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Electric vehicles in Norway

A qualitative study of the electric vehicle market in Norway

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Abstract

The Norwegian Government has set a goal stating that by 2020, emissions from new passenger cars shall not exceed an average of 85 gram CO_2/km. To meet the goal the Government is dependent on a large amount of EVs[1] in the national vehicle fleet. In this thesis we will use theory on path dependence (PD) and socio-technical transitions (STT) to examine what the Norwegian Government should do to support the emergence of EVs as an alternative to the ICE[2]. The Norwegian EV policy, with its many incentives, is said to be the world's most favorable. EVs are exempt from all non-recurring vehicle fees, including purchase taxes and 25 percent VAT on purchase. Modifying the extensive EV incentives, as the adoption rate of EVs increases, may be a major challenge. The incentive scheme is applicable until 2017; however there is considerable uncertainty about what will happen with the EV incentives after 2017. The success of the EV in Norway brings substantial costs for the Government, which has been the center of a series of public debates.

This debate caught our attention and we started our research journey with the aim to identify what the Norwegian Government should do if they want the EV market in Norway to become sustainable. In this thesis we have conducted an in-depth analysis of the Norwegian EV market and more 20 interviews with central industry actors, policy makers, and EV owners. Our results show that the Government must introduce a long-term plan for the incentive package that extends beyond 2017. The financial incentives have major influence and should be extended until EVs are price competitive, which we argue will happen in 2020. Furthermore, a modification of the operating incentives should be introduced. Additionally, the development of charging infrastructure, mostly fast charging, needs to keep up with the number of EVs on the market. We believe the Government should look further into the challenge of free charging and lack of standard points and plugs in order to enhance the development of the charging infrastructure and create a sustainable EV market.

KEY WORDS: Electric Vehicle (EV), Norway, Grounded Theory, Path Dependence, Socio Technical Transitions, Multi Level Perspective (MLP)

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[1] Electric Vehicles

[2] ICE = Internal Combustion Engine – we will use the term ICE for cars that have an internal combustion engine

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Table 1 – Conceptual Clarification. Source: Transnova: National Strategy and Finance Plan for Infrastructure for EVs

Term	Explanation
Battery Electric Vehicle (BEV)	A vehicle powered entirely by electricity and rechargeable battery
Internal Combustion Engine (ICE)	An engine powered through the burning of fossil fuels. The term 'ICE' is often used as shorthand for any vehicle powered by an internal combustion engine
Hybrid Electric Vehicle (HEV)	A vehicle powered by two or more power sources, usually a combination of an internal combustion engine and an electric motor
Plug-in Hybrid Electric Vehicle (PHEV)	A vehicle powered by two or more power sources, usually a combination of an internal combustion engine and an electric motor with rechargeable battery
Range	The distance a chargeable vehicle can drive before the battery requires a recharge. The Range depends on different factors, such as temperature, topography, speed, road condition ect.
Range Anxiety	The fear of running out of battery power before one reach the next charging station

1. Introduction and motivation

Interest in environmental issues has increased over the last decade. The world's politicians have expanded their focus on the climate and the large amount of greenhouse gas (GHG)[3], humanity emits daily. Identified as a key tool for promoting sustainable development, the advancement of EVs is a major policy incentive of the EU. Alternative vehicles powered by electricity have the potential to solve a number of environmental challenges related to automobile use such as climate change and air quality. In the Climate Compromise (2012) the Norwegian Government adopted a target to reduce CO_2. Average emissions from new passenger cars shall not exceed an average of 85 gram CO_2/km by 2020. The target is based on EU regulations for automakers which state that cars shall not exceed an average emission of 95g CO_2/km in 2020 in Europe (Figenbaum, Eskeland, Leonardsen, & Hagman, 2013). ICEs produce air pollution, which carries significant risks for the environment. As environmental problems related to automobile use keeps growing, the need for radical innovations emerge and large scale adoption of more environmental friendly alternatives become more likely (van Bree, Vergong, & Kramer, 2010). Norway has invested heavily in the phasing-in of EVs in the vehicle fleet as a measure to reduce CO_2 emissions from transport. Through EVs, Norway attempt to significantly reduce air pollution from transport.

In July 2014 over 34 000 EVs was registered in Norway, with a population of 5 million. This makes Norway the world leader on introducing EVs. Norway's capital Oslo is the EV capital of the world, with the highest EV density of any capital city (Grønn Bil, 2014). The proportion of EVs has increased from 20.000 in the end of 2013, to approximately 34.000 in July 2014. EVs account for 13 percent of all passenger cars sold in 2014 (The Norwegian EV association, 2014). Still, the share of EVs represents only 1 percent of the total vehicle fleet and although this number is unique on a global basis, Norway has set a goal to further increase the adoption rate of EVs.

Two major initiatives have both made it possible to purchase EVs and reduced the barriers for E-Mobility; The Incentive scheme for EVs and the establishment of Transnova, a government

[3]GHG represents carbon dioxide (CO_2), methane (CH4), nitrous oxide (N20), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), NF3 (European Commission)

organization which financially supports development of charging infrastructure (Figenbaum, Eskeland, Leonardsen, & Hagman, 2013).

The Norwegian Incentive Scheme for EVs is said to be one of the world's most favorable (EV Norway, 2014). The financial incentives will be in force until 2017, or until 50,000 EVs are sold in Norway, however several actors are pushing for the incentives to be extended. There are currently uncertainty regarding which of the incentives that will be phased out after 2017, and which of the incentives that will be extended. There is also considerable uncertainty whether the whole incentive scheme will be removed or whether the whole incentive scheme will be extended. The benefits for EVs in Norway includes among others no purchase tax, exemption from 25 percent VAT, no charge on toll roads, free parking and free access to public transport lanes. The Incentive scheme presents both opportunities and challenges; the adoption rate of EVs is increasing due to the favorable incentive package, while the TAX revenue loss is increasing for the state. Furthermore, the incentive package creates enduring debates in the media, where opponents claim that the EV benefits leads to numerous issues. These issues include among others a major loss of TAX revenue (purchase price benefits) and is said to cause traffic jams and delays the public traffic system (operating benefits). The incentive scheme and the uncertainty surrounding the future of the incentives lay the foundation for the thesis.

A transition from ICEs to EVs represents claims for substantial investments in infrastructure for recharging. In this thesis we will use theory on path dependence (PD) by Brian Arthur (1996) to explain the automobile pathway and why the ICEs are the dominant technology in the automobile industry. Furthermore, we will use theory on socio-technical transitions (STT) by Geels (2011) as an attempt to identify necessary factors for transitions from ICE technologies to consumer adoption of EVs. Socio technical transitions describe how technological innovations occur and are incorporated into society.

This thesis conducts an in-depth analysis of the Norwegian EV market; more specifically what measures the Norwegian Government should adopt if they want to create a sustainable market for EVs in Norway. Recognizing that transitions result from a joint development of technology and society, a multi-level perspective is adopted. Our fields of interest include how the government can increase the adoption rate of EVs without implying major costs for the Government and for the society. In order to do so we will investigate how the government will react to a steady increase in the number of EVs, and how the Government can prepare for an EV market that does not heavily rely on state subsidies. We will analyze which incentives that are necessary to maintain after 2017, and which incentives that can be gradually phased out. Furthermore, we will analyze the need for charging infrastructure and what measures and investments the Government needs to do in order to establish charging infrastructure, which fulfill the increasing demand for charging stations.

The aim of the thesis is to answer the following research question:

1.1 Research question

What should the Norwegian Government do if they want the EV market in Norway to become sustainable?

1.2 Scope and delimitations

In this thesis we direct attention to the Norwegian EV market and what measures the Norwegian Government should implement to build a sustainable EV market. In this regard, we focus on the period of time from the implementation of the Norwegian EV incentives in the 1990s until today. We define the Norwegian EV market as “all the activities related to battery electric vehicles (BEVs)”, which we will refer to as EVs, excluding hybrid, hydrogen and biofuel cars. Furthermore, we focus in the market for private cars, excluding public procurement and company cars. We will limit our self to recent EV history; however we include brief history from around 1880 and until today to give the necessary background information. When analyzing the EV market we will focus on the Norwegian market as a whole, more specifically the EV incentives and the charging infrastructure. This implies limited focus on regional differences and excludes other countries where EVs exists. We acknowledge that development of EVs in foreign countries can impact the EV market in Norway, however we consider this to be outside the scope of our thesis and will not take these conditions into account. We characterize industry actors involved as the policymakers, EV producers, commercial charging infrastructure providers (CCIP), NGOs, and EV end users. We assume that the EV is a zero-emission vehicle. We acknowledge that there has been ongoing debates regarding if the EV is environmental friendly, however we consider this to be outside the scope of our thesis.

Our scope is to determine some of the main challenges the Norwegian Government face when they are working towards creating a Norwegian EV market that can sustain on its own. We concentrate on challenges identified through our data research and specifically our interview process. The aim of this thesis is to identify what the Norwegian Government should do to affect the Norwegian EV market to become sustainable. After identifying the main challenges we will propose recommendations to the Norwegian Government. However, it is essential to point out that these will not be comprehensive solutions.

