*If there were electric charging stations in regional as well as major cities*" (Respondent 150, 15 October, 2015, Q27).
- The desire for greater choice of car features, with more models to choose from was important for 19% of all respondents; as summarised by "*choice of affordable vehicles in Australia*" (Respondent, 25 29 October, 2015, Q27) .
- Multiple conditions would incentivise uptake: as another respondent said, "*Extended range and increased access to fuelling stations for long trips. Price, style and type of car are also considerations. There are not too many electric hatchbacks that I have seen*" (Respondent 263, 13 October, 2015).

Results of international research (Section 2.3) are consistent with the thesis results, indicating attitudes to electric cars are multifactorial and complex. For example, people's attitudes can be shaped by demographic factors, including gender, and internalities and externalities such as knowledge, values and culture. Also, people who are concerned about harming the environment may weigh up other considerations such as budget and convenience when making car purchase decisions. That one size does not fit all is evidenced by the heterogeneous car market, there is the wide range of vehicle options available for sale to satisfy different customer needs.

Focusing on **PHEV**s, Q28 showed 61% of respondents would be encouraged by a reasonable price and 20% wanted greater choice with more models. That price was the most important factor is consistent with international studies; for example, for over 80% of Norwegian BEV owners, a reasonable price compared to ICVs was critical in purchase decision making (Bjerkan et al., 2016).

Given that EV uptake is extremely low and falling in Australia (Appendix D) it is possible that this survey's respondents were inexperienced with the technology in practical terms. Excluding incentives relating to purchase price, results from both questionnaires showed consistency in the incentives that were preferred by respondents. Questionnaire 2 analysed preferred incentives in further detail. After asking respondents to assume EVs were comparable in price to ICVs, Q14 listed programs offered in other countries to encourage EV purchase and respondents were asked to nominate the three most attractive to incentivise EV purchase. Responses revealed the most popular incentives were:

1. "*Government support for the roll out of a fast recharger network every 50 km on highways and in country towns*" for 63% of respondents, with more than half ranking it as the most important incentive. Further research would be needed to determine if the gender differences revealed for this preference, where fewer females (54%) nominated this incentive compared to males (69%), were due to differences in driving patterns.
2. "*No annual registration fees for EVs*" was nominated by 43% of respondents and was slightly more popular with women than men (46% versus 40%).
3. "*Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of privately owned recharger networks*" was important for 32% of respondents, again slightly more for women than men (35% versus 29%). That the convenience afforded by the introduction of such legislation would be welcome, it was the third most popular incentive, is consistent with Diffusion of Innovation Theory (Rogers, 1983) (Section 3.2.1). People who want to refill an ICV can make such payments for fuel, and without requiring membership of a network, for example, Caltex. It is possible that potential owners of EVs would like a similar level of convenience.

The results here demonstrate that Australians, who are largely unfamiliar with EV technology, have concerns about adopting EVs that are similar to those of ICV drivers inexperienced with EVs, in other advanced economies. Despite Australia's large geographic size, the average daily driving distances (36km /day) are lower than those in Norway (40km /day), for example (Section 5.2.1.9) so range anxiety is not due to Australia's size, but more about perception.

There have been many international studies focused on incentives and motivations for purchasing EVs including: Fearnley *et al*. (2015); Silvia & Krause (2016); Mersky *et al*. (2016); Figenbaum & Kolbenstvedt (2016); Bjerkan *et al*. (2016); and Rudolph (2016). These authors all found that incentives play an important role in encouraging adoption of EVs. One study revealed that EV users most valued lower *variable* costs, especially lower operating costs and free access to toll roads (Figenbaum *et al*. 2014, p 26). Norway's valuable national incentives impact on vehicle price and they offered a more extensive range of incentives, including local incentives, compared to other European countries (Figenbaum *et al*. 2014, p. 54). However, as EVs become more popular in centres away from the big cities, they identified that many of these smaller centres do not offer specific local incentives; indicating such incentives are not *essential* motivators for EV uptake (Figenbaum *et al*. 2014, p55) but do attract buyers. Another Californian study showed EV owners (who receive some purchase subsidies) were most motivated by money saved on fuel costs (35% for BEVs, 42% for PHEVs) followed by reducing environmental harm and access to HOV lanes (Center for Sustainable Energy, 2016). It is likely that a range of motivations drive sales, and establishing market-specific information, as revealed in this study, is important when determining useful programs to employ.

An earlier UK trial (Technology Strategy Board, 2011) showed that after three months of EV use, 83% of drivers said that [these earlier model] EVs met their daily needs with little or no change to their daily driving habits. While their range anxiety decreased, respondents wanted longer range capability than was available, showing that despite increasing confidence, they still wanted increased range. The results of this thesis show that the issue of driving range and the availability of rechargers, particularly on long trips are key concerns for those lacking familiarity with the technology in Australia. These results are consistent with those from a more recent UK survey (UK DfT, 2016), mainly of people unfamiliar with EVs, which showed that recharging and vehicle range were the most important factors deterring EV purchase. As battery technology improves it is likely that manufacturers will employ batteries with greater capacity providing longer range as already is the case with Tesla models (Table 4.1, p71) and it will be important to ensure car customers are informed of such advances.

That “*no registration fees*” was a popular incentive does indicate that while convenience of recharging was most important, respondents were still attracted to price reduction strategies. These results indicate that, if governments develop strategies to increase EV uptake, these are incentives worth considering.

To ascertain if there were differences in the popularity of incentives depending on other variables, results were analysed more closely by examining and comparing different variables, for example comparing new versus used car buyers. Again, this knowledge could be helpful in marketing and advertising programs by targeting specific audiences to increase the attractiveness of advertisements and hence the effectiveness. Notable differences include:

- For new and used car buyers there were marked differences in attractiveness of some incentive programs. Notably, two and half times as many *used* car buyers as *new* car buyers thought that government procurement programs were important.
- "*No registration fees*" was more important for *used* car buyers (56%) than *new* car buyers (40%), which was not surprising as new car buyers would probably be less budget sensitive than used car buyers.
- There were also marked differences in support of the development of information programs, for example, smart phone applications to locate recharging stations. Women were four times more likely to nominate this program compared to men (26% versus 7%), which is consistent with results of Chapter 6 about the utility of relevant information when buying cars. Similarly, new car buyers (24%) were five times more likely to nominate such information programs compared to used car buyers (5%). Perhaps this indicates that as used car buyers were less likely to be buying an EV they would have less interest or need for such information programs.

5.2.3.1 Incentivisation and environmental concerns

An important research finding was that environmental concerns were less important to these Australian respondents than other issues associated with car purchase (Section 5.1.2). Factors such as price and how easy the vehicles are to recharge were more important, even though this survey's respondents were more concerned about the environment than average Australians, as evidenced by the proxy measure of voting intention. International research has also revealed this conflicting result (Section 2.3). One possible explanation may lie in the economic circumstances of the respondents, half of whom favoured cars in the cheaper segments and half owning only one car. However, while individually shying away from buying EVs due to personal constraints, respondents valued the sentiment that alterations to transport could relieve environmental impacts. To support this argument, respondents overwhelmingly agreed (83%) that EVs are worth government investment (Q36), with 13.4% unsure and only 3.4% disagreeing. Pollution reduction was nominated by half (52%) of respondents (Q37) as the reason that governments should invest in EVs.

This result, it may be argued, fits the situation described by market failure (Section 3.2.2), where the sum of individual actions does not provide the most effective result for society. In this case respondents nominated that the desirable outcome should be acting to reduce pollution, although individually unable to take action to help achieve this goal. If reducing the considerable harm generated from ICV use (Section 1.3) is a key consideration for these respondents, particularly as such action causes environmental damage, then the current

Australian car market is inadequate and displays significant market failure, given Australia's massive dependency on fossil fuelled personal motorised transport (Section 1.2.1: 97.7% of Australia's passenger car fleet are petrol or diesel).

5.3 Summary

This research shows that even with the targeted more environmentally aware sample used (Section 3.4.3), when asked about the dependent variables of how likely they were to buy a BEV or PHEV, respondents were ambivalent about buying a BEV (Q30: WAR=2.94/5) and only slightly more likely to buy a PHEV (Q31: WAR=3.1/5). This research indicates that respondents regarded the perceived barriers as too high to enable more of them to consider an EV next time they buy a car. The questionnaires provided numerous opportunities for responses about perceived barriers and appealing incentives, including Questionnaire 1: Qs 26,27,28,32, 35, 38; and Questionnaire 2: Qs 10-15.

The most important barriers cited to purchasing EVs were:

- High purchase price
- Inadequate vehicle driving range
- Inadequate supply of recharge infrastructure

The most important incentives cited to encourage uptake were:

- An adequate recharge network, especially on highways and country towns
- Lower price for EVs
- Reduction in operational costs, for example, waiving registration fees
- Legislation to ensure easy access to rechargers and payment by credit/debit cards – no network membership required.

That the relatively high purchase price was important is consistent with factors influencing respondents' purchasing decisions for *any* car (Q26), and is supported by international research. Vehicle driving range and inconveniences relating to recharging, such as inadequate infrastructure, were also very important concerns affecting EV purchase. There was a high level of agreement (83%) that government should provide incentives and that provision of recharging infrastructure (WAR=4.25/5) was much more important than providing subsidies to reduce the costs associated with buying (WAR=3.6/5) and operating an EV (WAR=3.6/5). Half the respondents (51.6%) thought the underlying reason government should provide support for EVs was to reduce pollution.

Results of Questionnaire 2 enabled further investigation of respondents' thoughts about EVs. Assuming EV purchase price was equivalent to a similar ICV; data evidenced that the most important incentive was an adequate recharge network on highways and in country towns. This result showed that when people do travel away from home they would want to be able to recharge *en route* and at their destination. The reduction of ongoing operational costs via waiving annual registration fees was also very appealing, and second most popular, indicating the price sensitivity of many respondents. Legislation to ensure easy access to public rechargers and payment by credit/debit card, rather than requiring membership of individual recharger networks was the third most popular incentive.

This research provides important evidence to support recommendations that policy makers could consider to help make the transition to fossil free driving. The independent variables that had the closest relationship with the respondents' attitude towards purchasing EVs were the respondent's gender and whether a new or used car was preferred when buying vehicles. Those more likely to buy an EV were female, middle aged, self-employed people, those residing in accommodation without off-street parking and those willing to spend more than AUD 40,000 on their next car. Such characteristics may be useful considerations for policy makers investigating actions that could be taken to promote EVs among car buyers.

These results illustrate that the car market is heterogeneous, and the preferences of different niches need to be taken into account when trying to improve EV sales. Implementing a range of incentives, not just one, with consideration of the variables shown to be more important, could yield better results than if such findings were ignored.

However, it should be noted that these survey respondents were on average, less likely to have off-street parking than average Australians (Appendix C), which may explain the higher proportion of those without off-street parking among those more pre-disposed towards EV uptake. Other factors such as type of dwelling and home ownership status appeared to have no impact on preferences for EVs.

Building on the discussion of barriers and incentives in this chapter, in the next chapter the results of the experimental component of Questionnaire 1 are interpreted to shed light on the importance of providing relevant information about EVs to car customers.

Chapter 6 Utility of information for EV purchasing

6.1 Introduction

In Chapter 5 the research results from two questionnaires undertaken to generate data on barriers and motivations for purchasing EVs among a targeted sample of Australian car drivers were explained. These results found that many potential customers were dissuaded from purchasing an EV in part due to range anxiety and misconceptions about the technology. This finding resonates through international research (Section 2.2.3.1). Therefore, to provide some practical suggestions for policy makers, this chapter discusses the results of the experimental component of this research, undertaken to test the utility of providing information to potential car customers. Whether additional and targeted information about EVs increased the likelihood of buying an EV for the next car purchase was investigated. Questionnaire 1 included an independent design component using systematic variation. This component was included to investigate the null hypothesis and alternative hypothesis being used to test research question 3, as follows:

> *Null hypothesis*: There is no relationship between provision of information and likelihood to buy an EV: those who receive information about current model EVs are no more likely to buy an EV than those who do not receive information.
>
> *Alternative hypothesis*: There is a relationship between provision of information about current model EVs and likelihood to buy; people who receive information are more likely to buy an EV than those who do not.

This component of the research was enabled through the online platform provided by Survey Monkey. Its questionnaire formatting allows testing of alternative options for any question as required. Questionnaire 1 provided two alternative sets of information after Q28 (Appendix A):

1. *Variable 1* contained a page of information about EVs; and
2. *Variable 2* repeated a short statement about EVs provided earlier in the questionnaire to all respondents.

Survey Monkey randomly allocated respondents to each group. By this method 163 people saw Variable 1, the Test group; and 165 people saw Variable 2, the Control group.

The results gathered through this component are framed by the Theory of Diffusion of Innovations (Section 3.2.1), including the importance of various information channels. This discussion was also mindful of the concept that lack of information acts as a potential market failure (Section 3.2.2). As previously explained (Section 5.1.1), Questionnaire 1 contained eight closed questions (three of which contained 14 parts each) that required interval Likert scaled responses (Section 3.5). Calculating the Weighted Average Response (WAR) (Section 3.5) for any question, including that for any subgroups analysed, measured the average response for that question and enabled comparison to other questions and / or sub-groups. This chapter uses data from the Weighted Average Responses to Likert scaled questions, the larger the difference between WAR scores the more likely the results are significant. Full questionnaire results for all questions are provided in Appendix G.

6.2 Discussion of results

6.2.1 Introduction

In absolute and relative terms, very few Australians own an EV (Appendix D) thus most drivers could be considered relatively inexperienced with EVs. Due to this inexperience, there was a lack of detailed prior knowledge of the technology and issues involved in EV ownership, compared to markets where EV ownership is more widespread. When designing the questionnaires, the probability that most Australians would have a limited understanding of the difference between a BEV and a PHEV was considered, hence the inclusion of information to explain the difference. This assumption was made due to the rarity of EVs on Australian roads. One participant's response illustrates the utility that information could have to increase EV uptake in Australia; EV purchase could be encouraged by: "*Knowing its long term environmental impact, distance travelled between recharging, length of battery life, purchase cost, ongoing maintenance expenses, resale value*" (Respondent 146, 16 October, 2015, Q27). In this context, results of this chapter demonstrated that the provision of information about EVs was not uniformly related to an increased likelihood of buying an EV for every variable considered in the survey. The discussion hereafter elucidates the value of information to encourage EV uptake.

6.2.2 BEVs versus PHEVs

When considering the entire sample (n=330) this research revealed that PHEVs (Q31: WAR=3.1) were more popular than BEVs (Q30: WAR=2.94) as a vehicle choice. This outcome aligns with earlier findings of Carley *et al.*, (2013) who tested people in the US with no prior experience of EVs.

Table 6.1 Impact of information on likelihood of buying an EV: Test v Control groups

Scores: WAR /5

Vehicle Type	Test group	Control group
BEV	3.02	2.85
PHEV	3.12	2.99

Tabulating the results of Q30 and Q31 in Table 6.1, and dividing the responses into the Test group (respondents received a new page of information) and Control group (no new information) showed that:

1. The Test group preferred BEVs more highly than the Control group
2. The Test group preferred PHEVs more highly than the Control group
3. The Test group preferred PHEVs more than BEVs
4. The Control group preferred PHEVs more than BEVs

These results showed that the page of additional information provided did influence the Test group to prefer both vehicle types more than the Control group. Both groups were told of the range capabilities of PHEVs, but only the Test group was told that BEVs have a range of 120-150km. That the Test group were more likely to buy a BEV compared to the Control group indicates that being informed about the range of BEVs was important. This finding was consistent with other results from this survey as well as with international research (Section 2.2.3.1), which has indicated that issues relating to range /battery capacity/ and recharge requirements were among the most important aspects when considering a BEV purchase.

6.2.3 Gender

Further gender-based analysis revealed that both women and men preferred PHEVs compared to BEVs regardless of whether they received further information (Table 6.2). However, there were marked gender differences in preferences for BEVs. Women in the Test group were more likely to prefer a BEV than those in the Control group. By contrast, there was no difference between men's Test and Control group preferences. These results suggest that females were influenced by the information about BEVs provided while males were not. By contrast the Test group preferences for PHEVs were only slightly higher than the preferences of the Control group. However, men in the Test group were more encouraged to buy a PHEV than the Control group men in contrast to the results for BEVs where men showed no difference between the Test or Control groups. This could be for a number of possible reasons and more research would be needed to explore the preferences of PHEVs over BEVs by drivers of both genders.

Table 6.2 Influence of information on gender for EV preferences

Scores: WAR /5

Gender	BEV Test group	BEV Control group	PHEV Test group	PHEV Control group
Women	3.14	2.8	3.27	3.15
Men	2.87	2.88	2.93	2.86

Extensive prior research into advertising and marketing has shown that gender differences are well known (Wolin, 2003); as gender is increasingly implicated in how customers respond to advertisements, benefits could arise if these differences are taken into account when targeting specific markets. For example, Darley & Smith (1995) found gender differences in how advertising information is processed: women consider both subjective and objective product attributes and respond to subtle cues whereas men are more selective and tend to use heuristics processing and miss subtle cues. Darley & Smith (1995) point out that gender targeting has been practiced in advertising since at the least the early 20th Century. But as there is some debate (Alliance of Automobile Manufacturers, 2013) about the dominance of women or men in car buying decisions, it is an indication that advertising EVs could target a range of niche audiences to increase the impact of such marketing techniques. Another plausible explanation for gender based differences in opinions about EVs and openness to information and how it is processed, could relate to the cars' environmental attributes, as discussed in Section 6.2.4 hereafter.

6.2.4 Environmental benefits of EVs

As previously discussed (Section 5.2.1.5) it was assumed that these questionnaire respondents had a higher pro-environmental attitude than the Australian population. Thus, information provided in the page shown to the Test group that EVs were less environmentally polluting than ICVs may have influenced respondents' stated preferences about EV purchasing. As noted previously (Section 5.2.1.1) women are more likely to care more about the environment than men. It is contended that the additional information provided may have appealed more to women than to men in the Test group, as evidenced by the difference in results based on gender (Table 6.2), perhaps contributing to the higher likelihood that more women would buy EVs if they were given additional information, including about the environmental benefits they bring.

That Test group respondents, more often women, found the additional information about environmental aspects useful is supported by previous research. Research into gender bias (Mobley and Kilbourne, 2013) demonstrated that gender influenced environmental intentions. However, they asserted actual gender differences were likely to be overshadowed by culture; gender manifested its influence only for people who had scores high in technology and/or self-enhancement, for example, wealth, level of authority. Mobley & Kilbourne (2013) demonstrated in their research that women were more willing to change their views than men, but that women were more likely to change regardless of their views of technology or themselves. The authors asserted that males who were less willing to change their opinion also reflected high self-enhancement, or believed that technology could solve environmental problems. Mobley & Kilbourne (2013) explained that among people with low self-enhancement scores and low belief in technology there was no gender difference, men and women were equally willing to change behaviour. Thus, their findings could be applied to a technology that is not well understood by many Australians, including women, such as BEVs and may explain why men overall were not influenced by the information provided in my survey as much as women.

In earlier research into adoption of pro-environmental technologies, including EVs, Axsen *et al*. (2012) divided those with pro-environmental behaviours into three groups depending on their interest in technology and lifestyle practices: the 'engaged' group, the 'aspiring' group and the 'low tech' group. Their findings lend support to the notion that providing relevant information about EVs can help educate potential customers about the environmental and sustainability benefits that accrue from substituting EVs for ICVs. In this thesis' research some respondents appear to conform to the 'aspiring' group of Axsen *et al*. (2012). This group displayed interest in acting more sustainably, including adoption of technological solutions such as EVs to do so, and may be open to information about how EVs can help reduce environmental harm. Other respondents displayed similarities with the 'low tech' group, namely those who were the least open to change and less interested in technological solutions and would be more likely to adopt different environmentally friendly solutions such as using cars less and catching public transport more often. Comments elicited in response to Q27 (Questionnaire 1) support Axsen *et al.*'s groupings, and also evidenced one of the tenets put forward in the Theory of Diffusion of Innovations (Rogers, 1983), that if the consumer is unable to see that the innovation is superior to the incumbent technology there is a tendency to reject it. Some individual respondents hinted that they had doubts that EVs were superior to ICVs in regards emissions reductions, for example, if EVs were powered by the Australian electricity grid (Section 2.2.2): "*if the electricity is produced via renewable means, otherwise what is the point?*" (Respondent 19, 2 November, 2015, Q27); and "*availability to obtain electric power only from renewable energy sources*" (Respondent 60, 27 October, 2015, Q27). Another comment suggested the respondent lacked knowledge about the environmental benefits of EVs and needed certainty about EVs reduced emissions from the electricity consumed: "*it would need to be greener bearing in mind greenness of electricity source*" (Respondent 99, 19 October, 2015, Q27). When asked about what would encourage EV uptake Respondent 161 (15 October, 2015, Q 27) remarked: "*Nothing. The emissions are only shifted*". Such uncertainty, or disbelief, intimated that information about EVs' environmental credentials would need to be promoted to ensure the benefits are disseminated more widely, and could help convince some motorists to adopt EVs. However, pre-questionnaire levels of knowledge about EVs must have differed among respondents, not all needed convincing about the environmental attributes of EVs; as one participant noted "*independence from oil based fuels*" (Respondent 243, 13 October 2017, Q 27) was an encouragement to purchase a BEV.

Another aspect regarding environmental attributes was tested in Q35. Very few of either Test or Control respondents agreed that lithium batteries are very polluting compared to lead batteries (a deliberately false statement). Despite only the Test group receiving information about high recyclability of lithium and its low toxicity, many respondents would have been already aware of recent advances in battery technology from applications other than cars. However, the results of this question also support the notion that information about the environmental credentials of EVs helps people have more positive attitudes towards these cars. Almost half the Control group (45.7%) were 'unsure' if batteries were toxic compared to the Test group (18.2%). This is a strong endorsement that providing information about the environmental attributes of EVs can help sway potential customers that EVs are a more environmentally friendly alternative to ICVs.

6.2.5 New compared to used

Another variable, that of the condition of a car at purchase (Q14), displayed a noticeable difference between the Test and Control group results when comparing the respondents' likelihood of buying an EV; results are shown in Table 6.3.

Table 6.3 Influence of information on likelihood of EV purchase on people who buy new or used cars

Scores: WAR/5

Type of car - group	New car buyers	Used car buyers
BEV - all respondents	3.1	2.68
BEV - Test group	3.3	2.74
BEV - Control Group	2.85	2.62
PHEV - all respondents	3.1	2.91
PHEV - Test group	3.12	3.03
PHEV - Control group	2.98	2.87

Table 6.3 demonstrates that not only were *new car buyers* much more likely to want BEVs than *used car buyers*, but new car buyers were more likely to be influenced by the additional information than used car buyers. As new cars are more expensive than used cars, this result signals that used car buyers had already decided a BEV would not suit their needs/budget, and therefore were not influenced by the information in comparison to new car buyers, who were more open to buying BEVs. Similar results pertain to likelihood of buying a PHEV, although the influence of information was not as strong as for BEVs.

More than half the respondents (almost 57%)(Q14) were planning to spend less than $30,000 on their next car (Q15) and more people were planning to buy a used car (47%) than new (42%). These statistics show that even the cheapest current model EV on sale in Australia, Nissan Leaf at $40,000 (Table 4.1, p71) was unaffordable for more than half the respondents, even if this model was appropriate for their needs. One respondent would be encouraged to buy an EV if the "*Purchase price* [was] *under 12k second hand.*" (Respondent 269, 13 October, 2015, Q 27), which is illustrative of the financial capacity of many in the survey. That EVs are relatively more expensive than similar model ICVs is a difficult hurdle to overcome, without government support, if the aim is to increase EV uptake, but a bigger second-hand market established through government procurement programs (Section 4.5) could make EVs more accessible and affordable.

Analysis of information collected through the survey and critical review of international literature suggests that an increased EV market share may be assisted by increasing consumer choice:

1. Increasing the availability of EV models with lower prices within each market segment, which could occur as battery prices decrease (Section 4.2);
2. By car manufacturers expanding the variety of models available, with a wider range of features, such as number of seats and storage capacity, particularly in the lower price segments, to appeal to more niches in the market.

6.2.6 Impact of information on opinions

After being given information about EVs (Test group), or not (Control group), Q35 asked respondents to specify their level of agreement with statements relevant to EV purchasing (Appendix G1, p237 and p241). Overall, respondents (both groups) were most concerned about the lack of a recharge network (WAR=4.24/5) on their likelihood to purchase an EV, however, only two statements showed marked differences between Test and Control groups: those relating to purchase price and vehicle driving range.

6.2.6.1 Impact of information on purchase price opinions

To explain the results relating to purchase price, it is worth noting that the Test group were provided with information that total cost of ownership of EVs compared to ICVs is lower. This question (Q35) appeared after the page of information, and the Test group was much *less* likely to consider EVs were too expensive to *purchase* than the Control group (Test: WAR=3.25/5 v Control: WAR=3.7/5). To extend the examination further, respondents were also asked if they agreed with the statement "*the total cost of ownership of an electric vehicle is too high on a per kilometre basis compared to conventional cars*". This statement was made deliberately false and had low levels of agreement from both groups (Test: WAR 2.4/5 v Control: WAR 2.3/5), implying a reasonable understanding by both Test and Control groups that EV operational costs are lower than for ICVs, despite only the Test group receiving this information. However, the 'unsure' responses for the Control group (32.7%) were double that of the Test group (15.1%) again showing that more information is needed about this issue for car buyers. One of the longer responses revealed the breadth of information a prospective buyer might want if they are to consider an EV:

> *"Confidence that it can be easily setup at home, reliable, easy to find charge points out and about, not too expensive, trustworthy and easy to find installers and maintenance people. The technology will last for a while. Am I better off waiting till they sort it all out? Tick of approval from someone like CHOICE[10]. Gov(ernmen)t subsidy? Free parking. Becoming part*

[10] "CHOICE" is an independent member-funded consumer advocacy group who test products and services and endorse those they consider superior, based on a range of criteria.

of an EV community. Tech(nology) to say how far I can do and where the nearest charge points are" (Respondent 285, 13 October, 2015, Q 27).

