The Challenges of Establishing The Electric Vehicle in Ireland

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DECLARATION OF ORIGINALITY

SEPTEMBER, 2010

The substance of this thesis is the original work of the author and due reference and acknowledgement has been made, when necessary, to the work of others. No part of this thesis has been accepted for any degree and is not concurrently submitted for any other award. I declare that this thesis is my original work except where otherwise stated.

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Date: 17/9/2010

DEDICATION

This thesis is dedicated to my parents, John and Ann Bradley, and my brothers and sisters for all their support throughout the years.

ABSTRACT

This thesis investigates the challenges of establishing the electric vehicle (EV) in Ireland and how the Irish government and industry are trying to meet them. It further seeks to provide information on Irish consumers' attitudes towards the electric vehicle and their willingness to purchase it.

The review of the literature showed that the Irish government is investing significant funds in trying to establish the market for the electric vehicle and position itself as a world leader in adopting the electric vehicle. The EV will also have an important role to play in how Ireland meets its targets for CO_2 reductions towards 2020.

Climate change and use of fossil fuels are driving the need for increased use of renewable energy and increased energy independence while reducing the greenhouse gas emissions that are the leading cause of climate change. The transport sector is almost completely dependent on the use of fossil fuel and resultantly is one of the largest sources of these GHG emissions.

These issues are leading to the design and production of more energy efficient and environmentally friendly vehicles. The ultimate goal is to achieve a zero emissions vehicle.

The electric vehicle is presently the only vehicle being mass produced that has the potential to be zero emissions. There are however issues that customers may not be willing to overlook such as the lower range of the vehicle and the length of time it takes to recharge. Vehicle cost is also an important issue that customers may not overlook.

Knowing what the consumer's attitudes are towards the EV and their willingness to purchase them is important as these new vehicles begin to appear in the showrooms. The consumers will be vital to how successful this market becomes.

Using an online questionnaire methodology, in a sample of 118 consumers, the major conclusion to be drawn from the research is that the vehicle price, the convenience to recharge and vehicle range were the three most essential issues for the consumers if they were purchasing an EV. The success of the electric vehicle market may depend on what measures are taken to overcome them.

ACKNOWLEDGMENTS

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- The respondents who completed the web-based survey
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1.0 Introduction

Establishing the electric vehicle (EV) in Ireland will present many challenges for the stakeholders involved such as the government, industry and consumers. As electric vehicle technology continues to progress, with major investment projects by governments and leading car manufacturers, the potential to move the transport sector away from its traditional reliance on fossil fuels comes ever nearer to becoming a reality.

Many governments internationally, concerned about climate change and energy security, are seeking to reduce greenhouse gas emissions and pollution effects from the transport sector. This will prevent increased environmental damage and promote energy independence.

However, car buyers may have concerns about issues such as cost, battery range, location and availability of recharge infrastructure and other design features before committing to EVs.

It is in this context that the electric vehicle (EV) has assumed a new focus for governments, manufacturers and consumers. How receptive the Irish consumers are to the new EV will help determine how successful it may become here.

1.1 Background

While studying for the Master's degree in Environmental Systems at Galway-Mayo Institute of Technology (GMIT), the author became further interested in engineering and environmental matters relating to energy use and climate change.

Of particular interest was how damage from excessive levels of pollution could be eliminated using new technologies and in this way reduce or prevent further environmental damage. There is no single solution to the problems faced. Competitive interests in many sectors can both help and prevent advanced solutions that are necessary. Among these is the re-emergence of the EV as a technical solution to a large problem. There is increased awareness and agreement that the global fossil fuel reserves of petrol

and diesel are finite. This has led to the renewed and increased interest in electric vehicles by governments and car manufacturers and a willingness to increase investment in new EV projects.

There is therefore a changing policy and investment approach that seems to have the electric vehicle as a focus. It will become important for electric vehicle manufacturers to have a clear picture of the demand potential from the car owner's point of view.

Based on these considerations, this thesis will investigate the attitudes of a group of car owners in Ireland to the electric vehicle, and their willingness to purchase them. As new EVs are once again being produced, the consumers will ultimately be a key factor in the success or failure of the EV market.

1.2 Research Question

It is not possible to answer every research question that may occur to the author, if only because of time limitations and available resources [(1)]. The research question chosen for this research was:

To what extent do car owners in the sample possess favourable or unfavourable attitudes to the electric vehicle in Ireland?

1.3 Scope of the Research

The study is both exploratory and descriptive and applies a web-based survey questionnaire to obtain quantitative data on the attitudes of consumers to electric vehicles. It is not a research study of the whole field of the electric vehicle. The focus is on the attitudes of consumers towards battery electric vehicles which are an important source of valuable data. In reality, if car owners do not wish to buy electric vehicles because they do not like them or because of the price, battery problems or other factors, then the efforts of legislators and manufacturers will be less than productive.

Because of the limited nature of this research, it will not be possible to generalise to the total population of car owners and conclusions and recommendations are confined to the

data from the sample studied. The research is limited to study of the non-hybrid electric vehicles. This will be referred to as battery electric vehicle (BEV) or electric vehicle (EV).

The research however will be an important foundation for further research on attitudes of consumers to electric vehicles.

1.4 Objectives of the Research

The objectives of the research are:

- To examine studies in the literature relating to environment, energy, legislation in a national and international context, and the electric vehicle from its historic beginning.
- To gain an understanding of the current levels of development in electric vehicle manufacturing, with specific reference to technical development factors and major car manufacturers internationally.
- To develop an online questionnaire to research consumer attitudes towards electric vehicles in a population of Irish car owners.
- To identify consumer attitudes to electric vehicles in the targeted population of Irish car owners.

The research objectives will be achieved by reviewing the literature on electric vehicles and related environmental and legislative matters and by conducting a web-based survey on the attitudes of car owners towards electric vehicles.

1.5 Organisation of the Thesis

The thesis contains the following chapters:

Chapter 1: Introduction

The topic for research is introduced and the path and direction of the survey is outlined. The objectives and research question are presented along with the scope of the research.

Chapter 2: Literature Review

A comprehensive review of the literature is given. The literature is based on previous research in various publications with particular emphasis on books, journal articles and reports.

Chapter 3: Research Methodology

The chapter provides details of the questionnaire design, sampling and the target population and discusses the use of an online method for surveying respondents.

Chapter 4: Results and Discussion

The three sections of the questionnaire provide data which are presented for each question in sequence with comments and pie-charts. The results are discussed with a view to identifying areas of benefit to consumers, issues of potential difficulty, possible solutions and limitations. The literature will also be consulted for more enlightenment on the findings.

Chapter 5: Conclusions and Recommendations

Conclusions are drawn from the research. Recommendations are made and note taken of areas for further research on the topic.

1.6 Summary

This introductory chapter gives a brief outline of how new electric vehicles can be a part of the solution to the climate change and energy issues we face. The research is described along with the design and scope of the study. A brief statement on the contents of each chapter is included. In the following chapter, a review of the literature will be presented.

2.0 Literature Review

2.1 Introduction

Climate change has become, and will continue to be, of extreme importance to all nations. This chapter will detail how at the core of the issue is the use of fossil fuels and the transport sector which is so dependent on the use of oil for its energy supply. Reducing global reserves of oil and increasing global demand and costs will have an ever increasing impact on both the environment and economies of countries globally. The transport sector is the heartbeat of almost all industrial nations. It is a large source of global greenhouse gases emissions (GHGs). While it is dependent on oil it will be greatly affected by rising fuel costs while also greatly impacting the extent to which climate change occurs.

The development and widespread use of the electric vehicle (EV) could prove to be a solution to these problems faced by the transport sector. The success of the EV will depend on how the consumer views the new technology and how willing they are to purchase it. Governments and car manufacturers are making great efforts to establish the electric vehicle. It is in this context that the author will seek to determine the attitudes of the Irish consumers towards the electric vehicle and their willingness to purchase it.

2.2 Environment and Energy – electric vehicle market drivers

It has now become internationally accepted that climate change is one of the greatest challenges of our era [(2)]. It will potentially impact on all nations, for present and future generations, as well as the global natural environment. At the core of this issue is the use of fossil fuels as the primary source of our energy supplies. The transport sector is almost entirely dependent on their use.

Climate Change

Natural planetary cycles have occurred many times in the past that led to periods of both cooling and warming of global temperatures. These resulted in various ice ages and interglacial warming periods. These gradual changes from one climate state to another

have occurred over many thousands of years with the duration of the different periods themselves lasting even greater lengths of time. The last 2 million years have been largely characterised by these changes from one period to another with the average interglacial period lasting in the order of 100,000 years. The most recent ice age which covered most of Ireland in ice occurred just 15,000 years ago [(3)].

The main concern regarding the climate change debate is whether climate change has suffered from **anthropogenic (human) influence** *or* if it is simply a **naturally occurring cycle**. The core of the argument for anthropogenic influenced climate change is centered *on how emissions of the so called green house gases (GHGs), such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are affecting global climate conditions*. A vast amount of research is ongoing globally into this subject [(4)].

The international scientific body that has been tasked with collecting the ever increasing amounts of research into the climate change argument is the **UN's Intergovernmental Panel on Climate Change (IPCC)**. It was formed in 1989 by the United Nations Environment Programme (UNEP) and World Meteorological Organisation. Its role is to review and assess scientific evidence gathered worldwide and periodically provide world governments assessments on what was happening to the world's climate. It is composed of three Working Groups that compile separate reports. All the information it receives is collated and reviewed for any necessary revisions by hundreds of experts in contributing countries all over the world. As a result the IPCC is seen as the leading scientific body on assessment of global climate change. The IPCC has issued assessment reports in 1990, 1995, 2001 and 2007.

In a summary of its latest climate change report [(4)] the IPCC details how atmospheric concentrations of GHGs have been determined over the previous 650,000 years using ice core samples. The observed levels of CO_2, CH_4 and N_2O concentrations in 2005 were higher than at any other time in this period spanned by the ice cores. CO_2 levels had increased over 70% alone since the pre industrial era before the year 1750. The pre industrial era had CO_2 levels of typically 280ppm (parts per million) compared to a level of 379ppm in 2005. According to data from the NOAA/ESRL Mauna Loa Observatory in Hawaii [(5)] the mean average CO_2 recorded for 2009 was 387.35ppm compared to its value of 379.76ppm for 2005. The IPPC report also showed that levels of CH_4 had more

than doubled to 1779 ppb (parts per billion) and N_2O levels had risen 18% to 319 ppb in 2005. Data also links varying levels of CO_2 to varying average temperatures. What is most alarming is how the rate at which GHGs have increased in recent history and the levels they are currently at are far beyond anything observed from the ice core samples.

Figure 2.1 presents data on anthropogenic GHG emissions that shows fossil fuel based CO_2 emissions to be the biggest source of GHGs. Other GHGs are presented in terms of their equivalent CO_2 emissions (CO_2-eq).

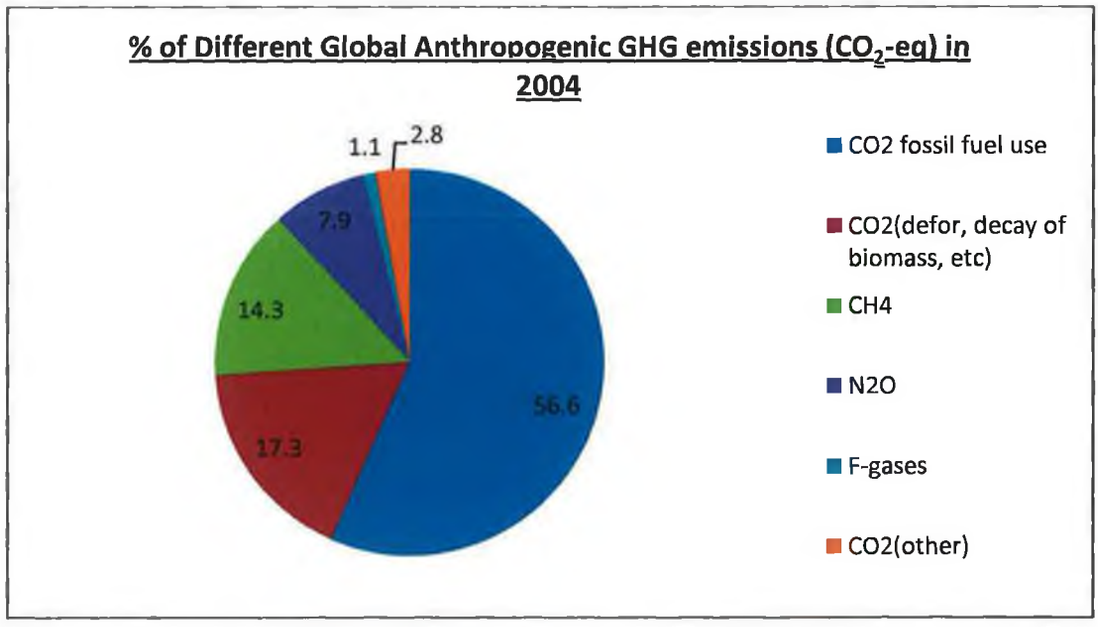

Figure 2.1: Different Global anthropogenic GHG emissions (CO_2-eq) in 2004 [(4)]

The data presented in Figure 2.2 details the source of CO_2-eq emissions based on different type of sectors. From this it is clear that the transportation sector is a major global source of GHG emissions as it is almost entirely dependent on the use of fossil fuels. The IPCC AR4 Working Group I report contains a further vast amount of scientific based evidence that supports the argument that *climate change is occurring and will continue to do so [* (4)*]*.

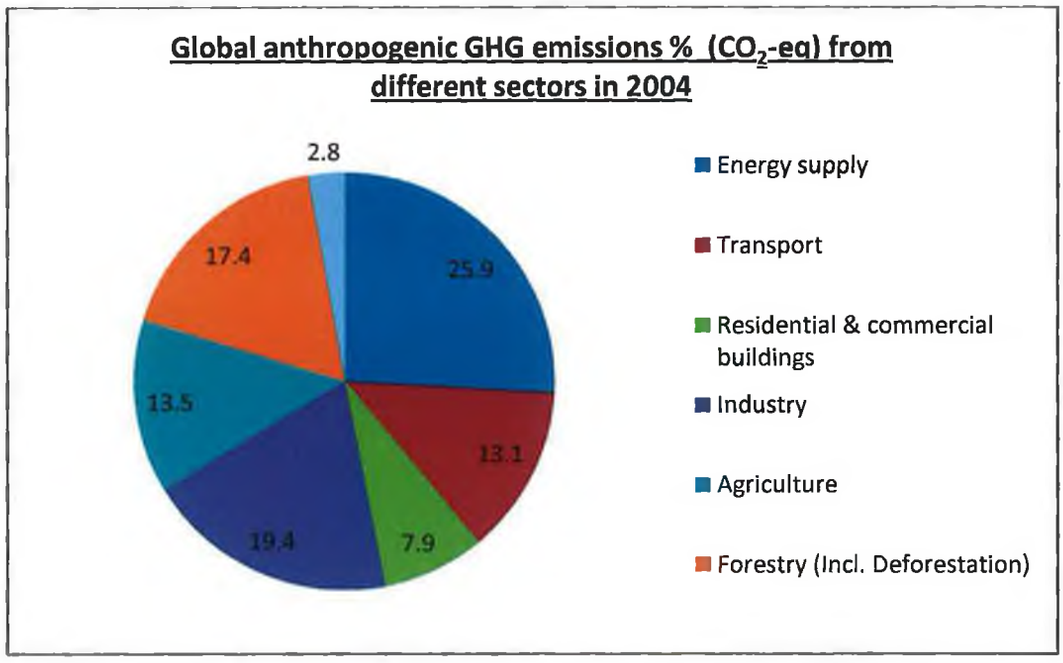

Figure 2.2: Global anthropogenic GHG sector emissions % (CO_2-eq) in 2004 [**(4)**]

The report [(4)] presents a summary of the three main reports that make up the IPCC Assessment Report 4 (AR4). Each of these three reports is compiled by a separate IPCC Working Groups (WG I, WG II, WG III). WG II compiles a report on the scientific evidence **impacts**, **adaptation** and **vulnerability** aspects of the climate change. Some of the most commonly known potential impacts include rising sea levels, reduced polar and glacial ice, rising global average temperatures both land and sea based. The potential impacts on food supply, freshwater resources, ecosystems, weather patterns and health are also extensively covered with a view to the different scenarios in levels of climate change.

The scale of **impacts resulting from climate change will depend largely on what mitigation measures are taken** (WG III). Many impacts can still be delayed, reduced or avoided altogether. Much will depend on the approach to our use of fossil fuels, the leading source of anthropogenic GHG emissions. These emissions are at the core of the climate change challenge, the impacts of which will only become clearer over many years to come. *Reducing the dependence of the transportation sector on fossil fuels* will be key to dealing with the emissions from this important sector of the global economy.

Fossil Fuel

Since the beginning of the Industrial Revolution mid 18th century, the use of fossil fuels such as coal, oil and natural gas has become the lifeblood which modern economies depend upon. This dependence on fossil fuels began with coal and has progressively increased ever since. Coal today is still a big source of electricity supply globally and one of the most abundant of the fossil fuels. Its use is also projected to increase greatly with the increased need for energy globally. Figure 2.3 details the extent to which fossil fuels are the primary source of global energy supplies with renewable energy sources supplying only 1.7% of global electricity supply.

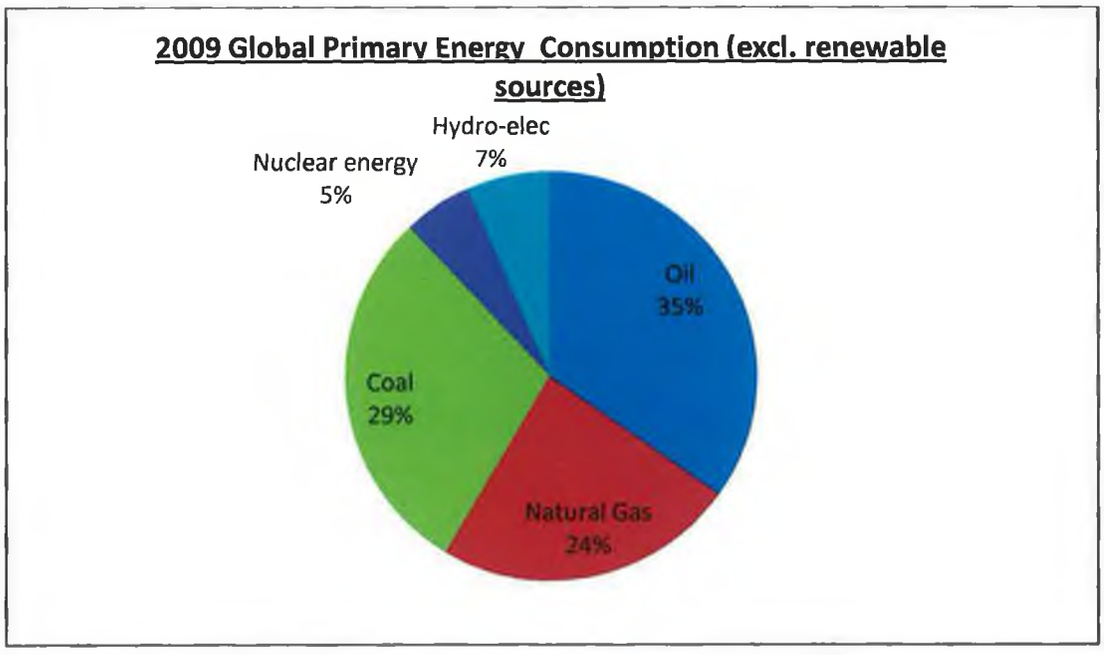

Figure 2.3: 2009 Global Primary Energy Consumption excl. renewable sources [**(6)**]

The BP report [(6)] also details the varying extent to which fossil fuel is being consumed regionally worldwide as can be seen in Figure 2.4 and to what extent various countries are consuming the greatest portion of these fossil fuels (see Figure 2.5).

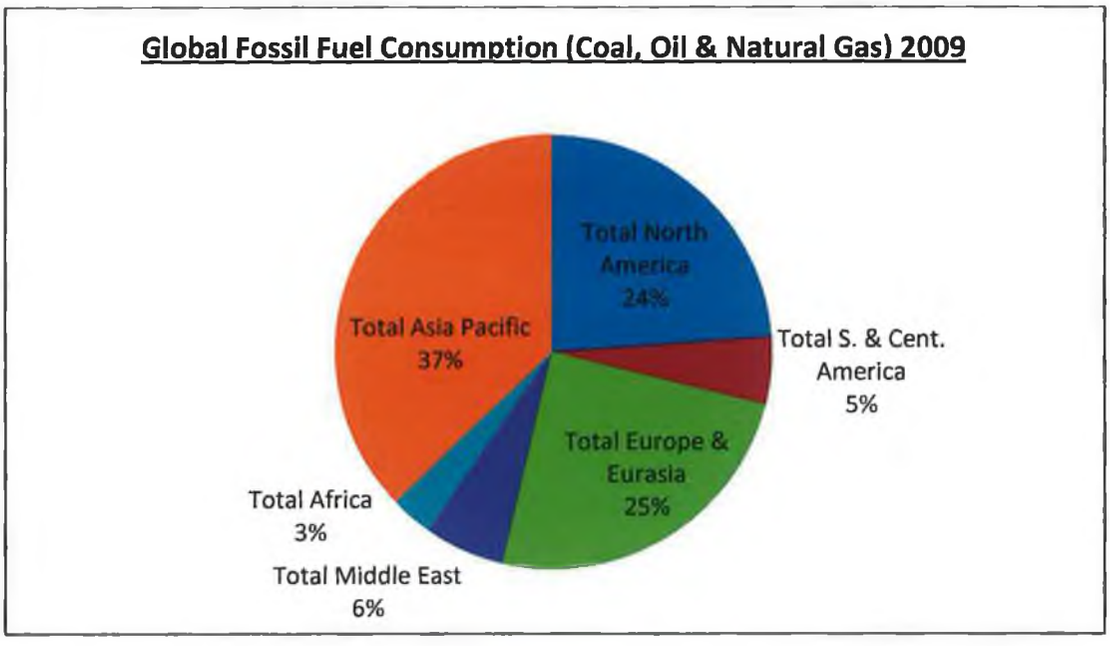

Figure 2.4: Global Fossil Fuel (Coal, Oil & Natural Gas) Consumption 2009[**(6)**]

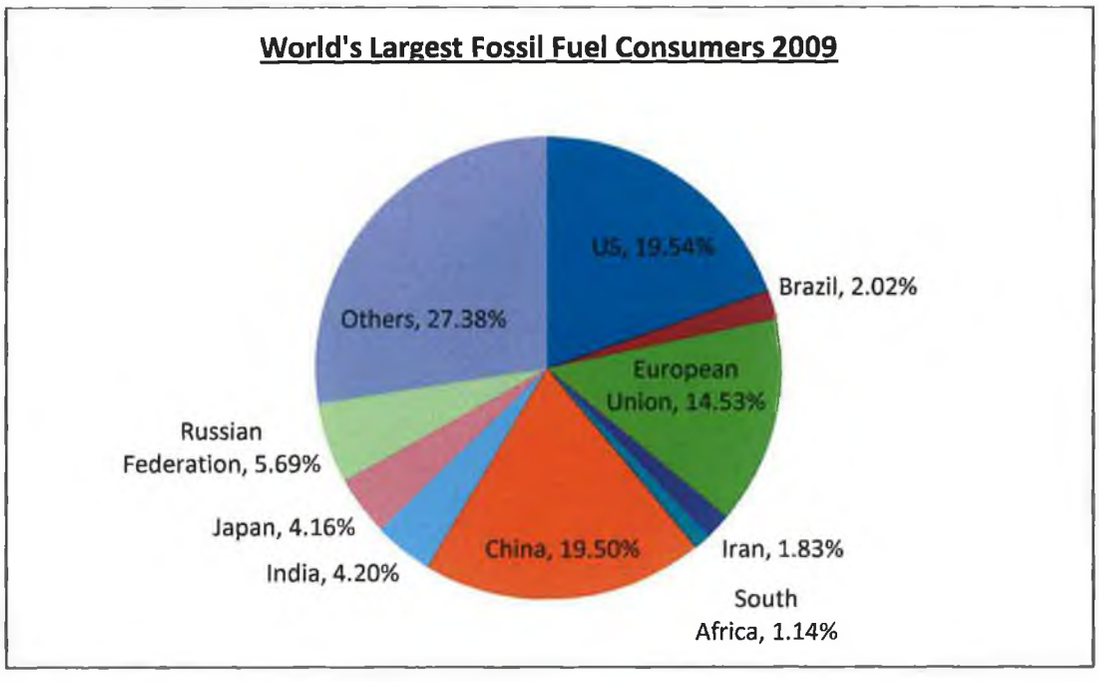

Figure 2.5: Worlds Largest Fossil Fuel Consumers 2009 [**(6)**]

According to a 2010 report by the US EIA [(7)] world *energy consumption is forecast to increase 49% above 2007 levels by year 2035*. Non- OECD total energy demand may increase up to 84% compared to 14% increase in OECD countries. Transportation accounts for nearly 30% of total delivered energy in the world. The global daily demand by year 2035 for liquid fuel could increase over 28% above 2007 levels. The report

forecasts that *87% of the liquid fuel increases will be due to the transportation sector* which will by the year 2035 account for 61% of the total global liquid energy demand. In OECD countries the transportation sector already accounts for almost 60% of liquid fuels [(7)].