1.3 Thesis structure guide

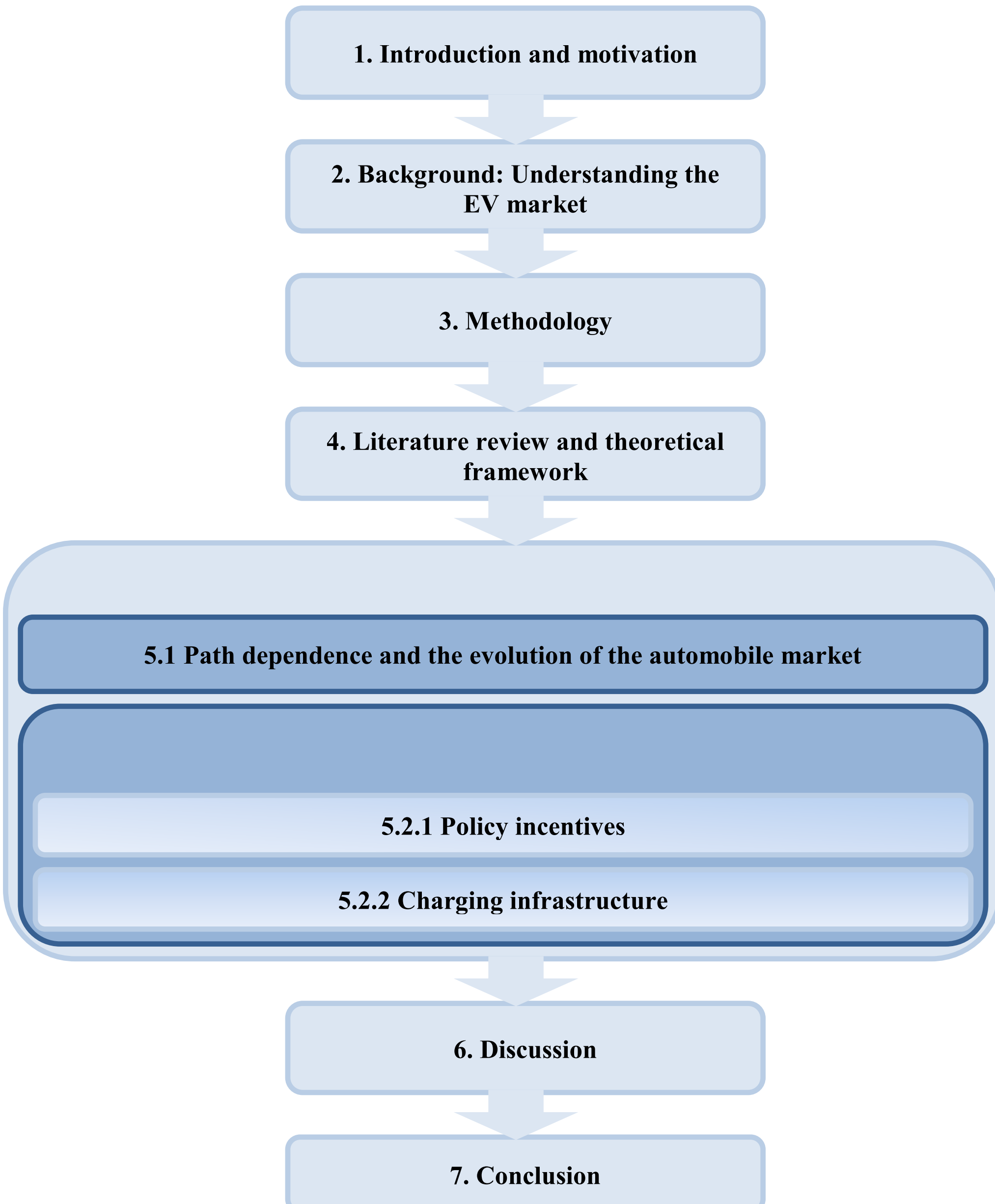

Figure 1 – Thesis structure guide. Source: Own development

In section 1, *Introduction and motivation,* we outline our motivation for examining the EV market in Norway. Additionally, we present our research question, which we follow up with scope and delimitations of our research.

Section 2, *Background: Understanding the EV market* provides an overview of the history of the EV. Furthermore, it gives an introduction to the Norwegian policy incentives, climate actions (in EU and Norway) and the legal frameworks and procedures. In this section we provide insights to the global EV market; a more specific understanding of the Norwegian EV market, the EV incentives and the legal process.

Section 3, *Methodology*, presents our methodology. We start by explaining our philosophical choice, research approach, purpose and strategy. We further follow up with a description of our data collection process.

Section 4, *Literature review and theoretical framework* provide a general overview of previous research within the EV market, Path Dependence (PD) and Socio Technical Transitions (STT). Furthermore, we give an introduction to the theory we utilize in our analysis.

Section 5, *Analysis and result,* is divided into two parts. First, we explain the evolution of the automobile market using PD theory. In the second part we will investigate the Norwegian EV market by analyzing our secondary data research, public hearings we have attended, debates and the series of qualitative interviews. We will first address how the policy incentives given by the Norwegian Government has affected the EV purchase price, operating costs and convenience, and the cost aspect of EV batteries. We also investigate how the incentives affect EV end users, EV producers and other relevant actors. Then, we will discuss the development of charging infrastructure and assess factors, such as charging demand, price of recharging, and standardization of charging points. Next, we analyze the range aspect of EV batteries, which has a major impact on the demand for charging infrastructure. Furthermore, we will explain the responsibility issue between the Government and CCIPs. After each subsection, we will address the challenges we identified and connect these to what is stated in the theory.

Section 6, *Discussion*, we explain implications of our findings, and make our recommendations for the future development of the Norwegian EV market. Finally, we will make suggestions for further research.

In Section 7, *Conclusion*, we will conclude on our research of the Norwegian EV market.

2. Background: Understanding the EV market

The following section presents an overview of the EV market. More specifically, we include history of the EV in a global, European and Norwegian context. Further we address the Norwegian governmental policy and the EV incentives the Government has implemented to promote the adoption of EVs in Norway. Furthermore, climate actions in EU and Norway will be identified. Lastly, we present the legislative system in Norway.

2.1 History of the EV in the global context

During the late 19th century the EV was competing with the ICE and the steam car. The battle was settled in the early 1900s in favor of the ICE, which has been the dominant design[4] ever since. The success of the ICE was caused by two main reasons; First, Henry Ford mass produced the Ford Model T and second; the oil industry managed to successfully develop infrastructure that made it more convenient to re-fuel ICEs (Asphjell, Asphjell, & Kvisle, 2013). Although ICE has been the dominant design for several decades, there have been numerous attempts to reintroduce the EV.

A new interest in EV occurred in the 1960's and 1970's in the US. The main reasons for the re-emerge of the EV were air pollution and rising oil prices. Clean Air Act[5] triggered various research centers and institutes to start doing research on EVs, and to further develop existing EV models. However, it turned out that it was difficult to compete with ICEs, and the results were disappointing in terms of technology performance and price. The EVs were small, expensive and with short driving range compared to ICEs. The commercialization of EVs failed to succeed again (Dijk, Orsato, & Kemp, 2011). A new attempt to introduce the EV to the mass-market emerged after the state of California and European policy makers made offensive regulatory changes. High standards for emission and legislation were set, for instance through the ZEV (Zero Emission Vehicle) mandate in California. In 1990 the ZEV mandate required

[4] Dominant design is a technology management concept identifying key technological features that become a de facto standard.

[5] Clean Air Act is a United State Federal law designed to control air pollution at a national level.

that 2 percent of all new cars sold in California had to be low emission, ultra emission or zero emission vehicles[6]. Considering the fact that California represented 4 percent of the world market and about 12 percent of the US market for cars, the ZEV mandate had a major impact. Forced by the ZEV mandate, high-volume car manufacturers showed increasing commitment to the EV technology and slightly increased the sales volume of EVs. The multinational corporation, General Motors (GM), was almost successful with their attempt to commercialize the EV. In 1990 GM presented their precursor to the EV1. This was the first attempt to mass-produce and purpose-design an EV since late 1890s. The EV1 was developed to meet the ZEV mandate made by the California Air Pollution Resources Board (CARB). A year after the launch of the EV1, car manufactures such as Nissan and Honda presented own prototypes of EVs. Between 1996 and 1999 GM produced 1117 EV1s and all of them were leased. It was perceived as a success for around 13 years. However, the enthusiasm was only temporarily. In 2009, after a reverse of the mandate, GM stopped the production of the EV1, ending all leasing contracts, and withdrew and destroyed all the EV1s. GM claimed that the EV1 was no commercial success and the sale was too poor to make a profitable market (Paine, 2007).

2.2 EVs in the European market - Pilot and demonstration projects

The interest for EVs in Europe had its main emergence in engineering schools. Denmark, Germany and Switzerland were seen as pioneers in developing electric technologies and a series of new technologies for low-emission cars were developed. After they had been showcased in California, several R&D projects were supported in Western Europe, involving sponsorship of demonstration projects, subsidies and tax reductions for low-emission vehicles (Dijk, Orsato, & Kemp, 2011).

One project was THINK, a Norwegian EV company, which manufactured EVs in Norway. Production of the THINK was stopped in March 2011, and the company filed for bankruptcy in June 2011 (Hoogma, Kemp, Schot, & Truffer, 2005). Another project was led by EDF[7] in France. EDF ordered 2000 EVs for a project in the French city, La Rochelle. The result of the project showed that the users valued the EVs. However, EDF did not succeed in commercialization, as it turned out that only a few people was actually willing to purchase the EV outside the project (Hoogma, Kemp, Schot, & Truffer,

[6] By 2003 75 percent had to be low emission vehicles, 15 percent ultra low vehicles and 10 percent ZEVs.
[7] EDF is a French Electric Utility

2005). Another recent attempt to commercialize the EV was made by Better Place, a developer and operator of battery-charging and battery-switching services in Denmark. Together with Renault they developed the world's first EV with a switchable battery. This could provide a fully loaded battery within five minutes and enabled the end users to use the drive-switch-go option (Better Place, 2013). With the switchable battery technology the actual range was "unlimited", even though the battery capacity was only up to 185 kilometers. Better Place expanded to several different countries, including China and the Netherlands. They estimated that there would be 500 000 EVs by 2020 on the Danish market alone, with a total share of 20 - 25 percent of the total car market. However, the sales never reached 500 000 and the 26th of May 2013 Better Place filed for bankruptcy (Woody, 2013). From 1990 until 2005 the main focus of the car industry was concentrated around ICEs. The number of patents and new products launched during this period shows that 80 percent of the new patents concentrated on ICE technologies, while only 20 percent focused on EVs or HEVs (Dijk, Orsato, & Kemp, 2011).