These results illustrate that information about total EV ownership costs could be very helpful in convincing customers that, despite a higher upfront purchase price, EVs are affordable after several years of ownership; with the number of years of ownership being dependent on car model, personal travel patterns and petrol prices. In previous American research, Dumortier *et al*. (2015) demonstrated that providing information about *total cost of ownership per month* was effective in encouraging potential EV buyers. Such information could assist customers to weigh up a higher EV purchase price against lower total operating costs. That such information could be useful to buyers concurs with some of the other results (Q26) where purchase price (WAR=4.36/5) and fuel efficiency (WAR=4.38/5) (affecting a large proportion of operating costs) were the most important factors considered when buying *any* car. Dumortier *et al*. (2015) also suggested that *how* such information is presented should be considered: presenting information about total cost of ownership, rather than fuel cost savings alone, had an important positive influence on the likelihood of buying EVs for buyers of small and medium vehicles, but interestingly, not SUVs.

This evidence from Dumortier *et al*. (2015) is compatible with this survey's research findings where owners of large cars were much less likely to buy a BEV than small and medium car owners (Q16) (asked before additional information was provided). A possible explanation could be due to two factors: vehicle price and torque. Prior to the importation of the Tesla Model S only two other BEVs were available in Australia, both small. Possibly many large car owners in this survey had perceptions that BEVs had insufficient torque (pulling power), for example to tow a trailer or caravan, influencing their stated likelihood to buy a BEV/PHEV. Another reason could be, that they thought, aside from high purchase price, EVs did not meet their needs: "*not sure about distance able to travel with a battery*" and "*it needs to be 4WD and powerful enough to tow our camper trailer*" (Respondent 249, 13 October, 2015, Q27), and "[*I would be encouraged to buy] if such a vehicle could do long interstate journeys towing a boat or caravan*" Respondent 230, 14 October, 2015, Q27). If suitable information was provided to potential buyers it may allay the concerns of many, especially the availability of PHEVs that could meet their needs.

There was a clear link between respondent's car price preferences (Q15) and whether they were in the Test or Control group. When comparing people in each category of car price (Q15), to the results of Q30 (likelihood to buy BEVs), results were higher in the Test group for some car purchase price categories. The $40-50,000 group were the most enthusiastic to buy a BEV overall (Test and Control groups combined) and the additional information had some influence on likelihood to buy a BEV (there was a 0.2 point difference between groups: Test WAR=3.3/5 v Control WAR=3.1/5). However, the additional information provided, including that total costs of ownership for BEVs are lower than for ICVs, may have been more influential for the $20-30,000 price group, where the Test group were much more likely to buy an EV than the Control group (there was a 0.45 point difference between groups: Test WAR=3.2/5 v Control WAR=2.75/5). Notably, the additional information seemed to have even more impact on those willing to spend $50,000+ (there was a 0.85 difference: Test WAR=3.6/5 v Control WAR=2.73/5). This group may not have previously considered EVs as an option, and hence found the information relatively more helpful. When considering PHEVs the additional information had little impact, except for the $70,000+ group. Combined, these results indicate that providing potential customers with pricing information, including for total cost of ownership, that compares EVs with ICVs can be an effective way to influence purchasing decisions, as well as the importance of targeting certain information to particular car price and size cohorts.

6.2.6.2 Impact of information on vehicle range opinions

The information page disseminated to the Test group included data about EV range, including that most Australian drivers travelled less per day than the range EVs can travel before topping up. Test group respondents were more likely to agree that the range of an EV was adequate for their day to day needs than the Control group (Test: WAR=3.6/5 v Control: WAR =3.3/5). Also, fewer than half Test group respondents were 'unsure' (4.4%) than in the Control group (11.1%), signalling that information about range could persuade car buyers to change to EVs.

Danish research, Jensen *et al*. (2013), identified that for single vehicle households EV range was a critical limiting factor, but in multi-vehicle households this was less important because ICVs could be relied on for long-distance trips (Section 2.3.1). An American study (Needell et al., 2016) calculated that 87% of vehicle days could be met by the range of affordable EV models available in 2013 without recharging during the day. This information could be important to communicate to multi-vehicle householders, who in this study were no more likely to buy an EV than single vehicle householders (Q12), however, in reality multi-vehicle householders could choose to use an EV for most day-to-day driving and use an ICV for longer trips. In Norway, most EV owners are in multi-vehicle households (Section 5.2). but importantly, only 1% of Norwegian BEV owners would not buy one again due to range being too short and recharging issues (Figenbaum and Kolbenstvedt, 2016b) providing strong evidence that BEV owning multi-vehicle householders manage their driving needs to their satisfaction. Furthermore, Norwegian Tesla drivers take much longer trips than other EV drivers; Figenbaum & Kolbenstvedt (2016) explained these drivers may choose to purchase a Tesla specifically because of less frequent recharging due to the larger battery capacity (enabling about 400km driving range) and access to the free electricity and short charge time from superchargers provided by Tesla for their customers as an exclusive service on major routes therefore providing zero energy costs on long trips.

As battery technology improves, battery capacity increases travel range in more EV models and decreases car production costs (Nykvist and Nilsson, 2015). Better communication about battery capacity, longevity and price to potential EV customers, which keeps motorists up to date with technological developments and can allay range anxiety, may help persuade more Australian drivers to make the change to EVs.

6.2.7 Car performance

A limitation of this study may be the lack of information provided for the Test group about the superior performance of EVs; for example, Respondent 250 (13 October, 2015, Q 27) acknowledged they would be encouraged by "*range/performance that matches my lifestyle*". However, it is notable that performance (acceleration) as a feature of *any* car had relatively low importance by both men and women (Q26: WAR=3.06/5, with men WAR=3.12 and women WAR+3.01/5), and ranked third lowest whereas attributes relating to cost or safety scored much more highly by both genders (WAR of 4+/5). The relative unimportance of performance was also noted in a Norwegian survey of EV buyers (Figenbaum and Kolbenstvedt, 2016b). However, information about performance may be influential on whether males, in particular, express a positive interest in EVs compared to conventional cars. At a rational level many drivers would have little need for high performance in Australia, due to moderate speed limits on all but Northern Territory highways. Thus, any desire for higher performance may relate to subconscious considerations, such as status.

Cars are thought to act as status symbols in addition to being a practical means of transportation (Rezvani et al., 2015). As discussed in Section 2.3.2, EVs might not confer adequate status on the owner and this factor may have subconsciously influenced the degree of preference for EVs, particularly by male respondents. For those respondents concerned with status, that early model EVs were small and perhaps gave a the feeling of embarrassment when driven (Graham-Rowe et al., 2012) may have led to a perception that EVs are incompatible with their lifestyle choices. Hardman *et al*. (2016) have noted the influence of more recent expensive, high performance EVs that, as the information becomes widespread, could increase their status (Section 4.2). Therefore, it is possible that male respondents, due to unconscious bias, had a greater tendency to reject EVs than women due to the perception that EVs had lower status than ICVs, despite respondents consciously valuing performance as of less consequence than most other factors (see above regarding Q26). Providing information about the superior performance of EVs could increase the desirability of EVs for men, which may be useful in marketing and advertising. As one male participant noted, he would be encouraged to buy a BEV if "*it could run as fast and powerfully as a petrol driven car, the price of electricity does not jump,* [and] *it is a good looking car*" (Respondent 34, 28 October, 2015, Q27).

As further evidence to support this assertion, Tesla have highlighted car performance rather than environmental attributes in their marketing strategy (Rezvani et al., 2015), and that Norwegian advertisers have focused on acceleration of PHEV models (Figenbaum and Kolbenstvedt, 2016b). That this focus on performance and status could be considered a valid marketing strategy was illustrated by one respondent: "*the stigma of driving a vehicle that inherently 'flaunts' its 'green' credentials*" (Respondent 205, 14 October 2015, Q27), again hinting at possible feelings of embarrassment on the possibility of driving an EV.

6.3 Information channels

This research not only included an experimental component to test if information did help encourage EV purchase (Section 6.2) but also asked questions about preferred communication channels. Rogers' Theory of Diffusion of Innovation (Section 3.2.1) maintains that for an innovation to diffuse into a society, communication channels, including print media, the internet and person to person, are the conduit.

6.3.1 Questionnaire 1

The *main source of information about new car models* (Q22), as listed in Table 6.4 below, was online articles (41.2%), with print media (20.6%) next most popular, followed by word of mouth (16.4%). Very few people used car manufacturers' websites to seek out information about car models (5.5%).

Table 6.4 Primary information source about cars (Questionnaire 1)

Source of information	Respondent numbers	Percentage
Online articles	136/330	41.2
Print media (newspapers / magazines)	68/330	20.6
Word of mouth	54/330	16.4
Television / radio	42/330	12.7
Car manufacturers' websites	18/330	5.5
Other (please specify) including: all of the above; not interested)	12/330	3.6

These results are consistent with Norwegian survey results (Figenbaum et al., 2014) who found that for EV owners the media (inclusive of all types) was the most important source of information, followed by family and friends.

Results of Q23 and Q24, from self-reported data, related to how much interest and knowledge respondents had in cars. Overall, interest in cars was only moderate (WAR=3/5) indicating that it would be important to provide reliable up to date, easily accessible data to potential EV customers, as it is likely that customers hold prior potentially out of date knowledge given how quickly the market is advancing. While it may not be important for people to understand how cars work (reported as less than moderate, WAR=2.82/5) disseminating information about the superior qualities of EVs including lower operating costs, lower emissions, less noise, equivalent safety, better performance, will be critical if people are to consider buying EVs rather than ICVs.

Other more successful markets provide examples of communication methods that have encouraged EV ownership. For example, Norwegian vehicle associations share useful information, including EV owners' experiences:

> *"Owners will, after the purchase, experience the limit of what the technology can do, when venturing on longer trips. Many BEV owners in Norway have a lot of experience with their BEVs, and they share it on the «Elbilforum» (EV forum) a website for BEV owners run by the Norwegian EV Association. New owners can find reliable information about what the BEVs can do when it comes to range, how to accomplish certain trips etc. The EV association also shares information on their web page and various pages present an overview of charging stations. The Norwegian Automobile Federation has a magazine and a web page also disseminating information"* Figenbaum & Kolbenstvedt (2016, p 80)

Similarly, on the UK website ZapMap (Next Green Car, 2015a) the EV owning community shares a wide range of helpful tips about owning EVs and travelling away from home. In the US, Plug in America (Plug in America, 2017) provides helpful information and organises field days for owners and potential owners alike. These examples demonstrate that comprehensive online forums, active online communities and helpful smart phone apps, amongst other platforms, have potential to help Australian car customers learn about EVs. Investigating potential programs and funding suitable ones could help encourage EV purchase. For example, results of Q14 (Questionnaire 2) about preferred incentives, showed that 16% of respondents selected the option '*Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs'*. However, notably this incentive was 3 ½ times more important for females than males (26% versus 7%) evidence that accessible information is far more important to female drivers and would be an important program for policy makers to consider and advertise appropriately. Similarly, this program was almost five times more important for new car drivers compared to used car drivers (24% v 5%) hinting at the greater degree of comfort that people in higher socio-economic groups, those most likely to buy EVs, have with such information channels, or, that people who consider EVs are unaffordable would have no interest in such programs.

Respondents' recollections of *media* coverage for EVs (including online and print) (Q25 WAR=2.87/5) showed that information in the media and people's recall was moderate. Such modest recall was probably because EVs are mainly reported on when new models are released onto the market, which are relatively few in comparison to number of ICVs coming out in any year, or other especially newsworthy story. As respondents had only moderate interest in EVs (Q23 WAR=3/5) it is possible information about EVs is infrequently remembered or searched for, if at all. Given the importance of online articles and the variety of information sources available, it is possible that many people only actively seek up to date information about specific models when they are looking to buy their next car.

6.3.2 Questionnaire 2

Questionnaire 2 further probed the usefulness of various channels of information. Respondents were asked about sources of information (Q6) when buying a car; results are shown in Table 6.5 below. Males were slightly more reliant on prior knowledge about cars than females. By contrast females valued external sources of information (family and friends, car salesperson, and formal sources) more than men did. Both sexes regarded advertisements the least, and valued experiential personal test drives most of all. While gender (Section 6.2.3) is an important advertising consideration, results here suggest that avenues other than advertising could be more important in marketing EVs especially before customers get to a showroom. Suitable methods of information dissemination could be considered for further research.

Table 6.5 Preferred information channels (Questionnaire 2)

Scores: WAR/5

Source of information	Overall	Female	Male
Prior knowledge about particular car models	3.63	3.50	3.73
Family and friends	3.0	3.28	2.76
Car sales person	2.24	2.57	1.96
Formal information sources (e.g. magazine articles, car brand websites, articles written by motoring journalists, TV shows)	3.9	3.93	3.87
Advertisements about specific car models	2.22	2.15	2.27
Test drive	4.1	4.15	4.05

The importance of test drives highlights the value of heuristics learning and underlines the importance of field days in helping promote EVs in less pressured settings than car dealerships. Such experiential knowledge would allow car customers to familiarise themselves with EVs before they shop, help normalise EVs in the community and improve people's prior knowledge about EVs (an important source of information for car buyers, especially men). This proposition is supported by previous research: Nayum and Klockner (2014) concluded that offering information and personal experiences helped potential car customers overcome their fears and doubts about the technical and practical aspects relating to new technology.

As noted, females preferred external sources of information more than men. In Q8, 63% of women knew someone with an EV compared to 49% of men. However, the results of this question may be of limited value given the importance of test drives as a source of information (Q6). It may have been more useful to ask respondents if they had ever driven or been a passenger in an EV. It is interesting to note that in Norway "in general, most BEV owners inspire others to buy and consider buying BEVs, with some variation based on years as a BEV driver and the type of vehicle. With 10-20% of BEV owners inspiring three or more friends or family members to buy and about the same number to consider buying" they could be considered to be "BEV ambassadors" (Figenbaum & Kolbenstvedt 2016 p 7). It is likely that Norwegian car buyers, like Australians, would share information about their car driving experiences particularly with family and friends who show interest in the technology or are a passenger and notice the differences with ICVs. Supporting this concept, recent research about purchasing EVs (Cherchi, 2017) underlined the importance of informational conformity, (where group members are used for guidance) and social conformity; in particular she noted that negative experiences had more impact than positive. Cahill *et al*. (2014) also recommended promoting the good experiences of early adopters to help normalise EVs, while also noting unsatisfactory experiences delay diffusion. Enabling drivers to experience EVs through 'ride and drive' field day events (such as, Plug In America 2017) allows people to gain practical experience away from car salerooms.

Respondents were asked "*Have you ever consulted the Australian Government's Green Vehicle Guide website?"* (Q7). Despite the importance of formal information sources (Q6), this government funded, accurate information source was not well used by respondents, with 20% of females and 25% of males saying they had used it and about half of both genders saying they had not. This result connotes that people were not particularly focused on "green" issues in relation to cars, despite half of the respondents identifying themselves as Greens Party voters. However, the Green Vehicle guide website (DIRD, 2017a) contains information about the costs of driving all the listed vehicles, and given the results of this survey and other research (for example, Dumortier *et al.*, 2015) relabelling the website to do with cost savings rather than environmental issues could be more productive as a focus for people using the website, while keeping the same information. As discussed in Section 5.2, this issue also tallies with results from Questionnaire 1, (Q26) showing that fuel efficiency (WAR=4.38/5) was much more important for car buyers than GHG emissions (WAR=3.84/5), which are interchangeable terms from a technical viewpoint (Tietge et al., 2016) but have different values associated with them.

As previously discussed (Section 6.2.2) men tend to use heuristics to process information, thus lack of hands on experience with EVs may be a hindrance to EV uptake (see also Section 2.3.1). Thus, in addition to information provision, customers benefit from trying before buying; this is consistent with Rogers' Theory of Diffusion of Innovation 'trialability' concept (Section 3.2.1). A Danish study by Jensen *et al*. (2013) supported the value of experiential knowledge, finding that that individual preferences change significantly after three months of real experience with an EV in the household. Similarly, a German study

(Peters and Dütschke, 2014) has asserted that EV compatibility with everyday life is the most important factor influencing uptake. This finding evidences that field days as a marketing tool are a worthwhile consideration to increase the uptake of EVs (Section 4.4). Silvia & Krause (2016) demonstrated that a range of strategies to encourage EV uptake was more effective than single approaches, and a study of Londoners (Bennett et al., 2016) concluded that social marketing campaigns, whether government or private, needed to be multi-faceted to appeal to various market segments and that a 'one-size-fits-all' approach should be rejected.

6.4 Summary of results and concluding remarks

The results of the experimental component of this research did not support the null hypotheses, but do provide support for the alternative hypothesis, that is "*There is a relationship between provision of information about current model EVs and likelihood to buy; people who receive information are more likely to buy an EV than those who do not.* "

Overall, Test respondents who received information expressed a higher likelihood to buy a BEV (Q30) than Control respondents (Test WAR=3.02/5 v Control=WAR 2.85/5). However, despite the higher popularity of PHEVs (Q31) than BEVs for all respondents, information provision for the Test group had a lower relationship with respondents' likelihood to buy a PHEV compared to a BEV (Test WAR=3.12/5 v Control WAR=2.99/5).

Results of other questions investigating the utility of additional information revealed that the independent variables of gender and whether the respondent wanted to buy a car that was new or used were more closely linked with a higher likelihood to buy EVs. The likelihood of buying BEVs varied for Test group respondents for different car purchase price categories (Q15). In particular, the additional information may have been far more influential for those willing to spend $50,000+ on a car, compared to respondents in the lower price brackets.

This research found some channels of information were more important in Australia, for example, online media, than other sources to assist diffusion. Test drives were very important for all drivers, as they can provide first-hand experience, an important way of learning. Events such as field days and formal information sources such as articles on the internet or in print could be strategically targeted when promoting EVs to increase marketing effectiveness, helping overcome market failures resulting from a lack of information.

This research also highlighted that potential customers are most influenced by information about EV ownership costs and vehicle driving range, demonstrated by many studies to be important globally (Section 2.3.1). It also demonstrates the similarity of Australian car customers with other people around the world who also have limited experiences of EVs (Chapter 5). As cost is a major factor in buying cars, while-ever the cost of an EV is high and there are limited models on the market, particularly in the lower price segments, and few cheaper second-hand EVs available, it will be difficult to persuade any but those in the upper price brackets to change from ICVs to EVs. Funding information programs about total cost of ownership benefits may be useful for potential EV customers including those prepared to spend less buying a car. Providing more information about EVs' environmental superiority to ICVs would also be important for those with pro-environmental attitudes but lacking detailed understanding, but who might otherwise buy an EV. Such information would help overcome important barriers to uptake.

Thus results of this research, combined with other evidence from international research, indicate that supplying up-to-date and relevant information, especially about operational costs and vehicle range and providing EV experiential information, well before people arrive at the point of sale is likely to increase EV adoption. Funding the dissemination of appropriate information via popular platforms could be considered as an appropriate government policy if the aim is to increase the acceptance of EVs in the Australian market.

Chapter 7 Conclusions and Recommendations

7.1 Introduction

It is well established that the global problem of climate change requires urgent action by all countries. Due to the reliance of motorised transport on oil for energy, a significant portion of greenhouse gas (GHG) emissions, which exacerbate global warming and hence lead to climate change, originate from the transport sector. There is a clear need for all countries to adopt alternative forms of transportation that produce fewer polluting emissions.

The electric vehicle (EV) industry has moved beyond the experimental phase and EVs have become a viable alternative to conventional internal combustion vehicles (ICVs), especially for personal motorised transport. The environmental benefits of EVs are many, not least as a means to reduce carbon emissions and other negative externalities. While recognising that promoting the use of public and active transport rather than cars for personal journeys could lead to emissions reductions, the public should be encouraged to employ electric cars for those times when using other transport modes is impractical. Contemporaneous transition to public and active transport alongside EVs would help accelerate beneficial outcomes more quickly than either one or the other.

EVs can potentially further reduce pollution as the renewable energy component of electricity generation increases. It has been demonstrated through life cycle analyses and other research (Appendix H) that regardless of a country's electricity grid mix (except in Iraq and South Africa, based on 2013 data). EVs reduce operational GHG emissions due to the inherent efficiency of electric motorisation compared to ICVs, which have fixed emissions for each model and fuel type combusted. In the Australian example, moving to personal transportation powered by the electricity grid, even with the current mix of energy sources, would help reduce GHG emissions (Section 2.2.2). However the widespread adoption of EVs could take decades, due to social inertia and the long life of cars. Implementing suitable measures to speed the transition away from the age of oil should be a concern for all governments

The overall aim of this research was to recommend practices to Australian governments that could encourage EV uptake by individual motorists, who are relatively unfamiliar with this newer technology. This thesis focused on social attitudes to electric vehicles for private use, and as such only represents one part of the field investigating transport emissions. Other barriers to the adoption of EVs, such as institutional practices, or commercial attitudes for fleet purchasing in Australia could be investigated to provide evidence to support additional mechanisms to encourage the adoption of EVs. This research employed a framework that considered interactions between governments, markets (focusing on market failures) and elements of the Theory of Diffusion of Innovations, and their impacts on consumer acceptance of EVs. This framework describes and explains factors that appear to be closely linked to consumer choice processes, which are important considerations when searching for suitable strategies to overcome any prejudices towards EVs. While consumer decision making is a complex process, a better understanding of a range of factors affecting EV purchase could provide evidence to support the recommendations made by this thesis (Section 7.4).

To reveal measures that governments could usefully implement, the following research questions were answered:

1. a. What policies and strategies have been most useful in encouraging electric vehicle uptake in countries with higher levels of EV adoption and what are some pitfalls that should be avoided?
   b. What is the Australian EV scenario and how does it compare to more successful markets?
2. What are some important barriers and incentives that could influence the likelihood of customers choosing to buy an EV in Australia?
3. Does the provision of up to date information about EVs influence the likelihood of customers choosing to buy EVs in Australia?
4. What are some potential interventions that could be recommended to policy makers to increase the rate of uptake of EVs in Australia?

In this chapter, conclusions are drawn from the data generated to address these questions. Section 7.2 illustrates best practice from successful markets that have addressed problems perceived by individual customers as hindrances to EV uptake. Section 7.3 outlines the Australian scenario and summarises the results of this original research into social attitudes to electric cars. It describe the main factors, including access to information, affecting Australians more pre-disposed than average motorists to consider the environment when considering car purchase, including EVs. Section 7.4 makes recommendations that policy makers could consider adopting to encourage uptake of EVs in Australia.

7.2 International best practice to encourage EV uptake

Reviewing the literature to answer research Question 1 revealed that successful rates of uptake require the introduction of, and attention to, certain policies and strategies. Without suitable government intervention, EVs struggle to attract buyers.

Many motorists perceive EVs as problematic. Two critical hurdles for potential customers are that EVs have a higher ticket price than similar ICVs, and, more importantly, the more limited driving range of EVs compared to ICVs is of particular concern, inducing what is known as range anxiety . This worry comes despite the global trend that most people drive locally most of the time, and that current model BEVs have ranges that can satisfy most daily kilometres travelled without needing a top-up recharge. However, there are certain situations where drivers take longer trips away from home, making a battery top-up a necessity. Thus drivers need convenient access to high speed chargers for longer trips, especially *en route,* for example, on highways and in country towns, to enable BEVs to completely replace ICVs. Close inspection of recharger maps of countries with high EV sales illustrates that well distributed numerous public recharge stations, including fast rechargers, are in place.

However, even with a comprehensive charging network, difficulties can be faced by a long distance BEV motorist. Charge networks may be operated by more than one company in a country or region, and drivers may need membership of more than one network to enable particular journeys if there is no legislation in place to require interoperability enabling easy payment options, such as by credit/debit card.

Even if battery capacity increases, thus extending vehicle range, individuals have unique trajectories requiring recharging at different points. The current frequency and distribution of petrol stations in advanced economies indicates that even with long range ICVs there is a market for conveniently located refuelling stations, particularly on intercity roads. This finding indicates that a well distributed recharge network of 'EV service centres' could also be economically viable, particularly on intercity roads such as when combined with other facilities such as shops and cafes. It is also worth noting that EV owners are far less concerned about recharging issues than those unfamiliar with the technology, and ICV motorists who know EV owners are more likely to buy an EV than those without such contacts. This evidence illustrates that increasing the familiarity of ICV motorists (the higher proportion compared to EV owners in any market) with the ever improving capabilities of EVs, and to the availability of recharging opportunities, would help reassure them that longer journeys are possible in BEVs, thus increasing their amenability towards purchase.