In the EU **the transport sector is the fastest growing energy consumer and producer of GHGs**. The number of passenger cars in the EU-27 increased 45% from over 158 million in 1990 to almost 230 million in 2006 according to Eurostat data [(8)]. The *transport sector accounts for over 31% of total EU energy consumption.* Road transport is by far the largest portion of this as shown in Figure 2.6. Further data in Figure 2.6 illustrates the transport sector which is almost wholly dependent on fossil fuels as an energy source. The use of renewable energy mainly in the form of biofuels has gradually increased in recent years in the EU road transport sector. In 2006 it was still only 1.5% of the EU transport sector energy use [(8)]. This has increased from a level of 0.1% in 1995 to the 2006 level with Germany the largest user of all EU members.

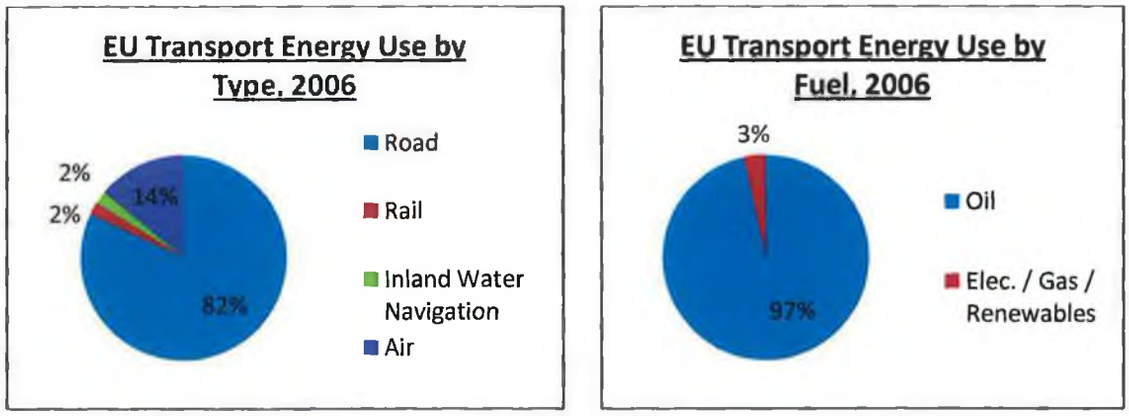

Figure 2.6: EU-27 Transport Sector Energy Use by Type and Fuel, 2006 [**(8)**]

The transport sector produced 19% of EU's total CO_2-eq emissions in 2006. It was also the only sector not to achieve a reduction in annual average GHG emissions from 1990 to 2006. Road transport is the largest source of emissions by far in this sector with 93% of the transport related CO_2-eq emissions [(8)]. Cars account for 72.7% of passenger transport and road transport for 45.6% of goods transport.

It is clear how highly dependent the EU transport sector is on fossil fuel use. The dependence on fossil fuel for such an important industry also makes it extremely vulnerable to **increasing costs in crude oil prices**. Security of supply is also an extremely important factor in the costs and supply of this source of energy. According to the latest Eurostat figures [(9)], crude oil production accounted for only 13.4% of total primary energy production for the EU-27 in 2006. The dependency of the EU-27 on net imports of crude oil and petroleum has increased from 75.6% in 1990 to 83.6% in 2006 with EU-27 oil production having peaked in 1999 [(9)] .

The dependency upon imports for sources of oil in the EU places **security of supply** as a highly important factor in the sourcing of this energy resource. Table 2.1 shows how the importation of crude oil is spread across numerous nations as suppliers and how some of these have increased and decreased in the percentages they supply between 2000 and 2006. Figure 2.7 is used to graphically illustrate the changes in the top 6 of these suppliers that comprised over 77% of crude oil imports in 2006 [(9)].

Table 2.1: Origin of crude oil imports for EU-27[**(9)**]

	EU-27 Origin of Crude Oil Imports (%)							% change
	2000	2001	2002	2003	2004	2005	2006	2000 - 2006
Russia	20.3	24.8	29.0	30.9	32.8	32.4	32.9	62.07%
Norway	21.0	19.6	19.3	19.2	18.9	16.8	15.5	-26.19%
Libya	8.2	7.9	7.3	8.3	8.7	8.7	9.3	13.41%
Saudi Arabia	11.8	10.4	10.0	11.1	11.2	10.5	8.9	-24.58%
Iran	6.4	5.7	4.9	6.3	6.2	6.1	6.3	-1.56%
Kazakhstan	1.8	1.6	2.5	2.9	3.9	4.5	4.7	161.11%
Nigeria	4.1	4.7	3.5	4.2	2.6	3.2	3.5	-14.63%
Iraq	5.7	3.7	3.0	1.5	2.2	2.1	2.9	-49.12%
Algeria	3.9	3.5	3.4	3.4	3.8	3.9	2.9	-25.64%
Azerbaijan	0.7	0.8	1.0	1.0	0.9	1.2	2.1	200.00%
Venezuela	1.3	1.6	1.7	0.9	0.8	1.2	1.9	46.15%
Others	15.0	15.5	14.4	10.2	8.1	9.4	9.2	-38.67%

These figures indicate how increasingly dependent the EU-27 have become on Russia as the main source which increased its supply over 62%. Supplies from Norway, our second largest supplier, decreased 26%. Production of oil in Norway itself has steadily decreased from a peak in 2001 by 30% overall compared to 2009. Domestic EU production in the UK has also steadily decreased over 50% from peak levels in 1999 levels by 2009 [(6)]. This all makes clear the further **increasing dependence on foreign crude oil supplies for EU nations**.

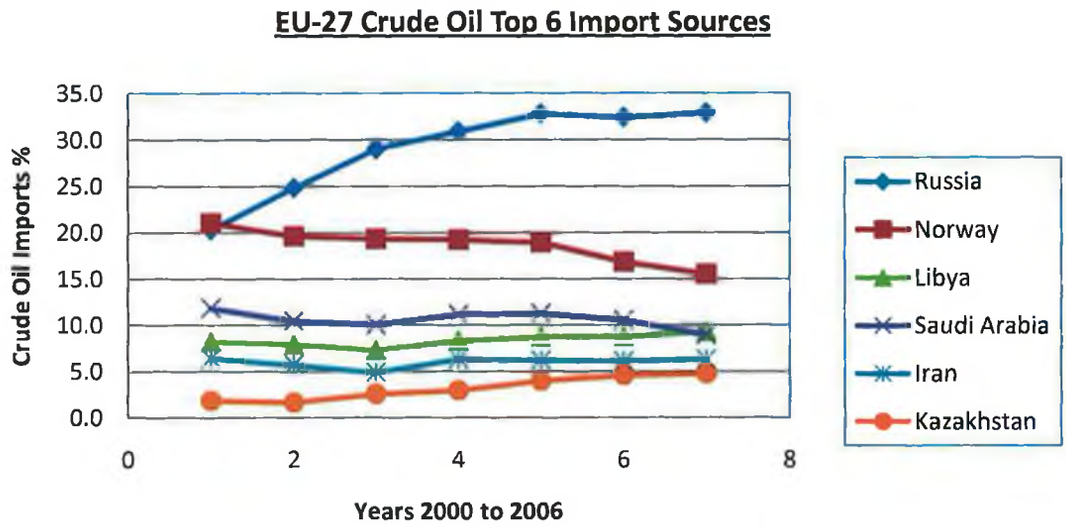

Figure 2.7: Top 6 EU-27 crude oil import sources [**(9)**]

With demand for and use of crude oil forecast to greatly increase by 2035 the cost of this resource is likely to rise. Though there have been many forecasts for when peak oil production will occur it is not likely to occur for several decades at least. New reserves have been discovered such as those off West Africa and other non-conventional sources such as oil-sands become more economically viable to produce at higher oil prices. According to the 2010 USEIA report [(7)] oil prices are likely to continue to rise. It forecasts that prices may fall as low as $51 per barrel or rise to as high as $210 when compared to a 2008 level of $100 per barrel. These would represent best and worst case scenarios with differing market conditions for each. Its reference case or likely case forecasts prices of $133 per barrel in 2035, which would represent a 33% rise on its 2008 level.

The report [(7)] also details how over 55% of the world's proven reserves in 2010 are in the Middle East and almost 80% of reserves are located in just eight countries including oil sands in Canada. With the forecasts for increased global oil consumption, the vast proportion being transport sector related, it is clear that increasing costs for this resource will lead in similarly increasing costs for the transport sector. With fossil fuel use being considered to be the leading cause of anthropogenic impacts on climate change due to the extent of their use largely over the last 30 years, these forecasted increases in fossil fuel use have the clear potential to cause greater impacts on the environment. The increasing

costs will also result in greater costs for the transportation sector which is so dependent on the use of fossil fuel.

2.3 International Environmental Agreements

The first international summit on environmental issues was held in Stockholm in 1972. Attended by 113 countries, it was known as the **United Nations Conference on the Human Environment** and it laid the foundations for the global environmental co-operation and governance among nations. As a direct result of this conference the United Nations Environment Programme was established.

In 1987 an international agreement called the **Montreal Protocol** dealt with controlling ozone damaging emissions. This agreement is seen as the most successful international treaty on environmental issues with 196 signatory nations. It resulted in 95% reduction of manmade damaging substances and it is forecast that the damage to the ozone may have recovered by the end of the 21st century. The damage occurring to the ozone was discovered in the 1970's and so it will take almost 100 years for this to have recovered [(10)]. This may serve to emphasise how long and severe the ongoing issues surrounding GHG emissions may persist even after reduction measures are taken.

The successor to the 1972 international conference was the **UN Conference on Environment and Development** in 1992 held in Rio de Janeiro, or the '**Earth Summit**' as it became known. It was attended by 172 nations, including 108 heads of State. The principle theme of the conference was environment and sustainable development [(11)]. This conference resulted in the United Nations Framework Convention on Climate Change (UNFCCC). This treaty set out the objective of controlling the levels of GHGs in the atmosphere to limit human interference with the climate. Though not a binding agreement itself it led directly to the adoption of the **Kyoto Protocol** in 1997. Drawing on work already completed by the IPCC, the Kyoto Protocol set legally binding targets on industrialised nations to *reduce levels of GHG emissions to 5% overall below 1990 levels by the year 2012*. The Treaty came fully into effect following Russia's ratification of the Protocol in November 2005. By late 2009, 187 countries had ratified the agreement. The USA did not ratify it.

Since 1995 an annual *Conference of Parties (COP*) to the 1992 treaty is held by UNFCCC. The locations of the COP meeting vary and it is from the host city's name that agreements achieved are often known, such as the 1997 Kyoto Protocol (COP 3) or the most recent **Copenhagen Accord** [(2)] from the COP 15 meeting in 2009. As binding agreements under the Kyoto Protocol do not extend beyond 2012, it was hoped that COP 15 would result in a new treaty to succeed Kyoto. No new legally binding agreement was achieved. The participant nations signed the Copenhagen Accord [(2)] listing a series of objectives and commitments. One of the principal aims is to *limit global average temperature rises to 2°C* above pre-industrial era temperatures.

EU Legislation

The EU has been at the forefront of efforts to combat climate change and was one of the first signatories to the Kyoto Protocol. The EU has made great efforts to meet the targets required of it under this agreement as it is one of the largest sources of GHG emissions in the world. The EU's efforts to tackle climate change have resulted in a wide range of new policies and programmes in important sectors such as energy and transport [(12)] among others.

To reduce emissions from cars, the EU adopted a three step strategy in 1995. As part of this a voluntary agreement was reached in 1998/1999 with European, Korean and Japanese car manufactures, comprising 95% of car sales, to limit CO_2 emissions to 140 g CO_2/km by 2012. In addition to this a CO_2/car labelling Directive (1999/94/EC) for improved consumer information and fiscal measures to promote efficient cars were used to reduce CO_2 emissions. In June 2000 a scheme was created (Decision No. 1753/2000/EC) to monitor CO_2 emissions from new cars. The overall emissions target set for the three steps was 120g CO_2/km by 2012.

In 2001, the EU passed a Directive (2001/77/EC) for the promotion of energy from renewable sources. A 2003 Directive on Promotion of Biofuels use and renewable energy fuel in transport (2003/30/EC) required 5.75% of transport fuels in member states to be from biofuels by 2010.

In April 2009 new legislation (Regulation 443/2009) was passed to set legal CO_2 limits for new passenger cars as the manufactures were not meeting targets despite making progress. A new target of 130g CO_2/km by 2012 for 65% of the fleet was set with 100% of the fleet required by 2015. This new Regulation replaced the previous voluntary agreement and emissions monitoring scheme mentioned earlier. A further target of 95 g CO_2/km has been set for 2020. Further legislation is proposed to also set new limits for light duty vehicles. Rolling resistance of tyres has been shown to account for up to 30% of the CO2 emissions for a typical car [(13)]. A new tyre design Regulation (EC No. 661/2009) was introduced to help improve fuel efficiency in this area. Tyre labelling, Regulation EC No. 1222/2009, is further aimed at improving fuel efficiency by providing improved information to the consumers.

In 2005 the EU began a GHG Emission Trading System (ETS) under Directive 2003/87/EC [(12)]. The ETS is another major EU policy towards combating climate change and achieving reduction targets required under the Kyoto Protocol. This established a trading scheme for CO_2 credits among the major industrial GHG emitting sectors in member states. Not all industry sectors are included in the scheme. This scheme has since been revised under the Effort Sharing Decision 2009/29/EC. Sectors that are not under the ETS, such as transport, are required to achieve a 10% average reduction in emissions by 2020. However this target for the non-sectors is different in each country ranging from -20% (e.g. Ireland) to +20% for Bulgaria [(14)].

The Clean Vehicles Directive (2009/33/EC) aims to increase use of more environmentally friendly and efficient road vehicles. It requires that public authorities consider the lifetime use including emissions in the procurement process for new vehicles. There is also extensive further legislation dealing with noise pollution, air quality and emissions of gaseous and particulate matter from combustion engines.

The EU has set ambitious targets for further emissions reductions and energy efficiency. The targets it has set are known as the '20-20-20 targets'. The EU renewable energy Directive (2009/28/EC) requires 20% reduction of GHG on 1990 levels, 20% energy consumption from renewable sources and 20% reduction in primary energy use through increased efficiency. This new Directive further requires that 10% of transport sector

energy must be from renewable sources. The new Directive repealed two previous ones (2003/30/EC and 2001/77/EC).

2.4 Electric Vehicles

History of EVs

Electrically powered vehicles are not by any means a new concept. Their beginning actually goes back to the early 19th century when motor vehicles themselves began to appear. Alessandro Volta is credited with inventing the first battery in the year 1800 by using a combination of copper and zinc which became known as a Volta pile. Following Michael Faraday's 1831 discovery of electromagnetic induction the first electric motor was displayed in 1832. About 1835 the first electric battery driven carriages are reported to have been used in Holland and the USA [(15)]. The lead acid starter battery, or Planté battery, was the next major advance in 1859 allowing for the charge and discharge of electric power.

In the 1860's and 1870's electromechanical generators appeared and the electricity supply industry was created. The first vehicles using the new battery appeared in the early 1880's in France and England. At about this time the internal combustion engine (ICE) was also developing and both forms were being used to power increasing numbers of vehicles as the new technologies developed further. By 1903 there were more electric vehicles than ICE vehicles in London. In 1912 there were more than 30,000 electric vehicles in the USA. However at this time there were already over 900,000 ICE vehicles in the USA and a similar amount in Europe [(15)]. Mass production of cars such as Henry Ford's Model T had started years earlier. In 1914 of the 568,000 cars produced in the USA, 99% were ICE vehicles [(16)].

The increased availability of cheap oil was one of the factors favouring the ICE. Other factors such as lower costs, mass production, better technology and range of travel all helped to ensure that the electric vehicle could not hope to compete with the ICE. The modern era of transportation had started and the electric engine vehicle would have practically no part to play in it for decades to come.

Modern Era Electric Vehicles

The electrical vehicle never fully disappeared. Many small scale production models and experimental cars were produced at various times since the early 1900's. In the later 20th century increasing attention was being given to the levels of pollution from ICE vehicles from environmental and health perspectives. Many countries have operated EV programmes of differing levels in attempts to evaluate and establish electric vehicle markets. Table 2.2 below lists just some of those countries and programmes.

Table 2.2: Previous EV programmes in various countries [**(17)**]

Country	Programme	Vehicles	Year
Austria	EV Promotion in Vienna	1782 EVs (passenger & LDV)	1995-2001
Switzerland	Large Scale Test with Light EVs	EVs	1996-2001
Germany	e-mobile Rugen	60 EVs (minibuses, vans and cars)	1992-1996
EU	ZEUS	270 EVs, 980 low emissions other types	1996-2000
Japan	Clean Energy Vehicle Diffusion Plan	Target of 3.65 million clean energy vehicles, incl. 100,000 EVs	1998-2010
USA (California)	Zero Emission Vehicle (ZEV) mandate	Set legal requirements for EVs sales	1990-2010
Sweden	Clean Vehicles with electric Drive	250 EVs	1993-2000

Prior to 1990 there had been very little interest shown by many of the largest car manufactures to develop the electric car market. This changed with the introduction by the state Air Resources Board (ARB) in California of the Zero Emission Vehicle (ZEV) mandate [(18)]. In response to growing levels of urban air pollution it introduced the ZEV legal requirement on seven of the largest car manufacturers that by 1998 zero emissions vehicles must account for 2% of car sales. This was to increase to 10% by 2003. This led the seven leading manufactures to renew research and development of EV technology.

The kick-start provided by the new ZEV law led to ***new electric battery vehicles being produced*** by GM, Ford, Chrysler, Toyota, Nissan and Honda. Some only produced a few hundred units and almost all cars were on a lease only basis. *These EVs had ranges of up to 160 km and recharge times up to 8 hours.* However, by 2003 the car manufacturers had almost all of the few thousand cars produced repossessed and scrapped and all the production lines stopped. Only Toyota and Ford sold a few hundred units to buyers. The manufacturers challenged the ZEV law and ultimately won. ***Manufacturers cited lack of consumer interest and costs as reasons for ceasing the production.*** It was argued by many that the manufacturers and other interest groups never had any serious intention of fully developing these EVs to the market [(19)].

Current EV Developments

There is once again renewed interest in the production of EVs. There are numerous companies that are near to or have already introduced new models of all electric vehicles. *They plan to mass produce them which it is hoped will further reduce costs based on economies of scale.* Some of the new EV models are listed below in Table 2.3.

Table 2.3: Examples of new EV models released or due out.

Manufacturer	**Model**	**Range km (predicted)**	**Battery Type**	**Location**	**Year**
Nissan [(20)]	Leaf	160 km	Li-ion	Japan, EU, USA,Ire(2011)	2010
Mitsubishi [(21)]	i-MiEV	160 km	Li-ion	Japan, UK	2009
Renault [(22)]	Fluence ZE (+3 others)	160km	Li-ion	EU	2012
TESLA [(23)]	Roadster. Model S.	340 km 250-480 km	Li-ion	USA, EU, Asia	2008 2012
Ford [(24)]	Focus	160 km	Li-ion	USA, EU	2012
BYD [(25)]	e6	300 km	$LiFePO_4$	Asia, EU	2011
VW [(26)]	E-Up e-Golf	130 km 160 km	Li-ion Li-ion	EU (EU Trial only)	2013 2011

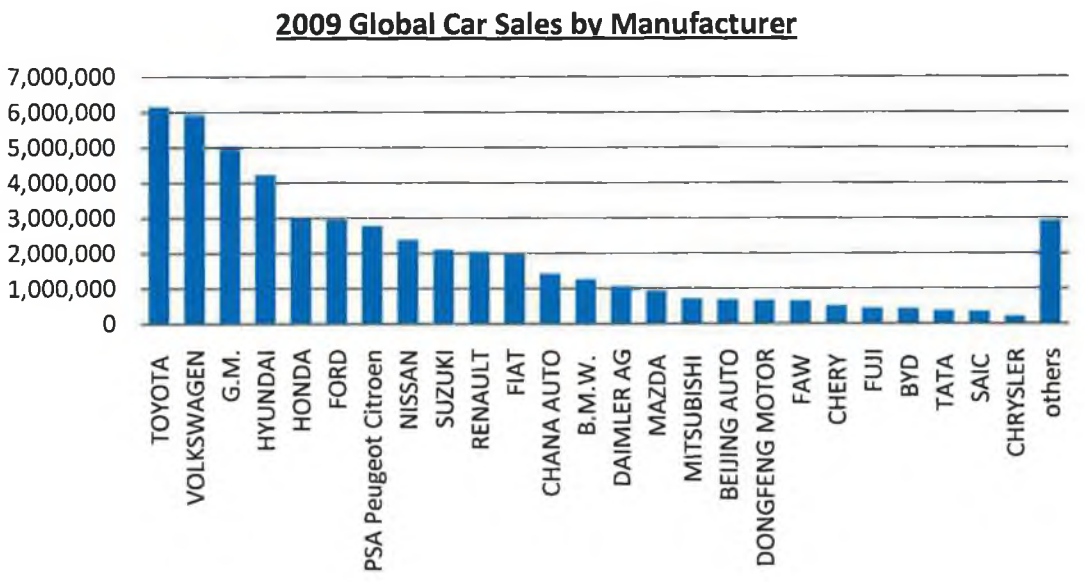

Figure 2.8: 2009 Global Car Sales Figures by Manufacturer [**(27)**]

In Figure 2.8 above, the graph shows the order of, and number of sales by, the world's leading car manufacturers. There are ***varying approaches being taken*** by the various car manufacturers to the type of vehicle they intend to produce. The president of Honda's R&D has been quoted as saying they *"lack confidence" in electric vehicles and that it was "questionable" as to whether consumers would overlook issues regarding range and charging [* (28)*].* Toyota have plans to release a small 'city' sized electrical car and a new version of their previously discontinued Rav4. These companies, and others among the top manufacturers, are focusing on other technologies to the EV in the short term.

The focus on *alternative technology options* being pursued by manufacturers will result in fewer fully electric vehicle model options. Among these are existing technology options like the hybrid fuel cars or the newer form of ***plug-in hybrid electric vehicles (PHEV).*** In 2011, GM is introducing a model called the Chevy Volt which they term an '***extended range electric vehicle (EREV)***'. This car will do the first 40 miles using an electric battery. Beyond this an additional 300 miles will be provided by a gasoline engine that will generate the required electricity to power the car's electric motors. There is some difference between PHEV and EREV but essentially both can be plugged in to recharge with electricity for shorter range distances. Longer range is provided for by fossil fuel use.

Another technology alternative is the conventional ***hybrid electric vehicle*** *(HEV)* such as the Toyota Prius and Honda Civic Hybrid. These hybrids use fossil fuel but with greater efficiency due to use of electric motors and batteries that are recharged when a car is in use. ***The HEVs are not plug-in electric vehicles*** such as the PHEV or the fully battery electric vehicle (BEV).