2.3 History of the EV in the Norwegian market

A 1902 Waverly Electric, imported to Norway in 1907 from the US, is most likely the oldest EV in Norway. Since then the EV has been visible for two periods of 20 years. I the first period between 1903 and 1923 there was some competition between cars powered by gasoline, vapor and electricity. From this point it took nearly a 100 years before Norway started to produce own EVs. The advantageous Norwegian EV policy stems from around 1988, when the NGO, Bellona[8], imported an EV, Larel (a modified Fiat Panda)[9], to Norway (Asphjell, Asphjell, & Kvisle, 2013). In addition, Bellona prepared a proposal for a regulatory framework that privileged EVs in traffic. In order to create momentum around their proposal, for a regulatory framework that privileged EVs in the traffic, they drove through the toll roads around Oslo without paying and parked without paying. Despite the fact that their EV was towed several times and lost lawsuits, their actions gained much attention and even famous Norwegian profiles[10] got involved in promoting Bellonas EV policy. The work of Bellona and other NGOs, such as

[8] The Bellona foundation is an independent organization that aims to meet and fight climate challenges.
[9] The Larel was registered as an diesel camper equipped with odometer
[10] Such as the pop-group AHA

NEVAs predecessor Norstart[11], creative entrepreneurs, ardent enthusiasts, and the opportunity to create Norway's own EV production (THINK) lead to "acceptance" of the EV by politicians and the Government. This resulted in the beginning of what has turned out to be one of the best benefit-related EV policies and now one of the world's best markets for EVs (Asphjell, Asphjell, & Kvisle, 2013). We will come back to Bellona and other NGOs later in this section.

EVs in Norway today

Norway has one of the world's best incentives schemes for EVs, and correspondingly the world's highest number of EVs per capita by a wide margin (EV Norway, 2014). It would appear there is an EV revolution in Norway. EVs reached 6 percent of the Norwegian car sales in 2013, which is exceptional in the global context.

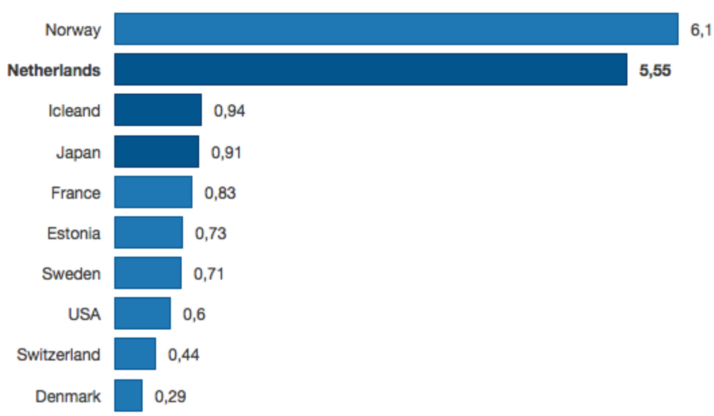

Figure 2 – Market share for EVs based on the total car sales in 2013, by country. Source: Own development, using data from ABB Conversations and Clean Technica (Shahan, 2014)

In April 2014, Norway could present, as the first nation in the world, that one out of every 100 automobiles on the road, is pure electric. One percent may not sound like an enormous figure, however, in contrast the equivalent number is close to 0,07 percent in the US (Overgaard, 2014). EVs in Norway accounted for 6,1 percent of global sales in 2013. The public incentive package has attributed much of the credit (Eide, Noreng, Fiksen, & Magnus, 2013). There was never a clear strategy behind this outcome, and the growing success of the EV in Norway has been the result of the implementation over

[11] That consisted of THINKs precursor, Pivco, and Kewet (another EV producer)

the years of many small incentives to support the EV industry and to reduce emission from road transportation (EV Norway, 2014). Even though the EV production industry in Norway never succeeded, the Government saw a potential in the growing interest in EVs. Today, the EV incentive scheme is used as measure to reach Norway's climate goals.

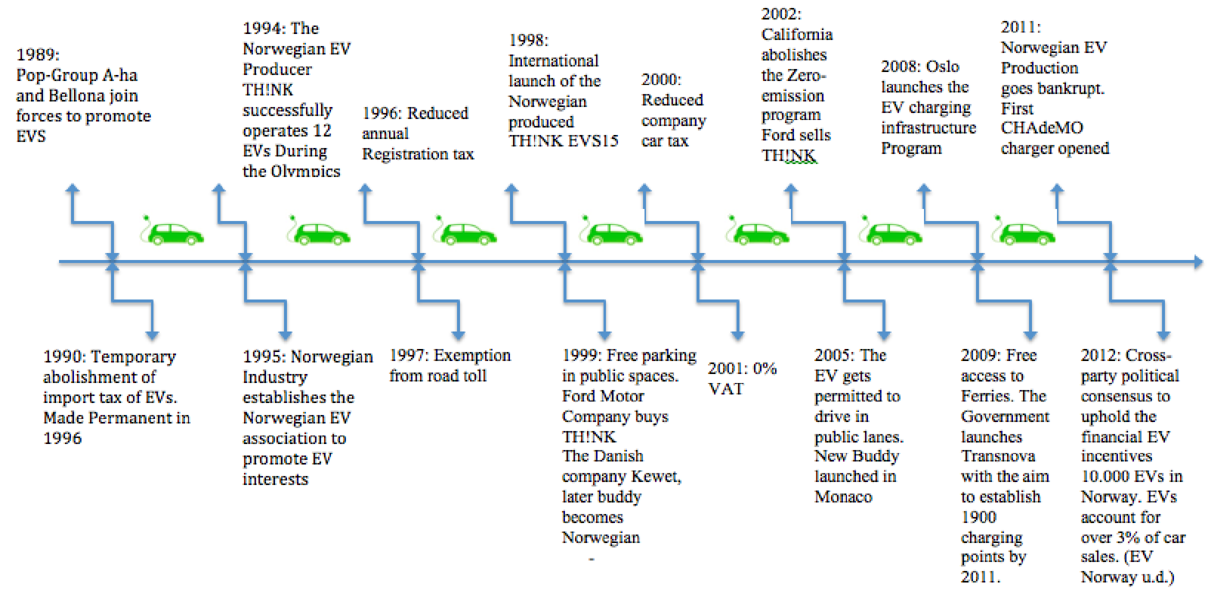

Figure 3 – Timeline: The development of EV policy and significant historical events in the Norwegian EV industry. Source: Own development

As seen from the figure, a variety of different incentives have been applied to increase the adoption rate of EVs. We will address these incentives in-depth later in the section.

2.4 The incentive scheme

The Norwegian incentive scheme for EVs is said to be one of the world's most favorable (EV Norway, 2014). The Norwegian Government has stated in the Climate Compromise (2012) that the financial incentives will last until the end of 2017 or until the number of EVs reach 50.000[12]. The incentive

[12] In the Revised National Budget 2014 the Government stated that the tax incentives will last until the end of 2017

package lays the foundation for this thesis. There are currently uncertainty regarding which of the incentives that will be phased out after 2017, and which of the incentives that will be extended. A list of all incentives, content and scope, together with information about ministry in charge and when the incentive was implemented, is presented below.

Table 2 – EV incentives in Norway – An overview of the policy incentives, scope and ministry in charge. Source: Own development based on information from EV Norway (EV Norway, 2014).

Year	Policy Incentives	Content and scope	Ministry in charge
1996	Exemption from registration fee	All vehicles registered in Norway must pay a registration fee. The registration fee is calculated by weight of the car, engine power and the CO_2 -emission. EVs were exempt from registration tax in 1991 as a trial that became permanently from 1996 (Figenbaum & Kolbenstvedt, 2013).	**MF**[13]
1996	Reduced annual fee	All cars registered in the vehicle register are imposed an annual fee. There are three rates of annual fee for private cars. EVs and hydrogen vehicles pay the lowest rate of 405 NOK, while other vehicles pay between 2885 NOK[14] and 3360 NOK (Figenbaum & Kolbenstvedt, 2013).	**MF**
1997	Exemption from toll (on toll roads)	EVs received in 1997 exemption from toll road projects governed by the Government.	**MTC**[15]
1999	Free parking	EVs have been able to park for free on municipal public parking spaces since 1999, some places it has been possible since 1993. Several public parking lots offers additional free charging.	**MTC**
2000	Reduced taxes for company cars	The benefit taxation for EVs is reduced to 50 percent less compared to other vehicles. Only half of the car's value is considered when calculating the benefit (Figenbaum & Kolbenstvedt, 2013).	**MF**
2001	Exemptions of VAT upon purchase	The VAT rate is 25 percent and is added to all goods and services sold in Norway. VAT on cars is calculated by the tax of the sales value exempt the registration fee. EVs have been exempt from VAT since July 2000 (Figenbaum & Kolbenstvedt, 2013).	**MF**
2005	Access to public lanes	In 2003 EVs got the permission to drive in certain selected test section of the public transport lane. The scheme became permanent in 2009 nationwide. It is mainly the major cities that have own public lanes.	**MTC**

[13] MF = The Ministry of Finance
[14] 1 NOK = 0,17 USD (August, 2014)
[15] MTC = The Ministry of Transport and Communications

2008	Free charging	The EV can charge for free at most public charging stations.	**MTC**
2009	Free ferry ticket	EVs have since 2009 been exempt from ticket fee on highway ferries, i.e. ferries that are counted as a part of national roads, but not on connections on a county road. Drivers and passengers must still pay, however they are charged a motorcycle fair. Ferry costs are outskirts Norway "tolls" (Figenbaum & Kolbenstvedt, 2013).	**MF**

Taxes

By far the most efficient GHG abatement measure applied so far in Norwegian transport is the CO_2 component of the vehicle purchase tax, coupled with the privileges and tax exemptions given to EVs. The very high initial levels of taxation on private cars condition the power of these policy instruments. To fully understand the potential impact of the incentives it is essential to determine the extent of the tax systems on vehicles in Norway.