International best practice indicates that government support has been critical for increasing EV adoption rates in individual markets, with some measures more successful than others. The most successful EV markets in 2016 were Norway, Hong Kong, the Netherlands and Iceland, although market positions are dynamic. In countries where government support has been removed, for example in Denmark, EV sales have declined. Where support has been insubstantial, sales have been insignificant, including Australia where sales are also in decline. There are also examples of governments whose attempts to introduce policies were inappropriate or inadequate, for example as demonstrated in the UK (Section 4.4). The full potential of the investment associated with supporting increased EV adoption may not be realised if customer concerns are not primary considerations when designing and implementing policy initiatives.

Research reveals that useful measures adopted by governments that have been successfully transitioning to EVs include:

- Providing subsidies, or similar measures, to reduce the purchase price of EVs for consumers. EVs are typically in the upper price brackets of any particular market segment, and frequently in the upper segments of the car market, and thus lowering the purchase price has been demonstrated as critical for attracting most EV customers;
- Rolling out an effective recharger network to provide an essential market co-condition, that is, locations to recharge EVs. This set-up includes a comprehensive network of highway locations to enable long-distance journeys, as well as in urban areas, for example, to service households without off-street parking; and appropriate legislation for multi- occupant buildings to include the capacity to install rechargers, a potential advertising feature to attract customers;
- Providing a mix of soft incentives to attract more than a small niche of EV enthusiasts. Useful incentives have included: toll free routes (the most cost effective incentive offered), access to high occupancy vehicle (HOV) / bus lanes, free car ferries, free parking, free recharging and information services to help customers and potential customers. Some incentives are more attractive to specific customer groups than others and some are economically more effective, but any option must be considered with the particular target market in mind.
- Implementing policies to ensure government fleets procure EVs in preference to ICVs. This measure increases EV numbers and, with relatively rapid turnover, could increase the second-hand EV market within a few years. Having EVs in car pools can also increase diffusion of innovation via workplace exposure and access to EVs;

- Providing up-to-date and reliable information to potential customers about EV technology, operating cost comparisons with ICVs, and infrastructure locations. Test drives (such as field days), websites and online EV forums, smart phone apps, and positive media stories are important channels of information to facilitate diffusion of the innovation and rectify a significant market failure.

7.3 Factors affecting Australian car buyers

Compared with other developed markets, the Australian EV market is extremely thin. In 2013, Australian EV sales represented 0.03% of all car sales; in 2014 this rose to 0.13%, declined a little in 2015 to 0.12% but then dramatically dropped to 0.02% in 2016. Two main factors, low fuel prices and low levels of supporting recharge infrastructure, appear to have dis-incentivised EV uptake. The current political and economic environment has ensured Australia has among the lowest priced petrol and diesel of all OECD countries due to its low taxing regime. Such low prices do little to encourage transition away from an oil dependent economy. Consequently, low fuel taxes have meant oil related externalities, such as air pollution and higher health costs are not paid fully by individuals, but by society as a whole. Limited government support for EVs compared to other countries, further evidences a lack of commitment to build recharge infrastructure. There is a tax reduction for lower emission luxury cars, but not specifically for EVs of any price. Some states have offered minimal support to encourage EV uptake, such as car registration fee discounts.

With the above scenario prevailing, the two most important factors affecting the likelihood of Australians buying EVs appear to be:

1. Limited exposure to the technology compared to other advanced economies, and,
2. The existence of significant barriers to uptake.

Previous research (Section 2.5) showed Australians who worry about climate change were more likely to consider an EV, but for many the barriers to purchasing an EV are too high resulting in an attitude-action gap (Section 2.3.2).

Primary data was collected to answer Research Questions 2 and 3 to:

1. Help understand important barriers faced by car customers;
2. Reveal appealing measures that could incentivise EV acquisition; and
3. Ascertain if providing relevant information could encourage uptake.

This research surveyed, via two online questionnaires, a sample of Australian drivers, targeting those who could be more likely to have pro-environmental attitudes, as previous

Australian research had shown they were more likely to favour EVs than the general population. By revealing factors affecting pro-environmentalists, it exposed barriers to EV purchase. Determining incentives that were popular with this sample could also apply to the broader population, assisting many motorists to bridge the purchasing gap.

The following summarises the main findings of this research in relation to the research questions, followed by considerations for implementing policy:

- When buying *any* car, respondents were most concerned about vehicle price and fuel efficiency;
- Supporting previous findings from Australia and abroad, motorists with pro-environmental attitudes are more likely to consider buying an EV than others, although preferences were not strong, respondents were only moderately likely to buy an EV;
- Respondents were concerned about high EV sales prices, and they were very concerned about lack of recharging infrastructure. This concern prevailed even if EVs were within their budget.
- Recharging convenience was a major consideration and a possible deterrent for potential customers. The data from this sample of Australian motorists, who were relatively unfamiliar with EVs, were consistent with the concerns of ICV drivers in other markets, even in countries with relatively high EV adoption rates. Driving distances and daily driving regimes were similar to other advanced economies, where most driving was local with only occasional long-distance journeys of more than 100km in a day;
- Purchasing incentives were demonstrated to be effective pull factors attracting respondents. Yet, other incentives such as a comprehensive recharge network, and enabling legislation, were more important. As battery prices, and hence EV sales prices, decline relative to ICVs, the provision of necessary market co-conditions and other soft incentives should become even more important to attract motorists to buy EVs;
- Half the respondents nominated a preference for buying used cars, and half were willing to spend no more than AUD30, 000 on their next car. As this sum was 25% below the price of any model EV on the Australian market in 2015, it demonstrated that manufacturers need encouragement to offer cheaper models of EVs to increase sales. Currently, most EVs models are in upper price segments limiting the market;
- On occasion throughout the year, most respondents drove more than 100km in a day, necessitating a well-located, functional and publicly accessible recharge network, with easy payment options. While a BEV would suit most day-to-day driving, without a comprehensive network enabling longer car trips, substantial pre-planning or access to

an ICV or PHEV would be vital. The perceived inconveniences of either option could present significant barriers to many ICV motorists, who are currently provided with many convenient refuelling opportunities. Whilst recharge infrastructure is lacking, PHEVs would present a more suitable alternative to ICVs than BEVs for most customers, however, the potential reduction of negative externalities would diminish;

- Recharging time was not a specific factor raised by many respondents; however, a lack of familiarity with the technology and that range anxiety was considerable signified that time was probably not regarded as important as access to a recharger for a long journey. Yet recharging convenience is an important consideration; for example, stopping to recharge for an additional two hours in the middle of a three-hour trip of 300km, extending the journey time to five hours, would not be acceptable to most drivers. There is a need to have *fast* rechargers to ensure that long trips are not overly burdensome with long recharging times. The Tesla business model and Irish research (Morrissey et al., 2016) evidence this;
- Even when asked to assume EVs and ICVs were equivalent in price, the second most popular incentive for EV purchase, after an adequate recharge network, was a reduction in annual registration fees, demonstrating that respondents are still price sensitive and are mindful of personal budgets;
- The third most popular incentive was for legislation to ensure open access to enable easy payment options for recharging, where membership of private recharger networks is not required, and payment can be made by credit / debit card; this demonstrates that motorists are attracted to convenient recharging payment options; and
- Additional information about the capabilities and benefits of EVs given to respondents increased their preferences for EVs, especially for women and buyers of new cars. This result illustrated that up-to-date and reliable information presented to potential customers before they arrive at a showroom can help alleviate concerns about the technology and promotes the benefits of EV ownership. The most effective channels for dissemination of such information for this group of Australians were online articles and print media as well as word of mouth.

7.4 Recommendations for policy makers

This thesis has focused on identifying and understanding measures that can facilitate the transition of cars from ICVs to EVs, in particular factors that affect private car customer buying decisions. To find means to facilitate this transition, research question 4 asked:

"*What are some potential interventions that could be recommended to policy makers to increase the rate of uptake of EVs in Australia*?"

From the results of this thesis it is proposed that there are numerous recommendations that could be adopted by governments to encourage the uptake of this newer technology. It is through government actions that market failures are addressed and the diffusion of innovation influenced, particular in the market's early stages. Also, as the current Australian EV market is negligible, a concerted effort should be made to grow the proportion of drivers who have received positive information or had first-hand experiences with EVs. These drivers, who are not necessarily owners, could share their experiences with the technology and its capabilities, particularly by addressing the range anxiety displayed by potential customers, but which data showed are rarely of concern to EV owners. Concurrently, appropriate EV infrastructure should be deployed including a network of fast rechargers. Policy makers should aim to negate a 'first the chicken or the egg' scenario, and instead focus on the essential market co-condition to encourage EV uptake.

The following recommendations (Table 7.1) have been compiled by analysing and synthesising data collected to answer questions 1-3 and with consideration of the dynamic nature of this field.

Table 7.1 Recommendations for policy makers

Recommendation	Action
Acknowledge that transport related fossil fuel consumption results in a wide range of negative externalities.	• Set goals and targets to effect a transition to EVs as an effective way to reduce negative externalities including: ○ Reducing GHG emissions, and toxic air pollution and noise, thus reducing associated health costs; ○ Improving fuel security; ○ Improving Australia's balance of trade; ○ Reducing job losses resulting from outsourcing of transport energy supply; ○ Reducing heat island effect in major urban centres, which in turn increases use of air conditioning and energy use in summer; and indirectly, ○ Reducing financial leakage due to repatriation of funds by foreign owned oil suppliers.
Deploy a comprehensive and effective network of publicly accessible rechargers.	• Install fast chargers every 50-100 km on main intercity routes as these are the most frequently used when recharging away from home, and in country towns, • Encourage the deployment of recharge stations at public places such as shopping centres, to enable recharging while motorists are parked in one place for a length of time • Ensure the network is in place as EV prices drop and motorists become increasingly familiar with the technology.

	• Support those householders with no off-street parking by providing on street rechargers near their homes, with sufficient points to avoid queues at popular spots; • Ensure an adequate maintenance regime with prompt repair of public rechargers; • Ensure public recharge stations are well signposted with standardised signage; improves accessibility for customers and maximises network value; • Ensure easy access regardless of time of day; • Maintain centralised and up-to-date data collection and dissemination for recharger location and status to aid availability of information to everyone, including users, and assists network planning; and • Encourage installation of workplace rechargers; while this is not as important compared to at home charging, it is important for people with long commutes to be able to recharge during worktime, and it increases visibility of EVs and rechargers.
Introduce legislation /regulation to increase consumer convenience.	• Legislate to ensure open access to rechargers, that there is interoperability and no need to join a private recharge network provider for recharging away from home, and that recharging can be paid for by credit/debit card; • Introduce standards for recharger hardware to maximise customer convenience when recharging and to maximise efficacy of the network, ideally one size fits all cars, to increase network utility and reduce negative feedback to intending customers; • Ensure availability of rechargers in multi-occupant carparks, whether residential or commercial; • New buildings with car parking must have capacity for recharger installation, including adequate electricity supply and parking space availability; • Compel building managers to allow retrofitting of rechargers in car parking spaces; as cities densify and people move into multi-dwelling buildings this will be a critical measure; and • Investigate a range of soft incentives to encourage uptake of EVs, for example, free access to toll ways, access to high occupancy vehicle lanes regardless of passenger numbers.
Increase the flow and availability of information for existing and future drivers.	• Support / introduce websites and smartphone apps to enable drivers to access to public recharger maps that have accurate up to date data; this reduces negative informational conformity due to frustrated users who tell their friends, and helps with planning for future locations of recharger sites; • Support and promote field days to help expose car customers to the technology, this would need to be in tandem with recharge network deployment, otherwise field days would be wasted. EV owners are far less concerned about technology limitations than non-owners so there is a need to familiarise non-owners with capability of the technology; • Support Formula e racing and/or other events; to further highlight developments in the EV field, it is good for tourism and

	information dissemination; and • Provide cost calculators for total ownership costs; for example, re-label the *Green Vehicle Guide* website as a fuel cost-calculator and guide to cheaper motoring, to promote the money saving aspects of EV ownership, thus appealing to a wider audience than might be attracted to the 'green' aspects of EVs; ensure monthly fuel bill is displayed for every vehicle when sold; such measures would appeal to peoples' concerns about personal budgets, allowing direct comparison of EV's 'fuel' saving aspects.
Implement procurement strategies, encourage fleet purchasing to prioritise EVs over ICVs.	• Implement government EV procurement strategies; • Encourage fleet purchasing, and hence increase the availability of second-hand EVs due to rapid turnover; and • Facilitate workshops for businesses and government departments to determine good operating practices, for example, to produce in-car user instructions and troubleshooting manuals to maximise EV use and output and to enhance user experiences. This also increases positive feedback rather than negative – an important influence on diffusion of innovation.
Encourage car manufacturers and dealerships to prioritise EV sales.	• Introduce long term fleet emissions targets for vehicle manufacturers importing to Australia to encourage greater use of EVs to reduce overall emissions from cars; • Support importation of a greater variety of EV models to Australia at the cheaper end of the car market; and • Provide support, such as training and workshops for sales staff to be positive and reliable sources of EV information, thus increasing positive experiences for customers.

The six recommendations of Table 7.1 and associated actions, emphasise that growing EV sales will be a long-term process, as with the adoption of any technology. Synergistic implementation of these recommendations by Australian governments at the relevant tier could increase the appeal of EVs to various niches of the heterogeneous car market, leading to an increased uptake more quickly than introducing one recommendation at a time. As the research has revealed, due to numerous market failures, there are many hurdles to overcome to convince potential customers to become EV owners. Due to the different types of customers, as per Diffusion of Innovation theory, not all people are ready to adopt at the same time and some will accept greater risks while others will be laggards. Over time, the implementation of the recommendations will increase the proportion of people ready to adopt the technology and EV sales will grow, ultimately contributing to Australia's shift away from fossil fuelled transportation. Implementation of the recommendations in a timely fashion could speed the uptake of electric vehicles more quickly than otherwise.

7.4.1 Subsidising EV purchase price may not be essential in the near term

When formulating the recommendations for policy makers consideration was made of the changing operating environment for EVs. In particular, the price of batteries is decreasing and within a few years it is predicted the price of EVs will be equivalent to similar model ICVs. Subsidising car purchase was shown to be critical for 80% of EV buyers in Norway, the most successful country, which has been an essential measure when the price difference between EVs and ICVs was high. Therefore, as EV purchase prices become relatively lower, subsidising vehicle purchase price may not be the most cost effective use of tax payer dollars. Based on publicly available information (Appendix D) it appears that to date the Australian Federal government has shown little interest in taking action to encourage uptake of EVs. Such inaction combined with continuing relatively low petrol/diesel prices could mean consumers may not have received adequate price signals to consider making the transition.

Therefore, in the near term, as battery prices decrease and petrol prices increase, financial incentives to reduce EV purchase prices may become less important while cheaper operating costs of EVs become more important, and the availability of rechargers to provide a market co-condition will be essential. Previous research has shown it is three times more cost effective to have a network of rechargers (S. Li et al., 2015) than to subsidise car purchase, and a recharge network is essential whereas subsidies are only nice to have (Lieven, 2015). In America, recharger distribution is the most important factor encouraging uptake (Lutsey et al., 2015). This research confirms that access to rechargers away from home was the most concerning factor affecting respondents' willingness to buy an EV.

7.5 Concluding remarks

The field of electric vehicles is dynamic, changing rapidly throughout the period of my candidature, with technological improvements and more models being introduced periodically. Much research is being generated, including my own; strategies and practices from more successful countries have been examined. Norway, as the most successful country adopting EVs, could be considered to be among the most reliable sources of information about customer attitudes; much of their data is based on responses from thousands of EV owners willing to share their post-uptake experiences. This data from revealed choice surveys has enabled a robust comparison of EV owners with non-EV owners living in the same locations with the same background conditions. Norwegians drive only slightly further per day, on average, than Australians, and their travel habits, with many short local trips, are similar to Australians. Thus, actions by their government and other pro-active countries can provide useful lessons for other markets that have been less successful or for governments that have done little to encourage EV uptake in their community. To help formulate recommendations that could be adopted by Australian policy makers I have considered two sources of information: the opinions of Australians with little exposure to EVs and I have endeavoured to reflect on international best practice by considering actions that have engendered success, and actions that could be considered less effective than possible for the investment made.

Action to reduce greenhouse gas emissions should be confronted in all sectors as quickly as possible if we are collectively to have the best chance to slow climate change. Transitioning to electric vehicles for personal transportation is one way that individuals can make a substantial contribution to this global problem. Many international governments have shouldered their responsibilities and in Australia we too could transition towards EVs. Such a transition would be contemporaneous with improvements to the supply of public transport and increasing the proportion of renewable energy sources to generate electricity. Together these actions would reduce transport related carbon emissions and other negative externalities. Australians should be given more opportunities to take individual actions that would benefit the whole community as well as themselves.

7.5.1 Further research

This research has revealed several areas where further research could increase knowledge in the field of electric vehicles, generating actions that could accelerate the transition to EVs as they are increasingly adopted by Australian consumers in preference to ICVs. Research could focus on several main areas:

1. Government action including: mapping locations for an effective recharger network; investigating soft incentives that could encourage EV uptake at minimal cost; cost benefit analysis (CBA) for whole of government spending including health costs; and economic modelling to determine suitable higher tax component of petrol and diesel that could send price signals to ICV owners, to encourage uptake of EVs; and
2. Social research: exploring motivations for BEV compared to PHEV buyers; research into vested interest groups to increase deployment of EVs and rechargers, for example, developers of multi-tenanted buildings, managers of existing multi-tenanted building stock; and commercial attitudes to EVs for fleets.
3. Research investigating the impact of EVs on traffic behaviour, and exploring the impact of a country's political background on EV uptake in any particular market.

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Appendix A: Questionnaire 1 Project Information Statement and Questions

Content as distributed by Survey Monkey

UNSW AUSTRALIA

Welcome to My Survey

PROJECT INFORMATION STATEMENT

Date: October 2015

Project Title: Social Attitudes to Electric Vehicles

Approval No.: 155078

Participant selection and purpose of study

You are invited to participate in a study of social attitudes to electric vehicles. You were selected as a possible participant in this study because you have a drivers licence, are aged 18 or over and are a resident of Sydney or Melbourne.

Description of study

If you decide to participate, we will ask you to answer questions supplied in an online questionnaire which should take about 15 minutes. We cannot and do not guarantee or promise that you will receive any benefits from this study.

Confidentiality and disclosure of information

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission, or except as required by law. If you give us your permission, we plan to use the data obtained as part of research into the social attitudes of drivers in Sydney and Melbourne to electric vehicles. The results will form part of a research thesis for UNSW Australia and may form part of journal articles or conference data. Your individual responses will be in no way identifiable.

Recompense to participants

There will be no recompense to participants.

Your consent

Your decision whether or not to participate will not prejudice your future relations with

UNSW, Australia. Your approval to undertake the online questionnaire is tacit by its completion and as such you will not be required to sign any forms.

If you have any questions, please feel free to ask Gail Broadbent by sending an email to z7446284@student.unsw.edu.au . If you have any additional questions later, Professor Graciela Metternicht Phone: (02) 9385 7761 Email: g.metternicht@unsw.edu.au will be happy to answer them. Thank you for participating in our survey. Your contribution to our research is important.

Top of Form

Part A General Questions

Top of Form

* 1. What is your postcode?

* 2. What is your gender?

- Female
- Male

* 3. What is your age?

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 to 74
- 75 or older

Top of Form

* 4. What is your highest educational qualification?

- Higher School Certificate
- Diploma or Advanced Diploma
- Bachelor degree
- Graduate Certificate or Graduate Diploma
- Post-graduate Degree
- Other (please specify)

* 5. Which term regarding employment best describes you?

- Employed full-time
- Employed part-time
- Self employed
- Unemployed
- Retired/pension recipient
- Home duties
- Other (please specify)

Top of Form

* 6. Are you studying at a tertiary institution?

- Yes, full-time
- Yes, part-time
- No

* 7. Please select the option which best describes your residence.

- Separate house
- Semi-detached / terrace house (townhouse)
- Flat / unit / apartment
- Other (please specify)

* 8. Please select the option that best describes your home ownership status.

- Fully owned
- Being purchased (mortgaged)
- Rented
- I am still living at home with family members
- Other (please specify)

Top of Form

* 9. How many off-street parking spaces are available to your household at your place of residence?

- Zero
- One
- Two
- Three or more

Top of Form

* 10. If you have off-street parking, is it a designated parking spot as part of the ownership / leasing arrangement?

- Yes
- No
- No off-street parking

* 11. If you have off-street parking, is it possible to have a mains electricity socket installed within 3 metres of your car?

- Yes
- No
- Unsure
- No off-street parking

Part B car ownership and use

Top of Form

* 12. In your household how many cars are available for you to drive?

- One
- Two
- Three or more
- I use a car share scheme
- Other (please specify)

Please answer the following questions with respect to the car you drive most often; the 'we' can refer to another person who may technically own the car but for practical purposes you regard it as your car.

Top of Form

* 13. Of the following, which best describes your car ownership status?

- I / we own the car
- I / we lease the car
- I / we don't own / lease a car but intend to get a car within 5 years
- I / we don't own or lease a car and do NOT intend to get a car within 5 years

Top of Form

* 14. If you intend to purchase a car at some time in the future would it most likely be new or used?

- New
- Used
- I will not be buying a car in the future

* 15. For your next car purchase how much would you be willing to spend based on current car prices?

- Less than $20,000
- $20 k - $30 k
- $30 k - $40 k
- $40 k - $50 k
- $50 k - $60 k
- $60 k - $70 k
- More than $70,000
- I will not be buying a car in the future

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Top of Form

* 16. How would you describe the size of the car you drive most of the time?

- Small
- Medium
- Large

* 17. What type of car do you drive most often?

- Sedan
- Station wagon
- Hatch back
- SUV
- Ute
- Other (please specify)

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Top of Form

* 18. Which term below best describes the type of fuel used by the car you drive most often?

- Petrol
- Diesel
- Hybrid (uses petrol or diesel to charge an onboard battery eg Prius)
- Plug-in hybrid electric (eg Audi e-tron or Mitsubishi Outlander SUV)
- Fully electric (eg Tesla, Nissan Leaf)
- Other (please specify)

* 19. What is the most FREQUENT purpose for your trips?

- I drive to work / education institution
- I use my car for work/business purposes
- I do short journeys for personal things such as shopping, visiting, obtaining services
- Other (please specify)

Top of Form

* 20. How often would you drive more than a total of 100 km in a day?

Most days

Most weeks

Once or twice a month

On occasion at various times during the year

Never

21. If you do drive more than a total of 100 km in a day, what is the most common purpose of the trip/trips?

Part C Knowledge about cars

Top of Form

* 22. Where do you get MOST of your information about new car models coming onto the market?

Print media (newspapers, magazines)

Online articles

Word of mouth

Car manufacturers' websites

Television

Other (please specify)

Top of Form

* 23. On a scale of 1-5, my INTEREST in cars as a technology is best described as?

No interest	minor interest	somewhat interested	quite interested	Highly interested
No interest	minor interest	somewhat interested	quite interested	Highly interested

* 24. On a scale of 1 - 5 my KNOWLEDGE of how cars work can best be described as?

Very low				Highly knowledgeable
Very low				Highly knowledgeable

* 25. On a scale of 1-5 what would best describe how much you have seen in the MEDIA about electric cars?

Nothing				A lot
Nothing				A lot

Top of Form

* 26. When thinking about buying cars please rank how IMPORTANT each listed feature would be.

	Not Important	Not very important	Neutral	Quite important	Very important
Purchase price (including on road costs, taxes/subsidies and charges)	Purchase price (including on road costs, taxes/subsidies and charges) Not Important	Purchase price (including on road costs, taxes/subsidies and charges) Not very important	Purchase price (including on road costs, taxes/subsidies and charges) Neutral	Purchase price (including on road costs, taxes/subsidies and charges) Quite important	Purchase price (including on road costs, taxes/subsidies and charges) Very important
Fuel efficiency	Fuel efficiency Not Important	Fuel efficiency Not very important	Fuel efficiency Neutral	Fuel efficiency Quite important	Fuel efficiency Very important
Safety features (eg air bags, safety cameras)	Safety features (eg air bags, safety cameras) Not Important	Safety features (eg air bags, safety cameras) Not very important	Safety features (eg air bags, safety cameras) Neutral	Safety features (eg air bags, safety cameras) Quite important	Safety features (eg air bags, safety cameras) Very important
Number of seats	Number of seats Not Important	Number of seats Not very important	Number of seats Neutral	Number of seats Quite important	Number of seats Very importan

	Not Important	Not very important	Neutral	Quite important	Very importan t t
Storage capacity (eg boot size)	Storage capacity (eg boot size) Not Important	Storage capacity (eg boot size) Not very important	Storage capacity (eg boot size) Neutral	Storage capacity (eg boot size) Quite important	Storage capacity (eg boot size) Very importan t
Car aesthetics	Car aesthetics Not Important	Car aesthetics Not very important	Car aesthetics Neutral	Car aesthetics Quite important	Car aesthetics Very importan t
Driver / passenger comfort	Driver / passenger comfort Not Important	Driver / passenger comfort Not very important	Driver / passenger comfort Neutral	Driver / passenger comfort Quite important	Driver / passenger comfort Very importan t
Car performance (eg rate of acceleration)	Car performance (eg rate of acceleration) Not Important	Car performance (eg rate of acceleration) Not very important	Car performance (eg rate of acceleration) Neutral	Car performance (eg rate of acceleration) Quite important	Car performance (eg rate of acceleration) Very importan t
Fuel costs	Fuel costs Not Important	Fuel costs Not very important	Fuel costs Neutral	Fuel costs Quite important	Fuel costs Very importan t
Servicing costs	Servicing costs Not Important	Servicing costs Not very important	Servicing costs Neutral	Servicing costs Quite important	Servicing costs Very importan

	Not Important	Not very important	Neutral	Quite important	Very importan t t
Car brand	Car brand Not Important	Car brand Not very important	Car brand Neutral	Car brand Quite important	Car brand Very importan t
Country of car manufacture	Country of car manufacture Not Important	Country of car manufacture Not very important	Country of car manufacture Neutral	Country of car manufacture Quite important	Country of car manufacture Very importan t
Ownership costs (total combining purchase price / fuel costs/ maintenance costs)	Ownership costs (total combining purchase price / fuel costs/ maintenance costs) Not Important	Ownership costs (total combining purchase price / fuel costs/ maintenance costs) Not very important	Ownership costs (total combining purchase price / fuel costs/ maintenance costs) Neutral	Ownership costs (total combining purchase price / fuel costs/ maintenance costs) Quite important	Ownership costs (total combining purchase price / fuel costs/ maintenance costs) Very importan t
Greenhouse gas emissions per kilometre of travel	Greenhouse gas emissions per kilometre of travel Not Important	Greenhouse gas emissions per kilometre of travel Not very important	Greenhouse gas emissions per kilometre of travel Neutral	Greenhouse gas emissions per kilometre of travel Quite important	Greenhouse gas emissions per kilometre of travel Very importan t

Top of Form

* 27. Next time you buy a car what, if anything, would ENCOURAGE you to purchase an electric vehicle (only uses mains electricity as the energy source for the rechargeable battery)?