A further alternative technology is the development of ***Hydrogen fuel cell cars***. These cars would operate similar to conventional vehicles by re-fuelling with hydrogen liquid fuel. The use of hydrogen would result in zero polluting emissions with water (H_2O) the only tailpipe emission. However this technology is largely in the research phase and would face quite a significant problem as insufficient infrastructure exists for its use. The fuel must be maintained at high pressures to use in a liquid state. This alone would require new infrastructure for both the vehicle owner and fuel suppliers.

Increasing production and use of ***biofuels*** is also being used to further lessen dependency of foreign oil imports and reduce CO_2 emissions. New and more sustainable sources of biofuels such as second generation biofuels plants and research into biofuels produced by algae are further ways in which the countries are seeking to reduce their use of fossil fuels.

Battery Technology

Battery technology has progressed enormously in recent years as greater funding and research into battery design is conducted. New research into batteries is also being driven by the need for storage systems for renewable energy systems. The advanced battery production industry is almost entirely based in Japan, China, and South Korea. The USA announced plans in 2009 to spend $2.4 billion on grants to support the electric vehicle market. This included increased research and need for increased production capacity [(29)]. As part of its Recovery Plan spending, the USA is building over 30 new battery production facilities and by 2015 plans to have 40% of global battery production capacity. These will lead to a significant reduction in costs, weight of batteries and increased battery lifespan.

Previous rechargeable batteries had used Nickel Cadmium (NiCd), Nickel Metal-Hydride (NiMH) or Lead acid which is the oldest form. **The *modern EVs are typically using batteries known as Lithium ion Li-ion* batteries**, (see Table 2.3). This new type of battery has greater energy density that allows for batteries to be smaller, weigh less, perform better and are over 90% recyclable. This material is widely in use in the latest laptop computers and mobile phones. Recharges of between 1000 and 2000 cycles are expected to be typical with Nissan offering an 8 year or 100,000 mile warranty in the USA with the Leaf model. The Chinese company BYD [(25)] has become one of the world's largest rechargeable battery suppliers. They are using a lithium iron phosphate ($LiFePO_4$) battery which they manufacture for their EVs.

The cost of the Li-ion battery is a significant element in the cost of the electric vehicle. Costs for the battery units are difficult to determine. A 2010 report puts the cost at over $1000/kWh [(30)]. Nissan estimates the cost of producing the Li-ion battery for the Leaf model at over £6000 per 24kWh battery or $387/kWh [(31)]. A report by the USGS [(32)] details how Lithium supplies may become cheaper with increased production from South American sources which contain the world's largest lithium reserves. It also says rechargeable batteries are the market with the largest growth potential for lithium.

The head of Volkswagen R&D in the USA has stated that he expects the range of electric cars to improve to over 800km within 10 years. The Li-ion batteries they currently use have more than twice the capacity of those used 5years earlier at Tesla Motors [(33)]. Lithium ion polymers are a more recent development giving greater energy density than standard Li-ion batteries

EV Costs

According to Nissan [(20)], the pre-orders for the Leaf are over 23,000 in Japan and the USA since April 2010. With pre-orders due to start in Europe (Portugal, Ireland and UK) from September 2010, over 12,000 people have registered an interest. With hopes of increased sales to 300,000 globally by 2014 [(31)] this will be key to reducing the costs further. The Nissan Leaf will cost €34,995 (excluding grants) in Ireland.

Mitsubishi have priced their i-MiEV slightly lower at €33,995 (excl. grants) in Ireland [(21)]. They had previously announced a significantly higher price in the UK but reduced it to compete when Nissan announced their vehicle price. In the USA the Leaf is over $8,000 cheaper than the new GM Volt model PHEV.

Other similar model costs are not presently available. These prices include purchase of the battery. However, Renault proposes to price their vehicle in 2012 ***based on lease of the battery*** to help reduce the purchase cost of their EV [(22)]. PSA Peugeot Citroen completed a deal to sell 100,000 units of the Mitsubishi i-MiEV model in Europe under the Peugeot and Citroen brands [(34)] so it is likely they will be similarly priced.

The costs of charging the Leaf model's 24 kWh battery are estimated by Nissan to be €232 per year based on 19,000 km use and night-time charging rates of €0.0745 per kWh [(20)]. This would be quite similar for other models. As it will have no direct emissions, it is in the lowest possible band for road tax and may become exempt. Maintenance is expected to be another area of savings as it will have far less moving parts with the traditional engine and other mechanical features removed. Electric motors replace them to power the vehicle.

Life cycle cost studies have been conducted to forecast the cost of using an EV compared to the alternatives such as the conventional ICEs. Most recent LCC studies, carried out before pricing of new EVs was confirmed, placed the EV as having a higher cost over the different periods of time in the studies. According to an SEAI publication [(35)], it would cost almost €9000 more over a ten year period. However, this may not accurately reflect the current costs of ICEs or EVs. The life cycle costs of the vehicle will depend on the purchase price, level of maintenance required, electricity costs and most importantly the depreciation of the cars' value over time. This will depend greatly on how long the batteries in the new models are found to last. This may vary also depending on the recharging habits of the users. Further research in this area following the introduction of the EVs may show how the batteries are performing over a number of years.

Without government or industry incentives to purchase, the present cost of the EV would likely be too much for consumers given the lifecycle costs.

EV Recharging Infrastructure

Many countries have stated their intent to develop domestic electric vehicle markets, (see Table 2.4). While the vehicle manufacturers are again producing EVs there are other significant issues which must be addressed in each country. Among these is the need for recharging infrastructures. As the range of the EVs may prove to be a weakness in selling them the need for a recharging infrastructure is critical to their success. Key to success in this will be co-ordination between governments and the energy providers. Many countries including Ireland have already started installing a network of recharging stations.

Standardisation of the recharging systems used in the EVs will be important. This will ensure the universal ease of access and safety for users of them. As a step toward achieving this, a European Electricity Industry conference of up to 50 energy suppliers in Europe issued a declaration of EV charging standardisation agreed by these companies [(36)]. The European Automobile Manufacturers Association (ACEA) has issued their recommendations [(37)] for standardisation and the European Commission have given a mandate to the European Standards Organisations to agree a new European Standard for EV charging [(38)].

Table 2.4: Some EV fleet targets incl. (PHEVs) announced by various nations [**(39)**]

Country	**Target**	**Source Date**
Europe	480,000 EVs per year by 2015	May 2009
China	2030: 20% to 30% market share	Nov 2008
Germany	1 million by 2020	Nov 2008
Ireland	10% of fleet by 2020 Or over 230,000 vehicles	Nov 2008
Israel	40,000 EVs by 2011, 40,000+ annually after	Sept 2008
UK	1,200,000 EVs	Oct 2008
Sweden	600,000 by 2020	May 2009

The recharging infrastructure can vary in different countries. Range and recharging times are two issues the electric car must overcome to succeed. An American company, named Better Place [(40)], have developed a system that will involve the swapping of electric vehicle batteries at purpose built swapping stations when recharge is required. The automated process takes approximately ten minutes. They have secured agreements in countries such as Denmark, Israel, Japan, China, Australia, Canada and the USA. By building and operating the swapping stations and securing deals with renewable energy providers they can provide an energy storage system for energy companies and fast recharge options to EV users. They are developing this system in Denmark with the renewable energy provider DONG. Israel is also adopting it on a large scale as it seeks to become increasingly energy independent. The battery swapping solution will not suit all though. It would require the battery leasing system as proposed by Renault. Other EV manufacturers are selling their cars at an all inclusive price for the batteries.

The alternative to the battery swapping system and home charging is to create a network of public charging points. Systems such as this are already being created in many countries. In Ireland, the ESB are responsible for establishing the infrastructure for these recharging stations [(41)]. They have decided not to pursue using the Better Place strategy. They plan to install 1,500 public charging points across the country before 2012. This will include 30 'fast' recharging points that can provide a full recharge in less than 30 minutes. These 'fast' recharge points will be located along national roads at approximately 60 km intervals. The remaining recharge points will be located in the major urban centres and towns across the country. They will offer full recharge times of a few hours. In addition to this, 2000 domestic charging points will be freely installed to the first buyers of the EVs in Ireland. These will require up to 8 hours depending on the level of charging required. The system being used by the ESB is supplied by a company called Elektromotive [(42)]. The differences between the different systems are technical capacities of the installation locations.

The charging systems networks will also be 'smart systems' that are linked to a central system. This can provide a charging system for users, provide information on use patterns and allow for controlled use of the system demands. This will be important to the energy companies as the use of EVs becomes more widespread. The introduction of the EV will create a new market segment for the energy sector with enormous potential.

Increased overnight energy demand would better suit them as it would reduce the level of variation between peak and off peak demands. In particular it will suit countries such as Ireland that are increasingly producing a growing portion of their energy production from renewable sources. Due to the variable nature of renewable energy a network of EVs would provide a form of energy storage system during off peak hours. In Ireland, EIRGRID are responsible for the electricity transmission system. They have forecast that the Irish government target of over 230,000 EVs by year 2020 will have little impact on their daytime peak demand. EV energy demand would indeed benefit their system if well managed and increased energy supply will not be an issue for them [(43)].

EV Emissions

One of the most environmentally beneficial aspects of the EV is the fact that they have no direct polluting emissions. However, the electricity they use is the principal source of any GHGs related to the EV. As electricity is usually generated by consumption of fossil fuel at the source there are GHGs attributable to them. The level of GHGs that can be attributed will depend on what mixture of primary energy sources are used to generate the electricity. An electricity generating station using natural gas will have far lower GHG emissions than a coal burning station. Renewable energy sources such as wind, hydro or tidal would have little or no GHGs attributable to them.

Research using Life Cycle Analysis methods has shown how the level of GHGs emitted by EVs vary depending on the mixture of the electricity used. A 2006 UK LCA study compared EVs against other technologies in use. It showed that all emissions from EVs are based on its manufacture phase and use phase. It found that the levels of reduction in GHG emissions ranged from 43% using an average electricity mix to 80% using renewable source mix [(44)]. While GHG emissions due to EVs would impact the environment regardless of their source, it must also be remembered that the emissions are not typically located in densely populated areas as most manufacturing facilities and energy stations would be located in more industrial type locations.

Apart from GHG emissions attributable to EVs, what also cannot be overlooked are the health impacts and deaths related to road transport emissions and noise levels. A 2005 World Health Organisation (WHO) study on the Europe region found that noise and air

pollution from road transport is related to diseases that annually affect many thousands of people in the European region [(45)]. It states that 100,000 deaths are attributable annually to air pollution though not all of this is transport related. The report shows how difficult a subject it is to relate direct figures to transport emissions. It highlighted one study in 2000 for Austria, Switzerland and France that attributed 40,000 deaths annually to transport related emissions [(46)]. A further WHO study on the economic cost of transport related pollution calculated that of the $1.818 billion related to road transport air and noise pollution, 45% of it related to car passenger transport [(47)]. Other effects from emissions also result such as impacts on the natural environment, acid rain and eutrophication of water resources.

2.5 International Trends and Consumer Information

The UN median level forecast for the World's population growth will see increases from almost 6.9 billion in 2010 to 8.3 billion in 2030 and further to over 9.1 billion by 2050 [(48)]. Globally it is estimated there are presently almost 1 billion vehicles which could double to near 2 billion in the next twenty years [(49)]. Most of this growth will occur in developing economies like China and India [(7)]. China has already become the world's largest vehicle producer as of 2009 [(27)]. China and India are still among the lowest rankings of vehicles per capita population, (see Figure 2.9). In China alone vehicles are forecast to have increased from 70 million vehicles today to over 330 million by the year 2030 [(50)]. Because of relatively low number of vehicles in China it has the opportunity to adopt an electric vehicle policy that could reduce its transport sector dependence on imported oil by up to 30% by 2030. This could also lead to China becoming a world leader in the electric vehicle market [(50)].

A 2009 report by Deutsche Bank [(51)] found that the automotive market could change rapidly. It estimated that the world's automakers will release up to 120 models of HEV, PHEV and EV by 2012 and that these forms of vehicle will be 17% of the global market by 2020, with EVs being 6% of EU market in 2020 (PHEVs 14%). The report details how the motor industry is being driven towards electrification by the legislation and regulation globally. ***It forecasts battery performance doubling and costs halving in the next ten years.***

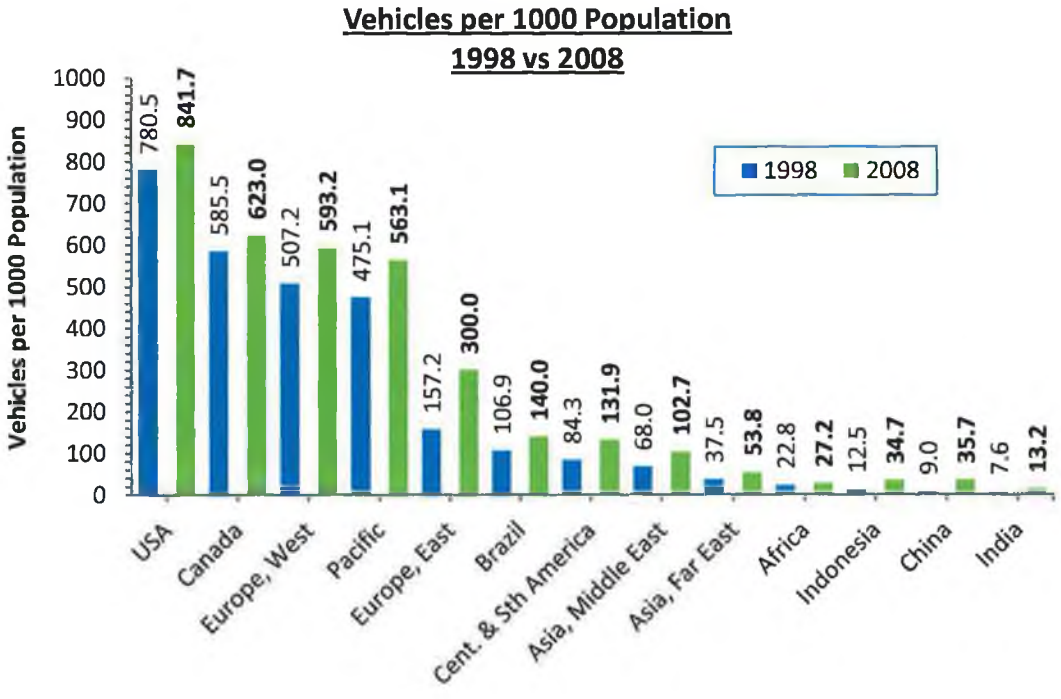

Figure 2.9: Vehicles per 1000 population 1998 vs. 2008 [**(52)**]

According to a 2009 report [(53)], prediction of consumer habits in an EV market is a challenge. It is also vital for developing effective policies to support the new technology. The report lists EV attributes that are considered as barriers by potential buyers. ***The first among these is higher purchase costs***. Others listed are *range, willingness to pay (a higher cost), charging infrastructure, innovation barrier and demographics*. A 2009 IEA report [(39)] states consumer acceptance will be key to the success of the EV. ***Some areas of uncertainty regarding consumer information are demographics, EV customer characteristics, and willingness to change behaviour patterns and adopt new vehicle types***. The IEA report further states that:

> *"Such information (at least on a public basis) is lacking or inadequate in most potential EV markets".*

Among its recommendations for action is inclusion of consumers in the planning process to help ensure needs are met and collection of better data on consumer behaviours and markets.

A 2010 Ernst & Young [(54)] survey compared 1,000 consumer opinions in each of Europe, China, Japan and the USA. The European element consisted of 250 from each of

Germany, France, Italy and the UK. This E&Y study gives a wide ranging insight into what the opinions of consumers were on a number of issues relating to electric vehicles and how they can differ regionally and nationally. ***Among the biggest concerns in buying an EV for consumers were price, range and charging infrastructure.*** 40% of respondents knew little or nothing about EVs. *Savings on fuel costs was one of the main attractions of buying an EV* and the vast majority in all cases would prefer to purchase than lease the EV. *Range was a principal concern* despite low average daily driving requirements.

2.6 Environment, Energy and Transport in Ireland

In Ireland, many of the issues surrounding climate change, energy and the environment are being tackled in line with European legislation and our commitments under the Kyoto Protocol (i.e.+13% on 1990 emission levels). There is a wide range of different government departments and bodies involved in implementing legislation and policies in these areas. Many different measures are being taken in each of these areas to deal with issues relating to energy and climate change. Reducing CO_2 emissions and use of fossil fuel while increasing energy produced from renewable sources such as wind are at the centre of how we are dealing with these issues.

The National Climate Change Strategy 2007 – 2012 [(55)] is the current version of Ireland's strategy to combat climate change. The previous version was issued in 2000. New versions will follow a 5 year review and renewal cycle. Other important policies, such as the Energy White Paper in 2007 and the Smarter Travel: A Sustainable Transport Future (2009), are examples of the policies being adopted by the Irish government. All are geared towards creating a sustainable energy future for Ireland and playing our part in combating climate change.

Ireland's Energy Use

Ireland is almost entirely dependent on imports of fossil fuels for its energy needs. In 2008, Ireland imported almost 95% of its total energy requirements; see Figure 2.10. *The Irish government's requirement under the EU renewable energy directive is to achieve 16% of our gross final energy consumption from renewable sources by 2020.* The Irish

government set a target of 15% of electricity supply from renewable energy by 2010. The share of electricity from renewable sources reached 14.4% in 2009, so the 2010 target is very likely to be exceeded [(56)]. *A further target of 40% electricity supply from renewable sources has been set for the year 2020.* These improvements in renewable energy sources though are truly put in perspective when compared to the overall total consumption of energy. In overall terms, ***renewable energy contributed approximately 4.7% in 2009 to gross final consumption of energy*** [(56)].

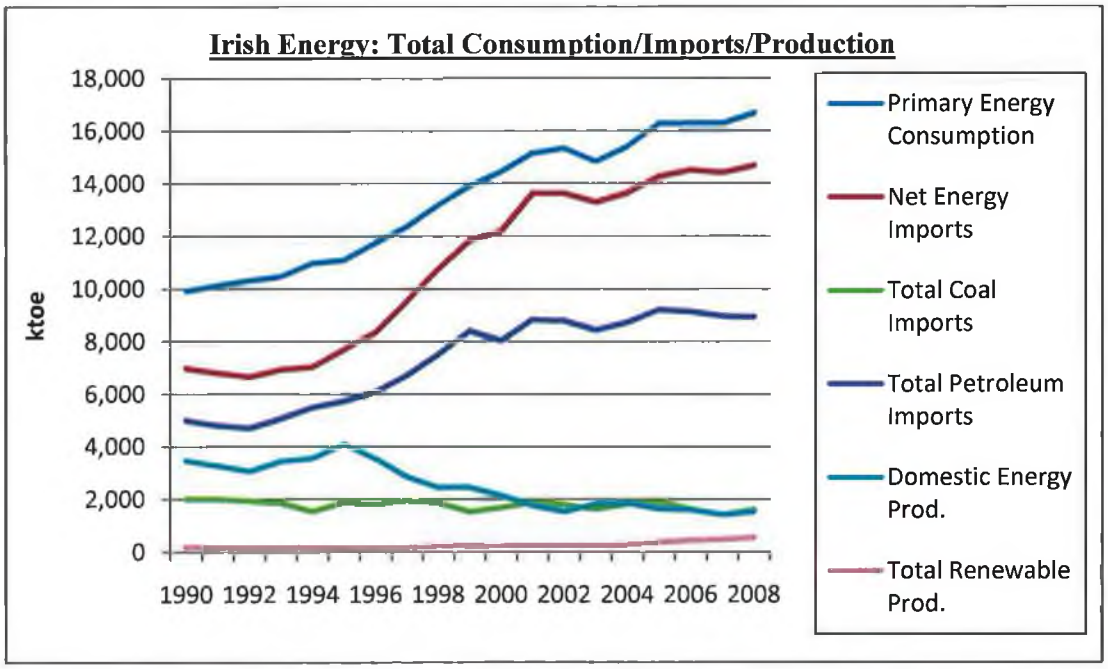

Figure 2.10: Irish Energy Consumption / Imports / Production [**(57)**]

The levels of domestically produced energy are shown in Figure 2.11. These reflect how decreasing use of peat and domestically sourced natural gas have resulted in a decline of domestic energy production supplies shown in figure 2.10.

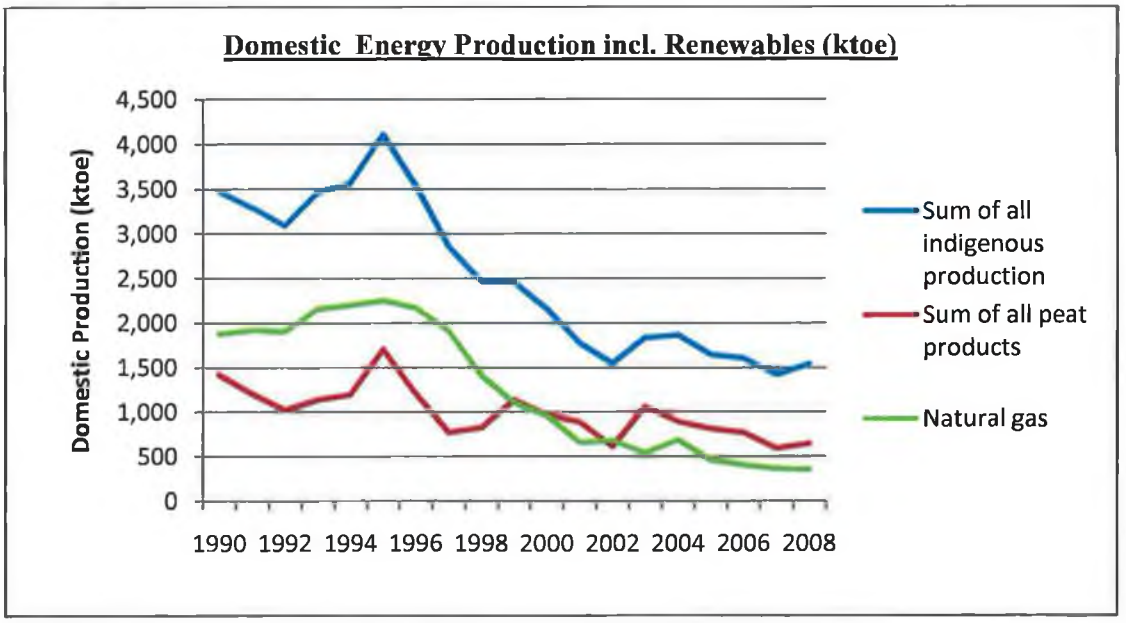

Figure 2.11: Ireland's domestic energy production including renewable [**(57)**]

The rapidly increasing levels of renewable energy production are shown in figure 2.12. The large levels of investment in wind farms and increased use of biomass (mainly wood) are the main sources of the increases in this area.