Independently of climate policy considerations, Norwegian automobile ownership and use have for a long time been subject to several taxes. This makes up an annual tax income of NOK 7,800 per capita, or close to 42 billion NOK each year (Fridstrøm, 2013, p. 10). The taxes on vehicles in Norway are higher than in almost any European countries, with the possible exception of Denmark. The purchase tax is made up by three components:

- Vehicle veight
- Engine power (kW)
- The vehicle's certified rate of CO_2 emission (g/km), as measured by the standardized EU testing cycle (NEDC[16])

[16] New European Driving Cycle

Table 3 – CO_2 purchase tax components at selected quantities of CO_2 emissions[17]. Source: Fridstrøm (2013)

CO_2 g/km	0	50	100	150	200	250	300	350
US$	-15 834	-7 961	-1 327	5 006	17 135	34 430	57 926	81 423

As seen from the table above, cars emitting over 110 grams of CO_2 per km are subject to progressively increasing tax rate, while cars releasing less than this actually obtain a subsidy in the form of a certain deduction in the tax levied on weight and engine power (Fridstrøm, 2013, pp. 9-10).

Market share

Norway has approximately 32 000 EVs per 01.08.2014. Nissan LEAF has the biggest share (48 percent) of the market, followed by Tesla (12 percent) and Mitsubishi (10,3 percent). There are currently 15 different EV models from 10 different EV manufacturers available on the Norwegian market. Furthermore, there will be launched 9 additional models by 2015 (EV Norway 2013). It is mainly foreign manufacturers that dominate the Norwegian market. In September 2013 Norway became the first country to have an all-EV top of the monthly best–seller list. The Tesla Model S was on top in September, followed by Nissan LEAF in October (Overgaard, 2014). The market has experienced a steady growth from 9546 cars per 4th quarter of 2012 to 19,678 per 4th quarter of 2013. Norway represents only 3 percent of the EV market worldwide, which indicates that Norway's role is limited. However, the market is still significant for EV manufacturers. Furthermore, measured as a share of number of car sales, Norway is the sovereign no.1 (Grønn Bil, 2014).

2.5 Climate actions

In this section, we will focus on EUs targets for reducing CO_2 emissions, from transport. Norway is not a member of the EU, however the EU's climate policy has laid the basis for Norway's commitment to reduce CO_2 emissions and have had an impact on the phasing-in of EVs in the Norwegian transport

[17] The Rates are specified in Dollar ($) values. 1 USD = 6,3 NOK (01.08.2014).

sector. We will first give a brief overview of the Kyoto Protocol. Then, we will focus on the objectives in EUs climate policy for the transport sector.

2.5.1 The Kyoto Protocol

The protocol is an international binding GHG[18] reduction agreement. This agreement is connected to the United Nations Framework Convention on Climate Change (UNFCCC) and was adopted 11 December 1997 in Kyoto, Japan. Each involved party has an individual emission target and is committed to comply with its assigned amount (United Nations Framework Convention on Climate Change).

Briefly summarized what this agreement means for the EU:

- The 15 countries[19] that were EU members before 2004 committed to reduce their collective emissions to 8 percent below their 1990[20] levels between 2008 and 2012 (European Comission/Climate Action 2014).
- In the second commitment period, the EU has committed to collectively cut GHG[21] emissions to 20 percent or 30 percent[22] below their 1990 levels between 2013 and 2020.

2.5.2 The European Union – Climate and transport policy

In agreement with the Kyoto Protocol one of EUs goals and a part of EUs 2020 growth strategy[23], is to reduce GHG emissions by 20 or 30 percent by 2020 from 1990 levels. To ensure that the target is met the EU has implemented the climate and energy package (European Commission). We will go more in depth with the climate and energy package later.

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[18] In the first commitment period of the Kyoto Protocol GHG represented: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N20), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (European Commission)
[19] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom (European Commission)
[20] 8 percent below the level they were in 1990
[21] In the second commitment period GHG also covers NF3 (Danish Energy Agency)
[22] 30 percent if other developed and developing countries commit themselves to undertake comparable or fair share of emission reductions (Danish Presidency of the Council of the European Union, 2012)
[23] *"Recommendations to EU Member States designed to strengthen their growth potential, increase competitiveness and create jobs"* (European Commission).

Overall EU initiatives to reduce GHG emissions:

- In 2010, the EU established a climate committee to ensure that member states develop and comply with the obligations of the agreed climate policy (the targets in the Kyoto Protocol and the targets below) (The Norwegian Government, 2013; Det Kongelige Miljøverndepartement, 2012).
- The EU has proposed a target of 40 percent GHG emission cut below 1990 levels by 2030 (European Commission).
- The EU has approved to reduce GHG emissions by 80 – 95 percent compared to 1990 levels by 2050 (European Commission).
- The European Climate Change Program (ECCP) resulted in the implementation of new policies and measures.

The transport sector is responsible for about a quarter of EUs GHG emissions and the emission from this sector is increasing[24]. Road transport is responsible for more than two thirds of transport emissions and cars constitute for about 12 percent of total CO_2 emissions in the EU. To achieve the long-term goals, the EU has stated that significant reduction in GHG from the transport sector is required (European Commission). As mentioned earlier, the climate and energy package ensure that the EU meets its targets for 2020, one of them being the 20 percent reduction in GHG from 1990 levels. The package consists of four pieces of complementary binding legislations. One of the pieces, the National Targets for non-EU ETS emissions, is an annual binding target for reducing GHG from sectors, such as transport (European Commission). One of the goals, to achieve the 20 percent reduction in 2020, is 10 percent of vehicles fuel should come from renewable energy (Det Kongelige Miljøverndepartement, 2012). In addition to this, the EU has applied other policies to reduce emissions from road transport:

- *A strategy is in place to reduce emissions from cars and vans, including emissions targets for new vehicles*
- *A target is in place to reduce the greenhouse gas intensity of fuels*
- *Rolling resistance limits and tyre labelling requirements have been introduced and tyre pressure monitors made mandatory on new vehicles*

[24] Emission from transport has increased by 36 percent since 1990.

- *Public authorities are required to take account of life time energy use and CO_2 emissions when procuring vehicles* (European Commission).

The fleet average to be achieved by all new cars is 130 grams of CO_2 per kilometer (g/km) by 2015 – and 95g/km by 2020. The EU has set limits according to the mass of vehicles, using a limit value curve. Only the fleet average is regulated, which allows manufacturers to make vehicles above the limit value curve. If the average CO_2 emissions of a manufacturer's fleet exceed its limit value in any year from 2012, the manufacturer must pay an excess emissions premium for each car registered. EVs will contribute significantly to reducing a manufacturer's average fleet emission. By selling one EV (0g/km), a manufacturer will also be able to sell one "gas-guzzler" (190g/km) and still, achieve an average of 95 g/km (Archterberg & Archer, 2014). The regulation gives manufacturers additional incentives to produce vehicles with low or zero emissions. It has been argued what this will encourage supply of "ultralow carbon vehicles" (ULCVs), such as EVs and plug-in HEVs. The EU regulations have also implemented "super-credits". This means that each low-emitting car (below 50g/km) will be counted as 2,5 cars in 2014 and 1,5 cars in 2015. They will count as 1 car from 2016-2019, before super-credits again are implemented in 2020 – 2022. The super-credits are awarded to incentivize manufacturers to invest in production of low, or EVs (European Commission; Archterberg & Archer, 2014).

2.5.3 The EU's policy impact on Norwegian policy - The EEA Agreement

The EU is an important actor and partner for Norway on climate and environment issues. As a recipient of pollution from Europe, it is in Norway's interest that the EU has strict environmental regulations. The EEA Agreement entered into force in 1994. The agreement extends the EU's internal market to the three EEA European Free Trade Association (EFTA) states Norway, Iceland and Lichtenstein. This means that virtually all environment and climate regulations from the EU that are included in the EEA Agreement, which is more than 250 environmental legislative acts, were implemented in Norwegian law through legislation (The Norwegian Government, 2013).

2.5.4 Climate policy goals for Norwegian transport

The Norwegian Climate Compromise from 2012 sets an important milestone for the target of a carbon-neutral transport sector. The Norwegian Government has set ambitious targets for the reduction of GHG emissions. By 2020, emissions from the transport sector are to be reduced to a level 30 percent below the 1990 benchmark. A mean to reach the 2020 target is another important climate goal, the 85 grams per kilometer. Norway wants to decrease the fleet-average CO_2 emissions from new passenger cars in Norway to 85 grams per kilometer, also referred to as the 85-gram target. Accordingly, 10 grams below the intended 2020 EU target of 95 grams per kilometer. It has been politically discussed that without EVs the 85g/km target is not attainable, in order to reach the goal a fair amount of EVs is necessary in the transport sector (EV Norway, 2014). By comparison, the fleet-average emissions in 2012 in Norway were 130 grams per kilometer. Another ambitious target is full carbon neutrality by 2050. The Norwegian Climate Agreement and policy goals are developed based on EU policies. We will further elaborate on this in the section *Climate actions*.

2.2.6 Climate agreement and the White Paper

The first White Paper and climate agreement were published in 2007.

Climate Cure 2008 – 2010

The Government, through a joint commission from the ministries to affected agencies, established the Climate Cure project. This included The Norwegian Public Road Administration (NPRA), The Norwegian Climate and Pollution Agency, The Norwegian Maritime Authority, The Agency for Railway Services, The Norwegian Petroleum Directorate, Anvinor (The National Air Navigation), and the Statistics Norway (Dijk, Orsato and Kemp 2012). The Climate Cure estimated the potential for national emission reductions in all sectors. NPRA governed the commission that affected the transport sector. The interim reports and the final report were published in February 2010. The following actions were described to reduce emissions for new passenger cars:

- Efficiency of vehicles with combustion engine
- Better tires
- **Electrification**
- Hydrogen

The electrification action means that the Government wants to replace ICEs with EVs and plug-in HEVs. Electricity is considered to be zero-emission in Norway. Each EV that replaces an ICE will therefore reduce the CO_2 emissions by 100 percent (Figenbaum & Kolbenstvedt, 2013) .