* 28. Next time you buy a car what, if anything, would ENCOURAGE you to purchase a plug-in hybrid electric car? (A plug-in hybrid uses mains electricity to recharge the car battery for the first 50 km of a trip then the car uses petrol/diesel to recharge the battery for up to 800 km until the next refuel)

Top of Form

A 50.0%

Please read the following information about electric cars then provide responses to the questions which follow.

Range:

- The range of most fully electric vehicles is about 120 – 160 km, and 80% of Australian drivers travel 50 km or less per day. Plug-in hybrid electric cars can travel about 50 km on battery alone and up to a further 800 km using petrol or diesel depending on the model.

Batteries:

- The batteries for modern electric vehicles are less damaging for the environment than lead batteries used in conventional cars, are classified as non-toxic, are recyclable and are typically guaranteed to last 5- 8 years or 100,000 – 150,000 km.

- The price of lithium batteries is continuing to drop due to economies of scale and technology improvements

Recharging:

- Fast chargers can recharge the battery of some electric cars to 80% capacity in about 20-30 minutes, with Level 2 rechargers it typically takes 4-6 hours. Electric cars can be "trickle charged" from any power point but this can take up to 12 hours.

- There is a modest network of publicly accessible rechargers in Sydney and Melbourne. In Europe and America most people recharge their electric vehicles at home overnight but tens of thousands of public recharging stations are available.

- In Sydney the NRMA offers "breakdown" mobile recharging for members' electric cars

Ref: http://www.mynrma.com.au/motoring-services/petrol-watch/charge-your-vehicle.htm

Cost and efficiency:

- Electric cars are about 70% cheaper to run than petrol or diesel cars and are much cheaper to maintain as there a far fewer moving parts.

- Total cost of ownership calculation: Although electric cars are more expensive to buy than comparable conventional cars, when comparing the total cost of ownership over 12 years and travelling 180,000 km for a Honda Jazz with a Mitsubishi iMiEV, the electric car is cheaper. (Ref: http://www.aeva.asn.au/content/you-might-well-i-miev)

Vehicle emissions:

- Electric cars have no tailpipe emissions, are better for air quality in cities, are much less noisy and are better for human health compared to conventional cars. They also have lower greenhouse gas emissions than conventional cars (magnitude of improvement depends on the electricity source). Diesel fuel is classified as a Class 1 carcinogen.

B 50.0%

This information applies to questions that follow.

A fully electric car (EV) uses only mains electricity to recharge its on board battery.
A plug in hybrid (PHEV) uses mains electricity to recharge a small on board battery to provide energy for the first 50 km of a trip then it uses petrol or diesel to provide energy for up to a further 800 km until the next refuel.

Top of Form

* 29. Imagine you are going to buy a new car in the next 5 years, on a scale of 1-5, HOW LIKELY are you to buy an electric car?

Not Likely	Not very likely	Neutral	Quite likely	Very Likely
○ Not Likely	○ Not very likely	○ Neutral	○ Quite likely	○ Very Likely

* 30. Imagine you are going to buy a new car in the next 5 years, on a scale of 1-5 HOW LIKELY are you to buy a plug-in hybrid car?

Not Likely	Not very likely	Neutral	Quite Likely	Very Likely
○ Not Likely	○ Not very likely	○ Neutral	○ Quite Likely	○ Very Likely

Top of Form

* 31. What are the TWO main reasons you would NOT choose to buy an electric vehicle or plug-in hybrid electric vehicle in the next 5 years?

Main reason: __________

Second reason: __________

* 32. If you bought an electric vehicle or plug-in hybrid which of the following options would be the MAIN place you would want to recharge the car?

○ Home

○ Work

Shopping centre

On the street near my home

Other (please specify)

* 33. Apart from the locations listed in the previous question list any OTHER places you would want to be able to recharge your car.

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Top of Form

* 34. Please indicate your OPINION about the following statements by selecting the most appropriate response in relation to the purchase of an electric car.

	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Electric vehicles are too expensive to buy compared to similar sized conventional vehicles (petrol/dies	Electric vehicles are too expensive to buy compared to similar sized conventional vehicles	Electric vehicles are too expensive to buy compared to similar sized conventional vehicles	Electric vehicles are too expensive to buy compared to similar sized conventional vehicles	Electric vehicles are too expensive to buy compared to similar sized conventional vehicles	Electric vehicles are too expensive to buy compared to similar sized conventional vehicles	Electric vehicles are too expensive to buy compared to similar sized conventional vehicles (petrol/diesel) Strongly agree

	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
el)	(petrol/diesel) Unsure	(petrol/diesel) Strongly disagree	(petrol/diesel) Disagree	(petrol/diesel) Neutral	(petrol/diesel) Agree	
A plug-in hybrid would suit my needs better than a fully electric car	A plug-in hybrid would suit my needs better than a fully electric car Unsure	A plug-in hybrid would suit my needs better than a fully electric car Strongly disagree	A plug-in hybrid would suit my needs better than a fully electric car Disagree	A plug-in hybrid would suit my needs better than a fully electric car Neutral	A plug-in hybrid would suit my needs better than a fully electric car Agree	A plug-in hybrid would suit my needs better than a fully electric car Strongly agree
Electric cars look too unconventional to me	Electric cars look too unconventional to me Unsure	Electric cars look too unconventional to me Strongly disagree	Electric cars look too unconventional to me Disagree	Electric cars look too unconventional to me Neutral	Electric cars look too unconventional to me Agree	Electric cars look too unconventional to me Strongly agree
The speed and acceleration of electric vehicles is adequate for my needs	The speed and acceleration of electric vehicles is adequate for my needs	The speed and acceleration of electric vehicles is adequate for my needs	The speed and acceleration of electric vehicles is adequate for my needs	The speed and acceleration of electric vehicles is adequate for my needs	The speed and acceleration of electric vehicles is adequate for my needs	The speed and acceleration of electric vehicles is adequate for my needs Strongly agree

	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	Unsure	Strongly disagree	Disagree	Neutral	Agree	
I am probably going to move house in the next couple of years	I am probably going to move house in the next couple of years Unsure	I am probably going to move house in the next couple of years Strongly disagree	I am probably going to move house in the next couple of years Disagree	I am probably going to move house in the next couple of years Neutral	I am probably going to move house in the next couple of years Agree	I am probably going to move house in the next couple of years Strongly agree
It would cost me too much to install a recharger at home	It would cost me too much to install a recharger at home Unsure	It would cost me too much to install a recharger at home Strongly disagree	It would cost me too much to install a recharger at home Disagree	It would cost me too much to install a recharger at home Neutral	It would cost me too much to install a recharger at home Agree	It would cost me too much to install a recharger at home Strongly agree
The total cost of ownership of an electric vehicle is too high on a per	The total cost of ownership of an electric vehicle is	The total cost of ownership of an electric vehicle is	The total cost of ownership of an electric vehicle is	The total cost of ownership of an electric vehicle is	The total cost of ownership of an electric vehicle is	The total cost of ownership of an electric vehicle is too high on a per kilometre basis compared to

	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
kilometre basis compared to conventional cars	too high on a per kilometre basis compared to conventional cars Unsure	too high on a per kilometre basis compared to conventional cars Strongly disagree	too high on a per kilometre basis compared to conventional cars Disagree	too high on a per kilometre basis compared to conventional cars Neutral	too high on a per kilometre basis compared to conventional cars Agree	conventional cars Strongly agree
The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs	The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs Unsure	The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs Strongly disagree	The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs Disagree	The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs Neutral	The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs Agree	The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs Strongly agree
I am concerned that I would find it difficult to locate	I am concerned that I would find it difficult to locate	I am concerned that I would find it difficult to locate	I am concerned that I would find it difficult to locate	I am concerned that I would find it difficult to locate	I am concerned that I would find it difficult to locate	I am concerned that I would find it difficult to locate public recharge stations Strongly

	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
public recharge stations	public recharge stations Unsure	public recharge stations Strongly disagree	public recharge stations Disagree	public recharge stations Neutral	public recharge stations Agree	agree
I am concerned that when I am driving a long distance there are no recharge stations on the way	I am concerned that when I am driving a long distance there are no recharge stations on the way Unsure	I am concerned that when I am driving a long distance there are no recharge stations on the way Strongly disagree	I am concerned that when I am driving a long distance there are no recharge stations on the way Disagree	I am concerned that when I am driving a long distance there are no recharge stations on the way Neutral	I am concerned that when I am driving a long distance there are no recharge stations on the way Agree	I am concerned that when I am driving a long distance there are no recharge stations on the way Strongly agree
An electric car would take too long to recharge when I am away from home	An electric car would take too long to recharge when I am away from home Unsure	An electric car would take too long to recharge when I am away from home Strongly disagree	An electric car would take too long to recharge when I am away from home Disagree	An electric car would take too long to recharge when I am away from home Neutral	An electric car would take too long to recharge when I am away from home Agree	An electric car would take too long to recharge when I am away from home Strongly agree

	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The lithium batteries of electric cars are very polluting compared to lead batteries	The lithium batteries of electric cars are very polluting compared to lead batteries Unsure	The lithium batteries of electric cars are very polluting compared to lead batteries Strongly disagree	The lithium batteries of electric cars are very polluting compared to lead batteries Disagree	The lithium batteries of electric cars are very polluting compared to lead batteries Neutral	The lithium batteries of electric cars are very polluting compared to lead batteries Agree	The lithium batteries of electric cars are very polluting compared to lead batteries Strongl y agree

Top of Form

* 35. Please indicate your OPINION about this statement: “Electric cars are worth government investment”.

- Agree
- Disagree
- Unsure

* 36. Please briefly explain your response to the previous question

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Top of Form

* 37. Imagine the government took actions to encourage ownership of electric cars, how important would each of the following factors be to motivate you to buy an electric car?

	Not Important	Somewhat important	Important	Very Important	Extremely Important
A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car	A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car	A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car	A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car	A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car	A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car

	Not Important	Somewhat important	Important	Very Important	Extremely Important
Subsidy to reduce battery replacement cost	Subsidy to reduce battery replacement cost	Subsidy to reduce battery replacement cost	Subsidy to reduce battery replacement cost	Subsidy to reduce battery replacement cost	Subsidy to reduce battery replacement cost

	Not Important	Somewhat important	Important	Very Important	Extremely Important
Free parking	Free parking	Free parking	Free parking	Free parking	Free parking

	Not Important	Somewhat important	Important	Very Important	Extremely Important
	Not Important	Somewhat important	Important	Very Important	Extremely Important
No annual registration cost	No annual registration cost Not Important	No annual registration cost Somewhat important	No annual registration cost Important	No annual registration cost Very Important	No annual registration cost Extremely Important
Free recharger for you to install at home	Free recharger for you to install at home Not Important	Free recharger for you to install at home Somewhat important	Free recharger for you to install at home Important	Free recharger for you to install at home Very Important	Free recharger for you to install at home Extremely Important
Public recharge stations available in every town and on highways	Public recharge stations available in every town and on highways Not Important	Public recharge stations available in every town and on highways Somewhat important	Public recharge stations available in every town and on highways Important	Public recharge stations available in every town and on highways Very Important	Public recharge stations available in every town and on highways Extremely Important
Access to transit lanes no matter how many passengers in the car	Access to transit lanes no matter how many passengers in	Access to transit lanes no matter how many passengers in	Access to transit lanes no matter how many passengers in	Access to transit lanes no matter how many passengers in	Access to transit lanes no matter how many passengers in

	Not Important	Somewhat important	Important	Very Important	Extremely Important
	the car Not Important	the car Somewhat important	the car Important	the car Very Important	the car Extremely Important
Higher taxes on petrol/diesel that results in more expensive fuel	Higher taxes on petrol/diesel that results in more expensive fuel Not Important	Higher taxes on petrol/diesel that results in more expensive fuel Somewhat important	Higher taxes on petrol/diesel that results in more expensive fuel Important	Higher taxes on petrol/diesel that results in more expensive fuel Very Important	Higher taxes on petrol/diesel that results in more expensive fuel Extremely Important
A tax deduction available at the end of the financial year in year of electric car purchase	A tax deduction available at the end of the financial year in year of electric car purchase Not Important	A tax deduction available at the end of the financial year in year of electric car purchase Somewhat important	A tax deduction available at the end of the financial year in year of electric car purchase Important	A tax deduction available at the end of the financial year in year of electric car purchase Very Important	A tax deduction available at the end of the financial year in year of electric car purchase Extremely Important
Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a similar sized petrol	Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a	Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a	Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a	Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a	Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a

	Not Important	Somewhat important	Important	Very Important	Extremely Important
/diesel car for 10 years	similar sized petrol /diesel car for 10 years Not Important	similar sized petrol /diesel car for 10 years Somewhat important	similar sized petrol /diesel car for 10 years Important	similar sized petrol /diesel car for 10 years Very Important	similar sized petrol /diesel car for 10 years Extremely Important
A recharger is installed in my block of flats for residents use	A recharger is installed in my block of flats for residents use Not Important	A recharger is installed in my block of flats for residents use Somewhat important	A recharger is installed in my block of flats for residents use Important	A recharger is installed in my block of flats for residents use Very Important	A recharger is installed in my block of flats for residents use Extremely Important
A recharge station is available to me at my workplace	A recharge station is available to me at my workplace Not Important	A recharge station is available to me at my workplace Somewhat important	A recharge station is available to me at my workplace Important	A recharge station is available to me at my workplace Very Important	A recharge station is available to me at my workplace Extremely Important
A recharge station is located in my residential street with exclusive parking for electric vehicles only	A recharge station is located in my residential street with exclusive parking for	A recharge station is located in my residential street with exclusive parking for	A recharge station is located in my residential street with exclusive parking for	A recharge station is located in my residential street with exclusive parking for	A recharge station is located in my residential street with exclusive parking for

	Not Important	Somewhat important	Important	Very Important	Extremely Important
	electric vehicles only Not Important	electric vehicles only Somewhat important	electric vehicles only Important	electric vehicles only Very Important	electric vehicles only Extremely Important
Reduction in company car tax for electric vehicles	Reduction in company car tax for electric vehicles Not Important	Reduction in company car tax for electric vehicles Somewhat important	Reduction in company car tax for electric vehicles Important	Reduction in company car tax for electric vehicles Very Important	Reduction in company car tax for electric vehicles Extremely Important

Top of Form

38. How did you find out about this survey?

- Email
- Facebook
- Word of mouth
- Other (please specify)

39. This question is optional. If a federal election were to be held next week for whom would you most likely vote in the lower house (ie House of Representatives)?

- Liberal National Coalition
- Labor
- Greens
- Other (please specify)

40. This question is optional. If a federal election were to be held next week for whom would you most likely vote in the upper house (ie The Senate)?

- Liberal National Coalition
- Labor
- Greens
- Other (please specify)

Top of Form

41. There will be a follow up survey in 2016, if you would like to be contacted about the follow up, please provide your first name and email address. Your contact details will not be used for any other purpose or passed to any third party and your survey responses will remain anonymous. THANK YOU for your participation in this survey. Please don't forget to forward the email request to your friends, family and colleagues.

Appendix B: Questionnaire 2 Project Information Statement and Questions

Content as distributed by Survey Monkey

More about attitudes to Electric Cars

Welcome to My Survey

PROJECT INFORMATION STATEMENT

Date: August 2016

Project Title: Social Attitudes to Electric Vehicles

Approval No.: 155078

Participant selection and purpose of study

You are invited to participate in a study of social attitudes to electric vehicles. You were selected as a possible participant in this study because you have a drivers licence, are aged 18 or over and participated in a previous UNSW survey about social attitudes to electric vehicles.

Description of study

If you decide to participate, we will ask you to answer questions supplied in an online questionnaire which should take about 7-10 minutes. We cannot and do not guarantee or promise that you will receive any benefits from this study.

Confidentiality and disclosure of information

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission, or except as required by law. If you give us your permission, we plan to use the data obtained as part of research into the social attitudes of Australian drivers to electric vehicles. The results will form part of a research thesis for UNSW Australia and may form part of journal articles or conference data. Your individual responses will be in no way identifiable.

Recompense to participants

There will be no recompense to participants.

Your consent

Your decision whether or not to participate will not prejudice your future relations with UNSW, Australia. Your approval to undertake the online questionnaire is tacit by its completion and as such you will not be required to sign any forms.

If you have any questions, please feel free to ask Gail Broadbent by sending an email to z7446284@student.unsw.edu.au . If you have any additional questions later, Professor Graciela Metternicht Phone: (02) 9385 5761 Email: g.metternicht@unsw.edu.au will be happy to answer them. Thank you for participating in our survey. Your contribution to our research is important.

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More about attitudes to Electric Cars

Section A

The information below may assist you in answering this questionnaire.

When compared to conventional petrol/diesel cars, electric cars have: the same safety features; lower carbon emissions when driven (magnitude of improvement depends on electricity source); are better for air quality in cities and for human health; are much less noisy; and EV batteries can be safely recycled. Diesel fuel is classified as a Class 1 carcinogen.

For the purposes of this questionnaire, electric vehicles (EVs) include:

1. Battery Electric Vehicles (BEV) rely on an on-board rechargeable, storage battery using mains electricity as the only power source. Range is typically 150km but can be up to 400km depending on the model. Examples are: Tesla, Nissan Leaf.

2. Plug-in Hybrid Electric Vehicles (PHEV), have both an on-board battery, (recharged from mains electricity), and a petrol or diesel energy system (that generates additional power

and/or range as required - includes range extended EVs). Typically PHEVs can drive 50km on electric and up to 600km on petrol/diesel.) Examples are: Mitsubishi Outlander, BMW i3 and Audi A3 e-tron

On charging rates: Electric vehicles can be recharged at four possible rates (depending on the model).

1. All EVs can trickle charge (up to 12 hours) from any standard household mains power point;

2. All EVs can be recharged on a specially installed 15 amp power point (4-6 hours);

3. Many models can be fast charged in 2 hours; and

4. A limited number of models can be super charged in 30 minutes (also called rapid charge).

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More about attitudes to Electric Cars

* 1. Gender

Female

Male

Other

* 2. Number of cars currently owned/leased

0

1

2 or more

* 3. Please choose the response that best describes the car you drive most often.

I /we purchased it NEW

I /we purchased it USED

I borrow a car or use a car share scheme/rental service as required

Other (please specify)

* 4. If you were to purchase an electric car could you install a power point in your own off-street parking spot to enable recharging?

Yes

No, it would be impossible to have a power point installed in my off-street parking spot

○ No, I don't have off-street parking

○ Unsure

○ Other (please specify)

[ ]

* 5. Since your completion of the previous UNSW 2015 survey on electric vehicles, please indicate if your level of interest in EVs has changed?

1. Not at all interested	2. Less interested	3. About the same	4. More interested	5. Much more interested
1. Not at all interested	2. Less interested	3. About the same	4. More interested	5. Much more interested

* 6. Imagine you are considering buying a car, how significant are the following sources of information about particular car models you might consider buying?

	1. Least significant	2. Low significance	3. Moderate significance	4. Quite significant	5. Most significant
Prior knowledge about particular car models	Prior knowledge about particular car models 1. Least significant	Prior knowledge about particular car models 2. Low significance	Prior knowledge about particular car models 3. Moderate significance	Prior knowledge about particular car models 4. Quite significant	Prior knowledge about particular car models 5. Most significant
Family and friends	Family and friends 1. Least significant	Family and friends 2. Low significance	Family and friends 3. Moderate significance	Family and friends 4. Quite significant	Family and friends 5. Most significant
Car sales person	Car sales person 1. Least significant	Car sales person 2. Low significance	Car sales person 3. Moderate significance	Car sales person 4. Quite significant	Car sales person 5. Most significant
Formal information sources	Formal information	Formal information	Formal information	Formal information	Formal information

	1. Least significant	2. Low significance	3. Moderate significance	4. Quite significant	5. Most significant
(e.g.magazine articles, car brand websites, articles written by motoring journalists, TV shows)	sources (e.g.magazine articles, car brand websites, articles written by motoring journalists, TV shows) 1. Least significant	sources (e.g.magazine articles, car brand websites, articles written by motoring journalists, TV shows) 2. Low significance	sources (e.g.magazine articles, car brand websites, articles written by motoring journalists, TV shows) 3. Moderate significance	sources (e.g.magazine articles, car brand websites, articles written by motoring journalists, TV shows) 4. Quite significant	sources (e.g.magazine articles, car brand websites, articles written by motoring journalists, TV shows) 5. Most significant
Advertisements about specific car models	Advertisements about specific car models 1. Least significant	Advertisements about specific car models 2. Low significance	Advertisements about specific car models 3. Moderate significance	Advertisements about specific car models 4. Quite significant	Advertisements about specific car models 5. Most significant
Test drive	Test drive 1. Least significant	Test drive 2. Low significance	Test drive 3. Moderate significance	Test drive 4. Quite significant	Test drive 5. Most significant

* 7. Have you ever consulted the Australian Government's *Green Vehicle Guide* website?

Yes

No

- Unsure
- I didn't know one existed

* 8. Do you know anyone who owns an EV (either fully electric or PHEV)

- Yes
- No
- Unsure

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More about attitudes to Electric Cars

Section B

Questions relating to EVs

The cost of batteries for electric vehicles is the biggest factor in the higher overall cost of EVs compared to conventional cars. A recent study in the journal *Nature* predicts that because the price of batteries is falling, EVs will achieve price parity with similar conventional cars by 2020-21 (http://www.nature.com/doifinder/10.1038/nclimate2564).

For the purposes of this questionnaire you should assume that price parity has already occurred (i.e. EVs cost the same as similar model conventional vehicles).

* 9. Assuming purchase price of EVs is the same as similar conventional cars, please select a response to the following questions.

	1. Least likely	2. Not very likely	3. Neither likely nor unlikely	4. Somewhat likely	5. Most likely
How likely are you to buy a fully electric car (BEV)?	How likely are you to buy a fully electric car (BEV)?	How likely are you to buy a fully electric car (BEV)?	How likely are you to buy a fully electric car (BEV)?	How likely are you to buy a fully electric car (BEV)?	How likely are you to buy a fully electric car (BEV)?

	1. Least likely	2. Not very likely	3. Neither likely nor unlikely	4. Somewhat likely	5. Most likely
How likely are you to buy a PHEV (plug in hybrid)?	How likely are you to buy a PHEV (plug in hybrid)?	How likely are you to buy a PHEV (plug in hybrid)?	How likely are you to buy a PHEV (plug in hybrid)?	How likely are you to buy a PHEV (plug in hybrid)?	How likely are you to buy a PHEV (plug in hybrid)?

	1. Least likely	2. Not very likely	3. Neither likely nor unlikely	4. Somewhat likely	5. Most likely

* 10. Apart from price, what is the main factor that would impact on your decision to buy a fully electric vehicle?

* 11. Apart from price, briefly list any other factors that might impact on your decision whether to buy a fully electric vehicle.

* 12. Apart from price, what is the main factor that would impact on your decision to buy a Plug-in Hybrid Electric Vehicle (PHEV)?

13. Apart from price, briefly list any other factors that might impact on your decision whether to buy a PHEV.

* 14. The governments of countries with the highest uptake of EVs have implemented programs to incentivise EV purchase. Assuming purchase price of EVs is equivalent to similar conventional cars, from the following list of statements please rank, in order of importance, which would have the most influence on your purchasing decision.

For this question Survey Monkey will only allow you to select three options, please put the most important as 1.