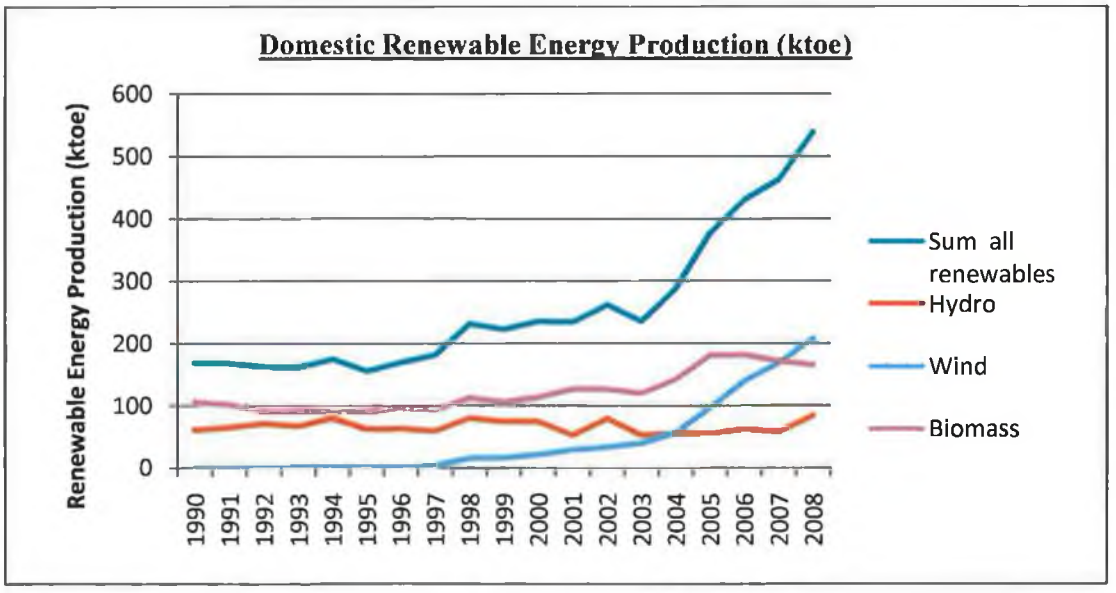

Figure 2.12: Ireland's domestic renewable energy production [**(57)**]

The transport sector is even more dependent on the use of fossil fuels given that ***over 99.7% of vehicles on Irish roads are of a petrol/diesel engine type vehicle*** [(58)]. Use of biofuels in transport is increasing to meet the EU requirements but is still behind the

target of 3% in 2010; biofuels share of Irish road transport fuel increased to just 1.5% in 2009 [(56)]. ***This indicates clearly how highly dependent the transport sector is on the importation of fossil fuels***. The increasing requirement for fossil fuels in Ireland's transport sector is shown in Figure 2.11. In 2007 the Irish transport sector consumed 46% of the country's final energy demand and was responsible for up to 36% of energy related CO_2 emissions [(59)].

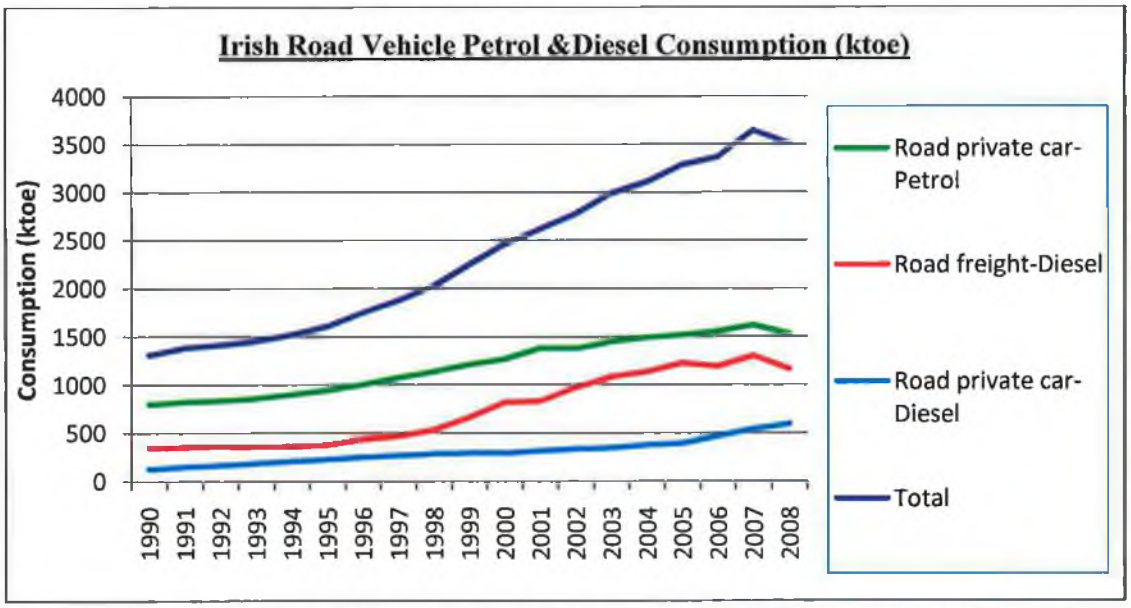

Figure 2.13: Irish Road Transport Fossil Fuel Consumption [(57)]

Ireland's Current Car Market

The level of increase in the number of cars in Ireland is shown in Figure 2.14. The number of private cars has increased by over 1.1 million from 1990 levels. Private cars now account for 77% of the vehicles on Irish roads. Goods vehicles account for another 14%.

Research by the Sustainable Energy Authority of Ireland (SEAI) has shown that, ***between 2000 and 2007, any CO_2 emission reductions achieved through technical efficiency in new motor vehicles were offset by consumer purchasing patterns***. A study of vehicle engine sizes showed that since 1990, there is a clear consumer preference for larger engine sizes. Only engine sizes less than 1.2L showed a decline in numbers. The larger engine categories above 1.7L all showed the greatest percentage increases [(59)]. ***This***

clearly shows that consumer purchasing behaviour can eliminate emission reductions gained in engine efficiencies.

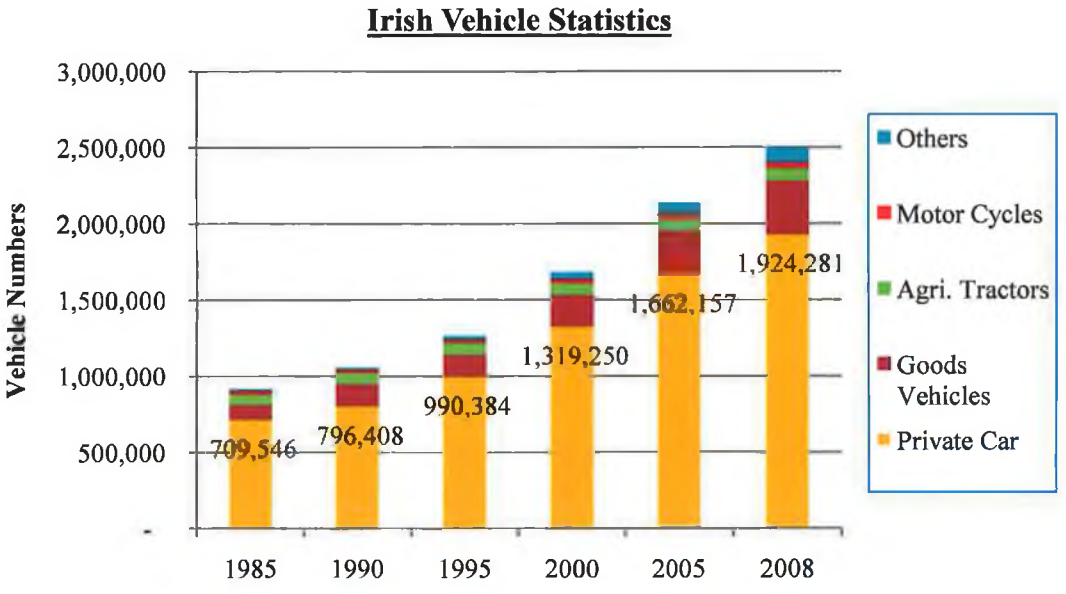

Figure 2.14: History of Irish Vehicle Statistics [**(58)**]

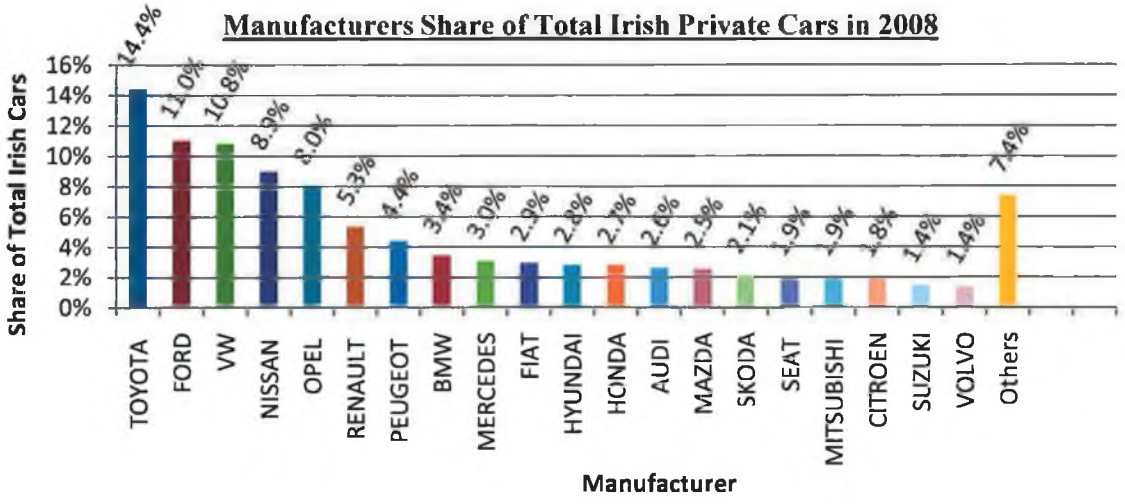

Figure 2.15: Manufacturer share of total Irish Private Cars in 2008 [**(58)**]

In Figure 2.15 above, the proportional share of existing cars on roads in Ireland in 2008 is shown. The data displays what manufacturers are the most popular with the Irish consumers and what their share of the car market is. This may reflect preferences for

particular manufacturer's brands. *As some of these manufacturers begin to introduce new EVs to the Irish market it may be important to note their lower levels of current market share and this may impact on their level of EV sales here.*

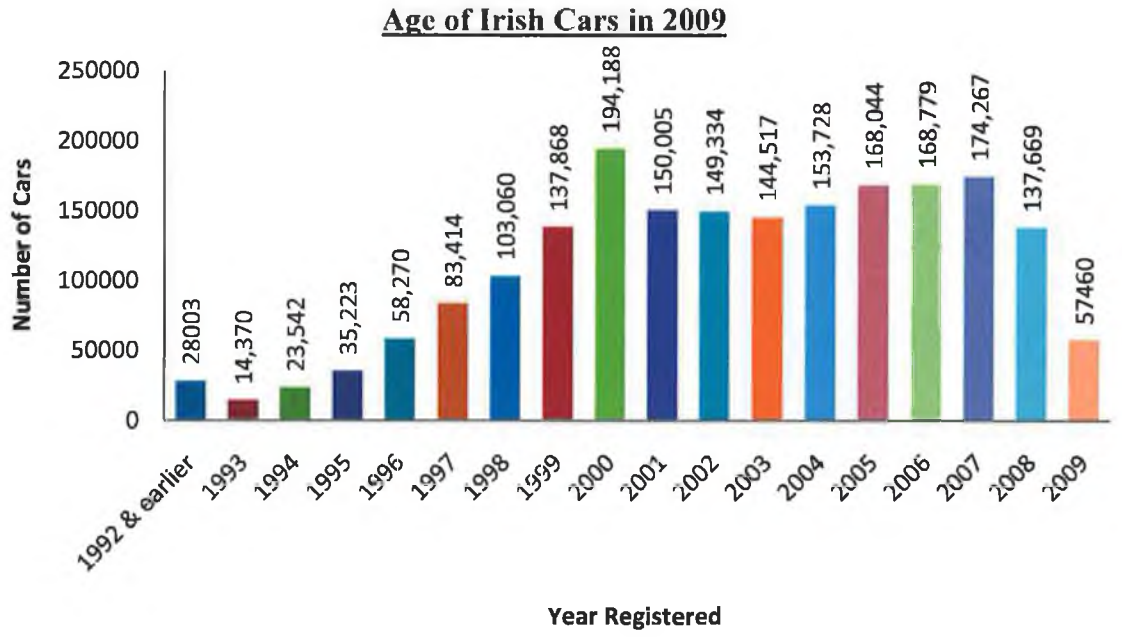

Figure 2.16: Age of Irish Cars in 2009 [**(58)**]

In figure 2.16 above, the data presented shows the age profile of the existing Irish car market and the annual sales figures for private cars. In years 2008 and 2009 the effects of the economic downturn can be observed in the severe level of fall in sales of new cars. Figures in the current year for 2010 show an approximate increase of almost 47% on 2009 figures but still well down on previous years. This is in contrast to EU sales showing a 7% decline in sales on the previous 12 months to June 2010 [(60)]. Given the economic climate in Ireland the new car market will prove to be an extremely competitive one in the years ahead and costs, and incentives, will be an important factor for potential new buyers. This may serve to hinder the success of the electric vehicle as the government hopes to increase the level of sales significantly in the years ahead. The commitment of the manufacturers to supply may also be tested if the levels of sales are not performing.

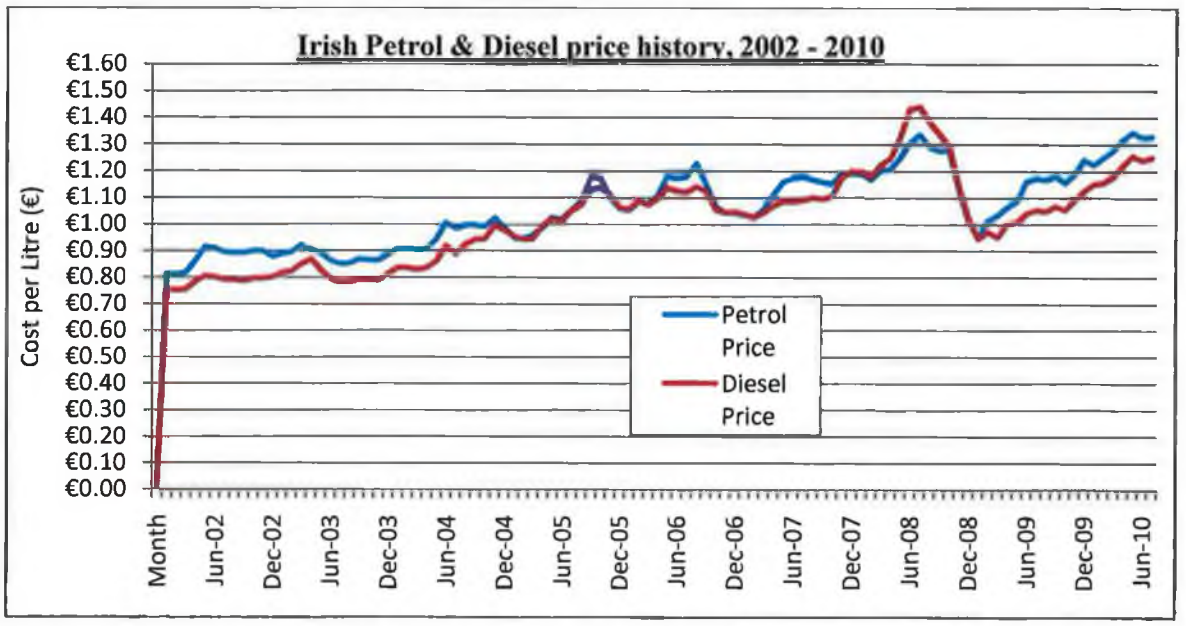

Figure 2.17: Irish Petrol and Diesel Price history [**(61)**]

In Figure 2.17 above, the data shows how the costs for petrol and diesel have varied since 2002. Since then ***the average monthly price for petrol has risen 64% and diesel by 66%.*** The surge in energy prices that occurred in 2008 resulted in the cost of oil reaching record prices of over $140 per barrel. That was followed by a steep decline in oil prices both of which are reflected in the data above. However, since then the cost of petrol and diesel has steadily risen in Ireland almost to the levels during the peak 2008 prices. The oil price in 2008 varied from $144 in July to $45 in November. The June 2010 price for the same oil priced above was $76; see Figure 2.18.

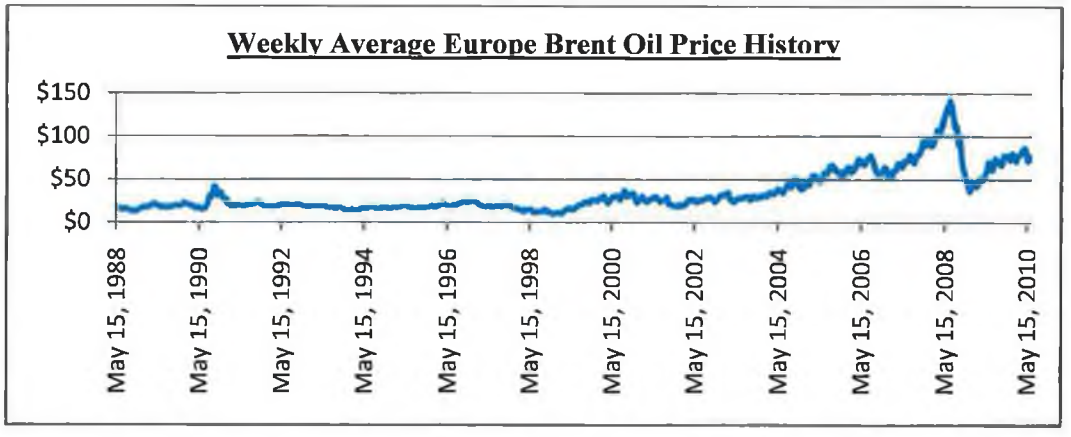

Figure 2.18: Europe Brent Oil price History [**(62)**]

A 2008 National Consumer Agency report investigated how fuel prices in Ireland relate to crude oil prices. It showed that the fuel prices do not necessary reflect crude oil prices, it is dependent on a number of factors including currency exchange rates and four different stages of the supply chain in Ireland. Fuel prices largely follow a 'Platt's price' for refined products that is updated twice weekly. It found that, in line with investigations in other countries, the prices paid by consumers largely followed those of the Platt price. According to SEAI data [(59)], the estimated average annual cost of fuel (for 20,000 km) ranges from over €900 to over €2300 depending on engine size and fuel type. However the prices used in that analysis have since risen 10% and 20% respectively for petrol and diesel. Of the prices paid by consumers at the pump the Irish government receives almost 60% of the cost in taxes [(63)].

Ireland's Electric Vehicle Policy

In 2008, the Irish government set out their objective of EVs having a 10% share of the Irish car market by the year 2020. That translates to over 230,000 cars, or 10% of vehicles, on the road being electric. This figure includes sales of HEV, PHEV and BEV type vehicles. In its press release in 2008 [(64)], the government recognised how an EV market would reduce the €6 billion spent on fossil fuels and provide an economic benefit by using domestically produced energy. The government has placed this policy at the front of its transport sector efforts to reduce emissions and promote renewable energy. This is presented it the National Renewable Energy Action Plan (NREAP) submitted to the EU as required under the EU Renewable Energy Directive [(65)].

To help achieve this goal requires the co-ordination of all the necessary stakeholders' efforts. ***The principal stakeholders in establishing Ireland's EV market will be the government, motor industry, energy providers and ultimately the consumers***. The government have established a task force to coordinate efforts in the EV program, comprising the following departments and state bodies:

- Department of Communications, Energy and Natural Resources
- Department of Finance
- Department of Transport
- Department of Enterprise, Trade and Innovation
- Electricity Supply Board (ESB)

- Sustainable Energy Authority of Ireland (SEAI)
- Enterprise Ireland
- IDA Ireland

The government has taken the decision to become one of the leading nations in rolling out the necessary infrastructure to support an EV market. Ireland is considered an ideal test market due to its small size and mostly urban population. The average daily driving distance in Ireland for car passengers is also less than 30km [(8)]. Ireland's geographical location has also been shown to be ideal for exploiting wind energy [(66)] and wave energy [(67)], though wave energy is still largely in the development phase. It is also on course to have up to 40% of its electricity being generated from renewable sources.

The Irish government hopes that by getting fully involved from the earliest stage in developing an EV market that ***it will result in new jobs in new industries and businesses***, particularly in the software area. This is where the smart metering of the charging infrastructure will become a crucial factor in maximising the usage of renewably generated and off peak electricity. It will also provide instant large amounts of information on the charging behaviours of the early adopters of the EVs. The ESB has already started to install the €20 million charging infrastructure and plans to have 1,500 public charging stations by 2011 with 2,000 more in EV purchasers' homes. The ESB also plan to change their entire fleet of vehicles to electric as part of their plan to become carbon neutral by 2035.

The ESB [(41)] and Eirgrid are also planning for the introduction of smart metering in homes and businesses. This will be in line with their Grid25 infrastructure upgrade [(68)] which is necessary as we progress to the 40% target of electricity from renewable sources. This will potentially offer the ability at a later stage for homes to supply energy back to the system. This would provide for reduced consumer costs and improve the battery storage potential of an EV market.

It is assumed that the 2020 target of achieving 10% renewable in transport will compose of 8.3% biofuels and 1.7% electricity based on the sales figures of the vehicles being achieved [(56)*]. According to a 2007 SEAI report [* (59)*], the task of reducing transport*

emissions to meet the EU ETS requirements will be far harder to achieve than the EV sales target. The forecast rates of sales that will be required to meet the 10% market share are shown in Figure 2.19. The ESB predict there could be up to 30,000 on street charging points to meet the 2020 targets [(69)].

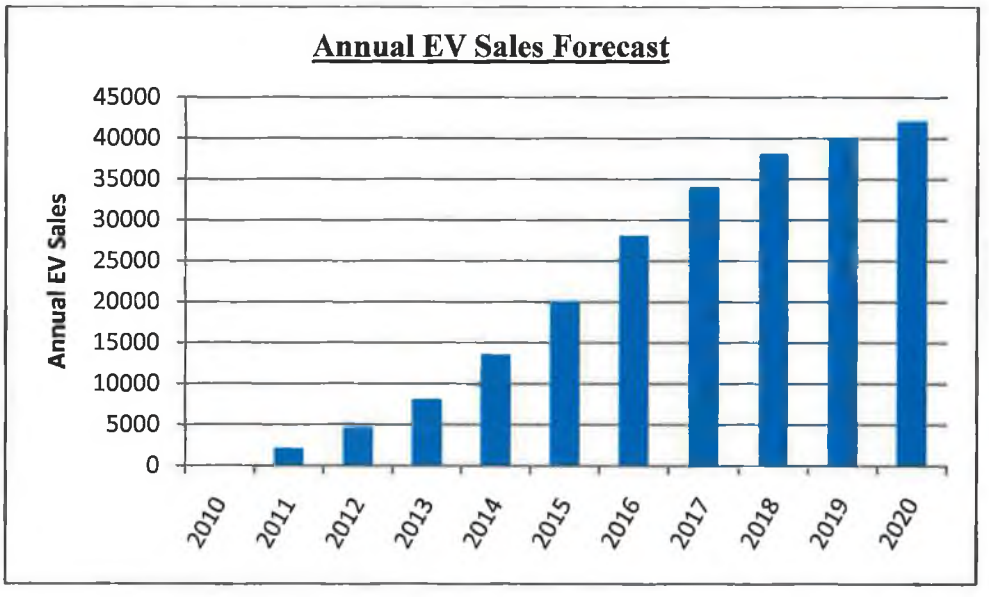

Figure 2.19: EV sales required to meet 230,000 by year 2020 [**(69)**]

The figures presented in Figure 2.19 include the sales of other types of electric vehicles, such as HEV and PHEV, but it can still be observed how big a change in consumer purchasing will be necessary to achieve the 2020 target. If it is assumed that car sales recover to its previous peak levels, it would require almost 25% market share for electric vehicles by 2020.

In 2008, the government changed the law to link VRT and road tax to CO_2 emissions (gCO_2 /km) and this resulted in a clear change in purchasing patterns. The sales of diesel models over petrol and lower tax band vehicles both increased [(59)]. This shows how consumer purchasing can be influenced through fiscal measures towards more energy efficient lower emission vehicles. Additionally, a Carbon Tax (€15/tonne of CO_2) was introduced on fossil fuels in December 2009. This increased the cost of petrol and diesel over 4 cents a litre. It did not apply to electricity as energy providers are already part of the EU ETS scheme.

The Department of Finance currently provide financial incentives for buyers towards electric vehicles. No VRT is applied presently, (it's usually 14%) and this will continue to apply for the next two years. Further assistance to purchasers is available as grants of up to €5000 presently for electric vehicles. The grants are handled by the SEAI and will continue for the next two years also when it is hoped that up to 6,000 electric vehicles will be sold in Ireland. Further incentive is given by way of allowing businesses to write off electric vehicle purchases against tax. As the cost of new EVs is likely to be one of its biggest obstacles for consumers, these financial incentives are important to help establish the market. It is hoped that purchase prices may reduce as production of EVs increases and further models come to market.

The SEAI are another important agency in helping the government establish the electric vehicle market. They are the government's main agency for implementing and monitoring sustainable energy and renewable energy policies made by the government. They also advise the government in the formation of these policies. They have issued numerous publications [(35), (59), (70), (71)] dealing with electric vehicles and energy use in transport. Publications on advice for electric vehicle buyers, technologies involved in EVs and on measures to stimulate uptake all provide important information for government and consumers alike.