2012 – Climate Compromise and the Norwegian White paper

In 2012 a new and updated White Paper was published. The 85g/km target was maintained in the climate compromise[25] that was published in 2012. The policy presented in the White Paper aims to transform Norway as a whole, across all sectors into a more climate-friendly society (Regjeringen Stoltenberg II, 2012). The White Paper further presents concrete actions and measures regarding how Norway's climate targets are to be achieved. Our focus will be on actions regarding transport as Norwegian EV policy is underlying this category.

In the Climate Compromise the Government reports *"to reduce emissions from the transport sector, the Government proposes to phase in new and environmental friendly vehicle technologies (...) more environmental friendly vehicle technology and fuel is to be applied"* (Figenbaum & Kolbenstvedt, 2013). Particularly interesting measures in relation to the EV incentives are:

- Develop procedures for environmental public procurement, update and develop the Agency for Public Management and eGovernment (Difi)[26], set criteria, with guidelines, for environmentally conscious procurement of cars (both purchasing and leasing)
- Work towards a more accurate road tax for heavy vehicles
- Establish Transnova as a permanent organization and gradually increase the financial support.
- Aim for that the average emissions from new passenger cars in 2020 shall not exceed an average of 85g CO_2 /km by:
    - Continue use of vehicle taxes to assist the transition to a more environment and climate friendly car fleet

[25] Opposition Parties the Conservatives (H), Liberals (V), and Christian Democrats (KrF) and the tri-Parties coalition has settled their climate differences in the new climate compromise

[26] Agency for Public Management and eGovernment (Difi) aims to strengthen the government's work in renewing the Norwegian public sector and improve the organisation and efficiency of government administration.

- Development of infrastructure for electrification and alternative fuels, partly through Transnova
- Remain at the forefront of facilitating the use of EVs and hydrogen cars
- Establish a better system for monitoring and control of traffic development in the public transportation lanes so that EVs and hydrogen cars can have access as long as possible without delaying public transport (Det Kongelige Miljøverndepartement, 2012)

2.2.7 Transnova

Transnova is a state owned[27] organization established in 2009 to reduce GHG emissions from the transport sector in Norway. Transnova is of great importance for the development of charging infrastructure and for the further development of the EV market in Norway. They provide causative grants to projects and initiatives that contribute to faster implementation of new and more environmentally efficient transport technologies and transport practices, such as replacement of fossil fuels with alternative fuels with lower or no CO_2 emissions. The supported projects are primarily in a demonstration phase, contribute to a reduction of various types of solution barriers and promote learning, transfer of experience and building competence. The Norwegian Government (The Ministry of Transport and Communication) allocates funds to Transnova through the annual budget resolution and Transnova is in charge of delegating funds. They are in charge of developing the National Strategy and Finance Plan for charging infrastructure and are considered to be the Governments "right hand" in relation to EV policies. Transnova has a close communication with the Government, NGOs and other stakeholders (The Ministry of Transport and Communications, 2013). Furthermore, Transnova shall be risk relieving for potential investors and users by providing financial support to projects that develop knowledge and experiences on transport solutions to reduce CO_2 emissions, but that is not being implemented due to various forms of barriers. This includes projects that are developing, but not yet have been tested; projects that need financial support to develop skills or projects, which are not yet competitive due to high cost or technological lock-in (The Ministry of Transport and Communications, 2013). Transnova has concluded that financial support for developing the charging infrastructure will help to achieve the 85g/km goal (Solem, Jonsen, & Nørbech, 2014, p. 8).

[27] Established by the MTC

2.6 The legislative system in Norway

We will now outline the structure of the legislation system in Norway by addressing the process of idea, to law suggestion and further to decisions. We include an explanation of this process in the thesis to emphasize that lobby organizations have a major influence on the Government and the promotion of new laws.

The Government is the legislative actor in Norway. Formal laws are determined in the manner specified in the constitution (§49, 75 A, 6 – 79 and §112). Proposals for laws generally come from the Government by a ministry. The Government submits most bills to the Storting. The Storting handles about 100 – 150 bills every year (The Storting, 2010).

2.6.1 Structure of the Norwegian Government

The Norwegian Government consists of 15 ministries and the office of the Prime Minister. Each ministry is responsible for a given sector and is governed by a Minister. In particular relevance for the EV market is the Ministry of Transportation and Communication (MTC), the Ministry of Finance (MF) and the Ministry of Climate and Environment (MCE).

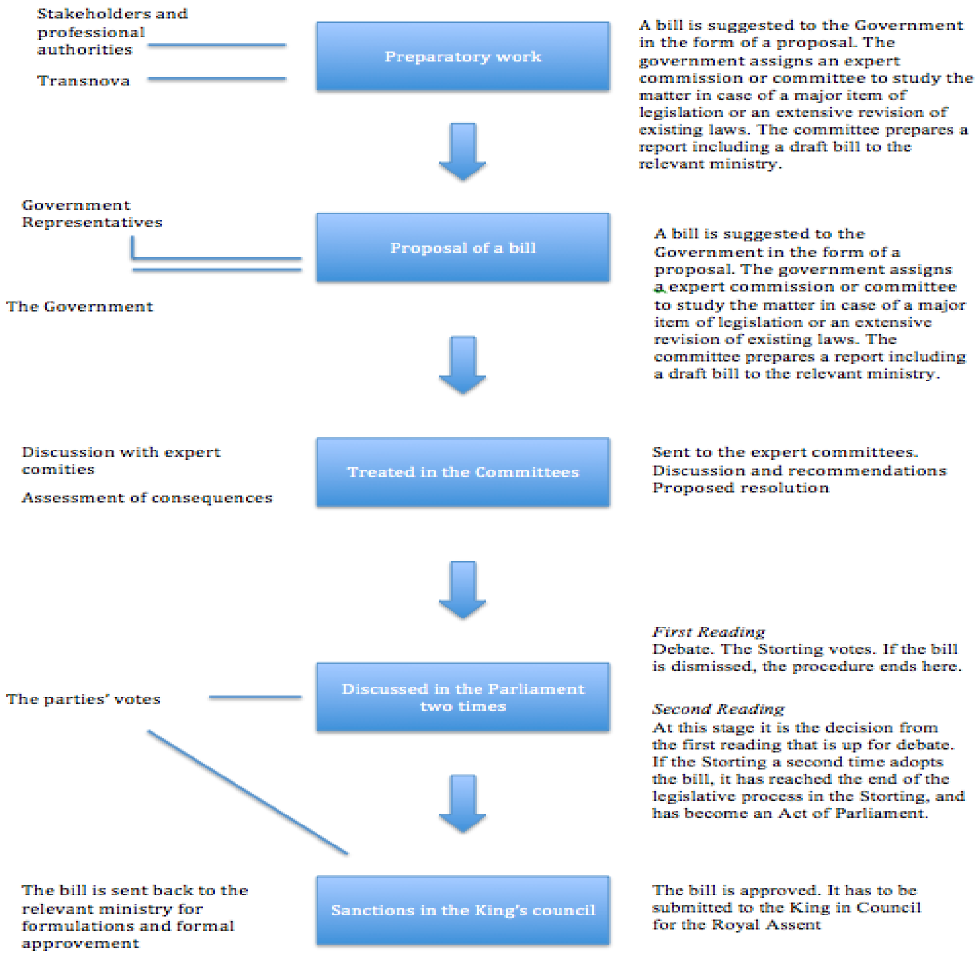


Figure 4 – The process from proposal to implementation of new laws. Source: Own Development (Regjeringen Stoltenberg II, 2012).

The ministries are responsible for tasks of different characters. On the one hand, the ministries perform tasks related to political issues and processes that are aimed at the Government and the Storting. The ministries have a central role in implementing the agreed sector policy i.e. the use of public policy instruments to achieve the agreed policy objectives. On the other hand, the ministries are responsible to fulfill classical administrative tasks including preparation of regulations, dealing with individual inquiries and complaints on individuals decisions made in their underlying departments (Antonsen, Nebben, & Rønning, 2002).

The Ministry of Transport and Communication (MTC)

MTC is in charge of for the framework condition for "*postal and telecommunications activities, for the civil aviation, public roads and rail transport sector, ferry services forming part of the national road system, coastal management, marine environment and sea transport policy"* (The Ministry of Transport and Communications, 2013). As mentioned earlier, MTC has established the organization Transnova. The MTC is, among other tasks, responsible for the charging infrastructure (The Ministry of Transport and Communications, 2013).

The Ministry of Finance (MF)

MF is responsible for "*planning and implementing economic policy, monitor financial markets and coordinate the work of the national budget".* MF is in charge of the policy for the financial incentives covering exception from taxes, VAT, one-time fee, toll-roads, ferries and any other exemption of expenses (The Ministry of Finance, 2014).

The Ministry of Climate and Environment (MCE)

MCE has the full responsibility for the climate and forestry initiatives, quota purchases and the CO_2 compensation scheme (The Norwegian Government, 2013).

2.6.2 Counties and municipalities

Each municipality in Norway belongs to a county. Each county with the exception of Oslo constitute a county authority. The politicians elected by the people to the Storting provide laws, resolve taxes and allocated funds. The municipalities solve many of the public tasks, however the Storting determines and limit how much they may spend within each sector. The municipality council and the county council is head of the municipalities and counties (local Governments) (Lovdata, Online Legal Resources, 1993). Municipalities have both their own tax and revenue income and transfers from the Government. In some cases the Storting adopts by law what the councils can do, or allocate specific funding for so-called earmarked grants, i.e. they have decided how the money should be spent (The Ministry of Finance, 2014). The EV incentives are determined by the Storting, however the municipalities manage the charging stations and the access to parking lots. The Storting has, as shown in Table 2, decided that ferries on highways are free for EVs, however the municipalities determine ferries covering county roads (Haugeland, 2014).

2.6.3 Non-governmental organizations and lobbying organizations

NGOs and lobby organizations have had a major impact on the Government's commitment to EVs. We consider in particular the organizations Bellona, ZERO, The Norwegian Electric Vehicle Association (NEVA) and Green Car (Grønn Bil) to be of importance. Opinions and research performed by these organizations will be discussed in the thesis.