	1. Most important	2. Second in importance	3. Third in importance
Programs enabling free	Programs	Programs	Programs

	1. Most important	2. Second in importance	3. Third in importance
access to high occupancy vehicle transit lanes for EVs regardless of passenger numbers	enabling free access to high occupancy vehicle transit lanes for EVs regardless of passenger numbers 1. Most important	enabling free access to high occupancy vehicle transit lanes for EVs regardless of passenger numbers 2. Second in importance	enabling free access to high occupancy vehicle transit lanes for EVs regardless of passenger numbers 3. Third in importance
Exclusive parking for EVs in public spaces	Exclusive parking for EVs in public spaces 1. Most important	Exclusive parking for EVs in public spaces 2. Second in importance	Exclusive parking for EVs in public spaces 3. Third in importance
Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs	Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs 1. Most important	Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs 2. Second in importance	Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs 3. Third in importance
Government support for the roll out of a fast recharger network every	Government support for the roll out of a fast recharger network	Government support for the roll out of a fast recharger network	Government support for the roll out of a fast recharger network

	1. Most important	2. Second in importance	3. Third in importance
50 km on highways and in country towns	every 50 km on highways and in country towns 1. Most important	every 50 km on highways and in country towns 2. Second in importance	every 50 km on highways and in country towns 3. Third in importance
Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of privately owned recharger networks	Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of privately owned recharger networks 1. Most important	Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of privately owned recharger networks 2. Second in importance	Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of privately owned recharger networks 3. Third in importance
Programs that buy EVs for government use (procurement) that, (every 3-5 years), will increase the size of the second-hand EV market	Programs that buy EVs for government use (procurement) that, (every 3-5 years), will increase the size of the second-hand EV market 1. Most important	Programs that buy EVs for government use (procurement) that, (every 3-5 years), will increase the size of the second-hand EV market 2. Second in importance	Programs that buy EVs for government use (procurement) that, (every 3-5 years), will increase the size of the second-hand EV market 3. Third in importance
Government support to	Government	Government	Government

	1. Most important	2. Second in importance	3. Third in importance
install rechargers at hotels, motels and other tourist destinations	support to install rechargers at hotels, motels and other tourist destinations 1. Most important	support to install rechargers at hotels, motels and other tourist destinations 2. Second in importance	support to install rechargers at hotels, motels and other tourist destinations 3. Third in importance
Government support to install rechargers at shopping centre car parks and other local destinations	Government support to install rechargers at shopping centre car parks and other local destinations 1. Most important	Government support to install rechargers at shopping centre car parks and other local destinations 2. Second in importance	Government support to install rechargers at shopping centre car parks and other local destinations 3. Third in importance
Where there is no off-street parking, government support to install rechargers on the street in front of private residences, on request of EV owners, with parking exclusively for	Where there is no off-street parking, government support to install rechargers on the street in front of private residences, on request of EV owners, with parking exclusively for EVs 1. Most important	Where there is no off-street parking, government support to install rechargers on the street in front of private residences, on request of EV owners, with parking exclusively for EVs 2. Second in importance	Where there is no off-street parking, government support to install rechargers on the street in front of private residences, on request of EV owners, with parking exclusively for EVs 3. Third in importance

	1. Most important	2. Second in importance	3. Third in importance
EVs			
Government support to install rechargers at workplace carparks	Government support to install rechargers at workplace carparks 1. Most important	Government support to install rechargers at workplace carparks 2. Second in importance	Government support to install rechargers at workplace carparks 3. Third in importance
No annual registration fees for EVs	No annual registration fees for EVs 1. Most important	No annual registration fees for EVs 2. Second in importance	No annual registration fees for EVs 3. Third in importance
Free parking in public places for EVs	Free parking in public places for EVs 1. Most important	Free parking in public places for EVs 2. Second in importance	Free parking in public places for EVs 3. Third in importance
Other	Other 1. Most important	Other 2. Second in importance	Other 3. Third in importance

15. Optional: Please briefly outline any other point, other than price, which you think might be helpful to understand factors that impact on purchasing an EV.
For Example: Car customers would buy EVs if….. OR I would not buy an EV because…..

Appendix C: Methodology details

C.1 Methodology:

Detailed justification of research; characteristics of the respondents; and comparison of sample to the Australian population

Table C.1 Design of the Questionnaires

Aspect	Details
Units of analysis	Individual Australian car drivers aged 18 or over
Self-reporting	To establish descriptive relationships among the variables, attitudes, beliefs /opinions but not cause-effect relationships
Cross sectional	• Questionnaire 1: Limited time-frame (one month) to help reduce bias by ensuring all respondents subjected to same outside influences e.g. current government policy and world events that could impact on decision making (Hall, 2008). • Questionnaire 2: Limited time-frame (3 weeks). No new government announcements regarding introduction of policies to encourage buyers of EVs, and no change of government in the 11 months since previous survey, thus external conditions relating to EVs were similar.
Data collection procedure	• Convenience sampling (p 72 Iain Hay): recruitment was non - random due to time and cost considerations. Respondents sourced via email and Facebook invitation to participate in online questionnaire hosted by Survey Monkey. To widen reach, request for participants to inform/share with others included. • Email lists included: Sustainability Educators, School of Biological Earth and Environmental Sciences at UNSW including MEM students, members of the Institute of Australian Geographers and employees of The Greens, Australian Conservation Foundation and WWF, as well as friends, family and colleagues. Also to a school newsletter to 3000 parents/staff, 2 Facebook groups in the inner west of Sydney – with more than 10,000 members, and to an EV forum and via Twitter. • A reminder email was sent to primary contacts after 1 week.
Types of	• Closed questions: easier for respondents to answer and easier to analyse

questions	but gave limited simplistic answers which may not cover the depth of a respondent's opinions • Open questions: permitted flexibility for answers, enabled responses not anticipated by researcher, increased difficulty in analysis, coding required. • Rating scale questions: partly numerical with itemised ratings (ordinal) assumed that intervals between the scale values were equal, so weighted averages could be calculated. • Single items on 5 part Likert scale: captured intensity of responses from strongly disagree to strongly agree • Multiple item scales covers more aspects of the construct being measured. Limitation: increases time spent on survey increasing risk of incomplete responses.
Justification	• Online questionnaires: cheap and quick to administer; reduced potential bias that may result from interaction between an interviewer and respondent; results for the quantitative questions easy to compute (Hall, 2008). While the qualitative open ended questions were more time consuming to analyse they allowed for unexpected responses and more nuanced opinions (Hall, 2008). • Respondents restricted to car drivers 18 years of age or over for ethical reasons, and, as they are experienced in driving, are potential car buyers. • Due to anonymity, online respondents are more likely to yield honest responses as it lacks peer pressure or bias of interviewer/ respondent interrelationship. This provided a value free setting for the respondent. • Pilot tested enabled assessment of: suitability of questions; question wording to determine if any ambiguity; whether range of questions was appropriate; whether range of closed question responses was adequate or if alternatives needed. Questions modified based on responses.
Sources of survey error	• Coverage errors: not a random sample of the whole population so results cannot be extrapolated to entire population of Australian drivers • Restricted to those with access to emails and internet: a source of error in data collection; however in early stages EVs are more expensive than ICVs, thus those without access to emails are unlikely to purchase an EV in the next five years. Gardener *et al.* (2011) found financially more secure people

	are more likely to purchase an EV than those in lower socio-economic groups • Self-administered questionnaire: no interviewer bias • Instrument errors: risk that questions were ambiguous was reduced by using a pilot group to test and refine questions. • mode error: only one mode was used, all were online, none by telephone or in person, therefore improved capacity to control the sequence of questions, less vulnerable to interviewer bias
Limitations	• Limited to self- report data so cannot check on the validity of the responses, however as participation was voluntary, likelihood respondents gave deliberately false information was low. • Limited ability to capture full richness of meaning in people's decision making processes especially when responses were brief and/or incomplete sentences were given. • Sampling bias: due to the targeted nature of the sampling regime respondents may not be representative of the entire population due to differences in education, political affiliation and environmental awareness. Many respondents could be considered more likely to act on climate change than a random selection of the Australian population. Gardner *et al*. (2011) found that purchasers willing to buy EVs were more likely to take action on climate change and tended to be better educated than those not predisposed to buy EVs • Convenience sampling: regarded as the least dependable method as it can yield information poor results. However it was useful as the aim of this research was to understand social attitudes to EVs, particularly of those with a pre disposition to act sustainably, and to gain insights into the attitude –action gap whereby even those pre-disposed to act sustainably don't carry out the action. • Limitation of survey: almost all survey participants did not own an EV therefore most respondents reported willingness to act rather than actual behaviour. However, respondents were asked how likely they were to buy an EV following a series of questions relevant to circumstances that could impact on purchase decision. These questions would help frame the respondent's thinking when asked the question about likelihood to buy an

	EV. (Environmental behaviour is less dominant in decision making, people pursue selfish goals and make decisions to maximise utility - reference)
Response rates	Shaped partially by research topic itself and potential interest of the respondent in the topic as much as by mode of distribution or survey method used ((Hay, 2005)
Validity	• High External validity: can deal in hypotheticals and wider range of subject matter than experimental research. • Internal validity: lower than purely experimental research, only one variable was controlled – information or not. • Two questionnaires held 11 months apart provided validity checks on conclusions • Use of two questionnaires gives the researcher a greater degree of flexibility in addressing the research questions which is advantageous in that it allows complex problems to be investigated. (Hall p 123)
Reliability	The second questionnaire was administered to a subset of respondents of the first survey. It aimed to understand in more depth important issues revealed by first survey; to validate understandings gained from first survey; to determine if there was consistency in responses from first survey; to determine stability ie if the answers provided in the first survey can be relied on (Bryman p 169).
Equivalence	Using two questionnaires assisted in understanding if the measures yielded results similar to alternative measures of the same variable. In Questionnaire 1 impact of barriers to EV purchase were measured on Likert scales and then asked about in open ended questions towards the end of the questionnaire. Questions on similar issues were asked again in second survey.

Table C.2 Sample attributes of 330 people surveyed in Questionnaire 1

Variable	Profile	Survey Percentage	Australian population percentage	
Gender	Female: 166/330	50.3	50.5	
	Male: 164/330	49.7	49.5	
Age	0-17 = 0/330	**0**	0 -19 = 25%	**if this = 0**
	18-24: 20/330	**6**	20-24 = 7%	7/75 = **9.3%**
	25-34: 61/330	**18.5**	25-34= 14.8%	14.8/75=**19.7**
	35-44:64/330	**19.4**	35-44= 13.6%	13.6/75=**18.1**
	45-54: 72/330	**21.8**	45-54=13.1%	13.1/75=**17.5**
	55-64: 68/330	**20.6**	55-64=11.5%	11.5/75=**15.3**
	65-74: 33/330	**10**	65-74=8.5%	8.5/75=**11.3**
	75 or older: 12/330	**3.6**	75+ = 6.6%	6.6/75=**8.8%**
Education	No formal qualification: 3/330	0.9 }5.1	}39.3%	
	Higher School Certificate: 14/330	4.2 }	}	
	Diploma /Advanced diploma: 31/330	8.8	31.9%	
	Bachelor degree: 101/330	30.6	16.9%	
	Graduate certificate/diploma 40/330	12	4.2%	
	Post-graduate degree including PhD 141/330	42.7	6.6%	
Employment status	Full time: 147/330	44.5	51.2	
	Part time/casual: 78/330	23.6	22.3	
	Self – employed: 38/330	11.5	Included in	

	Total in formal employment Not employed: 6/330 Student and no paid employment: 10/330 Retired/pension recipient: 46/330 Home duties 5/330	*79.6* 1.8 3 13.9 1.5 Total not in workforce = 18.4%	FT or PT *73.5* 4.4 Total not in workforce = 22.1%
Study status	Full time tertiary studies 35/330 Part time tertiary studies: 27/330 None: 268/330	10.6 8.25 81.2	Total tertiary full time equivalent 4.4% of all Australians
Type of residence	Separate house: 176/330 Semi-detached /terrace house (townhouse): 53/330 Flat/unit/apartment Other: 0/330	53.3 16.1 30.6 0	78.8 % (61% in Sydney) 10.5% 10.7%
Home ownership status	Fully owned 118/330 Being purchased (mortgaged) 107/330 Rented 87/330 Still at home with family members:18/330	35.8 32.4 26.4 5.5 0	32.6% 37.1% 30.3%

	Other 0/330		
Off street parking spaces available	Zero 57/330	17.9	
	One 105/330	31.8	
	Two 92/330	27.9	
	Three or more 74/330	22.4	
Designated parking	Yes 192/330	58.2	
	No 76/330	23	
	No off- street parking 62/330	18.8	
Mains electricity at parking space	Yes 206/330	62.4	
	No 25/330	7.6	
	Unsure 38/330	11.5	
	No off-street parking 61/330	18.5	
Number cars available to drive	Zero: 11/330	3.3	
	One: 156/330	47.3	
	Two: 119/330	36.1	
	Three or more: 28/330	8.5	
	I use a car share scheme: 16/330	4.9	
Car ownership status	I/we *own* the car 282/330	85.5	
	I/we *lease* the car 18/330	5.5	
	No car ownership:	9.1	8.4
	• I/we don't own/lease a car but intend to get a car within 5 years 18/330	5.5	
	• I/we don't own/lease a car and do NOT intend to get a car within 5 years 12/330	3.6	
Next Car purchase	New at purchase 140/330	42.4	

condition	Used at purchase 154/330 No intention to buy 36/330	46.7 10.9	
Value of next car purchase	Less than $20,000: 109/330 $20k – $30k: 79/330 $30k - $40k: 47/330 $40k - $50k: 39/330 $50k - $60k: 11/330 $60k - $70k: 5/330 More than $70,000: 14/330	33 23.9 14.2 11.8 3.3 1.5 4.3	
Size of car driven	Small 123/330 Medium 164/330 Large 43/330	37.3 49.7 13	
Type of car driven	Sedan 84/330 Station wagon/hatchback 172/330 SUV 59/33 Ute /van (limited seating) 13/330 Zero cars 2/330	25.5 52.1 17.9 3.9 0.6	
Respondent's car fuel type	Petrol 261/330 Diesel 49/330 Fuel hybrid 9/330 Plug-in Hybrid 6/330 Fully electric 1/330 Other: 4/330 zero cars = 2/330 dual fuel system = 2/330	79.1 14.9 2.7 1.8 0.3 1.2	Australian passenger vehicles: 80.6% fuel consumed is petrol
Most	Commuting 67/330	20.3	

frequent purpose of trips	Employment related 40/330 Short personal trips 198/330 Long journeys 16/330 Other 5/330	12.2 60 4.8 1.5
Frequency of total travel > 100km /day	Most days 6/330 Most weeks 46/330 Once or twice a month 90/330 Occasionally during the year 164/330 Never 24/330	1.8 13.9 27.3 49.8 7.3
Most common purpose of travel >100km /day	(open response) NB 198 people chose to answer this question; each providing up to 3 responses each, and one person answered N/A. 132 people skipped this question. Business 45/198 = Visiting Friends/Relatives (VFR) 64/198 = Holidays/leisure 125/198 = (Totals > 100% as many respondents included more than one category in their answer)	22.7% 32.3% 63%
Most frequent Source of information about cars	Print media (newspapers/mags) 68/330 Online articles 136/330 Word of mouth 54/330 Car manufacturers' websites18/330 Television/radio 42/330	20.6% 41.2% 16.4% 5.5% 12.7% 3.6%

	Other (including all of the above, not interested) 12/330	
On 1-5 scale Interest in cars as technology	No interest 41/330	12.4%
	Minor interest 84/330	25.5%
	Somewhat interested 86/330	26.1%
	Quite interested 74/330	22.4%
	Highly interested 45/330	13.65
		Weighted av = 3/5
On 1-5 scale Knowledge about how cars work	Very low 60/330	18.2%
	Low 78/330	23.6%
	Medium 89/330	27%
	Moderately high 66/330	20%
	Highly knowledgeable 37/330	11.2%
		WAR= 2.8/5
On 1-5 scale How much seen in the media about EVs	Nothing 22/330	6.7%
	Not much 112/330	33.9%
	Moderate 114/330	34.6%
	Quite a bit 51/330	15.5%
	A lot 31/330	3.4%
		WAR= 2.9/5
Voting intention Federal election: Lower House	Liberal/National Coalition 80/276	29%
	Labor 50/276	18.1%
	Greens 119/276	43.1%
	Other 27/276	8.8%
Voting intention	Liberal/National Coalition 60/276	22%

Federal election: Upper House (Senate)	Labor 37/276 Greens 152/276 Other 24/276	13.6% 55.7% 9.8%

C.2 Questionnaire respondents compared to Australian population

The sample of Australians used in this study (summarised in Table 3.1) differed somewhat from the Australian population as a whole and reflects characteristics of the people who chose to do the questionnaires (see Section 3.7 about limitations). The ratio of females to males matched the whole Australian population closely (Australian Bureau of Statistics 2015, p 30). However, this sample was slightly older (discounting young people who were disqualified), had much higher levels of education, with only 5.1% having no tertiary qualifications compared to 39.3% of all Australians with no qualifications; and more respondents worked, with 79.6% in employment compared to 73.5% of Australians (Australian Bureau of Statistics, 2015b). Compared to the national average, this sample had three times more tertiary students, most of whom also worked (Australian Government 2016; Australian Bureau of Statistics 2016).

Half the respondents lived in separate houses (53.3%) compared to three quarters of all Australians (78.8%; although for Sydney this is only 61%) and three times more respondents lived in flats (30.6%) compared to all Australians (10.7%) (Australian Bureau of Statistics, 2012). Home ownership status did not differ markedly from the national average (Australian Bureau of Statistics, 2015c). Federal voting intentions of those respondents who answered this optional question were markedly different to the general Australian population: many more intended a Greens vote, 43.1% for a lower house (House of Reps) member compared to 10.2% in the most recent election in July 2016 (Australian Electoral Commission, 2016a); and 55.7% stated they would vote Greens in the upper house (Senate) compared to the July 2016 election result of 8.7% (Australian Electoral Commission, 2016b).

Respondents were asked for their postcode (Appendix G). Results showed that most (272/330 = 82%), lived in the capital cities, the majority in Sydney metropolitan area (222/330 = 67%). The remainder were from regional areas, but this included large cities such as Newcastle and Wollongong. This differs from the national average; in 2013 (Australian Bureau of Statistics, 2014) 66% of Australians lived in the capital cities, although this was projected to grow. Thus it could be said my results are more likely to represent the views of urban residents, those assessed to be more likely to buy EVs (Higgins and Paevere, 2011), than Australian population as a whole.

Appendix D: International markets

Table D.1 Passenger cars registered in each of 2013, 2014, 2015 and 2016; incentives offered and sources (see References for date of access for individual sources)

Country/ Type of vehicle	**2013** Market Share % [units/total new registrations]	**2014** Market Share % [units/total new registrations]	**2015** Market Share % [units/total new registrations]	**2016** Market Share % [units/total new registrations]	**Rechargers** at 01.01. 2017 **Population**	**Notes**	References
Norway							
BEV	5.79 [8,232/142,151]	12.55 [18,098/144,202]	17.12 [25,792/150,686]	15.67 [24,224/154,603]	Fast: 1117 Other: 7040 Population: 5,194,000	Incentives have gradually increased since 1990 to ensure economic benefit for zero emission vehicles. • Exemptions (BEVs): vehicle purchase tax (VAT 25%) (including for leasing from 2015); first time registration tax; annual car taxes to 2018 • Exemptions (PHEVs): vehicle purchase tax (VAT 25%) max €10,000 • Soft incentives for BEVs (locally applied): Free public recharging; Free parking in public car parks; road and public ferry tolls exemption; free access to bus lanes • Government support for deployment of recharge infrastructure including fast chargers every 50km on highways • 50% reduced company car tax Note: Mitsubishi Outlander PHEV was the top selling EV in 2016	(European Commission, 2017) (ACEA, 2016) (Bu, 2015) (Bjerkan et al., 2016) (AVERE, 2012)
PHEV	0.23 [324/142,151]	1.17 [1,680/144,202]	5.19 [7,819/150,686]	13.37 [20,664/154,603]			
All EVs	**6.0** [8556/142,151]	**13.7** [19,778/144,202]	**22.3** [33,611/150,686]	**29.04** [44,888/154,603]			

Hong Kong	2013	2014	2015	2016			
All EVs	**0.09** [34/38,119]	**2.17** [843/38,843]	**6.31** [2646/41,922]	**8.76** [3023/34,490]	Fast: 274 Other: 1299 Population: 7,378,000	• BEV: Exemption from first registration tax (until 31/3/17) • Enterprises which procure EVs allowed 100% profits tax deduction for capital expenditure on EVs in first year of procurement. • Government support for deployment of recharge infrastructure • Government provided information website including locations of car retailers and rechargers. Note: Figures do not include government vehicles	(HK Gov Transport Department, 2016) (HK Gov EPD, 2017)
Netherlands	2013	2014	2015	2016			
BEV	0.53 [2251/419,388]	0.7 [2664/390,402]	0.6 [2543/449,350]	1.0 [3737/382,825]	Fast: 612 Other: 26,088* *Of these 11,768 operate 24/7	Note: Government focus has shifted to encourage more BEVs, fiscal incentives for PHEVs will gradually reduce 2015-2020 until same as regular cars • BEVs: Exemption first time registration tax (BPM) and annual road tax (MRB) • PHEVs: First time registration tax (BPM) is progressive based on emissions and 50% reduction in annual road tax (<$51gCO_2$/km) • Local support for rechargers • Some access to parking for BEVs in	(ACEA, 2016) (RVO, 2017) (Western Automation, 2016b)
PHEV	4.81 [20,164/419,388]	3.2 [12,425/390,402]	9.2 [41,226/449,350]	5.4 [20,740/382,825]			
All EVs	**5.3** [22,415/419,388]	**3.9** [15,089/390,402]	**9.7** [43,769/449,350]	**6.4** [24,477/382,825]			

					Population: 16,933,000	Amsterdam, and free for 1 year in Rotterdam Note: Figures include light delivery vans, and PHEVs include range extended EVs.	
Iceland	2013	2014	2015	2016			
BEV	1.1 [80/7274]	2.16 [206/9520]	2.77 [389/14,008]	2.04 [376/18,442]	Fast: 30 Other: 11 Population: 329,000	• No purchase tax (VAT 25.5%) (from 2012) for first US$47,000 of BEV price • Import excise duty exempt for BEVs and partially exempt for PHEVs (from 2006) • No annual tax for BEVs • Free 2 hours parking for EVs in Reykjavik and Akureyri • Plan to install 80 new recharger stations in all municipalities Note: Figures include all passenger vehicles except buses	ACEA 2016 (European Commission, 2017) EAFO (Iceland Monitor, 2016)
PHEV	0.33 [24/7274]	0.29 [28/9520]	1.21 [170/9520]	4.24 [782/18,442]			
All EVs	**1.43** [104/7274]	**2.45** [234/9520]	**3.98** [559/14,008]	**6.3** [1157/18,442]			

Sweden	2013	2014	2015	2016			
BEV	0.16 [1,112/269,558]	0.4 [1,207/303,948]	0.86 [2,978/345,108]	0.79 [2945/372,318]	Fast: 1084 Other: 1,654 Population: 9,816,000	• 2012-15 Swedish government provided a SEK 40,000 rebate on purchase of BEVs and PHEVS for individuals and companies, • From 2016 BEVs receive SEK 40,000 rebate, PHEVs (<50g CO_2/km) receive SEK20,000 • 5 year reduction on annual car tax 2013 – 17, dependent on emissions • 40% reduction in income tax levied for company car use; • Government procurement policy to attain fossil free car fleet by 2030.	(ACEA, 2016) (European Commission, 2017)
PHEV	0.41 [444/269,558]	1.14 [3,472/303,948]	1.66 [5,712/345,108]	2.81 [10,470/372,318]			
All EVs	**0.57** [1,556/269,558]	**1.54** [4,679/303,948]	**2.52** [8,690/345,108]	**3.6** [13,415/372,318]			
Switzerland	2013	2014	2015	2016			
BEV	0.37 [1127/305,928]	0.43 [1292/300,110]	0.95 [3065/321,855]	1.01 [3214/317,318]	Fast: 484 Other: 3,399 Population: 8,265,000	• EVs exempt from car import tax of 4% • Various Cantons have other fee waivers • Information about EVs distributed by government partners.	(ACEA, 2016) (European Commission, 2017)
PHEV	0.07 [218/305,928]	0.28 [837/300,110]	0.79 [2558/321,855]	0.81 [2585/317,318]			
All EVs	**0.44** [1,345/305,928]	**0.71** [2,129/300,110]	**1.74** [5,623/321,855]	**1.82** [5,799/317,318]			
Belgium	2013	2014	2015	2016			
					Fast: 480	• EVs pay lowest rate of annual circulation tax	(ACEA, 2016)

BEV	0.37 [494/ 486,065]	0.24 [1169/482,939]	0.27 [1358/501,066]	0.38 [2,052/539,519]	Other: 1,335 Population: 11,259,000	of €74 instead of €1,900 • Flanders only: registration tax exemption for EVs < 51g CO_2/km; Zero Emissions Bonus purchase grant of €4,000 from 1 Jan 2016 • Company car expenses tax deductions: 120% for BEVs; 100% for PHEVs <61g CO2/km; PHEVs >60g CO_2 progressive deductions 90%-50%	(European Commission, 2017)
PHEV	0.07 [319/ 486,065]	0.18 [852/482,939]	0.49 [2451/501,066]	1.36 [7,338/539,519]			
All EVs	**0.44** [813/ 486,065]	**0.42** [2021/482,939]	**0.76** [3809/501,066]	**1.74** [9,390/539,519]			