A 2009 SEAI report (72) provided economic analysis that estimated the savings and costs associated with all the various measures available for CO_2 abatement. It indicated that EVs were one of the most expensive abatement measures available (in year 2030) at \$125/tCO2-eq (per tonne of CO_2-eq) using a reference case scenario of \$60 per barrel of oil. However, a further scenario of \$120 per barrel of oil reduced this abatement cost to \$20/tCO_2-eq. This shows how changing costs of oil will greatly improve the cost effectiveness of using EVs as an abatement measure.

Another 2009 report (73) by an Oireachtas committee concluded that Ireland needed to set more ambitious targets for EVs than those already made. Among its recommendations was increasing the targets for BEVs in Ireland to 350,000 by 2020 and setting a further target of 2030 for completely replacing the car market with BEVs.

The government have agreed deals with Mitsubishi, Nissan and Renault for supply of the new EVs they will produce. These deals will guarantee a level of delivery of several thousand of the new EVs in the early stages and make Ireland among the first countries to receive them. As the motor vehicle industry will be an important stakeholder in achieving the EV targets all the government bodies involved are co-ordinating closely with the EV manufacturers. This also involves conducting research through trial programmes for EV use. The ESB began conducting one such programme in July 2010 using 15 of the Mitsubishi i-MiEVs. This is being co-ordinated with Trinity College Dublin as a two year research study into consumer use patterns of electric vehicles[(72)]. The SEAI is also researching EV use with another programme being conducted on the Aran Islands over three years.

Many of the steps the government and other stakeholders have taken are based on previous experience in other countries, such as some of those listed earlier in Table 2.2. The SEAI publication, Measures to Stimulate Uptake of Electric Vehicles, lists many other such schemes and their outcomes [(71)]. The SEAI report, and other more recent ones such as the IEA report [(39)], provides a list of recommendations for establishing the EV market in Ireland, many of which the government are doing. These recommendations include using small scale EV trials, setting clear goals for EV market penetration, building charging infrastructure, co-ordinating strategies with stakeholders, improving knowledge of customer need and behaviours and providing incentives.

2.7 Summary

Climate change is a challenge that will require a wide range of mitigation measures to reduce just the short term impacts. The use of fossil fuels as our primary source of energy supply is clearly one of, if not the biggest, influences on what the long term impacts of climate change will be. With the developing nations' economies growing rapidly it is clear that the global use of energy will increase greatly. This will not only have implications for climate change. The increasing use of fossil fuel, a finite resource, will ultimately result in increasing costs of energy use.

It has been shown how dependent transport is on fossil fuel use and that transport is one of the biggest sources of GHG emissions globally and locally. Transport is also one of

the most important sectors of every economy and increasing costs for this sector will continue as long as its fossil fuel dependency continues. The alternatives technology is now becoming available to begin to make this movement away from fossil fuel and the electric vehicle presently provides the lowest emission option, if not zero emissions, for the foreseeable future.

Ireland, and its transport sector, is completely dependent on the import and use of fossil fuels for its energy supply. The Irish government, and transport sector, have a golden opportunity to become one of the leading locations in the world for use of electric vehicles. This will help to address both our commitments to tackling climate change and improving our energy independence. It will also benefit the Irish economy by increasing use of domestically produced energy in the transport sector energy. It would also benefit Irish consumers by reducing their transport energy costs and protecting them from rising international fossil fuel prices.

Irish consumers will have a central role in whether or not the electric vehicle can succeed here. It is important to know what they want and what their attitudes are as the new market for EVs is developed here in Ireland.

3.0 Research Methodology

3.1 Introduction

The previous chapter showed the links between the environment and the transport sector and the challenges for car manufacturers in designing new vehicles. In facing this challenge the electric vehicle has attracted renewed interest and increased importance.

The current car market is dominated by the use and knowledge of conventional ICE based vehicles. In Ireland, this is almost 100% of the market. While the major car manufacturers are major drivers of the technical design and development of electric vehicles, governments internationally have started to require this change towards EVs also. This move towards EVs also requires the establishing of charging infrastructures. These help facilitate the change as less polluting forms of energy generation, from renewable sources such as wind and wave, increase rapidly to meet energy and environmental concerns. These will provide increasing levels of 'green' energy and help to further reduce emissions attributable to EVs.

International reports on establishing electric vehicle markets have indicated consumers are vital to the success of establishing the electric vehicle and further studies are necessary on consumer behaviours and demands towards electric vehicles. From the literature review it became evident that a gap exists in knowledge of consumers in this regard. As new EV models are again becoming available, this study seeks to reduce the knowledge gap and to contribute in some way towards improving understanding of Irish consumer attitudes towards electric vehicles.

3.2 Rationale for the Research

According to Bryman and Bell [(1)], the research process involves two important considerations for research practitioners:

3.3 The Research Question

The research question helps to keep a tighter focus on the research. It can help in guiding the literature search, the research design, data collecting decisions, analysis and presentation of results. It should not be too broad or narrow, have clarity and focus, connect with the literature and help to make a contribution to knowledge however small this may be [(1)].

Using this framework, and based on the literature review in chapter 2, the following research question was employed in the study:

To what extent do car owners in the sample possess favourable or unfavourable attitudes to the electric vehicle in Ireland?

3.4 Objectives of the research

The objectives of this research are:

- To examine studies in the literature relating to environment, energy, legislation in a national and international context, and the electric vehicle from its historic beginning.
- To gain an understanding of the current levels of development in electric vehicle manufacturing, with specific reference to technical development factors and major car manufacturers internationally.
- To develop an online questionnaire to research consumer attitudes towards electric vehicles in a population of Irish car owners.
- To identify consumer attitudes to electric vehicles in the targeted population of Irish car owners.

Objectives 1 and 2 are fulfilled in chapter two on the review of literature. Objective 3 is elaborated on in this chapter on research methodology. Objective 4 is fulfilled in the next chapter on the research findings. In the discussion section, the four objectives are integrated prior to the conclusions being drawn.

3.5 Research Design

A research design involves the creation of *"a structure that guides the execution of a research method and the analysis of the subsequent data" [* (1)].

Bryman and Bell [(1)] propose five research designs:

a) Experimental design: it seeks to determine cause and effect. An independent variable is selected for manipulation before conclusions are drawn.
b) Cross-sectional or survey design: A questionnaire or structured interview is commonly used to collect data. Patterns in the data can then be identified.
c) Longitudinal design: In this approach, the change occurring in the data over a period of time can be analysed.
d) Case Study Design: a single case, such as an organisation or a person, can be studied. It can be extensive and complex.
e) Comparative design: two cases may be compared, such as organisations or people. An example would be a study of cultural differences among nations

Variations on the five frameworks have also been developed. In considering the five designs, and because of time and cost considerations involved, the experimental, longitudinal, case study and comparative designs were excluded.

Survey research was adopted as a research design. This type of research has gained widespread acceptance and credibility in many countries. When information is required that is not easily available in some other way, a survey approach may be used. It can take a positivist approach and be used to develop a quantitative analysis. It can be less time-consuming than other approaches and can generate data quickly [(73)].

For the survey, a questionnaire was designed for which respondents completed a series of questions based on findings in the literature search. The questionnaire was piloted on a group of six car owners and modified as necessary for any errors, corrections and weaknesses revealed.

The questionnaire would provide information on consumer attitudes to electric vehicles under three headings: i) demographics ii) attitudes and iii) willingness to purchase. The data obtained were analysed and are presented with a discussion in chapter four. This is followed by conclusions and recommendations. The online survey was designed using a fee based resource called SurveyMonkey [(74)]. This provided a user friendly format for each question. A link was provided that allowed respondents to directly access the survey. This service also collected all responses and allowed the author to monitor progress.

3.6 Web-based Survey

Dillman et. al., pointed out that web surveys belong to a new era using electronic mail [(75)]. The study of on-line populations has continued to increase in the past decade. Survey researchers face different challenges compared with the traditional survey. Online surveys have become more popular since the introduction of a range of survey services such as SurveyMonkey. For this research, the SurveyMonkey package was used as it was reasonably priced at €20 a month and did not require the customer to purchase software.

While there are some disadvantages associated with online surveys such as sampling issues, there are a number of advantages of benefit to the researcher [(1)]. They can be respondent-friendly in design and give quick and easy access to those with e-mail facilities in homes and offices [(75)]. According to Madge, web-based surveys require questionnaires used to be carefully designed. This can take a substantial amount of time. The time saved however in collecting data and the quick turnaround make this approach to a survey worthwhile for the researcher [(76)].

3.7 The Survey Questionnaire

Careful design of the questionnaire (see appendix 1) has been the aim throughout the research, so that it could be more user-friendly, attractive and less time-consuming[(75)]. In its final form, after piloting, the questionnaire contained twenty-four questions. Seven questions dealt with demographic data. Ten questions on consumer attitudes were included. There were also seven questions on willingness to purchase electric vehicles.

Of the 24 questions in the survey, 23 gathered quantitative data. One qualitative question sought information on what the government could do, other than financial incentives, to promote the use of electric vehicles. The questionnaire time for completion, based on piloting trials, ranged from three to five minutes.

Assumptions

The following assumptions were made in conducting this survey:

- That the respondents answer each question honestly.
- That there is a readiness on the part of each respondent to co-operate in the research.
- That the survey findings relate to those in the sample who respond to the survey.
- That all questions are clearly understood and are not ambiguous for respondents.

Limitations:

There are limitations on the research conducted such as the following:

- The study is limited only to battery electric vehicles that operate solely using electricity as a source of energy. It is not related to the HEV or PHEV type of electric vehicles
- The design and size of the population sample limit the conclusions and generalisations that may be drawn from it.

The questionnaire was delivered via e-mail to a sample of males and females. In order to avoid invasion of privacy, the target population consisted of potential respondents known to the author who would be willing to co-operate. They would be known to be reliable and honest in their task. The emails to them would contain an invitation to extend the survey to others.

3.8 Sampling

Sampling techniques can be divided into two types: probability sampling and non-probability sampling. Using probability sampling would require that the probability of each participant being chosen is known and is usually equal. As each would typically have an equal chance of being chosen it can be presented as being representative of a population. The other method available is the non-probability method where the probability of the participant being chosen is not known.

There are a number of sampling methods available using the non-probability. Among the non-probability sampling techniques are those such as convenience sampling, judgement sampling, quota sampling and snowball sampling. The target population for the research was a group of 65 males and females who were known to be car owners. They were invited to extend the survey to others if they wished to do so and in total there were 118 respondents. The non-probability sampling method chosen was convenience sampling which is a method "*simply available to the researcher by virtue of its accessibility*" [(1)]. A non-probability sample has a major weakness when compared to a probability random sample as the degree of sampling error that may arise in data cannot be accurately determined. The probability sample on the other hand can be costly and time-consuming.

In business and management, convenience sampling is commonly used [(1)]. Although it is not possible to generalise beyond the sample itself because it lacks the representativeness of the total population of car owners, the convenience sample remains a useful strategy for exploring and gathering data. Although it may not be ideal, it is an opportunity to provide for the forging of links with research findings already available elsewhere [(1)].

To compare the level of respondents in relation to the population size which a random probability sample would have applied to, an online sample size calculator was used [(77)]. A level of 119 respondents would equate to a population size of 2 million people with a 95% confidence level and a 9% margin of error. A 5% margin of error for the same population would require 385 responses and a population of 20,000 would have required 377 respondents.

3.9 Data collection and analysis

Data was collected online. The service provider chosen was SurveyMonkey.com [(74)]. This service allows collection and correlation of the data submitted to the website and by logging in, the author could access the survey data. This was then analysed and information reproduced with a selection of graphs and charts. It allowed for further cross tabulations of selected questions against all other questions and further analyses.

3.10 Ethical issues and considerations

The author has a responsibility to the respondents to grant them anonymity and to treat their responses confidentially. The co-operation of the respondents is given freely and cannot be abused or relayed on line in a manner that would not have their support or permission. No personally identifiable data can be used in analysing the data. The invasion of privacy should not take place, deception should be guarded against and data should not be stored indefinitely. Legislation under Data Protection Acts must be complied with. Bryman and Bell point out that the integrity of the research is crucial and that "*ethical issues cannot be ignored*" [(1)].

In this research, the respondents were guaranteed anonymity and the data treated confidentially. No identifiable links with individual responses were made. The data were analysed in aggregated form so that individual identities will be lost. In the design and conducting of the research every care was taken to ensure that honesty prevailed throughout.

3.11 Summary

The gap in consumer knowledge on electric vehicles is taken as a base on which to carry out a research survey on consumer attitudes to electric vehicles. The objectives and rationale for the research are outlined. In the research design a questionnaire is developed for a web-based survey. Sampling issues, data collection and analysis and ethical considerations are discussed. The next chapter will deal with the survey findings.

4.0 Results and Discussion

4.1 Introduction

The results of the consumer survey are presented in this chapter. Details of the respondent demographics are shown in questions 1 to 7; their attitudes towards electric vehicles are presented in questions 8 to 17 and finally their willingness to purchase electric vehicles in questions 18 to 23, (see Appendix 1). Using these results the researcher will attempt to determine how receptive the respondents are to the new electric vehicles and what issues they may or may not have with them. In question 24, the respondents were asked to comment on what other measures they thought the government should adopt to promote the use of electric vehicles. Though not all respondents commented, many did and these are summarised towards the end of the chapter. Further information from the questionnaire is determined by cross checking respondent answers with other questions. This yields further useful information that is not obvious from the general responses.

4.2 Survey Results

The survey was conducted using a service by an internet company called SurveyMonkey. A link to the survey was provided as part of an invitation through email to 65 people initially. Respondents were invited to extend the survey to additional others if they wished to and informed that all responses would be anonymous and no personal details could be determined from them. Over 125 responses were received during a two week period in August 2010. Of these responses only 118 were completed. The remainder completed only questions 1 to 7 and proceeded no further. These responses were discarded for the purposes of the analysis. The remaining 118 respondent questionnaires were largely completed. As can be observed in Appendix 2, not every question has 118 as a total count. This is due to the fact that some questions were occasionally unanswered for reasons unknown but likely through simple error. In each case where this occurred it is presented as a total count of less than 118 respondents.

Demographics of Respondents

The respondents were asked a range of questions to establish some basic demographics such as gender, age groups, area type, housing type, number of cars in the house and typical commuting distances. Some of these characteristics may have a direct bearing on whether they would be willing to purchase an electric vehicle in the short-term or the long-term. This information can also be used to determine if there are any distinct differences between the various categories in terms of their willingness to adopt EV or in what they may or may not find important.

The ratio of male and female respondents is presented in Figure 4.1 below. Though not reflective of the wider population ratio of 50% male and 50% female [(78)], it can provide some useful information on any differences in preferences between the genders in the survey. There were, largely, no significant differences between the genders in terms of the majorities in each question asked. There were some areas of lesser or greater importance between the genders in some EV features. These will be discussed further at a later stage in this chapter.

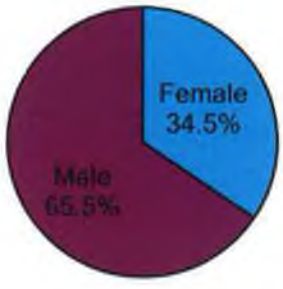

Figure 4.1: Respondent gender distribution

The age category with the largest number of respondents was the 30 to 39 age group with 41% overall. The ratios of the age groups are presented in Figure 4.2. Again, it is not fully reflective of the national ratios of age categories [(78)] but can also provide useful information on any differences in preferences between the age groups. There were largely similar outcomes in how the majorities in each group voted for their preferences in each survey question with some slight differences in some areas. These differences will also be discussed further in the chapter.

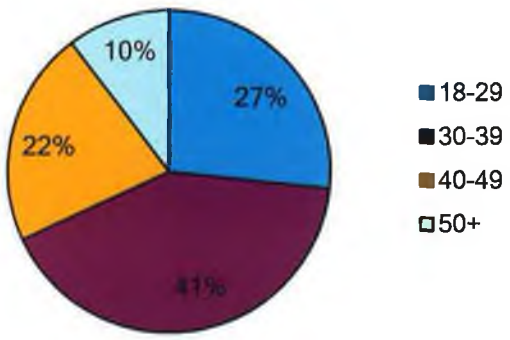

Figure 4.2: Age group distribution

The respondents were next asked to indicate what county they lived in to gauge how widespread the survey was based. The *majority of the respondents were based in County Galway (72%).* The remaining 28% of respondents were based across 16 other counties. This is indicative of how the use of the non-probability convenience sampling method can be biased towards a particular area and could not be generalised for a national population as would be possible with a random probability sample method.

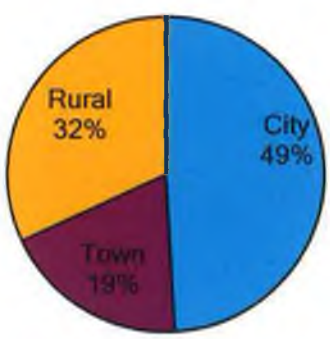

Figure 4.3: Respondent area type

The respondents were asked to indicate which of three types of area they lived in (city/town/rural). This may also affect how willing respondents may be to purchase EVs and the type of areas may lead to differences in what people may, or may not, consider important in an EV. For example, rural people may have greater average daily mileage than city based respondents. The majority of respondents (49%) were city based, as Figure 4.3 shows. 82% of city based and 76% of the town based respondents were in Galway. In all the age categories only the 18 to 29 group differed in that they were more rural based (45%) compared to the other groups being city based (51 % to 67%). Males

and females were 51% and 42% city based respectively and 30% and 37% rural respectively.

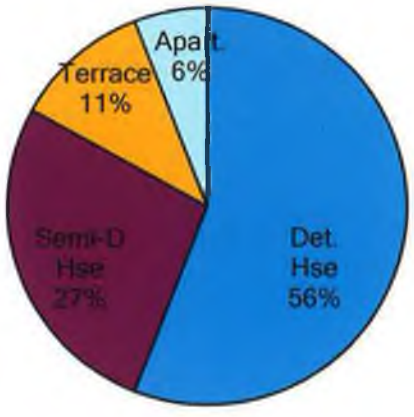

Figure 4.4: Types of Respondent Housing

Respondents were asked which of four types of housing they lived in (detached/semi-detached/terrace/apartment). The type of house the potential EV buyers lives in is very important as this may decide how suitable it is to recharge their EV overnight at the cheapest rates and hence affect their willingness to buy. According to the 2006 Irish census [(78)], almost 70% of over 1.46 million private residences were either detached or semi-detached. Figure 4.4 shows the distribution of the responses received. It is largely reflective of the national average figures. The respondents' overall answers showed many similarities again in how the majority in each section voted. The majority in each age group were in detached houses (between 42% and 76%). 80% of females and 84% of males lived in either detached or semi-detached accommodation. 50% of detached houses were rural and 90% of city respondents were either detached or semi-detached.

The majority of respondents, 71%, have 2 cars or more in their household presently. As range is a known concern among consumers with electric cars, this information can be used to determine any differing preferences based on the number of cars in the household. Also, the 2009 UK report [(53)] found that the majority (34 of 36) of existing EV owners surveyed were households with access to, or use of, more than 1 car. Figure 4.5 shows the distribution of the responses received. The 2006 Irish census [(78)] found 42% of households having 2 or more cars and 80% having at least 1 car. Almost 20% of over 1.46 million households had no car.

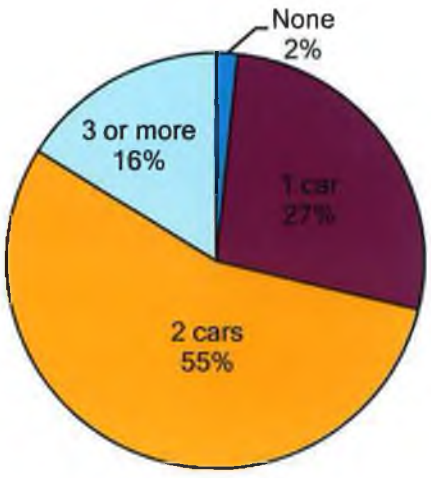

Figure 4.5: Number of cars in Respondents' house

The survey responses show that only 2% of the respondents had no car. This would give greater accuracy to the overall survey results as it is almost completely composed of current car owners. Detached housing accounted for 79% of the '3 cars or more' category and 60% of the '2 cars' category. 62% of semi-detached housing had 2 cars. The majority of all, but one, of the earlier age groups was in the 2 car category. All the area type majorities earlier were also in this category. 47% of the three car category was rural.

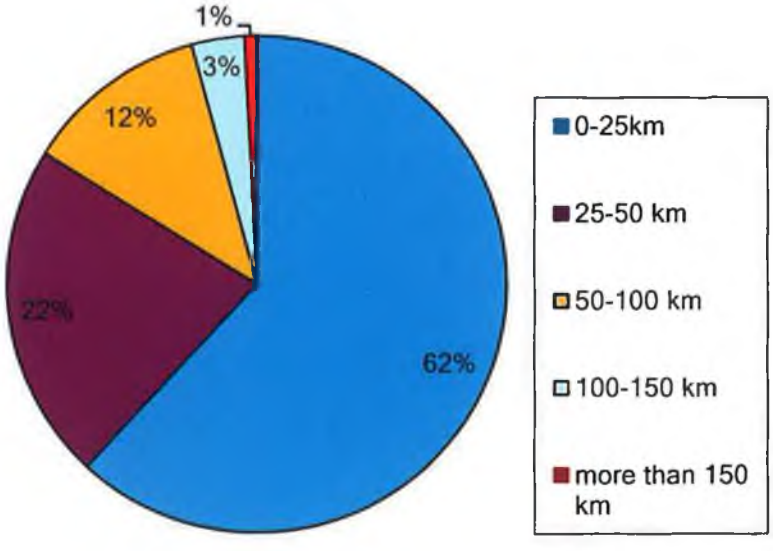

Figure 4.6: Respondents average daily commute distance

The respondents were asked to indicate what their average daily commuting distance was. Their responses, (see Figure 4.6), to this shows that almost 96% of them have daily

commutes less than 100 km. Almost 84% require 50 km or less for their daily commute. This clearly demonstrates that the vast majority of daily commuting is well within the range of the EVs for the respondents. It also corresponds to the earlier information for the European and Irish average daily driving distances [(8)] showing the vast majority of daily mileage requirements to be quite low. Though the majority of each area type (city/town/rural) earlier was in the 0-25 km category there was a noticeable difference in that it decreased from 77% of city respondents to 43% of rural respondents. Overall, only 4% of respondents required more than 100 km on average per day. ***This clearly shows that for the large majority of respondents, driving range on an average daily basis is easily achieved by EVs.*** Also, 98% of the detached house respondents drive less than 100 km per day. This also applies to 97% of the semi-detached respondents and 92% of the terraced house respondents. These are the house types most likely to be suited for charging EVs at home.

Consumer Attitudes towards Electric Vehicles

The respondents were asked if they had previously heard about electric vehicles. The vast majority (91%) indicated they had some level of knowledge of EVs (Figure 4.7).

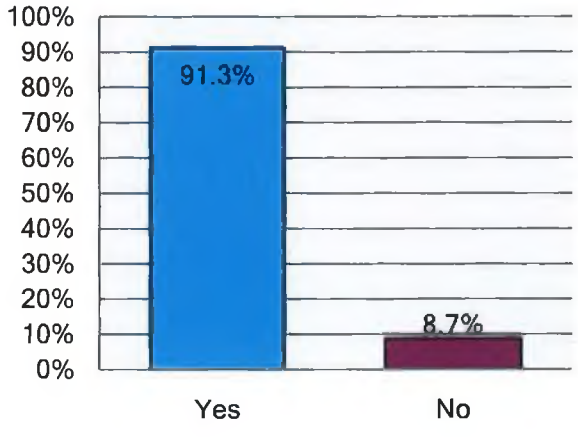

Figure 4.7: Previously heard of EVs

This level of knowledge corresponds with the E&Y survey [(54)], mentioned section 2.5 earlier, where over 90% of European survey participants had previously heard of EVs. Though this study does not determine how well the respondents are informed about EVs,

it indicates that there is already a good level of interest for a car that is only arriving to the market. The EV will also require quite a change in owner behaviours in terms of the recharging system alone. It is likely that apart from those early adopters that are willing to purchase EVs, the larger public, particularly if uninformed, will be wary of such new technology. This is what another of the earlier reports [(53)] referred to as the innovation barrier.