Bellona

The Bellona Foundation is an independent non-profit organization that aims to fight climate challenges through identifying and implementing sustainable environmental solutions. Bellona has been a key player and advocate for the investment in the EV industry in Norway and imported the first EV to Norway in 1989. The primary purpose of Bellona is to push politicians and businesses in an environmentally friendly direction. Bellona cannot enforce laws, however they try to influence by providing information and participate in public debates (Bellona, 2014).

Zero Emission Resource Organization (ZERO)

ZERO is an independent non-profit organization that is working to limit human-induced climate change and to meet the world's growing energy demand without harming the environment. ZERO was founded in 2002 by a team with extensive experience from diverse environmental organizations in Norway with the mission to find political and technological solutions to climate challenges. ZERO has conducted research on the Norwegian EV policy and published the report "Norway's commitment to EVs, hydrogen cars and plug-in HEV" (Zero Emission Resource Organization, 2014).

The Norwegian Electric Vehicle Association (NEVA)

The purpose of NEVA is to promote EVs that run fully or partially on renewable energies. NEVA represents the majority of EV owners in Norway. They cooperate with the Norwegian Government, the EV car industry and other stakeholders. NEVA is a consumer organization, which acts as a communication channel between the EV end users, Government and EV producers and other stakeholders (Elbilforeningen - Om Oss 2014).

Green Car (Grønn Bil)

The purpose of the Green Car project is to increase the phase-in rate for rechargeable cars in Norway until 2020, and to facilitate for EVs to drive as much as possible using power fuel. The quantifiable target of Green Car is a minimum of 200,000 rechargeable vehicles registered in the vehicle registration ("Motorvognregisteret") by 31.12.2020. The Green Car program works to structure non-commercial sub-projects that contribute to increase the phasing-in rate of rechargeable car. The project has an active role in the interface between users, suppliers, Government and the energy industry (Kvisle, 2014). Green Car is a project owned by Energy Norway, a non-profit organization representing about 270 companies involved in the production, distribution and trading of electricity in Norway. Largely Transnova funds Green Car. The Norwegian Association of Local and Regional Authorities (KS) and the NGO Zero are also a part of the steering committee (Grønn Bil, 2009).

3. Methodology

This section describes the methodology of the thesis. Initially, we started with a general interest in green innovation and technology, and EVs. This resulted in awareness of the success story of the Norwegian EV market and the incentives given by the Norwegian Government. Shortly after, we uncovered an ongoing public debate about the EV incentive scheme. These interesting insights were the starting point for the thesis and assisted in narrowing down the research and the design of our methodology. As a starting point, we begin with a presentation and discussion about the methodology. Thereafter, an explanation of the method will be given. An evaluation of the quality of data for primary and secondary data will follow.

3.1 Philosophical choice, approach, purpose and strategy

3.1.1 Philosophical choice

Critical realism is the philosophical position applied in this thesis. This perspective suggests that it is possible to develop knowledge by adopting a scientific approach. However, in agreement with Sanders et al. (2012), we believe that the knowledge of reality cannot be understood independent of the social actors involved (Saunders, Lewis, & Thornhill, 2012). This indicates that the EV market cannot be evaluated only based on what is immediately experienced and observed. It is also important to consider the social conditions that lie beneath by talking to the actors that form the social structure and relationships around and within the EV market in Norway (Saunders & Tosey, 2012). Additionally, our stance as critical realists means that we acknowledge the value and importance of adopting a multi-level research approach (Saunders, Lewis, & Thornhill, 2012).

3.1.2 Research approach and purpose

The thesis adopts a hybrid research approach, where we draw on aspects of both research approaches. This means that we use a combination of inductive and deductive in order to answer our research question and structure the arguments. As Saunders et al. (2009) argue *"Not only is it perfectly possible to combine deduction and induction in the same piece of research, but also in our experience it is often advantageous to do so"* (Saunders, Lewis, & Thornhill, 2009, p. 127). The first part of the research process started according to an inductive approach with an exhaustive search and collection of relevant data on the EV market in Norway. Contrary to the deductive approach, this implies that the EV market in Norway is studied using both qualitative and quantitative data with the purpose of figuring out what the Norwegian Government should do to affect the EV industry in Norway to become sustainable (Saunders, Lewis, & Thornhill, 2009). Continuing, the result of analyzing the data identifies themes and develops patterns that can be reflected upon. According to the deductive approach, we concentrate on communicating the results. We are adopting theoretical frameworks for the sake of systematizing and answering the research question and not for the sake of testing the frameworks.

The purpose of the research is to highlight challenges with the policy incentives for EV end users and the charging infrastructure. This will help us identify what the Norwegian Government should do to affect the EV market, by using appropriate policies and incentives, to become sustainable. To reach such an explanatory level, the thesis goes through phases. The exploratory phase of the thesis applies to figure out what is happening in the EV market and what questions to ask. Thus, the exploratory phase is used to seek new insights in this field (Saunders, Lewis, & Thornhill, 2009). As new information or understandings surface with the exploratory research, the path of the research might change along the way (Saunders, Lewis, & Thornhill, 2009). This works well with the usage of mixed methods. The descriptive phase of our thesis is an extension of our exploratory research and pertains to both understand the relations within the EV market and the incentives (Saunders, Lewis, & Thornhill, 2009).

3.1.3 Research Strategy

We have adopted Grounded Theory as a research strategy. Even though research strategies are associated with a particular research philosophy, Saunders and Tosey (2012) argue that the boundaries between research strategies and philosophies are permeable, which makes it possible to adopt a combination of Critical Realism philosophy and Grounded Theory (Saunders & Tosey, 2012). Grounded Theory is referred to as "theory building" using a mixture of inductive and deductive approach by Saunders et al. (2009) (Saunders, Lewis, & Thornhill, 2009). It implies that knowledge about the research process and result are not known prior to the data collection. In the beginning, we had little knowledge about the theme and there was great uncertainty around where the research would lead our thesis. Therefore, it was essential to gather information about the EV market in Norway and talk with individuals involved in this market. The next step of Grounded Theory, after collecting information and data, is to build theories and explain findings and draw conclusions with theoretical insights. However, constructing our own fully developed theory is not what we intend to do. Our aim is to understand and identify what the Norwegian Government can do to affect the Norwegian EV market to become financially sustainable. This will be presented in the *Analysis and Result* section.

Even though we base our findings on the EV market in Norway, our insights might be relevant to other industries or markets. Additionally, the results can be valuable to other researchers and actors, such as decision makers within different EV markets. This suggests that our research strategy is also a case study. More precisely, it is a case of identifying how governments can affect EV markets to survive on its own merits, with limited support from governments, by using appropriate policies and incentives.

3.2 The Data Collection Process

In the Critical Realist philosophy there is no restrictions towards using mixed methods for the data collection process. Thus, we decided to adopt both qualitative and quantitative data, from primary and secondary data sources.

As mentioned in the introduction to this section, the idea of the thesis began with our interest in the EV market in Norway, Norwegian Government incentives, the phase-out of the incentives and the potential effect this could have on consumers and producers. After realizing that it was a matter of predicting the future, a rather impossible task, we decided that we wanted to determine how the Norwegian Government could affect the EV industry to become sustainable.

In order to answer the research question we understood that we needed to begin by exploring the market and create an understanding of the incentives, the different actors involved in the EV network, as well as developing a perception of the relationship between the actors. Without knowing what would be uncovered, we started to examine the existing literature on the topic. In doing so, we realized that the Norwegian market was more complex than first imagined. It became evident that predicting the future of the market and the effects of the phase out of the incentives would be an impossible task. Therefore, we decided to look into what is needed to make this market sustainable and survive on its own without significant support from the Government. This meant that we needed to investigate and determine which incentives are most important and what difficulties the Government faces in the EV market. This is just one example of how our research strategy was a process in constant change and development in accordance with our grounded theory strategy. In order to get a full map of the EV network and the challenges we could not solely base it on secondary data sources, we had to dig deeper by talking to the actors involved. Consequently, we included primary data through semi-structured interviews in order to fully map the EV market. This is in line with our philosophical position as critical realist as we believe reality cannot be understood independent of the social actors involved.

Table 4 – Overview of the data collection process. Source: Own development.

Data Collection		
Secondary Data		
Customer Surveys	Media and Press Releases	Academic Papers
Primary Data		
Interviews with Customers	Interviews with Actors	Debates and Public heerings

3.2.1 Collection of Secondary Data

The secondary data will be complements to the primary data, in order to find similarities and differences, and serve as additional contributions to certain issues of interest.
A usage of a wide variety of reports, academic papers, books, debates, customer surveys, media and press releases constitutes our secondary data. We have utilized these to create an overview of existing literature about the industry development and the Norwegian EV market. This was done in order for us to understand and get a clear picture of the published literature on the topic, and also to place our own research within existing literature. As we displayed earlier in the section, the Grounded Theory implies that we had no knowledge about where our research would take us or what we would discover. This means that we did not, prior to the review of this literature, hypothesize how the Government can affect the EV industry in Norway to become sustainable. Thus, the literature review presents an overview of previous EV research in Norway.

It is important to note, when evaluating our secondary data sources, that some of these sources are issued by recognized European and Norwegian institutions, or in cooperation with such institutions. This provides credibility to the secondary data sources. Additionally, the academic papers we use are issued in peer-reviewed academic journals, which decrease the probability of severe bias and incorrect information (Saunders, Lewis, & Thornhill, 2009).

3.2.2 Collection of Primary Data

Our primary data source, qualitative data, was applied because of its strength in exploring a research area that previously has not been broadly researched and to increase the reliability of the thesis' conclusions. Qualitative primary data were collected with the aim of gathering the essential data to analyze and present a comprehensive view of the incentive, the actors, the relationship between the actors and the charging infrastructure challenges.

3.3.2.1 Qualitative Data – Interviews

The secondary data source revealed that we had to get further information about the different actors to answer our research question. The next step in our data collection process was to conduct semi-structured interviews with different actors within the Norwegian EV market and analyze information from a debate and a strategy meeting we participated in.