Austria	2013	2014	2015	2016			
BEV	0.2 [654/319,026]	0.42 [1,271/303,318]	0.54 [1,677/308,555]	1.16 [3,826/329,604]	Fast: 473 Other: 2356 Population: 8,662,588	• For private vehicles <€50,000: purchase subsidy €4,000 per BEV, €1,500 per PHEV with electric range >40km • For company or municipal vehicles: purchase subsidy €3,000 per BEV, €1,500 per PHEV • All cars <90g CO_2/km exempt from registration tax • BEVs are 100% exempt from all relevant federal taxes, except VAT • Circulation tax is calculated on the basis of the engine's horsepower. PHEVs pay only for the ICE part • In-kind benefits for private usage of company cars 0% tax (formerly 18%). PHEV's remain at 18%. Cars > 130gCO_2 /km raised to	(European Commission, 2017) (ACEA, 2017) (ACEA, 2016) (OAMTC, 2016)
PHEV	0.06 [184/319,026]	0.14 [434/303,318]	0.36 [1,101/308,555]	0.38 [1,237/329,604]			
All EVs	**0.26** [838/319,026]	**0.56** [1,705/303,318]	**0.9** [2,778/308,555]	**1.54** [5,063/329,604]			

						24% (threshold reduces 3 g CO_2/km every year until 2020) • Company BEVs exempt from VAT (eligible for pre-tax deduction) • Some large cities have free EV parking • The Austrian Automobile Club ÖAMTC publishes the incentives granted by local authorities • Government support for recharger installation	

France	2013	2014	2015	2016			
BEV	0.49 [8,779/1,790,456]	0.59 [10,561/1,795,885]	0.9 [17,269/1,917,226]	1.08 [21,776/2,015,177]	Fast: 1,593 Other: 14,290 Population: 67,063,000	• Diesel Scrappage Scheme: 11+ year diesel changed to BEV grants an extra €4,000; changed to PHEV grants an extra €2,500 • Road registration tax exemptions/ reductions • BEVs exempt company car tax, PHEVs exempt company car tax for 2 years after registration. • Government support for recharger installation Local subsidies may also apply	(ACEA, 2016) (European Commission, 2017)
PHEV	0.05 [863/1,790,456]	0.12 [2,070/1,795,885]	0.29 [5,518/1,917,226]	0.37 [7,429/2,015,177]			
All EVs	**0.54** [9,642/1,790,456]	**0.71** [12,631/1,795,885]	**1.19** [22,787/1,917,226]	**1.45** [29,205/2,015,177]			
United Kingdom	2013	2014	2015	2016			

BEV	0.11 [2,552/2,264,737]	0.27 [6,688/2,476,435]	0.38 [9,936/2,633,503]	0.39 [10,375/2,692,786]	Fast: 2247 Other: 10,376 Population: 65,081,000	• EVs<50gCO2/km and 70⁺ mile range grants up to £8,000; PHEVs <70 mile electric range and emissions 50-75gCO_2/km £2,500 (car price cap £60,000) • EVs exempt annual circulation tax • EVs reduced company car tax • EVs London Congestion Charge exemption • Incentives to install home / workplace /on-street chargers • Government procurement programs • Free resident parking (some London boroughs)	(ACEA, 2016) (ACEA, 2017) (European Commission, 2017) (UK DfT, 2015) (City of Westminster, 2016)
PHEV	0.04 [956/2,264,737]	0.32 [7,914/2,476,435]	0.71 [18,737/2,633,503]	1.06 [28,618/2,692,786]			
All EVs	**0.15** [3,508/2,264,737]	**0.59** [14,602/2,476,435]	**1.09** [28,673/2,633,503]	**1.45** [38,993/2,692,786]			

China	2013	2014	2015	2016			
All EVs	**0.1** [17,742/17,900,000]	**0.27** [53,082/19,710,000]	**0.84** [176,627/21,150,000]	**1.44** [351,861/24,380,000]	Total: 81,000	Note: Gradual subsidy phase out, to be complete after 2021 • Government support 30% EV procurement	(State Council People's Republic of China, 2016)

					Population: 1.382 billion	for government departments 2015-16 • Government subsidies for production of Chinese BEVs and PHEVs: From 2012 exemption from annual car taxes, 5 cities trial for EVs purchaser subsidy. • From 2015 no taxes for commercial EVs and 50% tax deduction for private vehicles. • No restrictions on using EVs and PHEVs on high pollution days. • Government support for recharger installation	(Statista, 2017) (Gu, 2014) (FlorCruz, 2015) (Xinhua News, 2015) (Xinhua News, 2016)
Finland	2013	2014	2015	2016			
BEV	0.05 [50/103,314]	0.17 [185/106,259]	0.22 [242/108,844]	0.19 [225/118,986]	Fast: 265 Other: 706 Population: 5,475,000	BEV: pay only 5% registration tax (based on CO_2 emissions)	(European Commission, 2017) (ACEA, 2017) (ACEA, 2016)
PHEV	0.16 [168/103,314]	0.27 [291/106,259]	0.38 [415/108,844]	1.01 [1207/118,986]			
All EVs	**0.21** [218/103,314]	**0.44** [476/106,259]	**0.6** [657/108,844]	**1.2** [1432/118,986]			
Portugal	2013	2014	2015	2016			
BEV	0.16 [166/105,921]	0.14 [196/142,826]	0.36 [639/178,503]	0.38 [1,089/207,330]	Fast: 58 Other:1,192 Population: 10,311,000	• EVs exempt from registration tax and annual circulation tax dependent on emissions • BEV: €2,250 grant to exchange end of life ICV for BEV • PHEV: €1,125 grant to exchange end of life ICV for PHEV	(ACEA, 2016) (ACEA, 2017) (European Commission, 2017)
PHEV	0.04 [44/105,921]	0.07 [103/142,826]	0.3 [541/178,503]	0.53 [784/207,330]			

All EVs	**0.2** [210/105,921]	**0.21** [299/142,826]	**0.66** [1,180/178,503]	**0.91** [1,873/207,330]		• Company cars: VAT is tax deductible for EVs < €50,000 • Free parking in Lisbon Utilities provide 1 year discount on electricity for BEVs	

United States	2013	2014	2015	2016			
All EVs	**0.6** [97,507/15.5M]	**0.7** [122,438/16.4M]	**0.7** [116,099/17.4M]	**0.9** [158,455/17.5M]	Fast: 1912 Other: 15,411 Population: 323,127,513	• Wide range of incentives offered: • Federal income tax credit US$7,500 & 8 states offer income tax incentives on purchase of BEV or PHEV • 6 other states offer purchase rebates • 3 other states offer reductions on vehicle purchase or registration tax • 2 states offer free parking for EVs • California also offers deductions on battery charging • 9 states have free access to bus or HOV lanes • Federal and some states have EV procurement policies • Government support for recharger deployment • 10 states offer rebates for private installation of rechargers. • Federal support for information	(Plug in America, 2017) (Pontes, 2017) (US DoE, 2017b) (US DoE, 2017a) (Kane, 2016) (US DoC, 2017) (US DoE, 2016c)

						dissemination. Note: nearly 50% of US EV sales are in California Note: Figures include Light Duty Vehicle Classes 1,2, & 3 trucks, up to 14,000 lbs	
Japan	2013	2014	2015	2016			
All EVS	**1.06** [30,587/2,872,111]	**1.17** [33,390/2,860,472]	**0.94** [25,328/2,704,485]	**0.8** [22,375/2,765,491]	Fast: 6958 chargers (Sept 2016) Population: 127M	Note: Figures include standard and small cars but not mini/kei cars Note: Until 2014, the Japanese government offered generous subsidies (up to US$10,000) on EV purchase.	(Pontes, 2017) (JAMA, 2017) (Loveday, 2016) (Kane, 2016)

Germany	2013	2014	2015	2016			
BEV	0.19 [5464/2,952,431]	0.28 [8,390/3,036,773]	0.38 [12,097/3,206,042]	0.34 [11,243/3,351,607]	Fast: 1,810 Other: 22,857 Population:	• Purchase subsidies for cars under €60,000 (max 400,000 cars)(ends in 2020): BEVs €4,000 grant; PHEV €3,000 • Tax deductions on company cars • Exemptions from ownership tax for first 10 years for cars registered before 1 Jan 2016; exempt for 5 years for cars registered until 31 Dec 2020	(European Commission, 2017) (ACEA, 2016) (ACEA, 2017)
PHEV	0.06 [1656/2,952,431]	0.14 [4,401/3,036,773]	0.35 [11,111/3,206,042]	0.40 [13,369/3,351,607]			

All EVs	**0.25** [7120/2,952,431]	**0.42** [12,791/3,036,773]	**0.73** [23,208/3,206,042]	**0.74** [24,612/3,351,607]	81,276,000	• Local incentives for BEVs may include: free parking, reserved parking, bus lane use	
Denmark	2013	2014	2015	2016			
BEV	0.27 [497/181,896]	0.81 [1.533/188,612]	2.19 [4,524/206,998]	0.55 [1,223/222,927]	Fast: 422 Other: 2114 Population: 5,673,000	• BEV registration tax reductions up to DKK10,00 ($1,470) • Municipalities and businesses get $1,470 - $3,675 subsidy on EV purchase by Danish Energy Agency • Tax rebate for installation of home recharger • Connection charge 50% discount public recharging stations • Local incentives include: • Payment up to DKK5,000 ($475) to parking lots to provide preferential parking to EVs • Dedicated parking for EVs • Fleet owners DKK2-4,000 per vehicle from utilities.	(European Commission, 2017) (Levring, 2015) (ACEA, 2016)
PHEV	0.01 [11/181,896]	0.05 [100/188,612]	0.21 [444/206,998]	0.08 [179/222,927]			
All EVs	**0.28** [508/181,896]	**0.86** [1,633/188,612]	**2.4** [4,968/206,998]	**0.63** [1,402/222,927]			

Australia	2013	2014	2015	2016			
All EVs	**0.03** [292/899,965]	**0.13** [1130/883,943]	**0.12** [1108/9224,154]	**0.02** [215/927,274]	Fast:37 Other: 671	Note: Figures include BEVs & PHEVs • Threshold for application of 33% Federal	(ATO, 2016)

					Population: 24,168,303	luxury car tax (new cars sold above Au$63,184) rises to Au$75,375 for cars <7L/100km fuel consumption • Low level state based annual car taxes exempt for EVs in state of Victoria. • State of Queensland commenced limited infrastructure support ACT government Green Vehicles Duty Scheme registration duty exemption for vehicles emitting <130g CO_2/km	(VicRoads, 2016) (O'Rourke, 2015) (ACT Govt, 2016) (FCAI, 2017) (PlugShare, 2016)

Appendix E: Questionnaire 1 email

Email for Questionnaire 1

What do you think about Electric Cars?

Never Stand Still | Faculty of Science | School of Biological, Earth and Environmental Sciences

This research has ethics approval. Approval number 155078

What do you think about electric cars?

You are invited to participate in a survey being conducted as part of a Master of Philosophy research project at UNSW. This research focuses on social attitudes to electric vehicles.

We are seeking your views in a short questionnaire.

Click here
https://www.surveymonkey.com/r/UNSW_electric_cars_social_attitudes5PFRHWZ

All responses to our survey will remain anonymous.

If you have any questions, please feel free to ask Gail Broadbent by sending an email to z7446284@student.unsw.edu.au . If you have any additional questions later, Professor Graciela Metternicht, Phone: (02) 9385 5761 Email: g.metternicht@unsw.edu.au will be happy to answer them.

Appendix F: Questionnaire 2 email

Email for Questionnaire 2

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

What do you think about electric cars?

Never Stand Still | Faculty of Science | School of Biological, Earth and Environmental Sciences

This research has ethics approval. Approval number 155078

Thank you for participating in last year's survey on electric vehicles for a UNSW Master of Philosophy research project, and for providing your contact details for a follow-up survey. You are invited to participate in this follow-up to more closely examine particular aspects relating to social attitudes to electric vehicles.

We are seeking your views in a short questionnaire which should take about 7-10minutes to complete.

Click here https://www.surveymonkey.com/r/SSCB5S6

All responses to our survey will remain anonymous.

If you have any questions, please feel free to ask Gail Broadbent by sending an email to **z7446284@student.unsw.edu.au** . If you have any additional questions later, Professor Graciela Metternicht, Phone: (02) 9385 5761 Email: **g.metternicht@unsw.edu.au** will be happy to answer them.

Appendix G: Detailed results of the surveys

G1 Questionnaire 1 Results

Results where N=330

1. **Postcode**

Postcodes	Area name	No. respondents
1000-2249	Sydney metropolitan	222
2600-2620 and 2900-2914	Canberra metropolitan	13
3000-3207	Melbourne metropolitan	29
4000-4207 and 9000-9499	Brisbane metropolitan	2
5000-5199 and 5900-5999	Adelaide metropolitan	4
6000-6199 and 6800-6999	Perth metropolitan	2
	Total metropolitan	**272**
	NSW regional	46
	Vic regional	5
	Qld regional	4
	WA regional	1
	other	2
	Total regional	**58**

2. Gender

Female 166/330 = 50.3%

Male 164/330= 49.7%

3. **Age**

AGE vs Likelihood to buy an EV /PHEV

Age group	N	Percentage	EV likelihood to buy	PHEV likelihood to buy

18-24	20/330	6.1%	2.6	2.8
25-34	61/330	18.5%	2.79	2.85
35-44	64/330	19.4%	**2.98**	**3.15**
45-54	72 /330	21.8%	**3.1**	**3.1**
55-64	68/330	20.6%	**3.04**	**3.1**
65-74	33/330	10%	2.82	2.95
75 or older	12/330	3.6%	2.67	3.05

4. What is your highest educational qualification?

Qualification	**n**	**%**	**BEV likelihood to buy**	**Test A**	**Control B**	**PHEV likelihood to buy**	**Test A**	**Control B**
Higher School Certificate	14/330	4.2%	3	3	3	3.2	**3.15**	**3.3**
Diploma or Advanced Diploma	31/330	8.8%	2.83	2.9	2.75	2.9	**2.75**	**3**
Bachelor degree	101 /330	30.6%	2.9	3	2.8	3.08	**3.05**	**3.1**
Graduate Certificate or Graduate Diploma	40 /330	12%	2.8	3	2.5	3.1	3.2	3
Post graduate degree including PhD	141/330	42.7%	3	3.05	2.95	3.04	3.15	2.8
No formal qualification	3/330	0.9%						

5. Which term regarding employment best describes you?

Weighted average response to the Likelihood to by an EV /PHEV v employment status

Employment status	% of sample	Likelihood to buy BEV	Likelihood to buy PHEV
Employed full time (n= 147)	44.5%	2.86	3.03
Employed part time (n=78)	23.6%	2.86	2.88
Self- employed (n=38)	11.5%	**3.32**	3.11
Total in formal paid employment n=263	**79.6%**		
Not employed (n= 7)	1.8%	2.83	**3.5**
Retired / pensioner(n=46)	13.9%	2.98	**3.41**
Home duties (n= 5)	1.5%	2.8	3.0
Student (n=10)	3%		

6. Are you studying at a tertiary institution?

Yes full time 35/330 = 10.6%

Yes part time 27/330 = 8.25%

No 268/330 = 81.2%

7. Please select the option which best describes your residence

Type of residence	Likelihood to buy EV	Likelihood to buy PHEV
Separate house 176/330 = 53.3%	2.9	3
Semi-detached/terrace house (townhouse) 53/330 = 16.1%	2.9	3
Flat/unit/apartment 103/330 = 30.6%	2.95	3.2

Other 0/330= 0%

8. Please select the option that best describes your home ownership status

Home ownership status	Likelihood to buy EV	Likelihood to buy PHEV
Fully owned 118/330 = 35.8%	3	3.05
Being purchased (mortgaged) 107/330 = 32.4%	2.95	3.1
Rented 87/330 = 26.4%	3	2.9
I am still living at home with family members 18/330 5.5%	2.75	3

Other 0/330 = 0%

9. How many off-street parking spaces are available to your household at your place of residence?

No. car spaces	Likelihood to buy an EV	Likelihood to buy an PHEV
Zero 57/330 = 17.9%	3.16	3.28
One 105/330 = 31.8%	2.88	2.95
Two 92/330 = 27.9%	2.78	3.02
Three or more 74/330 = 22.4%	3.04	3.08

10. If you have off-street parking, is it a designated parking spot as part of the ownership/leasing arrangement?

Yes 192/330 = 58.2%

No 76/330 = 23%

No off- street parking 62/330 = 18.8% (compare this to Qu 9: 57/330 = 17.9% for no off-street parking)

11. If you have off-street parking, is it possible to have a main electricity socket installed within 3 metres of your car?

Yes 206/330 = 62.4%

No 25/330 = 7.6%

Unsure 38/330 = 11.5%

No off-street parking 61/330 (18.5%)

12. In your household how many cars are available for you to drive?

Weighted average response to likelihood to purchase EV on a 1-5 scale

Number of cars	% of respondents	EV likelihood to buy Test A	EV likelihood to buy Control B	PHEV likelihood to buy Test A	PHEV likelihood to buy Control B
Zero 11/330 =	3.3%				
One 156/330 =	47.3%	3	2.9	3.1	3.1
Two 119/330 =	36.1%	3	2.8	3	2.9
Three or more 28/330 =	8.5%	2.9	2.6	3.2	2.6
I use a car share scheme 16/330 =	4.9%	3.25	3.6	3.5	3.75

13. Of the following, which best describes your car ownership status?

I/we own the car 282/330 = 85.5%

I/we lease the car 18/330 = 5.5%

I/we don't own/lease a car but intend to get a car within 5 years 18/330 = 5.5%

I/we don't own/lease a car and do NOT intend to get a car within 5 years 12/330 = 3.6%

14. If you intend to purchase a car at some time in the future would it most likely be new or used?

Car at purchase	Likelihood to buy EV	EV Test A	EV Control B	Likelihood to buy PHEV	PHEV Test A	PHEV Control B
New 140/330 = 42.4%	3.09	3.3	2.85	3.09	3.12	2.98
Used 154/330 = 46.7%	2.68	2.74	2.62	2.91	3.03	2.87
I will not be buying a car in the future 36/330 = 10.9%						

15 For your next car purchase how much would you be willing to spend based on current car prices? Weighted average scores based on scale 1-5

Willingness to spend on next car	**n**	**%**	**Willingness to buy EV**	**Test group A (n=154)**	**Control group B (n=148)**	**Willingness to buy PHEV**	**Test group A**	**Control group B**
Less than $20,000	109/330	33%	2.64	2.75	2.6	2.84	2.9	2.8
$20k – $30k	79/330	23.9%	2.99	**3.2**	**2.75**	3.09	3.2	3
$30k - $40k	47/330	14.2%	2.74	2.7	2.75	3.11	2.9	3.25
$40k - $50k	39/330	11.8%	**3.26**	3.3	3.1	**3.26**	3.3	3.1
$50k - $60k	11/330	3.3%					3.3	3.3
$60k - $70k	5/330	1.5%					2.7	2.5
More than $70,000	14/330	4.3%					**3.4**	**1.85**

>$50 k	30/330	9.1%	**3.2**	**3.6**	**2.73**	2.9
No future car	26/330	7.9%				

16. How would you describe the size of the car you drive most of the time?

Size of car	**n**	**percentage**	**EV Test A**	**EV Control B**	**PHEV test A**	**PHEV control B**
Small	123/330	37.3%	3.1	3	3.25	3.1
Medium	164/330	49.7%	3.0	2.8	3.1	3
Large	43/330	13%	2.75	2.4	2.75	2.4

17. What type of car do you drive most often Vs willingness to buy an EV/PHEV test and control groups. Weighted average score 1-5

Type of car	**N = 330**	**Percentage**	**EV Test group A**	**EV control group B**	**PHEV test group A**	**PHEV control group B**
sedan	85	25.8	2.9	2.4	2.9	2.85
Station wagon	48	14.6	2.75	3	2.8	2.9
Hatch back	124	37.6	3.1	3.1	3.3	3.2
SUV	59	17.9	**3.1**	**2.8**	**3.15**	**2.8**
Ute* /van	11	3.3%	**3**	**3.5**	**2.5**	**3.2**
Zero cars	3	0.9%				

18. Which term best describes the type of fuel used by the car you drive most often?

Petrol 261/330 =	79.1%
Diesel 49/330 =	14.9%
Hybrid (uses petrol or diesel to charge an on-board	2.7%

battery eg Prius) 9/330 =

Plug-in Hybrid (eg Audi e-tron or Mitsubishi Outlander SUV) 6/330 =	1.8%
Fully electric (eg Tesla, Nissan Leaf) 1/330 =	0.3%

Other (please specify)

4/330 = 1.2%

(zero cars = 2/330; dual fuel system = 2/330)

19. What is the most FREQUENT purpose for your trips?

I drive to work/education institution 67/330 = 20.3%

I use my car for work/business purposes 40/330 =12.15%

I do short journeys for personal things such as shopping, visiting, obtaining services 198/330 = 60%

Long journeys 16/330 = 4.8%

Other (please specify) 5/330 = 1.5%

20. How often would you drive more than a total of 100 km in a day?

Likelihood to buy EV v perceived frequency that daily driving exceeds 100km

Frequency >100km daily drive	% of sample	BEV	PHEV
Most days (n=6)	1.8%	3.17	2.83
Most weeks (n=46)	13.9%	2.8	2.80
Once/twice month (n=89)	27.3%	2.79	2.82
Occasionally (n=163)	49.75%	3.07	3.32
Never (n=24)	7.3%	2.75	2.71

21. If you do drive more than a total of 100km in a day, what is the most common purpose of the trip/trips?

(open response) NB 198 people chose to answer this question and provided up to 3 responses each, and one person answered N/A. 132 people skipped this question.

Business 45/198 = 22.7% of respondents included this

Visiting Friends/Relatives (VFR) 64/198 = 32.3% of respondents included this

Holidays/leisure 125/198 = 63% of respondents of respondents included this

(Totals do not add to 100% as many respondents included more than one category in their answer)

22. Where do you get MOST of your information about new car models coming onto the market?

Print media (newspapers/magazines) 68/ 330 = 20.6%

Online articles 136/ 330 = 41.2%

Word of mouth 54/330 = 16.4%

Car manufacturers' websites 18/330 = 5.5%

Television/radio 42/330 = 12.7%

Other (please specify) (including: all of the above; not interested) 12/330 = 3.6%

23. On a scale of 1-5, my INTEREST in cars as a technology is best described as?

1 No interest: 41/330 = 12.4%

2 Minor interest 84/330 = 25.5%

3. Somewhat interested 86/330 = 26.1%

4 Quite interested 74/330 = 22.4%

5 Highly interested 45/330 13.6%

Weighted average score = 3/5

Showing this survey's respondents are somewhat interested in cars as a technology.

24. On a scale of 1-5 my KNOWLEDGE of how cars work can best be described as?

1. Very low 60/330 = 18.2%

2. Low 78/330 = 23.6%

3. Medium 89/330 = 27%

4. Moderately High 66/330 = 20%

5. Highly knowledgeable 37/330 = 11.2%

Weighted average= 2.82/5

25. On a scale of 1-5 what would best describe how much you have seen in the MEDIA about electric cars?

1. Nothing 22/330 =6.7%
2. Not much 112/330 = 33.9%
3. Moderate 114/330 = 34.6%
4. Quite a bit 51/330 = 15.5%
5. A lot 31/330 = 3.4%

Weighted average = 2.87/5

26. When thinking about buying cars please rank how IMPORTANT each listed feature would be

Feature	**1 Not important**	**2 Not very important**	**3 Neutral**	**4 Quite important**	**5 Very important**	**Weighted average on scale 1-5**	**Female**	**Male**
Purchase price (Including on road costs, taxes/subsidies and charges)	2/330 = 0.6%	5/330= 1.5%	34/330 = 10.3%	120/330 = 36.4%	169/330 = 51.2%	**4.36/5**	4.39	4.34
Fuel efficiency	1/330 = 0.3%	1/330 = 0.3%	32/330 = 9.7%	133/330 = 40.3%	163/330 = 49.4%	**4.38/5**	**4.52**	**4.24**
Safety features (eg air bags, safety camera)	6/330 = 1.8%	13/330 = 3.9%	43/330 = 13%	119/330 = 36.1%	149/330 = 44.9%	**4.19/5**	**4.39**	**3.99**

Number seats	8/330 = 2.4%	29/330 = 8.8%	104/330 = 31.5%	127/330 = 38.5%	62/18.8%	**3.62/5**	3.7	3.54
Storage capacity eg boot size	4/330 = 1.2%	28/330 = 8.8%	77/330 = 23.5%	149/330 = 45.2%	72/330 = 21.7%	**3.78/5**	3.81	3.74
Car aesthetics	26/330 = 7.9%	50/330 = 15.2%	107/330 = 32.4%	102/330 = 30.9%	45/330 = 13.6%	**3.27/5**	**3.19**	**3.35**
Driver/passenger comfort	6/330= 1.8%	14/330 = 4.2%	72/330 = 21.8%	149/30 = 45.5%	89/330 = 27%	**3.91/5**	3.95	3.87
Car performance	30/330 = 9.1%	63/330 = 19.1%	127/330 = 37.9%	81/330 = 24.6%	31/330 = 9.4%	**3.06/5**	3.01	3.12
Fuel costs	0/330 = 0%	14/330 = 4.2%	64/330 = 19.4%	28/330 = 38.8%	124/330 = 37.6%	**4.1/5**	**4.26**	**3.93**
Servicing costs	1/330 = 0.3%	21/330 = 6.4%	62/330 = 18.8%	144/330 = 43.6%	102/330 = 30.9%	**3.98/5**	4.10	3.96
Car brand	54/330 = 16.3%	80/330 = 24.2%	87/330 = 26.4%	86/330 = 26.1%	23/330 = 7%	**2.83/5**	**2.67**	**2.99**
Country of manufacture	52/330 = 15.8%	80/330 = 24.2%	112/330 = 33.9%	66/330 = 20%	20/330 = 6.1%	**2.76/5**	2.8	2.73
Ownership costs (total combining purchase price / fuel costs/ maintenance)	1/330 = 0.3%	13/330 = 3.9%	52/330 = 15.8%	136/330 = 41.2%	128/330 = 38.8%	**4.14/5**	4.20	4.08
Greenhouse gas emissions per kilometre travel)	10/330 = 3%	24/330 = 7.3%	80/330 = 24.2%	112/330 = 33.9%	104/330 = 31.5%	**3.84/5**	**4.08**	**3.59**

27. Next time you buy a car what, if anything, would ENCOURAGE you to purchase an electric vehicle (only uses main electricity as the energy source for the rechargeable battery).(open response).