Figure 4.8 indicates the preferences among the respondents between refuelling conventionally with petrol/diesel compared with recharging an EV with electricity. ***The clear preference (64%) among the respondents is for use of electricity to supply their vehicle energy***. Given that the current car market is essentially 100% based on use of petrol and diesel and the complete lack of any experience in using the new system, it is clear that most consumers would prefer to change to use of electricity. In each of the earlier demographic categories, with one exception, the majority chose to use electricity over conventional fuels. The one exception to this was in the 18-29 age category, where 52% chose a preference for petrol/diesel. 70% of city based respondents chose electricity and 62% of rural responses. Of those that never heard of EVs previously, 70% preferred the electricity concept.

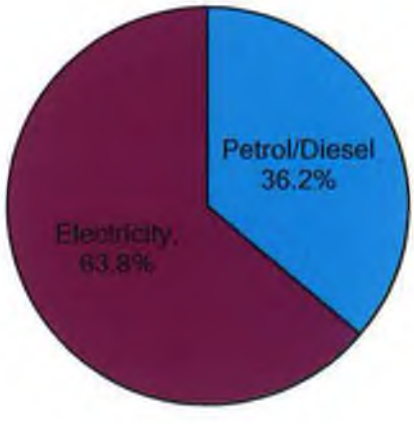

Figure 4.8: Would you prefer using fuels or electricity for your vehicle?

The review of literature earlier showed how steeply the cost of fuel has risen in a short period of time in Ireland through both taxation and international demand for crude oil and refined petroleum products. It also indicated that such energy costs are likely to keep rising as global demand increases. Such future increases would obviously lead to reduced

EV life cycle costs. It would also increase its cost effectiveness as a CO_2 abatement measure. Both petrol and diesel have risen over 60% since 2002 in Ireland. *There is a clear desire among consumers for an alternative to using these types of fuel.* The international report by E&Y [(54)] also found that rising fuel costs and dependence on foreign oil imports to be among their highest concerns in the survey.

To gauge the levels of importance respondents place on a range of different electric features, they were asked to rate 11 different options between being 'very unimportant' to 'very important'. The results, presented in Table 4.1, show that in every category given to the respondents they found that the feature was either 'important' or 'very important'. Five of the options were found to of a lesser importance including the vehicle make and model, performance, re-sale value and emission levels. The '*' placed with last option on emissions was related to the survey introduction where it was explained that the emissions depend on the generation source of the electricity. It was still considered important or more so by 74% of respondents. *When comparing what respondents considered 'important' or more so,* ***the top three features*** *were* ***vehicle price, convenience to recharge*** *and* ***vehicle range.*** ***All three of these received 94%*** of the votes made. *The three lowest options were vehicle model 62%, vehicle make 71% and emissions 74%.*

Table 4.1: Levels of importance of EV features

Answer Options	Very Unimportant	Unimportant	Neither	Important	Very Important	Response Count
Vehicle Make	11	11	11	60	23	116
Vehicle Model	9	16	19	61	11	116
Vehicle Price	6	1	0	35	73	115
Vehicle Speed/Performance	4	6	8	67	32	117
Convienence to recharge	6	1	0	18	92	117
Battery Recharging time	7	2	3	23	83	118
Vehicle Range between charges(km's)	6	1	2	31	78	118
Battery lifespan (no. of years)	5	1	8	40	63	117
Cost of operation(ie electricity,tax,insure,maint.etc.)	5	3	0	43	66	117
Re-sale value	5	8	13	57	35	118
Zero emissions of Environmental pollution*	4	4	23	52	35	118
					answered question	118

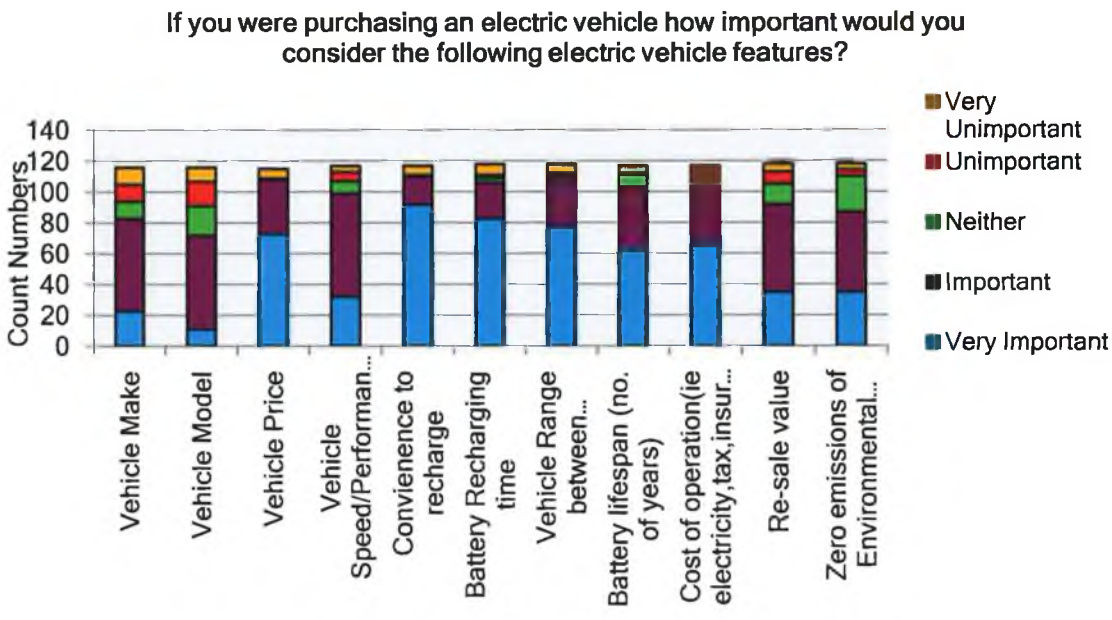

Figure 4.9: Levels of importance of EV features

Figure 4.9 displays where the different levels of importance in each option were. The results show that the consumers are unwilling to compromise their expectations in any area of the available options but there is a clear difference in the levels of importance they place on some of the features. ***Vehicle costs recharge infrastructure and battery issues are the principal areas of importance for them. Costs of operation (93%), recharging times (92%) and battery lifespan (88%) were also of high importance***.

Under various demographics, there were some small differences in choices in a few of the features. A higher percentage of women thought vehicle make (20%) and model (18%) 'Very unimportant' compared to men (4% and 2% respectively). Men considered convenience to recharge 'very important' (77%) more so compared to women (10%), though women (80%) still considered it 'important'. Men (34%) also placed less importance on emissions, choosing 'neither' or less, compared to 12% of women. In the vast majority of all cases under demographics, the majority in each section were matching in what their importance levels were.

Following the previous question, respondents were then asked to choose which five of the same options they would consider their most important (in no particular order). The results from this, presented in Table 4.2, show that ***the EV feature chosen most by the***

consumers as important was the vehicle price (n=91, 77%). The other four most important features were ***convenience to recharge*** *(n=84, 71%),* ***vehicle range*** *(n=80, 68%),* ***battery recharge time*** *(n=68, 58%) and* ***cost of operation*** *(n=61, 52%).*

Table 4.2: Respondents five most important EV features

Answer Options	1st	2nd	3rd	4th	5th	Response Count
Vehicle Make	8	9	2	7	9	35
Vehicle Model	2	3	8	0	1	14
Vehicle Price	49	15	8	10	9	91
Vehicle Speed/Performance	11	13	11	9	12	56
Convienence to recharge	16	16	20	21	11	84
Battery Recharging time	7	18	17	17	9	68
Vehicle Range between charges (km's)	12	21	25	13	9	80
Battery lifespan (no. of years)	0	3	5	11	17	36
Cost of operation(ie electricity,tax,insure,maint.etc.)	8	14	14	11	14	61
Re-sale value	0	1	3	7	10	21
Zero emissions of Environmental pollution*	4	3	3	10	11	31
					answered question	118

The least chosen options in this question were vehicle model (n=14, 12%), re-sale value (n=21, 18%) and emissions (n=31, 26%). The results in this area reflect those found in the previous question in terms of what the consumers consider their most important features and the less important features. The E&Y [(54)] global survey found that the three features that consumers would be most hesitant about in choosing EVs were typically *price, range and access to charging infrastructure*. The element Energy report [(53)] found that the *mass market considered price and range to the top concerns* of consumers and *the environmental benefits to be lowest.*

These findings are largely reflected in the results of the previous two questions for Irish consumers. It is clear that these areas will be where the public hinge their decisions on whether to purchase EVs. The environmental benefits of the vehicle will not, for the large majority, be a deciding factor even though it is still considered an important feature of the EV.

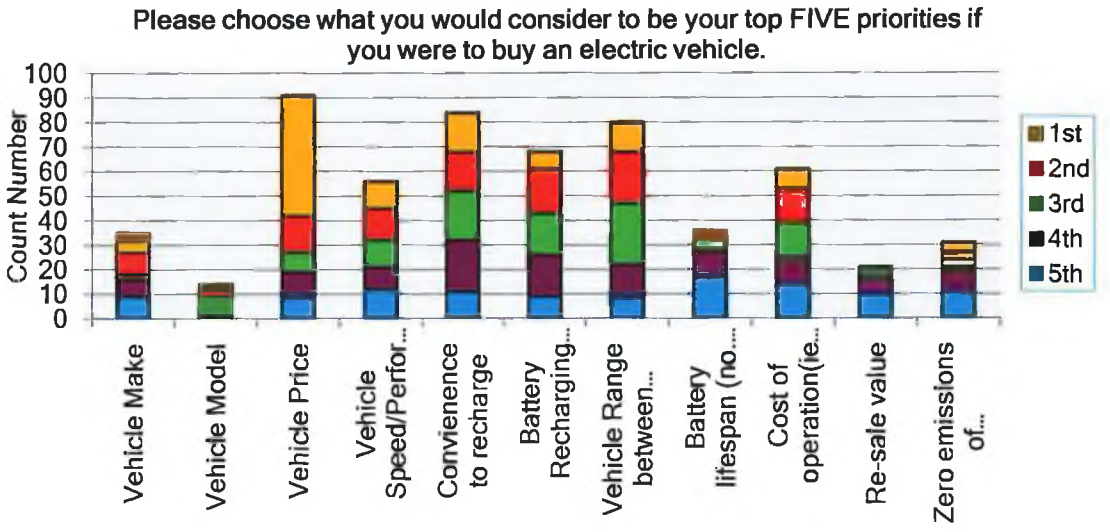

Figure 4.10: Respondents' top five EV features

In Figure 4.10, the preferences of the respondents are made clear. Vehicle makes and models do not appear relatively important in choosing to purchase an EV. It is important to note also though that the vehicle make is considered to be the more important of the two. It was earlier shown how, for both the global and local vehicle market, the majority of the market is among a small number of manufacturers. Brand loyalty may also be a barrier to the EV becoming widely adopted. Some of the top manufactures will not release fully EV models for some years yet and competition for sales will be particularly fierce as the market recovers from the downturn. Establishing the EV in such a market where vehicle price is considered to be so important will hinder its adoption and even more so without incentives to purchase at the higher prices.

It can be observed from the responses to the previous questions that *the majority of respondents have a low level of daily commuting typically*. ***However, vehicle range has been shown to be one of the principal EV features they would consider as most important.*** The respondents were asked to indicate what range they would consider acceptable if buying an EV. Most of the new EVs coming to Ireland are advertised with ranges of 160km. This, however, may well prove to be less in everyday use such as urban driving, use of AC, heating etc. ***The vast majority of respondents (77%) indicated they would only consider battery range acceptable above 150 km, (see Figure 4.12). Almost 47% required 200 km or more as an acceptable level.*** This clearly indicates how vehicle range beyond what is typically required is still a high requirement of respondents.

The majority in terrace housing (54%) chose 150+ km but apart from this, most demographic categories wanted the highest range.

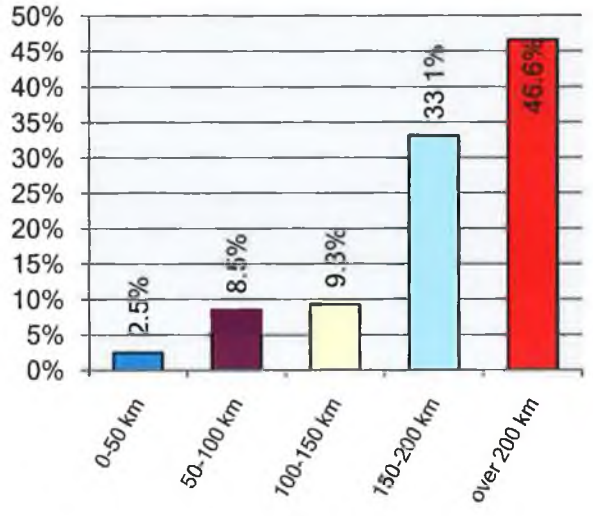

Figure 4.11: Acceptable EV battery range for respondents

There are no easy solutions to improving the EV range available other than higher capacity batteries (increased costs) or waiting on improvements in battery technology. The Better Place option, mentioned earlier in section 2.5, would resolve this in some way but this would require a leasing of battery or 'buying' the miles used on the battery. This system has another advantage in that it would allow for the EVs to be sold at a reduced cost but it is unlikely to become available in Ireland at least until there is sufficient demand for its use.

The respondents were further asked to choose which three options from a list of seven they would consider likely to prevent them from buying an electric vehicle. The results, presented in Table 4.3, show the three most chosen are all related to battery range and charging infrastructure. ***Lack of charging infrastructure (72%) proved to be the most selected concern with range and recharging times both (55%).*** There were again some minor differences between some of the demographics in terms of what they selected such as those shown in Figure 4.12 for males and females, but for the most part the majorities were in similar categories.

Table 4.3: **Features likely to prevent purchase of EVs**

What do you think might prevent you buying an electric car? (Please choose 3 of the following)				
Answer Options	**1**	**2**	**3**	**Response Count**
I don't know enough about them	21	3	12	36
They are too expensive	26	8	8	42
The range is too limited	28	22	16	66
They are not big enough	0	6	10	16
They might not perform as well	11	18	6	35
Recharging might take too long	8	29	29	66
There isn't enough recharging infrastructure	24	30	31	85
			answered question	118

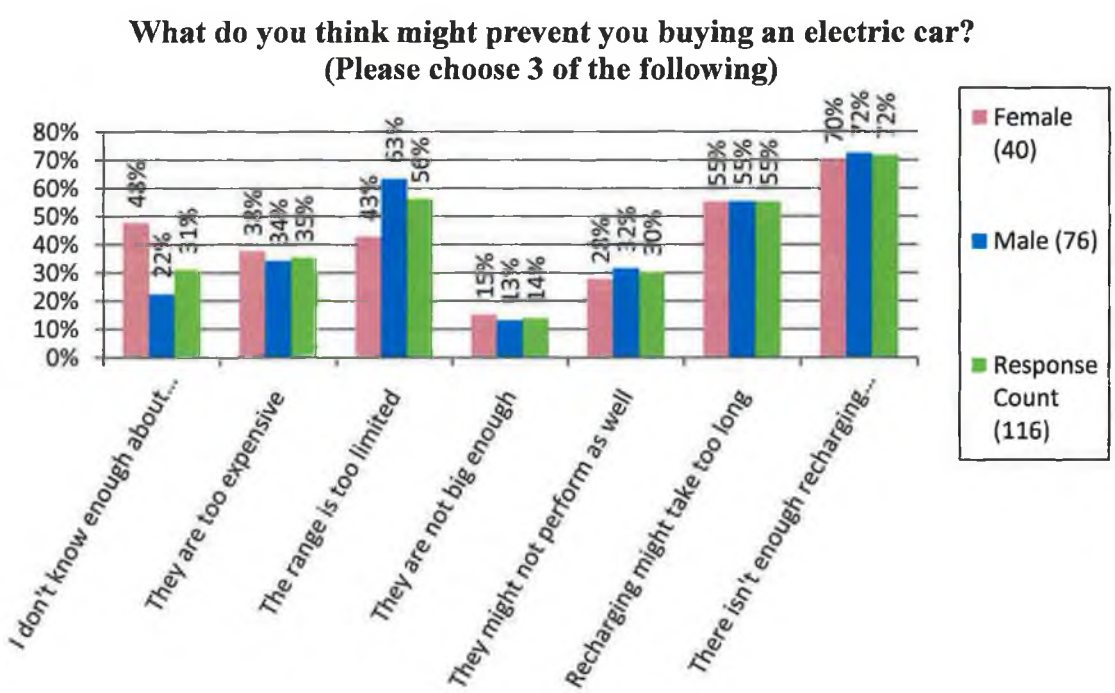

Figure 4.12: Top three EV concerns among Males and Females

Lack of recharging infrastructure has been shown to be a primary concern in respondents' answers to several different questions. This again is reflected in some of the international surveys mentioned previously [(54)]. The public charging infrastructure in Ireland is being installed by the ESB which hopes to have installed its initial network by end of 2011. GPS systems in the EV will be able to inform the driver of the nearest available charging points. As manufacturers are depending on governments and energy providers to install these public systems it shows that co-ordinated effort such as those by the ESB will be vital to the success of the EVs, particularly at the early stages.

As charging at home or work will be an important aspect of a successful EV market, the respondents were asked if these locations were presently suitable for them. ***The vast majority (94%) responded that home charging would suit. Only 102 respondents completed the workplace question but there was also a large majority (72%) where it suited***, (see Figure 4.13). Getting recharging points into the workplace will require more effort than that of the public points as much of it will be on private grounds. Government incentives or tax breaks for installing these points would be likely improve the appeal for employees of the EV on a daily basis. *As charging infrastructure is one of the biggest considerations and concerns of potential buyers, it will be important to have as extensive and accessible a system as possible.* Other places like shopping centres and car parks would prove ideal locations for installing recharging systems but, again, this will be less likely to happen unless the private operators of such places are encouraged to do so.

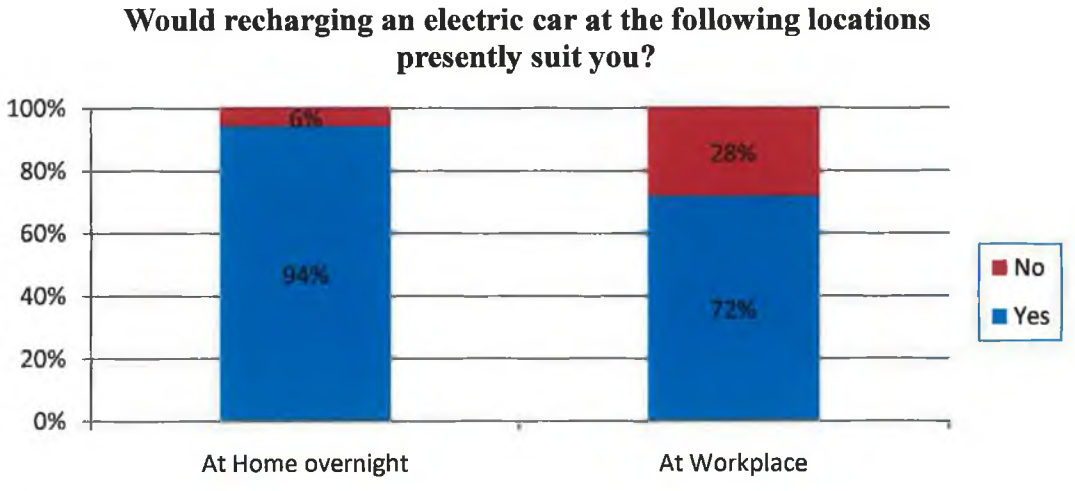

Figure 4.13: Recharging suitability

To gauge the acceptance levels of using the public charging points, respondents were asked both if they were willing to do so and if they were willing to pay for doing so. ***The vast majority (86%) surveyed were willing to use the public charging points***, (see Figure 4.14). The responses previously (see Figure 4.12) indicated that lack of charging infrastructure would likely prevent consumers from buying the EV. The fact that such a large majority is willing to use the system is positive, given that it would require a complete change in normal behaviours for drivers. Of those who earlier said they would prefer to use petrol/diesel, 83% were willing to use the public charge points compared to

88% of those who preferred electricity. ***Almost all demographic groups were highly preferable to using them also.***

Recharging times at these public points will vary depending on whether it is a regular or fast charge point. *The consumers will have to become accustomed to waiting while recharging takes place.* Additionally, it is likely they will have to remain with the vehicle while it is doing so to prevent possible risk of theft or damage of the connecting lead. *This may prove unappealing to some users and further research at a later date may establish how EV users feel towards having to do this.*

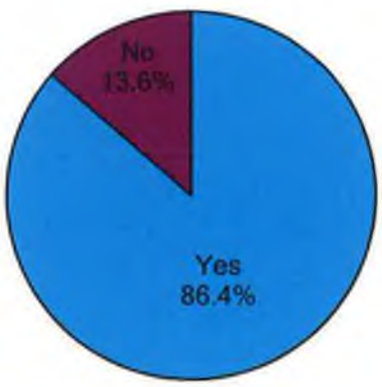

Figure 4.14: Willingness to use public charging points

The survey respondents were also largely willing to pay (75%) for using these public charging points, (see Figure 4.15). This is a positive indication that charging for use would not deter potential EV owners from using them. Also, 62% of those who preferred using petrol earlier were also willing to pay for charging use compared to 82% of those who preferred electricity. The ESB is making a long-term substantial investment in setting up this system around the country and many more public points will follow. It is also an important requirement for the car manufacturers who have signed the agreements for supplying the new EVs into Ireland. It is important therefore to know how the public would feel about the charge for this service. Were there largely negative sentiments towards paying for this it may lead to reduced charging infrastructure through lack of use and could also ultimately affect EV sales. The system being used in Ireland is provided by one of the leading suppliers of these systems in Europe where it is also in use in the UK, Denmark and France. This system will allow for ongoing monitoring by the company and provide further information on usage patterns.

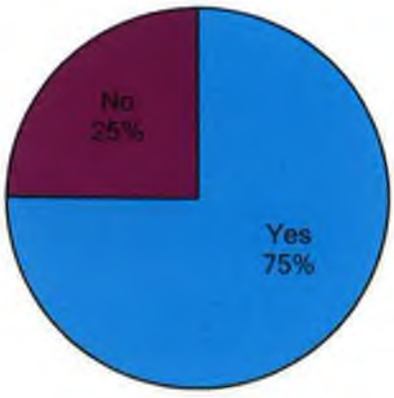

Figure 4.15: Willingness to pay for use of public charge points

The only other clear alternative to having recharge the EV battery, at home or in public, is the Better Place proposal (discussed earlier in chapter 2) being adopted in some other countries. This would involve the swapping of the battery in purpose built swapping stations in approximately 10 minutes. Though not available in Ireland, and unlikely to be anytime soon, the respondents were asked which option they found more appealing. ***The majority of the respondents in this survey (67%) indicated that they would prefer the option of recharging at home or in public,*** (see Figure 4.16). The battery swapping business model would help to somewhat overcome the range issue for the EV also if there were enough of the stations but it would also require the leasing of the battery or purchasing of miles on the battery from the company.

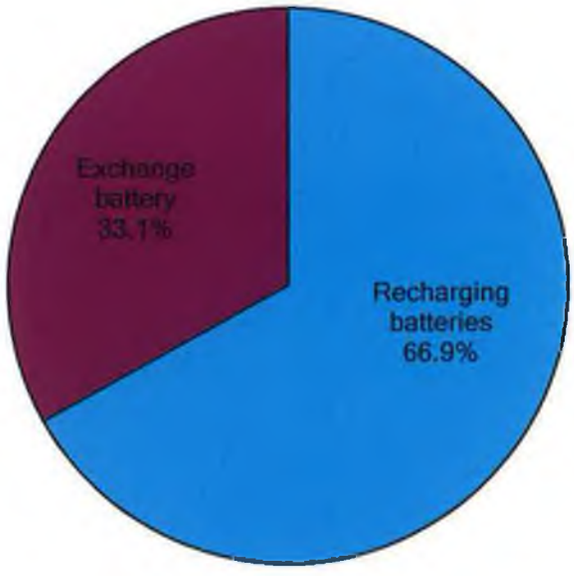

Figure 4.16: Preferences for battery charging or swapping

The demographic categories were all largely in favour of the recharging option. The 18-29 age groups however, preferred the swap option (55%) as opposed to the other age groups. Those who preferred refuelling with petrol were 50/50 on the swapping concept. It will be interesting to see how the two different models develop over time in the other countries as competition for EV sales increases between the various manufacturers.