We collected semi-structured interviews with a sample of ten EV owners from the Norwegian market (see Table 5). The interviews were conducted with the aim of giving us new insights about EV end users that could not be found by simply using secondary data sources. The interviewees were a semi-random sample of customers that we got in touch with through EV forums, EV groups, and friends and family.

Table 5 – Table of conducted EV owner interviews in chronological order. All of the interviews were phone interviews. All real names have been substituted for aliases. Source: Own development.

Interview	Name	Living Area	EV	Length of Interview (min)
1	Roger	Norstrand	Nissan LEAF	22
2	Barney	Asker	Tesla	18
3	Vain	Bergen	Tesla	16
4	Erin	Haugesund	Nissan LEAF	17
5	Max	Vigra	Tesla	15
6	Berta	Oslo	Citroën C-Zero	10

7	Brad	Asker	Tesla	12
8	Kyle	Oslo	Tesla	7
9	Oliver	Asker	Nissan LEAF	10
10	Matthew	Oslo	BMW i3	16

The other interviewees (the Government, EV producers, CCIPs and NGOs) were not a random sample. The process of analyzing secondary data helped us to identify some of the individuals to arrange interviews with. The initial research process uncovered different actors within the Norwegian EV market context, while some of the interviewees also referred us to other individuals within the EV market. The latter process is called snowball sampling. It is defined by Biernacki and Waldorf (1981) as *"[Snowball sampling] yields a study sample through referrals made among people who share or know of others who possess some characteristics that are of research interest"* (Biernacki & Waldorf, 1981, p. 141). According to Biernacki and Waldorf (1981) this method of finding individuals suggests that the group of individuals is not a statistically random sample. We intended to interview representatives from industry members, the Government, NGOs and CCIPs. By interviewing all these groups we secured a comprehensive understanding, and also that different viewpoints are taken into account with our selection of interview objects.

After having identified important individuals in the Norwegian EV market we continued the interview process by calling and emailing the representatives from different groups within the EV market identified in reports, publications and media and press releases, such as EV producers, policymakers, NGOs and CCIPs. We experienced almost no difficulties in arranging interviews with the any of the different groups. After establishing contact we succeeded in arranging interviews with eleven selected individuals from EV producers, policymakers, NGOs and CCIPs (Table 6).

Table 6 – Table of conducted actor interviews in chronological order. EV producers are marked with green, policymakers are red, CCIPs are purple, and NGOs are marked with blue. Half of the interviews were conducted in-person, while the other half was phone interviews. All real names have been substituted for aliases. Source: Own development.

Interview	Name	Interview Group	Role	Length of Interview (min)
1	Erik	Policymaker	CEO	56
2	James	Policymaker	State Secretary	42
3	Kerstin	Policymaker	Advisor	42
4	Michael	NGO	Consultant	71
5	Simon	NGO	General Secretary	35
6	Peter	EV Producer	CEO	47
7	Tyler	Policymaker	Senior Advisor	24
8	Adam	Commercial Charging Infrastructure Provider	Senior Product Manager	33
9	Earl	EV Producer	Communication Manager	60
10	Kyra	NGO	Head of Transport Department	45
11	Keith	EV Producer	Project Manager	20

3.3.2.2 Interview design and structure

We conducted non-standardized and semi-structured interviews with pre-prepared list of questions and themes to cover with in total ten EV end users and eleven other actors (the Government, EV producers, CCIP and NGOs). For the first interviews we had an initial list of questions and topics we asked the representatives from the different groups[28] (Appendix 1, 2a and 2b). During the initial interviews we gained new insights, which made us decide to prepare a second set of questions and topics for our latter interviews (Appendix 1c). These new insights made it possible for us to

[28] For EV end users we only prepared one set of questions and topics to cover

continuously focus on important issues that were raised in the initial interviews that we had not thought about in advance.

We had a clear agenda regarding what to cover in each interview, but the flow of the conversation was the determining factor. The flow of the conversation controlled which questions and topics that were covered and to what degree (Saunders, Lewis, & Thornhill, 2009). The questionnaires were developed separately for each group, however the questions and themes had similarities so it was possible for us to compare answers and develop our results. As our interviews were semi-structured, instead of structured or non-structured, each interview was unique and themes were never covered in an identical way.
Our purpose for carrying out interviews was to establish an extensive and multifaceted picture of the EV market in general, and to gain the nuances from the different individuals involved in this particular field.

We choose non-standardized interviews mainly because of two reasons. First, due to differences between groups we needed to ask different questions to different individuals. Second, we saw open-ended questions as important because then the individuals could explain and build their responses, and we could ask follow-up questions both to clarify reasons and to gain additional information about a specific area of interest. Open-ended questions could also lead us into areas which we had previously not considered, but that could be highly valuable in understanding the Norwegian EV market and addressing the research question (Saunders, Lewis, & Thornhill, 2009).

In addition to the interviews we also gathered primary data from other sources. More specifically, a debate about how environmental friendly the EV is, a Transnova strategy meeting about National Strategy and Finance Plan for Infrastructure for EVs, a Norwegian documentary program about the EV challenges, and a TV debate about the EV. The reason for using this information was justified by the attempt to give a clearer picture of the EV market and the connections within the market. Using these sources also helped us gain more insight into a particular area of interest.

3.3.2.3 Evaluation of Data Quality

When developing our questions, we discussed possible data quality issues of adopting semi-structured interviews, as well as actions to limit these. First of all, we could explain questions, meanings could be explored, and topics could be debated from numerous of different approaches to increase validity in a non-standardized interview. The problem with this is that it would not establish outcomes with high reliability, since the non-standardized interview might be problematic to duplicate for other researchers. Second, before the qualitative data collection and every interview, systematic and thorough secondary research was undertaken. This lead to more informed questionnaires, and enhanced ability to ask additional questions and conclude from answers from the interviewees. Additional to the mentioned biases, in non-standardized interviews, the main weaknesses and biases are connected to reliability, such as interviewer bias and interviewee bias (Saunders, Lewis, & Thornhill, 2009).

Interviewer bias is associated with whether comments, non-verbal behavior or tone from us as researchers change the respondents' answer to the questions. There was always a risk that we imposed our own beliefs and frame of reference. In order to minimize this potential bias we took two actions. First of all, by avoiding expressing our own beliefs and opinions we believe we reduced this bias. Second, by having a set list of questions we minimized imposing our own view, which lowered the potential bias (Saunders, Lewis, & Thornhill, 2009). If we wanted more elaborating answers we could ask in-depth probing questions. Additionally, there is a bias linked to interpretation, such as how the respondents interpret our questions and how we interpret interviewees' responses. We believe we minimized this bias to a certain degree since most of the interviews were conducted in the native language, Norwegian.

Interviewee or response bias relates to whether the interviewees' perception of us as researchers could have shaped their response. The interviewees' answers may be affected by what they though we wanted to hear, since it is in human nature to want to be liked. To decrease this bias we only introduced our theme, the Norwegian EV market, though some interviewees required more information about our topic or a list of interview themes we would address in advance before they agreed to be interviewed. This may have caused the interviewees to assume we have a certain perspective and give corresponding answers. However, the validity of the results can improve by supplying interviewees with information because this allows them to assemble supporting information prior to the interview. All our interviewees were informed prior to the interview that we would keep their identity a secret and that all names would be given aliases. We did this to make sure that our interviewees would share their personal thoughts (Saunders, Lewis, & Thornhill, 2009).

Additionally, the interviewees might be biased in relation to their position in the industry. For instance, an individual that represents the Government seems to be optimistic concerning the development in the charging infrastructure, while an individual from a private infrastructure provider is less optimistic about the charging infrastructure development. One way to overcome these biases was to draw information and opinions from different representatives in various parts of the industry, and from publishing, academia and debates.

4. Literature review and theoretical framework

4.1 Literature review

The following section will present an overview of significant research done within the fields of EVs, Path Dependence and Socio Technical Transitions. The relevant research field of EVs is relatively new and the literature presented in this thesis dates from 2009 – 2014 with an increasing amount of research the recent years. Research on socio-technical transitions is as similar to EV research new with literature that dates from 2005 – 2014. The focus on sustainability that has arisen over the recent years has led to an increasing amount of research within the fields of socio-technical transition. Path Dependence on the other hand takes an older perspective and the literature dates back to 1893 – 2009.

4.1.1 EVs

With increasing concern on environmental protection and energy conversion there is a fast growing interest in EVs from automakers, government and customers (Raines, 2009). As Norway is in the forefront of electric mobility, summarizing and publishing Norwegian experiences with electric mobility can therefore be useful for those working with electrification in other countries.

Taking a global perspective, The EVs research service focuses on the emerging market opportunities for electrified vehicles on a worldwide basis. Enabling technologies such as batteries and charging equipment, infrastructure are analyzed in depth and the service examines the key industry players within the EV ecosystem as well as policy and regulatory factors and drivers of consumer and fleet demand for EVs (Navigant Research, 2014).

In Norway, the NGO ZERO has contributed to important research within the fields of policy incentives and EVs. ZERO has contributed much to existing knowledge on EVs in Norway. In 2010, ZERO developed the report "Norways commitment to EVs, hydrogen cars and plug-in hybrid cars". ZERO has analyzed the future of the Norwegian incentive scheme and finds that Norway needs to expand the incentive scheme to last even after 2017. The research points out that the Norwegian Governments needs to strengthen Transnova, to further invest in charging infrastructure and fast charging, and to increase the financial subsidies to EVs (Halsør, Myklebust, & Andreassen, 2010).

Another organization that has contributed much to the Norwegian knowledge base on EVs is the Institute of Transport Economics (TØI) – Norwegian Centre for Transport Research. In the Report "Electromobility in Norway – Experiences and Opportunities with EVs, Figenbaum and Kolbenstvedt (2013) finds that the Norwegian Electrical Vehicle policy, with its many incentives, and the establishment of Transnova have reduced the barriers for e-mobility. They further argue that it is likely that EV-drivers in Norway will continue to use EVs in the future, and that range is less of an issue for existing drivers than expected. Their concluding remarks states that modifying the extensive Norwegian EV-incentives as e-mobility enter the market expansion phase will be a major challenge (Figenbaum & Kolbenstvedt, 2013).