Number	Category	Mentioned by number of respondents/330	Percentage of respondents who mention
1	*Affordable price /cost of ownership issues*	184	**56.1**
2	*Acceptable range/improved battery capacity*	85	**25.8**
3	*Improved battery issues (including warranty, longevity, disposal)*	17	5.1
4	*Shorter recharge time*	40	12.1
5	*Adequate recharge network*	92	**27.9**
6	*Unable to recharge at home/ want recharger on the street near home*	21	6.4
7	*Concerns about environmental impacts*	42	12.7
8	*Issues related to EV models eg availability, aesthetics, performance, comfort, seats, storage capacity, safety, support services, reliability*	64	19.4
9	*Unsure, including want more information*	9	2.7
10	*Other (including already own, will buy next time, want free guaranteed parking)*	5	1.5
0	*Not interested*	9	2.7

Note: many respondents included a number of issues.

28. Next time you buy a car what, if anything, would ENCOURAGE you to purchase a *plug in hybrid car*. (A plug-in hybrid uses mains electricity to recharge the car battery for the first 50km of a trip then uses petrol/diesel to recharge the battery for up to 800km until the next refuel).

Number	Category	Mentioned by number of respondents/330	Percentage of respondents who mention
1	*Affordable price /cost of ownership issues*	202	**61.2**
2	*Acceptable range/PHEV is better than fully electric*	27	8.2
3	*Improved battery issues (including warranty,*	10	3

	longevity, disposal)		
4	*Shorter recharge time*	4	1
5	*Adequate recharge network*	24	7.3
6	*Unable to recharge at home/ want recharger on the street near home*	16	4.8
7	*Concerns about environmental impacts*	38	11.5
8	*Issues related to PHEV models eg availability, aesthetics, performance, comfort, seats, storage capacity, safety, support services, reliability*	65	**19.7**
9	*Unsure, including want more information*	13	3.9
10	*Other (including already own, will buy next time, want free guaranteed parking)*	40	12.1
0	*Not interested*	14	4.2

29.
Variable 1: was seen by 163 respondents randomly allocated to Test Group A

Please read the following information about electric cars then provide responses to the questions which follow.

- Range:
  - The range of most fully electric vehicles is about 120 – 160 km, and 80% of Australian drivers travel 50 km or less per day. Plug-in hybrid electric cars can travel about 50 km on battery alone and up to a further 800 km using petrol or diesel depending on the model.
- Batteries:
  - The batteries for modern electric vehicles are less damaging for the environment than lead batteries used in conventional cars, are classified as nontoxic, are recyclable and are typically guaranteed to last 5- 8 years or 100,000 – 150,000 km.
  - The price of lithium batteries is continuing to drop due to economies of scale and technology improvements
- Recharging:
  - Fast chargers can recharge the battery of some electric cars to 80% capacity in about 20-30 minutes, with Level 2 rechargers it typically takes 4-6 hours. Electric cars can be "trickle charged" from any power point but this can take up to 12 hours.
  - There is a modest network of publicly accessible rechargers in Sydney and Melbourne. In Europe and America most people recharge their electric vehicles at home overnight but tens of thousands of public recharging stations are available.
  - In Sydney the NRMA offers "breakdown" mobile recharging for members' electric cars (Ref: http://www.mynrma.com.au/motoringservices/petrol-watch/charge-yourvehicle.htm)

- Cost and efficiency:
  - Electric cars are about 70% cheaper to run than petrol or diesel cars and are much cheaper to maintain as there a far fewer moving parts.
  - Total cost of ownership calculation: Although electric cars are more expensive to buy than comparable conventional cars, when comparing the total cost of ownership over 12 years and travelling 180,000 km for a Honda Jazz with a Mitsubishi iMiEV, the electric car is cheaper. (Ref: http://www.aeva.asn.au/content/you-mightwell-i-miev)
- Vehicle emissions:
  - Electric cars have no tailpipe emissions, are better for air quality in cities, are much less noisy and are better for human health compared to conventional cars. They also have lower greenhouse gas emissions than conventional cars (magnitude of improvement depends on the electricity source). Diesel fuel is classified as a Class 1 carcinogen.

Variable 2: was seen by 165 respondents randomly allocated to Control group B

This information applies to questions that follow.
A fully electric car (EV) uses only mains electricity to recharge its on board battery. A plug in hybrid (PHEV) uses mains electricity to recharge a small on board battery to provide energy for the first 50 km of a trip then it uses petrol or diesel to provide energy for up to a further 800 km until the next refuel

30. Imagine you are going to buy a new car in the next 5 years, on a scale of 1-5, HOW LIKELY are you to buy an *electric car?*

	Not likely	**Not very likely**	**neutral**	**Quite likely**	**Very likely**	**Weighted average on scale 1-5**	**Female**	**Male**	**New car buyer**	**Used car buyer**
All respondents N=330	50/330 = 15.2%	68/330 = 20.6%	102/330 = 30.9%	73/330 = 22.1%	37/330 = 11.2%	2.94/5	3	2.8	3.1	2.68
Test A - received information	18/163 = 11%	31/163 = 19%	59/163 = 36.2%	39/163 = 23.9%	16/163 = 9.8%	3.02/5	**3.14**	**2.87**	**3.3**	**2.74**
Control B - no	32/165 =	36/163 = 21.8%	43/165 = 26.1%	33/165 =20%	21/165 =12.7	2.85/5	**2.8**	**2.88**	**2.85**	**2.62**

information	19.4%	%

31. Imagine you are going to buy a new car in the next 5 years, on a scale of 1-5 HOW LIKELY are you to buy a *plug-in hybrid* car?

	Not likely	Not very likely	neutral	Quite likely	Very likely	Weighted average on scale 1-5	Female	Male	New	Used
All respondents	40/330 = 12.1%	52/330 = 15.8%	116/330 = 35.2%	91/330 = 27.6%	31/330 = 9.4%	3.1/5	3.22	2.89	3.1	2.91
Test A - received information	13/163 = 8%	28/163 = 17%	59/163 = 36.2%	52/163 = 31.9%	11/163 = 6.7%	3.1/5	**3.27**	**2.93**	3.12	3.03
Control B - no information	27/165 = 16.4%	24/165 = 14.5%	56/165 = 33.9%	39/165 =23.6%	19/165 =11.5%	3/5	**3.15**	**2.86**	2.98	2.87

32. What are the TWO main reasons you would NOT choose to buy an *electric vehicle* or *plug-in hybrid electric vehicle* in the next 5 years?

325 people answered this question

category	reason	Number /325	Percentage
1	Price too high	142	**43.7**
2	Inadequate range	27	8.3
3	Batteries not good enough	2	0.6
4	Excessive recharge time	12	3.7
5	Inadequate recharge network	34	**10.5**
6	Unable to have home recharger	18	5.5

7	Environmental impact concerns	9	2.8
8	Other	57	**17.8**
9	Want to buy one	9	2.8
10	Unsure	2	0.6
0	Not interested/not buying within 5 years	14	4.3

There was a wide range of issues that respondents nominated as deterrents when considering purchase of an EV or PHEV, with price nominated as the most important by a wide margin. While "other" was the next largest category it composed disparate issues such as a limited choice of available models, not having the desired features, unknown reliability; the next most important category was the lack of an adequate recharger network.

33. If you bought an electric vehicle or plug-in hybrid, which of the following options would be the MAIN place you would want to recharge the car?

326 people answered this question

Answer choices	**Number of responses**	**Percentage**
Home	265	81
Work	11	3.4
Shopping centre	6	1.8
On the street near my home	35	10.7
Other (please specify)	9	3

This percentage wanting to recharge at home (81%) is very high and compares to results from international studies but the percentage nominating on the street near my home (<11 %) was lower than the percentage of survey respondents who did not have off street parking (Qu9: about 18%)

34. Apart from the locations listed in the previous question list any OTHER places you would want to be able to recharge your car. (Open response, more than one place can be listed)

Category	**Place**	**Number respondents out of 327**	**Percentage of respondents who mention this place**
1	Petrol station	58	17.7

2	Parking lot including shopping centres, airport, entertainment, library, hospital, train station, church	90	27.5
3	Holiday destinations including hotels, motels, beaches, campsites, parks, tourist facilities,	37	11
4	Work	44	13
5	On the street	18	5.5
6	Highways including service centres	50	15
7	Friends/relatives	10	3
8	Regional towns	13	4
9	Everywhere	14	4
0	None /declined to provide location	20	6

These results show that people want to recharge where they will spend a lot of time when away from home or somewhere familiar such as a petrol station. The low percentage who wanted to recharge at work as a secondary place for recharging (13%) is lower than those nominating driving to work/education institution as the most frequent destination (Q19: 20%) but could reflect the low number of people who drove more than 100km in a day on most days (Q 20: 1.8%), indicating many could get to and from work on one charge.

35. Please indicate your OPINION about the following statements by selecting the most appropriate response in relation to the purchase of an electric car.

323 people answered this question, and of these: 159 people were in Test Group (information provided), and 162 people were in Control Group (no information provided). See question 29 for the information provided to Test group and Control group.

Statement	Unsure	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree	Weighted average on Scale 1-5

		e					
Electric vehicles are too expensive to buy compared to similar sized conventional vehicles (petrol/diesel)	27/323 = 8.4%	8/323 = 2.5%	17/323 = 5.3%	80/323 = 24.8%	132/323= 40.9%	59/323 = 18.3	**3.53**
Test Group **A**	15/159 = 9.4%	4/159 = 2.5%	9/159 = 5.7%	50/159 = 31.5%	63/159 = 39.6%	18/159 = 11.3%	**3.25**
Control Group **B**	/162 = 7.4%	/162 = 2.5%	/162 = 4.9%	/162 = 18.5%	/162 = 41.4%	/162 = 25.3%	**3.7**
A plug-in hybrid would suit my needs better than a fully electric car	22/323 = 6.8%	25/323 = 7.7%	42/323 = 13%	84/323 = 26%	108/323 = 33.4%	42/323 = 13%	**3.25**
Test Group **A**	11/159 = 6.9%	11/159 = 6.9%	15/159 = 9.4%	45/159 = 28.3%	55/159 = 34.6%	22/159 = 13.8 %	3.25
Control Group **B**	11/162 = 6.8%	14/162 = 8.6%	27/162 = 16.7%	39/162 = 24.1%	53/162 = 32.1%	20/162 = 11.7%	3.2
Electric cars look too unconventional to me	16/323 = 5%	148/323 = 45.8%	66/323 = 20.4%	63/323 = 19.5%	21/323 = 6.5%	9/323 = 2.8	2.36
Test Group **A**	6/159 = 3.8%	66/159 = 41.5%	37/159 = 23.3%	33/159 = 20.8%	13/159 =8.2 %	4/159 = 2.5%	2.3
Control Group **B**	10/162 = 6.2%	82/162 = 50%	29/162 = 17.9%	30/162 = 17.9%	8/162 = 4.9%	5/162 = 3.1%	2.3
The speed and acceleration of electric vehicles is adequate for my needs	40/323 = 12.4%	16/323 = 5%	21/323 = 6.5%	51/323 = 15.8%	98/323 = 30.3%	97/323 = 30%	**3.54**
Test Group **A**	16/159 = 10.1%	11/159 = 6.9%	11/159 = 6.9%	24/159 = 15.1%	55/159 = 34.6%	42/159 = 26.4%	3.36
Control Group **B**	24/162 =	5/162 =	10/162 =	27/162 =	43/162 =	55/162 =	3.7

	14.8%	3.1%	6.2%	16.7%	25.3%	34%	
I am probably going to move house in the next couple of years	36/323 = 11.2%	97/323 = 30%	35/323 = 10.8%	40/323 = 12.4%	56/323 = 17.3%	58/323 = 18.3%	2.9
Test Group **A**	16/159 = 10.1%	44/159 = 27.7%	21/159 = 13.2%	21/159 = 13.2%	32/159 = 20.1%	25/159 = 15.7%	2.9
Control Group **B**	20/162 = 12.4%	53/162 = 32.7%	14/162 = 8%	19/162 = 11.7%	24/162 = 14.8%	33/162 = 20.4%	2.9
It would cost me too much to install a recharger at home	82/323 = 25.4%	45/323 = 13.9%	41/323 = 12.7%	91/323 = 28.2%	46/323 = 14.2%	18/323 = 5.6%	2.48
Test Group **A**	34/159 = 21.4%	18/159 = 11.3%	22/159 = 13.8%	53/159 = 33.3%	27/159 = 17%	5/159 = 3.1%	2.5
Control Group **B**	48/162 = 29.6%	27/162 = 16.7%	19/162 = 11.7%	38/162 = 22.8%	19/162 = 11.1%	13/162 = 8%	2.4
The total cost of ownership of an electric vehicle is too high on a per kilometre basis compared to conventional cars	78/323 = 24.2%	50/323 = 15.5%	57/323 = 17.7%	87/323 = 26.9%	36/323 = 11.2%	15/323 = 4.6%	2.39
Test Group **A**	24/159 = 15.1%	29/159 = 18.2%	39/159 = 24.5%	44/159 = 27.7%	17/159 = 10.7%	6/159 = 3.8%	2.4
Control Group **B**	54/162 = 32.7%	21/162 = 13%	18/162 = 10.5%	43/162 = 26.5%	19/162 = 11.7%	9/162 = 5.7%	2.3
The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs	25/323 = 7.7%	25/323 = 7.7%	42/323 = 13%	40/323 = 12.4%	119/323 = 36.8%	72/323 = 22.3%	**3.45**
Test Group **A**	7/159 = 4.4%	11/159 = 6.9%	22/159 = 13.8%	20/159 = 12.6%	61/159 = 38.4%	38/159 = 23.9%	**3.6**

Control Group **B**	18/162 = 11.1%	14/162 8.6= %	20/162 = 12.4%	20/162 = 12.4%	58/162 = 35.2%	34/162 = 20.4%	**3.3**
I am concerned that I would find it difficult to locate public recharge stations	12/323 = 3.7%	14/323 = 4.3%	17/323 = 5.3%	41/323 = 12.7%	148/323 = 45.8%	91/323 = 28.2%	**3.85**
Test Group **A**	4/159 = 2.5%	5/159 = 3.1%	8/159 = 5%	21/159 = 13.2%	82/159 = 51.6%	39/159 = 24.5%	3.85
Control Group **B**	8/162 = 4.9%	9/162 = 5.6%	9/162 = 5.6%	20/162 = 11.7%	66/162 = 40.1%	52/162 = 32.1%	3.8
I am concerned that when I am driving a long distance there are no recharge stations on the way	4/323 = 1.2%	8/323 = 2.5%	10/323 = 3.1%	30/323 = 9.3%	115/323 = 35.6%	156/323 = 48.3%	**4.24**
Test Group **A**	0/159 = 0%	3/159 = 1.9%	5/159 = 3.1%	15/159 = 9.4%	66/159 = 41.5%	70/159 = 44%	4.2
Control Group **B**	4/162 = 2.5%	5/162 = 3.1%	5/162 = 3.1%	15/162 = 8.6%	49/162 = 29.6%	86/162 = 53.1%	4.2
An electric car would take too long to recharge when I am away from home	38/323 = 11.8%	22/323 = 6.8%	39/323 = 12.1%	60/323 = 18.6%	116/323 = 35.9%	48/323 = 14.9%	**3.23**
Test Group **A**	10/159 = 6.3%	14/159 = 8.8%	17/159 = 10.7%	32/159 = 20.1%	64/159 = 40.3%	22/159 = 13.8%	3.3
Control Group **B**	28/162 = 17.3%	8/162 = 4.3%	22/162 = 13.6%	28/162 = 17.3%	52/162 = 31.5%	26/162 = 16.1%	3.1
The lithium batteries are very polluting compared to lead batteries	103/323 = 31.9%	82/323 = 25.4%	42/323 = 13%	68/323 = 21.1%	20/323 = 6.2%	8/323 = 2.5%	2.09
Test Group **A**	29/159 = 18.2%	60/159 = 37.7%	27/159 = 17%	34/159 = 21.4%	6/159 = 3.8%	3/159 = 1.9%	2.1

Control Group **B**	74/162 = 45.7%	22/162 = 13%	15/162 = 8.6%	34/162 = 21%	14/162 = 8.6%	5/162 = 3.1%	2

Q35 WAR for responses when excluding the unsure respondents

Statement **Overall n=323** **Test n=159** **Control n=162**		**Unsure** **Percentage (x/n)**	**WAR** **on Scale 1-5** **(Excluding 'unsure' respondents)**
Electric vehicles are too expensive to buy compared to similar sized conventional vehicles (petrol/diesel)	Overall	8.3 (27/323)	3.73
	Test	9.4 (15/159)	**3.63**
	Control	7.4 (12/162)	**3.96**
A plug-in hybrid would suit my needs better than a fully electric car	Overall	6.8 (22/323)	3.33
	Test	6.9 (11/159)	3.4
	Control	6.8 (11/162)	3.29
Electric cars look too unconventional to me	Overall	5 (16/323)	1.9
	Test	3.8 (6/159)	2.15
	Control	6.8 (10/162)	1.77
The speed and acceleration of electric vehicles is adequate for my needs	Overall	12.4 (40/323)	3.84
	Test	10.1 (16/159)	**3.74**
	Control	14.8 (24/162)	**4.01**
I am probably going to move house in the next couple of years	Overall	11.1(36/323)	2.81
	Test	10.1(16/159)	2.8
	Control	12.3 (20/162)	2.84
It would cost me too much to install a recharger at	Overall	25 (82/323)	2.8

home	Test	21.4 (34/159)	2.83
	Control	29.6 (48/162)	2.81
The total cost of ownership of an electric vehicle is too high on a per kilometre basis compared to conventional cars	Overall	24.1 (78/323)	2.63
	Test	15.1 (24/159)	**2.5**
	Control	33.3 (54/162)	**2.84**
The distance an electric vehicle can travel on one charge (range) is adequate for my day to day needs	Overall	7.7 (25/323)	3.57
	Test	4.4 (7/159)	3.61
	Control	11.1 (18/162)	3.58
I am concerned that I would find it difficult to locate public recharge stations	Overall	3.7 (12/323)	**3.92**
	Test	2.5 (4/159)	3.9
	Control	4.9 (8/162)	4.0
I am concerned that when I am driving a long distance there are no recharge stations on the way	Overall	1.2 (4/323)	**4.26**
	Test	0 (0/159)	4.23
	Control	4 (2.5/162)	4.34
An electric car would take too long to recharge when I am away from home	Overall	11.8 (38/323)	**3.45**
	Test	6.3 (10/159)	3.42
	Control	17.5 (28/162)	3.54
The lithium batteries are very polluting compared to lead batteries	Overall	31.9 (103/323)	2.23
	Test	18.2 (29/159)	**1.96**
	Control	45.7 (74/162)	**2.67**

36. Please indicate you OPINION about this statement "Electric cars are worth government investment"

	All (320 responses)	**Test A (n = 157)**	**Control B (n= 161)**
Agree	83.1%	86.6%	79.5%
Disagree	3.4%	2.6%	4.4%

Unsure	13.4%	10.8%	16.2%

37. Please briefly explain your response to the previous question

Category	Reason	Number respondents/320	Percentage respondents including this reason
1	Pollution reduction	165	51.6
2	Infrastructure investment	33	10.3
3	Government should provide incentives (including cheaper cars)	20	6.3
4	Government should kick-start the market (including government procurement)	26	8.1
5	It is the future/ EVs are innovative	23	7.2
6	Government should invest in research	12	3.8
7	Other benefits accrue (including reducing oil use, better for economy, reduces noise, better for health, reduce oil dependency)	53	16.6
8	Unsure	28	8.8
9	Other	25	7.8
0	No investment	11	3.4

38. [Incentives] Imagine the government took actions to encourage ownership of electric cars, how important would each of the following factors be to motivate you to buy an electric car?

315 responses, weighted average response shown for a scale 1-5

Preferred incentive	Weighted average response	Test (n=156)	Control (n=158)

A subsidy to make the cost of an electric car the same as an equivalent petrol/diesel car	**3.6**	**3.6**	**3.6**
Subsidy to reduce battery replacement cost	3.3	3.2	3.25
Free parking	2.68	2.85	2.6
No annual registration cost	2.97	3	2.9
Free recharger for you to install at home	3.41	3.4	3.25
Public recharge stations available in every town and on highways	**4.24**	**4.2**	**4.25**
Access to transit lanes no matter how many passengers in the car	2.7	2.8	2.75
Higher taxes on diesel/petrol that results in more expensive fuel	2.98	2.85	3.1
A tax deduction available at the end of the financial year in year of electric car purchase	3.24	3.1	3.25
Subsidies that make total cost of ownership of the electric vehicle equivalent to owning a similar sized petrol/diesel vehicle for 10 years	**3.5**	**3.3**	**3.6**
A recharger to install in my block of flats for residents'	2.96	**2.8**	**3.1**

use			
A recharge station available to me at my workplace	3.03	**2.9**	**3.1**
A recharge station is located in my residential street with exclusive parking for electric vehicles only	3.05	3	3.1
Reduction in company car tax for electric vehicles	2.88	2.85	2.9

39. How did you find out about this survey?

Email 206/315 = 65.4%

Facebook = 34/315 = 10.8%

Word of mouth 54/315 = 17.1%

Other (please specify) 21/315 = 6.7%

40. This question is optional. If a federal election were to be held next week for whom would you most likely vote in the lower house? (ie House of Representatives)

Voting Intention	Likelihood to buy EV	Test	Control	Likelihood to buy PHEV	Test	Control
Liberal/National Coalition 80/276 = 29%	2.8	2.9	2.7	2.9	3.15	2.75
Labor 50/276 = 18.1%	2.85	3	2.8	3.15	3.3	2.95
Greens 119/276 = 43.1%	3.1	3.2	3	3.1	3	3.05
Other (please specify) 27/276 = 9.8%						

Voters for any party were equally influenced by information when indicating likelihood to buy an EV compared to Control group people. However, Coalition and Labor voters were more likely to be influenced by information to buy a PHEV than Greens Voters, and Greens voters were more likely to buy an EV than either Coalition or Labor voters with or without being given information.

Percentage owning this no. cars v Voting intention in **House of Reps (lower house)** (n= 264)

No. Cars Owned	Coalition	Labor	Greens	Other	Total % owning this no. cars
1	22	21	48	9	50
2	33	12	47	12	37
3 or more	61	13	17	9	9
Car share or borrow	8	33	50	8	5
% respondents	28.8	17.8	43.2	10.2	100

Percentage owning this no. cars v Voting intention **in Senate** (n = 261)

No Cars Owned	Coalition	Labor	Greens	Other	Total % of sample owning this no. cars
1	17	16	59	8	49
2	26	9	54	10	37
3 or more	46	17	29	8	9
Car share or borrow	0	8	83	8	5
% total respondents	22.2	13.4	55.6	8.8	100

Half the respondents owned 1 vehicle and only 9% owned 3+ vehicles. Greens voters were more likely to own 1 or 2 cars, whereas owners of 3 or more cars were far more likely to be Coalition voters. Similarly people who borrowed vehicles or used a car share were much more likely to be Greens voters.

41. This question is optional. If a federal election were to be held next week for whom would you most likely vote in the upper house? (ie The Senate)

Senate voting intention	EV	PHEV
Liberal/National Coalition 60/273 =22%	2.75	2.9
Labor 37/273= 13.6%	2.75	3.1
Greens 152/273 = 55.7%	3.1	3.1
Other (please specify) 24/273 = 8.8%		

G2 Questionnaire 2 Results

Results: where N=102. Due to rounding, percentages may not add to 100%.

"More about attitudes to electric cars"

Section A

The information below may assist you in answering this questionnaire.

When compared to conventional petrol/diesel cars, electric cars have: the same safety features; lower carbon emissions when driven (magnitude of improvement depends on electricity source); are better for air quality in cities and for human health; are much less noisy; and EV batteries can be safely recycled. Diesel fuel is classified as a Class 1 carcinogen.

For the purposes of this questionnaire, electric vehicles (EVs) include:

1. **Battery Electric Vehicles (BEV) rely on an on-board rechargeable, storage battery using mains electricity as the only power source. Range is typically 150km but can be up to 400km depending on the model. Examples are: Tesla, Nissan Leaf.**

2. **Plug-in Hybrid Electric Vehicles (PHEV), have both an on-board battery, (recharged from mains electricity), and a petrol or diesel energy system (that generates additional power and/or range as required - includes range extended EVs). Typically PHEVs can drive 50km on electric and up to 600km on petrol/diesel.) Examples are: Mitsubishi Outlander, BMW i3 and Audi A3 e-tron**

On charging rates: Electric vehicles can be recharged at four possible rates (depending on the model).