Consumer Willingness to Purchase Electric Vehicles

The respondents were asked if they planned to buy any new car in the next ten years. This would help indicate to what extent the respondents might consider an EV in the same period as the government hopes to greatly increase the market share of the new vehicles in the years leading up to 2020. The sales figures presented earlier (see figure 2.19) show the level to which these EV sales will need to reach as sales in the next few years slowly improve with the better availability of the EVs.

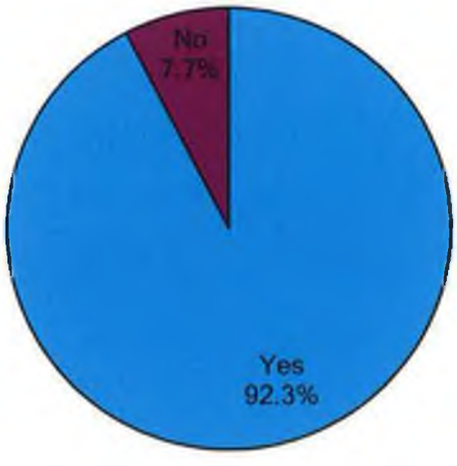

Figure 4.17: Plan to buy any new car in next ten years

Figure 4.17 shows that **92% plan to buy a new car in the next 10 years**. It is probable that the majority of them may only purchase one new vehicle between 2010 and the government's target of 2020 for 10% market share of electric vehicles. The Irish car 2008 statistics earlier (see Figure 2.16) showed that over 66% of the car market were 4 years or older. That would make them now almost 6 years or older in December 2010. Significantly fewer cars have also been sold annually since 2008, also due to the economic crisis. *These figures would indicate that the large majority of the almost 2 million vehicles in the Irish car market are likely to be replaced in the next ten years.*

This would give the government a golden opportunity to incentivise the purchase of EVs for new buyers and provide these incentives for EVs more so than for other ICE based car models.

Having asked respondents about their various preferences, both for and against EVs, and how suited their circumstance were to using them, the respondents were asked if they could foresee at some future point that they would be willing to purchase an electric vehicle. ***The responses indicated that 81% of those surveyed would be willing to consider an EV as a future purchase***, see Figure 4.18. This compared favourably with the E&Y international study [(54)] that found only 13% would never consider purchasing one. The result indicates that there is a definite willingness among those surveyed to consider purchasing the EVs despite all its perceived drawbacks and lack of history among the public. The large majority of all demographic groups were willing to consider EVs at a future stage. Of those who preferred to refuel with petrol earlier, 62% were willing to consider EVs. 92 % of those who would prefer electricity were willing to consider it. Of those planning to buy in the next 10 years, 82% were willing to consider the EV. In every previous survey question and each subsection the majority were willing to consider the EV at some future point.

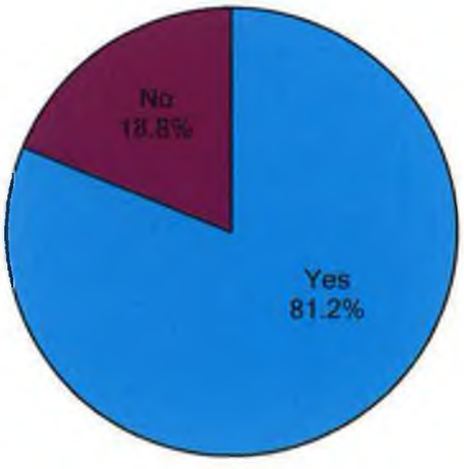

Figure 4.18: Would choose to buy an EV at a future point

This provides a positive outlook for the long-term prospects of the electric vehicle. *With increasing makes and models of electric vehicles, increased recharging infrastructure and improvements in battery technology, the potential is there to further convince the*

buyers to purchase the electric vehicle. The result in no way accounts for how many will actually purchase the EV, but we have seen previously that there were majority preferences for vehicle use of electricity, short commuting distances, access to more than one car and suitability of home and work for charging. There is also a majority willingness to use and pay for use of public charging points.

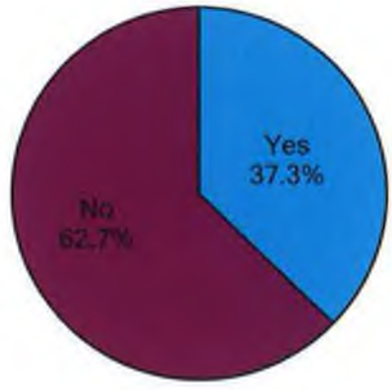

Figure 4.19: Willing to pay a higher price for an EV

As observed in the previous survey answers, vehicle price was the most important point for the respondents. ***The majority (63%) stated they would not be willing to pay a higher price***, Figure 4.19**.** This will prove to be one of the electrical vehicles' biggest obstacles in getting established. There was still a significant portion of respondents willing to pay a higher price. It is not known to what extent how much more those people are willing to pay. 98% of those who were willing to pay a higher price had answered 'willing to consider an EV at a future point' previously. This indicates *that a large portion (72%) of the 'No' replies in this question had previously stated they would consider an EV in the future*. Obviously, price is a significant barrier for this element of the 'no' respondents.

Vehicle prices are likely to remain relatively high in the short term, even with subsidies and incentives, until battery and production costs become more competitive and there is increased EV competition. Prices for other alternatives such as PHEV may be higher if the GM Volt in the USA is anything to judge by. It will cost significantly more than the Nissan Leaf EV, as mentioned in chapter 2. How much users of this type of vehicle benefit in fuel savings will depend entirely on what their behaviour patterns towards recharging will be.

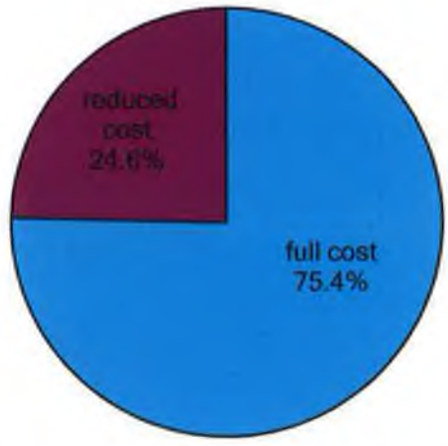

Figure 4.20: Purchase at full cost or lease at reduced cost

There are two separate approaches being developed by car manufacturers towards how they intend to price their EV models. These involve buying the EV outright including the battery, which is one of the most expensive components of the price. The other is the leasing of the battery and the purchase of the car such as Renault is proposing when they release their EV models in 2012. This would allow for a reduced price and an ongoing payment for the battery. The respondents were asked to indicate which option they found more preferable. ***The majority of the respondents in this survey (75%) indicated that they would prefer the option of purchasing at full cost,*** Figure 4.20**.** The international survey by E&Y [(54)] also found that consumers preferred this option in all areas surveyed. It found a lower willingness in Europe to lease, ranging from 10% in France to 16% in Germany. Preference for leasing was even less in other countries.

Given that vehicle cost was the most important feature in this survey and high in others, it is interesting to note that consumers prefer not to be committed to a leasing arrangement. One factor in this may be the level of knowledge which exists among the public regarding electric vehicles. As battery technology improves, increasing range and reducing costs, it will have a depreciating effect on the value of other older models of EV. Given the high cost presently of EVs, depreciation of value is likely to be greater than the conventional ICE vehicles. The lifespan of the batteries is also something that will only become more apparent over time for the new EVs.

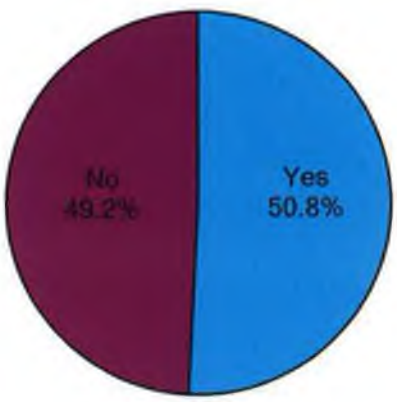

Figure 4.21: Willing to buy EV as next car

To determine how strongly the respondents would consider purchasing a new EV they were asked if they would consider buying an EV as their next car. As shown in Figure 4.17, the majority of respondents plan to buy a new car in the next ten years. Also 81% of respondents stated they would consider it in the future. The responses to this question, (see Figure 4.21) indicate that almost 51% of respondents would consider doing so as their next car. 65% of these 'no' responses had answered yes previously to considering an EV in the future and 97% of the yes response had also done so. 91% of the 'no' in that previous question repeated their 'no' answer in this question.

With so many of the respondents planning to purchase a new car before 2020, such high proportions willing to consider it both at some point in the future (81%) and also, as their next vehicle (51%), ***it can be concluded that there is a very high level of interest among the respondents in EVs***. Converting interest into sales is a completely different task.

Men (56%) were more likely than women (40%) to buy an EV next. City based (65%) were most likely compared to town (45%) and rural (35%). Those over 40 years of age were more likely (65%) than those under 40 (43%). Detached house residents were 43% (31/66) likely to consider and semi-detached 53% (17/32) likely. Terrace house residents had the highest percentage (61%) but only 13 respondents were in this category, so it more likely that those in detached or semi-detached houses would prove most preferable. Those with 2 car household (51%, 33/66) were slightly more likely than respondents with one car (50%, 16/32) and three cars (47%, 9/19). Those with the lowest daily commute

were most likely to consider (56%, 41/73) followed by those with 25 to 50 km daily commute (50%, 13/26).

Based on the above information, the demographic profile of those most likely to buy an EV as their next car was male, over 40 years old, city based with a detached or semi-detached house, with 2 cars in the household and driving less than 25km daily on average.

Of those who previously stated they would consider purchasing at a future point, 66% said they would consider an EV as their next car. Also, 28% (12/43) of those who would not buy at a higher price would consider an EV for their next car. 66% (19/29) of those interested in leases would not consider buying in this question.

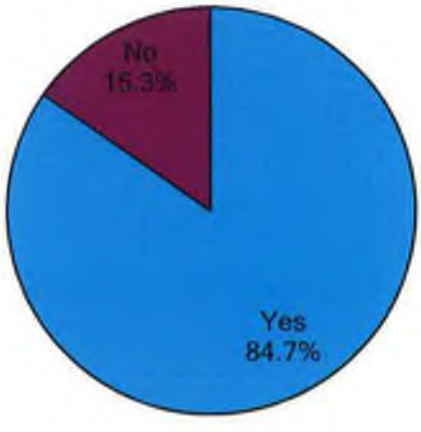

Figure 4.22: More willing to purchase with incentives

Respondents were asked if they would be more willing to consider purchasing an EV, if given government financial incentives to do so. The results, in Figure 4.22, show that ***the vast majority, 85%, of respondents would be more likely to consider buying***. Of those who had stated 'no' in the previous question, 83% (15/18) would not be further interested by incentives. Of those who answered 'yes' in this question, 43% (43/100) stated they were not interested in buying an EV as their next car in the previous question. Out of those who stated they would never consider an EV in question 19, 45% (10/22) would be more interested with incentives. This clearly shows how government financial incentives can have a positive impact on people not thinking of buying an EV. ***Considering that the EV price was found to be the most important feature earlier in the survey, this result***

gives an indication of how financial incentives can possibly change minds and strengthen the view of those already interested in EVs.

The final question in the questionnaire was designed as a qualitative question. It allowed for respondents to write comments suggesting what else they thought the government could do, other than financial incentives, to encourage the growth of the electric vehicle market in Ireland. A variety of responses, 80 in total, was received. The themes emerging from the comments were analysed and grouped to facilitate discussion.

Respondents suggested that there should be some incentives for driving electric vehicles. The incentives ranged from no VRT, no tax, lower insurance rates to free parking and scrappage incentives. The following examples were evident:

> *"Reduced road tax, Reduced Insurance premiums"*
> *"Awareness, larger discount with scrappage if you buy electric vehicles"*
> *"Rebate for usage, incentives to update/renew battery"*
> "*Reduce cost of motoring overall*" and "*Cheaper Electricity or Reduced tax*".
> *"Give a rebate to the purchaser" and "Free parking, restrict access to city centres to electric cars "*

The government already have incentive schemes in place for both VRT and buyers' grants as shown earlier in chapter 2. These scheme are however limited at the present until the end of 2012. Comments about these may indicate some lack of knowledge among the respondents in terms of what incentives are in place for new EVs. Greater publicity regarding these, particularly given the short time frame of them, would help better inform the public.

There were a number of suggestions regarding how the government should be seen to take a very proactive lead in adopting the EV for use in all government departments. This would help to state the seriousness with which they are approaching the establishment of the market. Comments such as the following from respondents reflect these sentiments:

"1 - replace all current elected government personnel vehicles with electric ones. 2 - Use in all government state & semi-state bodies. 3- Vigorously promote the campaign and be seen as 100% supportive to the concept".

"Make all government vehicles battery operated to show they work effectively"

"Use them themselves as an example to all"

"Roll out electric vehicles for government/state bodies"

"Show that they are committed to a greener environment by using electric vehicles themselves..."

"Using these vehicles more within the government structure in order to give people more confidence in the vehicle".

Increasing exposure and publicity of EVs is what others suggested as it is felt that public knowledge is severely lacking about EVs. One respondent commented:

"Invest in exposing Irish society to the electric car. I am pretty sure only a small percentage of the population know they exist. Generally people don't know much about them".

While a further comment expressed similar sentiment regarding knowledge related to the EV:

"The government has done very little to promote electric cars in Ireland and as a result very little is known about them and there are very few places to actually recharge these cars. This means that buying an electric car is not the most practical option in Ireland at the moment but hopefully these cars will become more popular in the coming years. I believe our government should run various ad campaigns to promote the electric car and make it more widely known. They should also put more charging stations around the country-these would be especially beneficial on motorways and at airports. I believe the government has quite a bit of work to do in the promotion of electric cars and other alternative transport methods in Ireland."

One respondent simply asked for the government to "*get out of office and call an election*" or another who wanted them "*given away for free*". These may reflect too much optimism among some of the respondents though both may have some merit. Only two comments were made directly towards promoting the environmental benefits of the EVs. This may reflect some of the survey findings that the environmental aspects of the EVs are not a priority among the potential buyers, at least not in their purchasing decisions. Another comment wanted reduced carbon emissions linked to reduced tax rates.

From the questionnaire, respondents chose price as the single most important factor for them when considering buying a new car. It also ranked highly when choosing five responses from eleven available for factors important for them when deciding to purchase. There were, however, only a few comments related to costs made, and these mainly related to reducing operating costs of the EV. Mainly these looked for more favourable tax and insurance rates. As the operating costs of the EV would be quite low these would be the main expense. Realistically, insurance will not be an area that the government would use to promote the EV. There is however good potential for the government to give exemption for road tax. This tax, as shown in chapter 2, is now based on CO_2 emissions of vehicle engines. With no tailpipe emissions from the EV there is clear scope for the government to exempt the EV as a further means of promoting it.

The biggest number of responses however was in the area of infrastructure and recharging the EVs. There were 53 separate comments where charging infrastructure for EVs was referred to in some way. Some comments covered a number of topics, such as this comment:

> *"Once they are proven to perform to the same standard range, cost of operation, ease of refuelling, performance etc.... This will require building an infrastructure where operating an electric car is simple. The government could promote this by greatly reducing tax on new electric cars and ensuring that everyone has the chance to test them. Potentially running events where the public can test drive and learn about electric cars."*

Several comments also suggested free parking, restricted city access, use of bus lanes as other forms of incentives for potential buyers:

> *"Do more research to improve the lifespan of the battery and more public recharging points"*
> *"Make it possible to recharge at all parking locations for free".*
> *"Improve Infrastructure with low/zero cost recharging".*
> *"More public charging points, priority use of bus lanes in cities, free parking, Use of electric vehicles by public services and ministers, promotion of electric bicycles as well as cars,*

The single most common theme emerging from the comments is the need for the charging infrastructure. This has been shown in the survey responses to be a very high priority for the respondents. The work of installing this infrastructure is already underway but will take a couple of years to become widely available. Promoting the use of EVs and better informing the public about them is also widely commented on. To coincide with increased infrastructure there needs to be a concentrated effort to promote the EV itself, so that the knowledge level in the public arena is increased and improved. Widespread adoption of EVs by government agencies, such as the ESB's plan to have all its fleet become electric vehicles, would provide a high public profile for the use of EVs and help to create a level of confidence among the consumers.

Aside from any major financial incentives, the respondents' comments provide useful insight into other smaller concessions that they would like to see. The government should clearly indicate whether they consider the EV as a zero emissions vehicle in terms of applying tax. The survey responses showed a high level of interest in the EV. It seems drivers want free recharging facilities to encourage uptake but the majority also answered that they did not mind having to pay for use of them. It might be an option to provide a reduced cost or some level of free service with public charging points. Incentives would have to be made available to the service providers though as infrastructure costs can vary greatly.

The earlier Element Energy report [(53)] noted UK prices ranged from £1,000 to £100,000 between slow and fast charging points. The report also found that the increased

availability of fast recharging facilities in Japan resulted in EV users making greater use of the battery range. The level of battery discharge recorded by the smart system showed drivers had doubled the level of battery discharge before recharging. This showed how increased access to quicker recharging times could increase utilisation of battery range. There is no doubt that the battery recharging time and distance between recharging is also very important to consumers. This was indicated in their top five when choosing factors that were important to them when considering purchasing an EV.

Provision of recharging infrastructure beyond that being provided by the ESB will also greatly help to increase access to charging points for the public. Areas that will provide ideal locations such as workplace carparks in addition to others mentioned like multi-storey carparks and shopping centres are just some of the possible locations. The current lack of infrastructure and recharging facilities must also be addressed if sales are to reach projected targets.

Overall, from the responses to this question, it is clear that respondents had some strong feelings on the topic. Their answers provide the scope for future research in this area as the electric vehicle market becomes more established. It is also evident that the Irish government will need to do more to promote this market in the country by taking a leading role in their own use of EVs as widely as possible. The Government also have a distinct advantage in being able to bulk order vehicles and can use this position to reduce their spending on such vehicles. Ultimately, there needs to be increased knowledge put out there for the general public to make informed choices when purchasing a new car. The potential buyers' views should be considered if there is any hope of meeting projected targets for sales in this market.

4.3 Summary

The need for increased knowledge of consumers' needs and behaviour in relation to EVs was highlighted earlier in chapter 2 [(39)]. They will be central to the success of establishing the EV market. The survey results have shown that the consumers' most important features if considering purchasing an EV would be the price, its convenience to recharge and its battery range. Issues relating to battery and range were also found to be the factors most likely to prevent them buying an EV.

The high level of interest found in EVs from the survey shows that consumers would be very receptive to the alternative form of vehicle and would prefer to use electricity over petrol/diesel. The environmental benefits of the vehicle would not be high on their list of priorities. It is clear that the greatest appeal of the EV is the reduced cost of motoring it could provide.

Vehicle range and charging infrastructure will improve gradually and if there is similar improvement in reducing the cost of vehicles then the potential for much wider consumer uptake of electric vehicles is there. The respondents clearly want to see that the infrastructure is in place and that the electric vehicle concept is being widely practiced by the government who ultimately need this market to succeed. Easy, convenient, and widespread recharging points are something the public want to see before they can build their level of trust in using the system.

As the survey confirmed, the majority of the average daily commuting is well within the range of the new EVs. Most respondents still want greater range than presently available and this is understandable. However, the EV is still highly capable of providing for the majority of everyday needs. They will be particularly suited to those with some form of detached home and even more suited to those with access to a second car.

Above all else, the most important factor for the survey respondents was the vehicle price. As it is relatively high, even with the government grants, the consumer would need to consider the lifespan cost of the vehicle. Its rate of monetary depreciation, and that of the battery, would be a large part of this. Consumers will be sceptical about any forecasted lifespan of EV batteries until they are proven in performance. ***Some issues regarding the battery may only become clear with extended use*** in the public eye. *Consumers will need to have confidence that they can get up to 10 years or more from batteries to maximise their overall savings from use of EVs*. Also, EV purchasers must be clearly informed of how best or often to use charging of their EVs. Any potential impact that charging habits may have, such as repeated short charging, should be avoided to maximise battery performance and durability. Only with time and research will the ability and durability of new forms of batteries become clear. This will be highly important in building the public's trust in EVs.

5.0 Conclusions and Recommendations

5.1 Introduction

This thesis set out to determine the challenges that need to be overcome to establish the electric vehicle in Ireland as a long term viable solution for the transport sector and the challenges it faces from climate change and energy use issues.

Use of fossil fuels is the leading source of greenhouse gases that are impacting on the global climate. The transportation sector is almost completely dependent on fossil fuel use. It is a vital sector in every economy but is also one of the biggest sources of GHGs due to its dependence on oil. With increasing efforts being taken globally to reduce GHG emissions and reduce dependency on increasingly expensive oil, the electric vehicle is one of the few options available to the transport sector that can reduce its emissions and its dependency on oil.

Ireland has set out to become a leading nation in adopting the new EVs that are being manufactured by some of the leading car brands. Getting this market to succeed in Ireland will present challenges for the government, industry and ultimately the consumer upon whom the level of success will depend.

Using the review of literature, the author sought to gain a better understanding of the issues relating to the environment, energy use, international and national legislation and the transportation sector's role in these areas. The author further sought to understand the background to the electric vehicle from its early beginnings to its current state and what challenges it faces in developing further to become a solution to the present and future needs of the transport sector.

Having reviewed the Irish governments' and car manufacturers' efforts to establish a new market for electric vehicles in Ireland as a means to tackling climate change and increased energy independence, an online survey was developed for the purpose of identifying the attitudes of a sample population of Irish car owners towards electric vehicles and how willing they would be to purchase them.

5.2 Limitations

There are a number of limitations that apply to this research. The first of these limitations is that the research was focused solely on the electric vehicle (EV) or battery electric vehicle (BEV). It does not deal with the hybrid electric vehicles (HEVs) or the plug-in hybrid electric vehicles (PHEVs). A further limitation of the research was the convenience sampling method used in the survey. It is a non-random probability method of sampling and as such findings from it cannot be generalised to the wider population of car owners in Ireland. The sample population was largely based in Co. Galway as the survey results indicate.

5.3 Conclusions

The government have taken a very proactive approach to establishing the EV market in Ireland. By the end of 2011, with the completion of the initial ESB charging infrastructure, Ireland will be among the first countries in the world to have a national charging infrastructure for EVs. They have set their EV targets for 2020 (this includes PHEV) and meeting our CO_2 emissions reductions targets from transport will depend on those targets being achieved. Further incentives through grants and VRT exemption will help to promote the EV sales in the next two years. Further tax breaks for businesses may help to further promote sales. Funding into research through SEAI and ESB into EVs is also being done. However, if they are to meet their 2020 targets it is likely they will have to do more. The level of sales will need to reach almost 42,000 of these vehicles per year by 2020 assuming that previous year's targets were met. These sales also need to be achieved in a car market that is still a long way from recovering to its previous levels and will likely provide intense competition for sales against these higher priced vehicles.

Many of the car manufacturers, and particularly some of larger ones in Ireland, are not seriously pursuing the EV market as yet. Some like Toyota and Honda have pioneered existing hybrid technology and will focus their immediate attention on the PHEV type vehicles rather than EV. Such competition between manufacturers for sales will most likely hinder EV uptake but it has yet to be seen what the costs of the new PHEVs will be. However, as battery technology improves, the EVs range will increase and battery

costs will reduce, while battery production capacity greatly increases. This will most probably lead to greater interest by both manufacturers and consumers in the EVs.

The clear conclusion that can be drawn from the results of survey is that the three most important factors for the consumers were they to purchase an EV would be vehicle price, the convenience to recharge and vehicle range. They would not expect to compromise in quality for any feature of the EV. There was a high level of interest in the EV and almost half of respondents said they would consider it for their next car purchase. However, it is quite clear that they want to see an extensive, convenient and low cost charging infrastructure and other issues like range and price will not be far from their thoughts.

5.4 Recommendations

As the new models of the electric vehicle are only beginning arrive in Ireland, there is widespread scope for future research in areas related to the EV. Some of the new EV models mentioned in this research such as the Nissan Leaf and the Renault Fluence, do not enter the Irish market until 2011 and 2012 respectively. The following recommendations arise from the research:

- Government incentives towards EVs should be extended beyond their present end date. The survey showed clear evidence of increased interest with incentives. Also, government incentives given for new cars should be focused towards the new EVs and away from ICE vehicles. Scrappage schemes could also be used to favour the use of EVs. The focus should be on keeping incentives only towards the new EVs. The present system of higher grants for EVs over hybrid should be maintained also.
- The government should seek to incentivise the installation of charging points into carparks, work places, and shopping centres to increase the availability of the charging infrastructure. Charging infrastructure concerns were strongly featured throughout the survey respondents' answers.

- After a period of time following the release of the new EVs, a study of the actual lifecycle costs associated with ownership and use of the EV could be conducted. This could include the maintenance or repairs required by the new electric vehicles and average EV energy usage. It would also include the variations of fossil fuel prices over the same period. This would help to give the consumers more accurate information such as the rate of depreciation of the EVs and establish the real costs of owning such vehicles compared to the alternatives available.

- Research into possible secondary uses of EV batteries as energy storage systems as the older batteries become obsolete and replaced. This would leave potential for the battery to retain monetary value for battery trade-in schemes as manufacturers continue to make improvements in battery technology and range increases.

- Research into the performance and usage patterns of the EV battery and whether there are any differences in performance between geographical regions and climate conditions needs to be carried out. This could also determine if there are any issues relating to extreme weather conditions such as heat and cold weather in Ireland.

- Further consumer information studies based on the experiences of the early adopters of the EVs to determine any clear demographic patterns in type of purchasers would be beneficial. This could also be used to determine any possible differences in battery performances based on whether the owner is urban/rural based and if there are any effects of charging behaviour patterns on the EV battery.

5.5 Summary

This chapter began with an introduction that discusses the overall outline of the thesis, its goals and how they were achieved. The limitations of the thesis were then presented, followed by presentation of the conclusions and recommendations. The research question, objectives, literature and findings are integrated throughout.

While the research conducted in this thesis on the consumer attitudes and willingness to purchase EVs was based on a relatively small sample, it never the less portrays an area of strategic importance to government, manufacturers and consumers in that the electric vehicle will become a focus for future development.

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APPENDIX 1

Consumer Survey for Electric Cars

1. Introduction

The Battery Electric Vehicle is a relatively new option available to potential car buyers.

It will operate solely using electric batteries which can be recharged at home or using public recharging points as opposed to the traditional use of petrol/diesel.

The Vehicle will also have no polluting emissions due to using only electric batteries.

*Some emissions can ultimately be attributed to the vehicle if fossil fuels are used by the energy supplier to generate the electricity.

It is estimated that an annual driving range of 19,000 km will cost less than €250 per year (based on overnight charging rates).

The current range of driving presently available between recharging for electric cars is up to 160 km.

This survey is being used to determine consumer attitudes to the battery electric vehicle and their willingness to purchase them.

The survey is completed as part of a minor thesis.
The identity of all survey respondents and the information provided is anonymous and will be used only for the purpose of the thesis.

Your help in completing this survey is very much appreciated, Thank You.

Consumer Survey for Electric Cars

2. Demographics

1. Gender

◯ Female ◯ Male

2. Please choose your age category.

◯ 18-29 ◯ 30-39 ◯ 40-49 ◯ 50+

3. County.

[ ]

4. Which of the following areas do you live in?

◯ City ◯ Town ◯ Rural

5. What form of accommodation do you presently live in?

◯ Detached house

◯ Semi detached house

◯ Terrace house

◯ Apartment

6. Number of cars presently in your household?

◯ None ◯ 1 car ◯ 2 cars ◯ 3 cars or more

7. What would your approximate daily commuting distance be?

◯ 0-25km

◯ 25-50 km

◯ 50-100 km

◯ 100-150 km

◯ more than 150 km

Consumer Survey for Electric Cars

3. Consumer Attitudes

8. Have you previously heard of battery electric vehicles?

◯ Yes ◯ No

9. Which of the following methods would you find more preferable?

◯ Refueling your car conventionally with Petrol/Diesel type fuels.

◯ Recharging your car with electricity at home or public charging stations.

10. If you were purchasing an electric vehicle how important would you consider the following electric vehicle features?

	Very Unimportant	Unimportant	Neither	Important	Very Important
Vehicle Make	◯	◯	◯	◯	◯
Vehicle Model	◯	◯	◯	◯	◯
Vehicle Price	◯	◯	◯	◯	◯
Vehicle Speed/Performance	◯	◯	◯	◯	◯
Convienence to recharge	◯	◯	◯	◯	◯
Battery Recharging time	◯	◯	◯	◯	◯
Vehicle Range between charges(km's)	◯	◯	◯	◯	◯
Battery lifespan (no. of years)	◯	◯	◯	◯	◯
Cost of operation(ie electricity,tax,insure,maint.etc.)	◯	◯	◯	◯	◯
Re-sale value	◯	◯	◯	◯	◯
Zero emissions of Environmental pollution*	◯	◯	◯	◯	◯

Consumer Survey for Electric Cars

11. Please choose what you would consider to be your top FIVE priorities if you were to buy an electric vehicle.

	1st	2nd	3rd	4th	5th
Vehicle Make	◯	◯	◯	◯	◯
Vehicle Model	◯	◯	◯	◯	◯
Vehicle Price	◯	◯	◯	◯	◯
Vehicle Speed/Performance	◯	◯	◯	◯	◯
Convienence to recharge	◯	◯	◯	◯	◯
Battery Recharging time	◯	◯	◯	◯	◯
Vehicle Range between charges (km's)	◯	◯	◯	◯	◯
Battery lifespan (no. of years)	◯	◯	◯	◯	◯
Cost of operation(ie electricity,tax,insure,maint.etc.)	◯	◯	◯	◯	◯
Re-sale value	◯	◯	◯	◯	◯
Zero emissions of Environmental pollution*	◯	◯	◯	◯	◯

12. If you were to purchase an electric vehicle which of the following ranges, between recharging of batteries, would you consider acceptable?

- ◯ 0-50 km
- ◯ 50-100 km
- ◯ 100-150 km
- ◯ 150-200 km
- ◯ More than 200 km

13. What do you think might prevent you buying an electric car? (Please choose 3 of the following)

	1	2	3
I don't know enough about them	◯	◯	◯
They are too expensive	◯	◯	◯
The range is too limited	◯	◯	◯
They are not big enough	◯	◯	◯
They might not perform as well	◯	◯	◯
Recharging might take too long	◯	◯	◯
There isn't enough recharging infrastructure	◯	◯	◯

Consumer Survey for Electric Cars

14. Would recharging an electric vehicle in the following locations presently suit you?

	Yes	No
At home overnight?	◯	◯
At place of work?	◯	◯

15. Would you be willing to use the public recharging points for electric cars?

◯ Yes ◯ No

16. Would you be willing to pay to use public recharging points?

◯ Yes ◯ No

17. Which of the following systems would you find more preferable?

◯ Recharging batteries at home/work/public points.

◯ Exchange battery for fully charged one at a swapping station.

Consumer Survey for Electric Cars

4. Willingness to Purchase

18. Do you plan to buy any new car within the next ten years?

◯ Yes ◯ No

19. Could you foresee at some future point that you would choose to purchase an electric vehicle?

◯ Yes ◯ No

20. Would you be willing to pay a higher price for a new electric car than a similarly sized model petrol/diesel engine car?

◯ Yes ◯ No

21. As the battery is one of the most expensive components used in the electric car, which of the following options would be more preferable?

◯ Purchasing the car at full cost including the battery?

◯ Purchasing the car at a reduced cost then paying monthly to lease the battery?

22. Would you consider buying a battery electric vehicle when purchasing your next car?

◯ Yes ◯ No

23. Would you be more likely to consider purchasing an electric vehicle given government financial incentives to do so?

◯ Yes ◯ No

24. Other than financial incentives, what else do you think the government could do to promote the use of electric vehicles?

APPENDIX 2

Consumer Survey for Electric Cars

1. Gender

	Response Percent	Response Count
Female	34.5%	40
Male	65.5%	76
answered question		116
skipped question		2

2. Please choose your age category.

	Response Percent	Response Count
18-29	26.7%	31
30-39	41.4%	48
40-49	21.6%	25
50+	10.3%	12
answered question		116
skipped question		2

3. County.

	Response Percent	Response Count
Antrim	0.0%	0
Armagh	0.0%	0
Carlow	0.0%	0
Cavan	0.0%	0
Clare	0.0%	0
Cork	3.5%	4
Derry	0.0%	0
Donegal	0.9%	1
Down	0.0%	0
Dublin	3.5%	4
Fermanagh	0.0%	0
Galway	**72.2%**	**83**
Kerry	0.0%	0
Kildare	0.9%	1
Kilkenny	0.9%	1
Laois	0.0%	0
Leitrim	1.7%	2
Limerick	0.9%	1
Longford	1.7%	2
Louth	0.9%	1
Mayo	3.5%	4
Meath	0.0%	0
Monaghan	0.0%	0
Offaly	1.7%	2

Roscommon	3.5%	4
Sligo	0.9%	1
Tipperary	1.7%	2
Tyrone	0.0%	0
Waterford	0.9%	1
Westmeath	0.9%	1
Wexford	0.0%	0
Wicklow	0.0%	0
answered question		115
skipped question		3

4. Which of the following areas do you live in?

	Response Percent	Response Count
City	49.1%	57
Town	19.0%	22
Rural	31.9%	37
answered question		116
skipped question		2

5. What form of accommodation do you presently live in?

	Response Percent	Response Count
Detached house	**55.9%**	**66**
Semi detached house	27.1%	32
Terrace house	11.0%	13
Apartment	5.9%	7
answered question		**118**
skipped question		**0**

6. Number of cars presently in your household?

	Response Percent	Response Count
None	1.7%	2
1 car	27.1%	32
2 cars	**55.1%**	**65**
3 cars or more	16.1%	19
answered question		**118**
skipped question		**0**

7. What would your approximate daily commuting distance be?

	Response Percent	Response Count
0-25km	**61.9%**	**73**
25-50 km	22.0%	26
50-100 km	11.9%	14
100-150 km	3.4%	4
more than 150 km	0.8%	1
answered question		**118**
skipped question		**0**

8. Have you previously heard of battery electric vehicles?

	Response Percent	Response Count
Yes	**91.3%**	**105**
No	8.7%	10
answered question		**115**
skipped question		**3**

9. Which of the following methods would you find more preferable?

	Response Percent	Response Count
Refueling your car conventionally with Petrol/Diesel type fuels.	36.2%	42
Recharging your car with electricity at home or public charging stations.	**63.8%**	**74**
answered question		**116**
skipped question		**2**

10. If you were purchasing an electric vehicle how important would you consider the following electric vehicle features?

	Very Unimportant	Unimportant	Neither	Important	Very Important	Response Count
Vehicle Make	9.5% (11)	9.5% (11)	9.5% (11)	**51.7% (60)**	19.8% (23)	116
Vehicle Model	7.8% (9)	13.8% (16)	16.4% (19)	**52.6% (61)**	9.5% (11)	116
Vehicle Price	5.2% (6)	0.9% (1)	0.0% (0)	30.4% (35)	**63.5% (73)**	115
Vehicle Speed/Performance	3.4% (4)	5.1% (6)	6.8% (8)	**57.3% (67)**	27.4% (32)	117
Convienence to recharge	5.1% (6)	0.9% (1)	0.0% (0)	15.4% (18)	**78.6% (92)**	117
Battery Recharging time	5.9% (7)	1.7% (2)	2.5% (3)	19.5% (23)	**70.3% (83)**	118
Vehicle Range between charges (km's)	5.1% (6)	0.8% (1)	1.7% (2)	26.3% (31)	**66.1% (78)**	118
Battery lifespan (no. of years)	4.3% (5)	0.9% (1)	**6.8% (8)**	34.2% (40)	**53.8% (63)**	117
Cost of operation(ie electricity,tax,insure,maint.etc.)	4.3% (5)	**2.6% (3)**	0.0% (0)	36.8% (43)	**56.4% (66)**	117
Re-sale value	4.2% (5)	6.8% (8)	11.0% (13)	**48.3% (57)**	29.7% (35)	118
Zero emissions of Environmental pollution*	3.4% (4)	3.4% (4)	19.5% (23)	**44.1% (52)**	29.7% (35)	118
					answered question	**118**
					skipped question	**0**

11. Please choose what you would consider to be your top FIVE priorities if you were to buy an electric vehicle.

	1st	2nd	3rd	4th	5th	Response Count
Vehicle Make	22.9% (8)	**25.7% (9)**	5.7% (2)	20.0% (7)	**25.7% (9)**	35
Vehicle Model	14.3% (2)	21.4% (3)	**57.1% (8)**	0.0% (0)	7.1% (1)	14
Vehicle Price	**53.8% (49)**	16.5% (15)	8.8% (8)	11.0% (10)	9.9% (9)	91
Vehicle Speed/Performance	19.6% (11)	**23.2% (13)**	19.6% (11)	16.1% (9)	21.4% (12)	56
Convienence to recharge	19.0% (16)	19.0% (16)	23.8% (20)	**25.0% (21)**	13.1% (11)	84
Battery Recharging time	10.3% (7)	**26.5% (18)**	25.0% (17)	25.0% (17)	13.2% (9)	68
Vehicle Range between charges (km's)	15.0% (12)	26.3% (21)	**31.3% (25)**	16.3% (13)	11.3% (9)	80
Battery lifespan (no. of years)	0.0% (0)	8.3% (3)	13.9% (5)	30.6% (11)	**47.2% (17)**	36
Cost of operation(ie electricity,tax,insure,maint.etc.)	13.1% (8)	**23.0% (14)**	**23.0% (14)**	18.0% (11)	**23.0% (14)**	61
Re-sale value	0.0% (0)	4.8% (1)	14.3% (3)	33.3% (7)	**47.6% (10)**	21
Zero emissions of Environmental pollution*	12.9% (4)	9.7% (3)	9.7% (3)	32.3% (10)	**35.5% (11)**	31
					answered question	**118**
					skipped question	**0**

12. If you were to purchase an electric vehicle which of the following ranges, between recharging of batteries, would you consider acceptable?

	Response Percent	Response Count
0-50 km	2.5%	3
50-100 km	8.5%	10
100-150 km	9.3%	11
150-200 km	33.1%	39
More than 200 km	**46.6%**	**55**
	answered question	118
	skipped question	0

13. What do you think might prevent you buying an electric car? (Please choose 3 of the following)

	1	2	3	Response Count
I don't know enough about them	**58.3% (21)**	8.3% (3)	33.3% (12)	36
They are too expensive	**61.9% (26)**	19.0% (8)	19.0% (8)	42
The range is too limited	**42.4% (28)**	33.3% (22)	24.2% (16)	66
They are not big enough	0.0% (0)	37.5% (6)	**62.5% (10)**	16
They might not perform as well	31.4% (11)	**51.4% (18)**	17.1% (6)	35
Recharging might take too long	12.1% (8)	**43.9% (29)**	**43.9% (29)**	66
There isn't enough recharging infrastructure	28.2% (24)	35.3% (30)	**36.5% (31)**	85
			answered question	118
			skipped question	0

14. Would recharging an electric vehicle in the following locations presently suit you?

	Yes	No	Response Count
At home overnight?	**93.9% (107)**	6.1% (7)	114
At place of work?	**71.6% (73)**	28.4% (29)	102
		answered question	**117**
		skipped question	**1**

15. Would you be willing to use the public recharging points for electric cars?

	Response Percent	Response Count
Yes	**86.4%**	**102**
No	13.6%	16
	answered question	**118**
	skipped question	**0**

16. Would you be willing to pay to use public recharging points?

	Response Percent	Response Count
Yes	**75.2%**	**88**
No	24.8%	29
	answered question	**117**
	skipped question	**1**

17. Which of the following systems would you find more preferable?

	Response Percent	Response Count
Recharging batteries at home/work/public points.	**66.9%**	**79**
Exchange battery for fully charged one at a swapping station.	33.1%	39
answered question		118
skipped question		0

18. Do you plan to buy any new car within the next ten years?

	Response Percent	Response Count
Yes	**92.3%**	**108**
No	7.7%	9
answered question		117
skipped question		1

19. Could you foresee at some future point that you would choose to purchase an electric vehicle?

	Response Percent	Response Count
Yes	**81.2%**	**95**
No	18.8%	22
answered question		117
skipped question		1

20. Would you be willing to pay a higher price for a new electric car than a similarly sized model petrol/diesel engine car?

	Response Percent	Response Count
Yes	37.3%	44
No	62.7%	74
answered question		118
skipped question		0

21. As the battery is one of the most expensive components used in the electric car, which of the following options would be more preferable?

	Response Percent	Response Count
Purchasing the car at full cost including the battery?	75.4%	89
Purchasing the car at a reduced cost then paying monthly to lease the battery?	24.6%	29
answered question		118
skipped question		0

22. Would you consider buying a battery electric vehicle when purchasing your next car?

	Response Percent	Response Count
Yes	50.8%	60
No	49.2%	58
answered question		118
skipped question		0

23. Would you be more likely to consider purchasing an electric vehicle given government financial incentives to do so?

	Response Percent	Response Count
Yes	84.7%	100
No	15.3%	18
answered question		118
skipped question		0

24. Other than financial incentives, what else do you think the government could do to promote the use of electric vehicles?

	Response Count
	80
answered question	80
skipped question	38

Question 24: Respondent Comments

- Extend the recharging infrastructure around the country
- develop the recharging infrastructure
- Install the charging points and give demos
- Reduce cost of motoring overall.
- by carbon reduction an entitlement to better tax rates
- nothing
- give them away for free
- Show that they are committed to a greener environment by using electric vehicles themselves, and ensure that the infrastructure is present around the towns, cities and motorways for recharging.
- using these vehicles more within the government structure in order to give people more confidence in the vehicle
- promote infrastructure
- awareness, larger discount with scrappage if you buy electric vehicles
- Provide public recharge facilities and promote the cars
- not sure
- More charge points
- Once they are proven to perform to the same standard (range, cost of operation, ease of refuelling, performance etc...). This will require building an infrastructure where operating an electric car is simple. The government could promote this by greatly reducing tax on new electric cars and ensuring that everyone has the chance to test them. Potentially running events where the public can test drive and learn about electric cars.
- scrappage schemes etc
- put in the infrastructure for recharging
- Ban petrol/ diesel cars from being sold.
- dedicated parking with charging stations 'green parking'
- Promote a recharging infrastructure.
- no tax, lower insurance rates
- Do more research to improve the lifespan of the battery and more public recharging points.
- put a decent charging infrastructure in place

- Free Parking
- Free Charging stations. Ban on petrol Vehicles in towns
- Network of charging points across the country
- give information
- don't know
- free recharging facilities
- Putting car battery charging infrastructure in place
- invest in exposing Irish society to the electric car. I am pretty sure only a small percentage of the population know they exist. Generally people don't know much about them
- Improve the infrastructure in particular in rural areas
- Infrastructure
- Provide greater incentives to electric power suppliers to install more charging/battery swap stations.
- reduce car tax,
- Make all government vehicles battery operated to show they work effectively.
- make it possible to recharge at all parking locations for free
- Improve charging infrastructure
- Financial incentives
- Promote environmental aspects
- 1- replace all current elected government personnel vehicles with electric ones. 2 - use in all government state & semi-state bodies. 3- Vigorously promote the campaign and be seen as 100% supportive to the concept.
- rebate for usage, incentives to update/renew battery
- more information, especially about the recharging process
- freely available recharge stations using renewable energy
- Improve re-charging infrastructure
- More public charging points, priority use of bus lanes in cities, free parking, Use of electric vehicles by public services and ministers, promotion of electric bicycles as well as cars,
- There are safety risks for pedestrians and cyclists as the electric cars make no sound. Maybe the Govt. could have a marketing campaign on TV/radio/internet to promote the cars and make the public aware that they soundless.

- Market the cost savings and environmental benefits more
- Charge point infrastructure
- Provide re charging infrastructure within close ranges
- increase infrastructure and media campaigns
- Low Tax, insurance, running costs
- Provide Plenty of recharging points
- Prove that they believe this is the way forward through improved infrastructure and recharging points
- far more areas to recharge battery
- More infrastructure, more information on costs and performance
- public recharge points
- recycle vehicles after 3 years and give more incentives again for second time buyer and so on
- Billboards, electric signs, radio and TV ads, people speaking at schools and drive around every county in 32 days (well publicised of course) and more recharging points.
- research into longer battery life
- More recharging points and low tax and insurance rates.
- The government has done very little to promote electric cars in Ireland and as a result very little is known about them and there are very few places to actually recharge these cars. This means that buying an electric car is not the most practical option in Ireland at the moment but hopefully these cars will become more popular in the coming years. I believe our government should run various ad campaigns to promote the electric car and make it more widely known. They should also put more charging stations around the country-these would be especially beneficial on motorways and at airports. I believe the government has quite a bit of work to do in the promotion of electric cars and other alternative transport methods in Ireland.
- NO VRT and more charging infrastructure
- Free parking, restrict access to city centres to electric cars
- Increase charge points or battery swap centres
- infrastructure i.e. charging stations, convenient battery swap stations.
- get out of office and call an election

- Improve Infrastructure with low/zero cost recharging
- pollution damage
- more convenient recharging stations- more infrastructure
- Cheaper Electricity or Reduced tax
- Start using them for public transport, service vehicles for all industries to make people more aware of them and to learn to have confidence in them, 5year guarantee as standard, free parking in cities,
- Reduced road tax, Reduced Insurance premiums
- Give Incentives
- 2nd car to be Electric vehicle for more frequent use and shorter journeys.
- Roll out electric vehicles for government/state bodies
- Charing infrastructure essential
- use them themselves as an example to all
- give a rebate to the purchaser
- Infrastructure in place first for all new recharging points

APPENDIX 3

Thesis Gantt Chart

	Task	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10
1	Preparing and Planning Proposal Topic								
2	Proposal Presented								
3	Proposal Accepted								
4	Planning Thesis Research								
5	Literature Review								
6	Design of Survey								
7	Design of Questionaire								
8	Piloting Questionaire								
9	Questionaire Approval								
10	Engaging SurveyMonkey								
11	Distribution of Questionaire								
12	Collection of Data								
13	Analysis of Data								
14	Writing Chapter on Research Methods								
15	Writing Chapter on Literature								
16	Writing Chapter on Results and Discussion								
17	Writing Introductory Chapter								
18	Arranging References								
19	Editing, Printing & Binding Thesis								
20	Presentation to GMIT								
21	Supervisior Consultations								

APPENDIX 4

GLOSSARY

ACEA	European Automobile Manufacturers' Association
ARB	Air Resources Board
BEV	Battery Electric Vehicle
CH_4	Methane
CO_2	Carbon Dioxide
COP	Conference of Parties
E&Y	Ernst & Young
EREV	Extended Range Electric Vehicle
ETS	Emission Trading System
EU	European Union
EV	Electric Vehicle
FEHRL	Forum of European National Highway Research Laboratories
GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ktoe	Kilo Tonnes Oil Equivalent
$LiFePO_4$	Lithium iron phosphate
Li-ion	Lithium Ion
N_2O	Nitrous oxide

NiCd	Nickel Cadmium
NiMH	Nickel Metal-Hydride
NREAP	National Renewable Energy Action Plan
PHEV	Plug-in Hybrid Electric Vehicle
SEAI	Sustainable Energy Authority of Ireland
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USEIA	US Energy Information Administration
USGS	US Geological Survey
WHO	World Health Organisation
WMO	World Meteorological Association
ZEV	Zero Emission Vehicle