1. **All EVs can trickle charge (up to 12 hours) from any standard household mains power point;**
2. **All EVs can be recharged on a specially installed 15 amp power point (4-6 hours);**
3. **Many models can be fast charged in 2 hours; and**
4. **A limited number of models can be super charged in 30 minutes (also called rapid charge).**

1. Gender

Female n= 46 = 45%

Male n= 55 = 54%

Other n= 1 = 1%

2. Number of cars currently owned or leased?

0 = 11%

1 = 58%

2 or more = 31%

3. Please choose the response that best describes the car you use most often

New = 44%

Used = 39%

I borrow a car or use a car share scheme/rental service as required 9%

Other= 5%

4. If you were to purchase an electric car could you install a power point in your own off-street parking spot to enable recharging?

Yes = 62%

No, it would be impossible to have a power point installed in my off-street parking spot 7%

No, I don't have off-street parking= 16%

Unsure 16%

5. Since your completion of the previous UNSW 2015 survey on electric vehicles, please indicate if your interest in EVs has changed.

1. Not at all interested 2. Less interested 3. About the same 4. More interested 5. Much more interested

Total Weighted average on a scale of 1-5 = 3.5

Female WAR = 3.56

Male WAR = 3.47

NB: only 1 respondent was less interested.

6. Imagine you are considering buying a car, how significant are the following sources of information about particular car models you might consider buying?

Data expressed as Weighted Average based on a scale of 1 – 5 where:

1. Not at all interested 2. Less interested 3. About the same 4. More interested 5. Much more interested

Source of information	Overall WAR	Female WAR	Male WAR

Prior knowledge about particular car models	3.63	3.50	3.73
Family and friends	3.0	3.28	2.76
Car sales person	2.24	2.57	1.96
Formal information sources (e.g. magazine articles, car brand websites, articles written by motoring journalists, TV shows)	3.9	3.93	3.87
Advertisements about specific car models	2.22	2.15	2.27
Test drive	4.1	4.15	4.05

The results of the first questionnaire (Qu 22) showed that 41.2% of respondents thought online articles were the most important of those listed and the print media was next most important for 20.6%, which is corroborated by the results here (Qu 6) showing that, apart from test drive, formal information sources were most important.

7. Have you ever consulted the Australian Government's *Green Vehicle Guide* website?

Response	Overall total	Female %	Male %
Yes	23%	20	25
No	52%	46	55
Unsure	7%	9	5
I didn't know one existed	20%	26	15

8. Do you know anyone who owns an EV (either fully electric or PHEV)?

Response	Overall total %	Female %	Male %
Yes	55%	63	49
No	44%	37	47
Unsure	2%	0	4

Section B

Questions relating to EVs

The cost of batteries for electric vehicles is the biggest factor in the higher overall cost of EVs compared to conventional cars. A recent study in the journal *Nature* predicts that because the price of batteries is falling, EVs will achieve price parity with similar conventional cars by 2020-21 (http://www.nature.com/doifinder/10.1038/nclimate2564).

For the purposes of this questionnaire you should assume that price parity has already occurred (ie EVs cost the same as similar model conventional vehicles).

9. Assuming purchase price of EVs is the same as similar conventional cars, please select a response to the following questions.

How likely are you to buy a fully electric car (BEV)? (n=102)

How likely are you to buy a PHEV (plug in hybrid)? (n=102)

Type of EV	Gender	1. Least likely	2. Not very likely	3. Neither likely nor unlikely	4. Somewhat likely	5. Most likely	Weighted average
BEV	Female	0	11	18	51	20	3.83
BEV	Male	2	13	18	36	31	3.82
BEV	All respondents N=102						3.83
PHEV	Female	2	7	20	49	22	3.83
PHEV	Male	2	7	31	36	24	3.73
PHEV	All respondents						3.78

N=102

These results (Females WAR 3.83/5 v males WAR 3.82/5) compared to first questionnaire show a much higher weighted average score (previously females scored 3/5 and males scored 2.8/5 for likelihood to buy an EV).

10. *Apart from price,* what is the *main* factor that would impact on your decision to buy a *fully* electric vehicle? (open response) n= 101 respondents

Factor	**Overall**	**Female**	**Male**
Range of the vehicle	41/101	19/46 =41%	22/55 =40%
Availability of recharge stations (adequate network)	26/101	15/46 =**33**%	11/55=**20**%
Battery issues	1/101	0/46 = 0%	1/55 = 1.8%
Environmental factors	9/101 = 9%	5/46 = **11**%	4/55 = **7.3**%
Recharge time	2/101	2/101=4%	0/55 = 0 %
Car model features eg performance, aesthetics, storage capacity	19/101	7/46 =**17**%	12/55 = **21.8**%
Cost issues eg running costs	4/101	0/46 = **0**%	4/55 = **7.3**%
Other	7/101	3/46 =6.5%	4/55 = 7.3%

11**. Apart from price, briefly list *any other factors* that might impact on your decision whether to buy a *fully* electric vehicle.** (open response) response mentioned by % of respondents

Range of the vehicle = 23/102 =23%

Availability of recharge stations (adequate network) 23/102 = 23%

Battery issues 7/102 =7%

Environmental factors 14/102 = 14%

Recharge time 12/102 =12%

Car model features 39/102 =41%

Cost issues 9/102= 9%

Other 6/102 = 6%

The range of the vehicle and the availability of an adequate network of rechargers were the most important *other* impact.

12. ***Apart from price*, what is the *main* factor that would impact on your decision to buy a *Plug-in Hybrid* Electric Vehicle (PHEV)?** (open response)

Range of the vehicle = 16/100

Availability of recharge stations (adequate network) 14 /100

Battery issues 2 /100

Environmental factors **17** /100

Recharge time 1/100

Car model features **29** /100

Cost issues 11/100

Prefer PHEV to BEV 7 /100

Prefer BEV to PHEV 2/100

Other 5/100

Providing information about Plug in Hybrids (PHEVs) at the start of this questionnaire showed respondents still had concerns about range and availability of rechargers but less than car model features and environmental factors.

13. *Apart from price*, briefly list *any other factors* that might impact on your decision whether to buy a *PHEV*. (open response)
Range of the vehicle = 13/78 = 16.7% respondents mentioned this issue

Availability of recharge stations (adequate network) 8/78 = 10.3%

Battery issues 3/78 = 3.8%

Environmental factors 5/78 =6.4%

Recharge time 2/78 = 2.6%

Car model features 35/78 = 44.9%

Cost issues 13/78 = 16.7%

Other 6/78 = 7.7%

Car model features were the dominant secondary concern about PHEVs for respondents.

14. The governments of countries with the highest uptake of EVs have implemented programs to
Incentivise EV purchase. Assuming purchase price of EVs is equivalent to similar conventional cars; from the following list of statements please rank, in order of importance, which would have the most influence on your purchasing decision.

For this question Survey Monkey will only allow you to select three options, please put the most important as 1.
NB Survey Monkey presented these options in a rolling manner so that, except for Other, each option appeared in different order for different respondents.

Government Incentive Program	Most important	Second in importance	Third in importance	**Total respondents nominating this incentive (n)**
Programs enabling free access to high occupancy vehicle transit lanes for EVs regardless of passenger numbers	2	5	12	**19**
Exclusive parking for EVs in public spaces	1	3	8	**12**
Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs	3	10	3	**16**
Government support for the roll out of a fast recharger network every 50 km on highways and in country towns	34	20	9	**63**
Legislation to ensure you can use a credit/debit card to pay for your recharging	10	8	14	**32**

away from home, rather than requiring paid membership of privately owned recharger networks				
Programs that buy EVs for government use (procurement) that, (every 3-5 years), will increase the size of the second-hand EV market	4	9	8	**21**
Government support to install rechargers at hotels, motels and other tourist destinations	2	5	1	**8**
Government support to install rechargers at shopping centre car parks and other local destinations	7	8	10	**25**
Where there is no off-street parking, government support to install rechargers on the street in front of private residences, on request of EV owners, with parking exclusively for EVs	10	5	9	**24**
Government support to install rechargers at workplace carparks	2	3	5	**10**
No annual registration fees for EVs	19	14	10	**43**
Free parking in public places for EVs	7	12	10	**29**
Other	1	0	3	**4**

The most important incentive for respondents was:

- "Government support for the roll out of a fast recharger network every 50 km on highways and in country towns" (63 respondents nominated this program as important)
- followed by "No annual registration fees for EVs" for 43 respondents
- and "Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of privately owned recharger networks" for 32 respondents.

15. Optional: Please briefly outline any other point, *other than price*, which you think might be helpful to understand factors that impact on purchasing an EV. *For Example:* Car customers would buy EVs if….. OR I would not buy an EV because… N=54

1. Believe that the models on the market now are inadequate for their needs including inadequate range = 15/54 = 27.8%
2. Believe that current models are too expensive: two respondents specifically noted the models were too high end for them = 2/54 = 3.7%
3. Believe that more information about EVs should be provided 9/54 = 16.7%
4. Believe that more recharging infrastructure should be provided 12/54 = 22.2%
5. Would like to receive incentives that reduce costs associated with ongoing ownership 10/54 = 18.5%
6. Believe that better sales and servicing from dealers would increase uptake 6/54 = 11.1%
7. Would like to see petrol made more expensive 1/54 = 1.9%
8. Believe battery related issues need to be resolved 2/54 = 3.7%
9. Want better government support for measures that reduce GHG emissions and other pollution 8/54 = 14.8%

0. Other 4/54 = 7.4%

This question was included to provide respondents an opportunity to express opinions about EVs that they might think was particularly important or had not had the chance to express in previous questions. Slightly more than half (54%) answered this question. An EV owner provided additional insights relating to reactions of their passengers.

Results based on gender and car condition on purchase – these factors were revealed in the first questionnaire to provide widely different results compared to other factors.

	Female N=	Male	New car	Used car	Borrowed

	46	N =55	**n= 45**	**N=39**	**car n=9**
Gender: Female	100	0	49%	33%	44%
Male	0	100	51%	64%	56%
No. cars owned: 0	13	9	0	0	89
1	54	60	67%	67%	11
2 or more	33	31	33%	33%	0
Car driven most often					
New	48	42%	100	0	0
Used	30	45	0	100	0
Borrowed	9	9			100
Other	13	4			0
Ability to have electric power point at parking space					
Yes	57%	64	69%	64	22
No -unable	9	5	9%	9	0
No off-street spot	20	13	16%	8	56
Unsure	4	18	7%	21	22
Has level of interest in EVs changed since last survey?					
Much less					
Less	0%	0	0	0	0
About the same	2	0	0	0	0
More	52	62	60%	23	56
Much more	35	29	33%	11	33
Weighted average	11	9	7%	5	11

	3.54	3.47	3.47	3.54	3.56
Sources of information			WAR	WAR	
Prior knowledge	**3.5**	**3.73**	2.73	3.56	3.33
Family /friends	**3.28**	**2.76**	3.93	2.92	3.22
Car sales person	**2.57**	**1.96**	2.38	2.05	2.33
Formal info sources	**3.93**	**3.87**	3.91	3.87	3.89
Advertisements	**2.15**	**2.27**	2.29	2.31	2.00
Test Drive	**4.15**	**4.05**	4.13	4.10	3.67
Consultation of Australian Government's Green Vehicle Guide website					
Yes	20	25	20%	26	11
No	46	55	51%	54	34
Unsure	9	5	9%	8	0
Didn't know one existed	26	16	20%	13	56
Do you know anyone who owns an EV?					
Yes	63	49	47	59	67
No	37	47	53	38	33
Unsure	0	4	0	3	0
Assuming purchase price of EVs is the same as similar conventional cars, please select a response to the following questions			Weighted average score =		

How likely are you to buy a fully electric car (BEV)? How likely are you to buy a plug-in hybrid electric car (PHEV)?	3.83 3.83	3.82 3.73	3.71 Weighted average score = 3.76	3.85 3.87	4.11 4

In questionnaire 2, with respondents asked to assume price parity of EVs with conventional cars, women and men were equally likely to buy an EV, whereas in the first questionnaire women were more likely to say they would buy an EV.

Q 14. For this question (14) each respondent could nominate three factors they thought were important programs that would influence their decision to buy an EV.

Government Incentive Program	**Total respondents nominating this incentive**	**Female** **45%**	**Male** **55%**	New N=45/102 = 44%	Used N=39/102 = 38%	Borrowed N=9/102 =9%
Programs enabling free access to high occupancy vehicle transit lanes for EVs regardless of passenger numbers	19/102 = 19%	11/46=24%	8/55=15%	9/45=20	6/39=15	0/9=0
Exclusive parking for EVs in public spaces	12/102=12%	5/46= 11%	7/55=13	8/45=18	3/39=8	1/9=11
Programs to develop information to help EV drivers e.g. smartphone app to locate publicly accessible recharging stations, list of car dealerships selling EVs	16/102=16%	12/46=26	4/55=7	11/45=**24**	2/39=**5**	1/9=11
Government support for the roll out of a fast recharger network every 50 km on highways and in country towns	**63/102=63%**	25/46=54	38/55=69	26/45=**58**	24/39=**62**	7/9=78
Legislation to ensure you can use a credit/debit card to pay for your recharging away from home, rather than requiring paid membership of	**32/102=32%**	16/46=35	16/55=29	11/45=**24**	14/39=**36**	3/9=33

privately owned recharger networks						
Programs that buy EVs for government use (procurement) that, (every 3-5 years), will increase the size of the second-hand EV market	21/102=21%	8/46=17%	13/55=24	6/45=**13**	13/39=**33**	1/9=11
Government support to install rechargers at hotels, motels and other tourist destinations	8/102=8%	2/46=4%	6/55=11%	3/45=7	4/39=10	1/9=11
Government support to install rechargers at shopping centre car parks and other local destinations	25=25%	11/46=24%	14/55=25	11/45=24	9/39=23	2/9=22
Where there is no off-street parking, government support to install rechargers on the street in front of private residences, on request of EV owners, with parking exclusively for EVs	24=24%	12/46=26	12/55=22	13/45=29	5/39=13	5/9=56
Government support to install rechargers at workplace carparks	10/102=10%	4/46=9%	6/55=11	3/45=7	3/39=8	1/9=11
No annual registration fees for EVs	43/102=**42**%	21/46=46	22/55=40	18/45=**40**	22/39=**56**	2/9=22
Free parking in public places for EVs	29/102=28%	12/46=26	17/55=31	14/45=31	10/39=26	3/9=33
Other	4/102=4%	2/46=4%	2/55=4%	2/45=4	2/39=5	0/9=0

Appendix H: Publication

The following material has been accepted for publication in the journal Transportation Research Part D.

Comment on "Consumer purchase intentions for electric vehicles: Is green more important than price and range?" K. Degirmenci, MH Breitner *Transportation Research Part D* 51 (2017) 250-260

By Gail Broadbent BSc Dip Ed MEM, School of Biological, Earth and Environmental Sciences, University of New South Wales, Australia; Email: ghbroadbent@gmail.com

This recently published article about electric vehicles (EVs) is a reminder of the importance of well identified premises used in the design of research and the need for substantiated assertions.

My primary concern regards the statement contained in their Discussion p 255, "For example, in the United States a transition from combustion to EVs **would** in fact increase CO_2 emissions, because **half of the electricity is produced from coal**." (my emphases)

The authors use dated source material to back up this statement about electricity production in the United States of America (US). The information source Degirmenci & Breitner (2017) used was Hasan & Dwyer (2010) who wrote "A transition in the US from gasoline to electric vehicles **could** increase CO_2 emissions, because half of US electricity is produced by coal", for which Hasan & Dwyer did not provide any reference.

The paper by Degirmenci & Breitner (2017) in my opinion falls short by not ascertaining this claim about US electricity generation. A quick internet search reveals more recent information on this matter. For example, the US Energy Information Administration (US EIA, 2017a) lists that in 2016, 30.4% of electricity in the US was generated using coal. The Degirmenci & Breitner (2017) statement needs to be substantiated with recent, reliable sources given the very dynamic nature of electricity production. Historical data (US EIA, 2017b) reveals the changing nature of energy sources for electricity production in the US, for example the year before in 2015, 33% was generated from coal, demonstrating its decreasing role.

The authors' outdated information source allows a misleading interpretation of the resulting greenhouse gas (GHG) emissions from electricity consumed by EVs compared to the use of gasoline by Internal Combustion Engine Vehicles (ICEVs). Furthermore, the subtle change of qualification from "could" to a more definite "would" perhaps leads the reader to believe that making the transition from ICEVs to EVs definitely would increase CO_2 emissions in the US. Degirmenci & Breitner (2017) fail to justify the assertion that a transition from gasoline to electricity **would** increase CO_2 emissions.

Conventional ICEVs have fixed emissions per kilometre, depending on the model, whereas BEV emissions are variable, depending on the electricity supply. Calculations (see Table 1) to compare ICEV emissions with BEV emissions can be made for cars used in countries with poor and good grid mixes. Ang & Su (2016) calculated the aggregated carbon intensity (ACI) of electricity production at the global and country level; while most countries decreased their ACI in the period 1990 – 2013, some increased. The grams of CO_2 emissions per kilometre of travel for BEVs can be calculated based on data from laboratory tests (US EPA, 2017) and the ACI of a particular country where a car is being driven. Improvements in thermal efficiency of electricity generation, switching to cleaner fossil fuels and reducing fossil fuel share reduce ACI values (Ang and Su, 2016); as ACI values become lower so too do the emissions from BEVs. Most countries use a mix of fuel sources to generate electricity; the share of coal is different for each country and in many is dropping, for example South Africa used 94% coal in 2012 (World Coal Association, 2016) whereas in the UK (UK DBEIS, 2017) coal use dropped to 9.3% in the 4th Quarter of 2016 (half of the previous year's share). Different states in the US have widely different grid mixes e.g. West Virginia in 2015 used 94% coal while California used 0.2% coal (US EIA, 2017c).

It can be demonstrated that for most countries using BEVs results in lower emissions per kilometre of travel than using ICEVs. The following formulae, using data provided from the US Environment Protection Agency (EPA) (US EPA, 2017) and 2013 ACI values for particular countries (Ang and Su, 2016), were used to calculate emissions per kilometre for ICEVs and BEVs. Popular models of vehicles available in 2013 and 2016 were selected; these readily accessible and consistent figures could be used to calculate emissions /km for any model of vehicle published on the EPA's fuel economy website (US EPA, 2017). While it is recognised that manufacturers produce models specific to individual markets, and that as newer models are developed emissions may decrease, Table 1 gives an indication of the efficacy of EVs compared to ICEVs.

EV Formula: $$ACI\ emissions\ \times EV\ consumption\ \times 1000 =\ gCO_2/km$$

(units) $$\frac{kg\ CO_2}{kWh} \times \frac{kWh}{km} \times \frac{g}{kg} = gCO_2/km$$

ICEV Formula: $ICEV\ emissions\ \times\ ICEV\ consumption\ \times 100\ =\ gCO_2/km$

(units) $\frac{gCO_2}{L} \times \frac{L}{100\ km} \times 100 = gCO_2/km$

Table 1 Aggregated carbon intensity (ACI values)(Ang and Su, 2016) **for electricity production in select countries (including five most intense) and vehicle emissions per kilometre travel**

Country	ACI 2013 (kg CO_2 /kWh)	Model of car	EVs Published(US EIA, 2017d) Fuel Economy kWh/km [kWh/100 miles]	ICEV Published[11] fuel consumption (combined) L/100km [US gall/ 100 miles]	Vehicle Emissions g CO_2 /km
ICEV examples					
US models		2016 VW Golf 1.8L automatic turbo(gasoline)		8.0 [3.4]	187.9
		2016 BMW 328d 2L turbo (diesel)		6.8 [2.9]	210.3
		2013 VW Golf 2.5L automatic (gasoline)		8.9 [3.8]	209.1
EV examples					
Iraq[12]	1.0151	2016 VW e Golf	0.18 [29kWh/100mile]		182.7
		2016 Tesla Model S AWD 85D	0.21 [34kWh/100mile]		213.2
South Africa	0.9333	2016 VW e Golf	0.18		168

[11] ibid
[12] Iraq's ACI in 1990 was 0.5512 but subsequent wars have seen a dramatic change in its ACI.

		2016 Tesla Model S AWD 85D	0.21	196
Poland	0.8135	2016 VW e Golf	0.18	146.4
		2016 Tesla Model S AWD 85D	0.21	170.8
India	0.7927	2016 VW e Golf	0.18	142.7
		2016 Tesla Model S AWD 85D	0.21	166.5
Australia	0.7806	2016 VW e Golf	0.18	140.5
		2016 Tesla Model S AWD 85D	0.21	163.9
China	0.6916	2016 VW e Golf	0.18	124.5
		2016 Tesla Model S AWD 85D	0.21	145.2
United States	0.4858	2016 VW e Golf	0.18	87.4
	0.4858	2016 Tesla Model S AWD 85D	0.21	102.0
Germany	0.4639	2016 VW e Golf	0.18	83.5
		2016 Tesla Model S AWD 85D	0.21	97.4
United Kingdom	0.4382	2016 VW e Golf	0.18	78.9
		2016 Tesla Model S AWD 85D	0.21	92.0
France	0.0550	2016 VW e Golf	0.18	9.9
		2016 Tesla Model S AWD 85D	0.21	11.6
Sweden	0.0144	2016 VW e Golf	0.18	2.6
		2016 Tesla Model S AWD 85D	0.21	3.0

Notes for the table:

Conversion rates:

1 mile = 1.61 km;

1 US liquid gallon = 3.785 Litres

1 pound = 453.59 g

1 US gallon of gasoline (no ethanol) produces 19.6 pounds CO2 (or 8890.41g CO2/ gallon = 2349g CO2/L gasoline) (US EIA, 2017d).

1 US gallon of diesel produces 22.4 pounds CO2 (or 10160.47 g CO2/gallon = 3092.61g/L diesel)(US EIA, 2017b).

The examples used in Table 1 demonstrate that even in the five countries with the highest carbon intensity for their electricity production (Iraq, South Africa, Poland, India, Australia), the smaller BEV selected had lower emissions per kilometre than the ICEVs selected. Only in Iraq and South Africa did the larger more powerful Tesla have slightly higher emissions than at least one of the smaller ICEVs selected. For all other countries, which have lower ACI values, these BEVs produced fewer emissions than these ICEVs.

However it should be noted that (National Transport Commission, 2014) have compared real world data with type approval values for car emissions and found increasing divergence. They showed, based on European Environment Agency data, type approval values (EU averages) for ICEV CO_2 emissions went from 170g/km in 2001 to 120g/km in 2015, a decrease of 30%. However their evidence (n=134,000) indicates there is an increasing divergence between laboratory results and real world performance of new cars: real world data (EU averages) suggests that new European cars actually went from 183 g CO_2/km in 2001 to 167g CO_2 /km in 2015, a decrease of less than 10%. If this assertion is applied it may be expected that the benefits of using BEVs are even higher than demonstrated above.

Further to the above arguments, different countries would achieve different total emissions from their fleets depending on a number of factors: the numbers of vehicles, the types of vehicles favoured by drivers and the design rules. For example, in Australia in 2013, the national average carbon emissions from new passenger cars and light commercial vehicles was 192 g CO_2/km, ranging from 144 g CO_2/km for the smallest passenger vehicles to the highest of 288 g CO_2/km for the largest SUVs (National Transport Commission, 2014).

Additional evidence to rebut the authors' assertion can be applied from a number of sources:

1. (Renault, 2011) conducted a Life Cycle Analysis (LCA), for company purposes, of its *Fluence* vehicle in its two motorisations – the ICEV (in both forms – petrol and diesel) and fully electric vehicle (BEV). Calculations for electricity used British and French data separately. While production of EVs results in higher GHG emissions than ICEVs due to the batteries, operationally the BEV outperformed the ICEVs, even with the grid mix of that time, due to BEVs' global efficiency and lower primary energy needs for driving (Renault, 2011). Including production inputs, when using French electricity the *Fluence* EV had lower total GHG emissions compared to the *Fluence* ICEVs after only about 2 years average use, whereas using British electricity it was after about 4 years (Renault, 2011). As a country's electricity transitions to renewables, these results should improve.
2. (Needell et al., 2016) conducted LCAs and calculated that if a BEV was driven, using average European electricity for 150,000 km, emissions were reduced by 10% compared to diesel vehicles, and a 24% improvement over petrol vehicles. However, they noted other aspects of EVs supply chain resulted in other forms of pollution. Improvements in battery technology, production and recycling techniques may reduce such pollutants.
3. Furthermore, research into the potential of EVs used for personal travel to meet current US policy targets for transport emissions reductions of 26-28% of 2005 levels by 2025, determined that EV models available in 2013, even with the prevailing US electric grid mix, were capable of meeting the target (Needell *et al.*, 2016), although to meet higher targets electricity sources would need to decarbonise. Those US states with relatively low coal use for electricity production should have higher emissions reduction than these averages.

In summary, while in other fields using older data may be acceptable, the fields of electricity production and EVs are dynamic and caution should be exercised when relying on such material in modern research. I am concerned that Degirmenci & Breitner (2017), by inadequate attention to sources of information, are perpetuating out of date notions about the usefulness of electric vehicles in mitigating GHG emissions from motorised personal transport.

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