4.1.2 Path dependence

PD was originally formulated for use in economics. The concept of PD is now used frequently in other social sciences, such as historical sociology and political science. PD is mainly used to explain how certain outcomes are the result of a particular event, and how that particular event constrains future options (Lewis-Beck, Bryman, & Liao, 2004).

PD refers to complex processes that are non-ergodic, or in other words, those processes that are unable to shake free of their history (Garud, Kumaraswamy, & Karnøe, 2009). The accumulated experience and path-dependent development of petroleum-based transport fuels and ICE vehicles has created an apparent technological lock-in. PD means that technical choices today are often dedicated by historical development due to scale and learning economies, technical compatibility and industrial networks (Åhman & Nilsson, 2008). David (1994) identifies three main conditions that give rise to PD: 1: The role of historical experience in forming mutually consistent expectations that permit coordination of individual agents behavior without centralized directions. 2: The information challenges and codes required by multi-person organizations to function. And finally, 3: The interrelatedness of the constituent elements of complex human organizations and the constraints that result from pressures to maintain consistency and compatibility within larger structure (David P. , 1994). Further, Garud et al. (2009) have studied the assumptions that underlie path dependence. They find that an alternative perspective arises, which is referred to as path creation. "Path creation entails a notion of agency that is distributed and emergent through relational processes that constitute phenomena. Viewed from this perspective, initial conditions are not given, contingencies are emergent contexts for action, self-reinforcing mechanisms are strategically manipulated and lock-in is but a temporary stabilization of paths in-the-making (Garud, Kumaraswamy, & Karnøe, 2009).

4.1.3 Socio-technical transitions

STT theorists have made important contributions to our knowledge of the challenges and possibilities for achieving more sustainable societies (Lawhon, 2013). Today, many innovations and policy makers are concerned with developing responses and strategies to climate change and energy supply issues. The increasingly complex mix of economic, social, environmental and political problems requires new ways of thinking (Cohen, Brown, Szjenwald, & Vergragt, 2013). This effort is critical for STT towards greener economies with reduced energy consumptions and lower GHG emissions. Technological eco-innovations such as energy-efficient passenger cars based on alternative technologies plays a key role in this process, however they are to a large extent hindered by lock-in effects favoring ICE technologies. Ulli-Beer (2013) suggests that the challenge of STT requires an understanding of physical infrastructure and governance including the actors which create and recreate the rules of the game, how to overcome existing lock-in effects and governance principle that help to cope with systemic sources of policy failures (Ulli-Beer, 2013).

The Multi-Level Perspective (MLP) will be addressed in this thesis as a tool to analyze STT. The MLP has emerged as a framework for analyzing STT to sustainability. In our theoretical framework we apply research by Geels (2010, 2011). MLP offers a systemic perspective on socio-technical change and is useful for identifying and engaging with different stakeholder groups. The MLP consists of three different levels; the regime level, niche level and landscape level (Geels, 2011). Smith et al. (2005) finds that radical changes at the regime level are needed to deliver sustainable development (Smith, Stirling, & Berkhout, 2005).

4.2 Theoretical framework

Our theoretical framework is divided in two parts. First, we will use PD theory to explain the automobile industry pathway and why the ICE is the preferred technology and dominant design in the automobile industry. In the second part we will take a deeper look into theory on STT and use the MLP model as an attempt to identify and understand necessary factors for changes from ICE technologies to consumer adoption of EVs.

4.2.1 Path dependence

In order to understand the why the ICE has been the preferred technology and the dominate design in the automobile industry for over 100 years we will by with explaining PD by Brian Arthur (1996). The author (1996) is known for publishing numerous of articles, which are now considered as the foundation of path dependence.

The understanding of economic behavior and how businesses operate have largely been influenced by economists, such as Alfred Marshall (Arthur B. W., 1996). Marshall argued that the basis of the processing industry was made upon the assumption of diminishing returns; *"products or companies that get ahead in a market eventually run into limitations, so that a predictable equilibrium of prices and market shares is reached."* (Arthur B. W., 1996, p. 1).This was considered as standard theory until Arthur (1996) extended it to include increasing returns. He included increasing returns to meet the transformation of Western economies, from volume based manufacturing to design and use of technology, or in other words, from processing of resources to processing of information – or from applications of raw energy to application of ideas. Arthur (1996) explained the modern economy by dividing it into diminishing- and increasing returns, where increasing returns not only complements the standard theory; but also plays an important part of the economy – high technology. Arthur (1996) describes diminishing returns as goods with increasing supply costs and increasing returns as *"the tendency for that which is ahead to get further ahead, for that which loses advantages to lose further advantage"* (Arthur B. W., 1989, p. 116).. Explained differently, diminishing returns is the basis of the processing industry while; increasing returns escalates the current situation whether it is positive or negative. Or as Arthur states it *"the more they [technologies] are adopted, the more experience is gained with them, and the more they are improved."* (Arthur B. W., 1989, p. 116).

While previous analysis of markets with increasing returns has had difficulties describing the dynamics, Arthur (1983, 1989) explain that there are multiple equilibrium outcomes in markets with increasing returns. He compares these markets to a pencil perfectly balanced on its tip; *"we cannot say which way it will "fall"; we cannot describe uniquely which path it will follow; hence we cannot pursue conventional analysis"* (Arthur B. W., 1983, p. 1). As the example with the pencil, markets with increasing returns are uncertain and it is impossible to predict the result in advance (Arthur B. W., 1983). To demonstrate the dynamics of the choice between competing technologies (market with increasing returns) Arthur (1983, 1989) uses a mathematically simple model. Here heterogeneous agents' choose between competing technologies (Arthur B. W., 1983). He assumes the technology choice to be subject to small historical events, which he describes as conditions or events that the observer has little or no knowledge of (Arthur B. W., 1983). The model reveals a stochastic process; that the market share of each technology follows a random walk. A random walk has *"absorbing barriers"* when the rival technologies show increasing returns. Arthur found four different characteristics of the outcome when there is competing technologies with increasing returns: *"(a) a potential inefficiency of aggregate outcome, even where individual choices are perfectly rational; (b) an inflexibility of outcome, in that market shares become locked-in – they cannot always be influenced by standard, marginalist policy measures; (c) a non-predictability, in that knowledge of supply and demand conditions does not suffice to predict ultimate market shares; and (d) a non-ergodicity, in that small historical events are not always averaged away, but can determine the path of the market share."* (Arthur B. W., 1983, p. 3). The first aspect implies that increasing returns technologies competing for dominance can be locked-in to a future technological path, or in other words become path dependent on a technology, which not necessarily is the one with the superior technological structure. This means that increasing returns become the source of path dependence. The second aspect points out that the outcome is in flexible and locked-in to the "chosen" technology. The third mean that it is impossible to predict the result of the competing technologies, while the final one point out that historical insignificant events may by chance become magnified and "choose" the path of the technology (Arthur B. W., 1983).

The last outcome aspect is the aspect that can influence the choice sequences. It can by chance give one of the competing technologies an initial advantage in adoptions. This means that an insignificant event can influence an agent, with a natural preference for technology A, to switch preference to technology B. Technology B can then improve more than technology A, so it may appeal to a wider potential of agents. Another agent with a natural preference for technology A, will switch preference to technology B if by chance the adopted numbers and payoffs are far enough ahead of the numbers adopting technology A. Technology B can therefore become further adopted and improved. Thus, technology B may "corner the market" by chance, while technology A becomes locked-out (Arthur B. W., 1989).

One way, Arthur (1983) proposes, to balance the increasing choices is by providing small or large subsidies. This can underwrite the adoption of a sub-optimal technology, however exploration of unknown technological paths by the government can lead to high cost and drive the favored technology out (Arthur B. W., 1983, pp. 16-17).

As a conclusion of Arthur's (1983, 1989 and 1996) articles is can be said that micro-events become magnified and may "choose" the path for the technological development (Arthur B. W., 1983, p. 16). Unfortunately, it is usually insufficient with information about preferences, endowments and transformation possibilities to determine the market outcome and this might lead to that the chosen technology becomes locked-in to an inefficient technological structure (Arthur B. W., 1983, p. 18). The consequence of this is questions about models for economic prediction, historical interpretation, and policy (Arthur B. W., 1983, p. 2).

The fundamental indication of PD is that "Where we are today is a result of what happened in the past". In other words, the automobile industry is dominated by ICE because ICE won the battle of dominant design in the past. A dynamic process whose evolution is governed by its own history is path dependent

(Liebowits & Margolis, 1995). A key finding of PD is a property of "lock-in" based on historical events. If such path dependence does occur, it implies that marginal changes of individual agents may not lead to the assurance of optimization or the revision of suboptimal outcomes. In turn, this implies that markets fail (Liebowits & Margolis, 1995). However, not all phenomena that have been described as path dependence lead to market failure, these normative concerns have been an important part of the path dependence literature. Liebowits and Margolis (1995) identify three different degrees of path dependence. First-grade dependence refers to instances in which sensitivity to starting point exists, but has no implied inefficiency. Second-degree path dependence arises when information is imperfect, and efficient decisions may not always appear to be efficient in retrospect. Sensitive dependence or initial conditions leads to outcomes that are regrettable and costly to change. However, they are not inefficient in any meaningful sense, given the assumed limitation on knowledge. Further, in third degree path dependence sensitive dependence on initial conditions leads to an outcome that is inefficient. In this case, the preferred outcome is also remediable, i.e there is, or was any possible arrangement for recognizing and achieving a preferred result, but the result is not achieved (Liebowits & Margolis, 1995). The essence of the distinction between third-degree path dependence and the weaker forms is the availability of feasible, wealth-increasing alternatives to actual allocations, now or some times in the past. Third degree path dependence occurs of an action path is inefficient, in other words if there at some point there is an alternative action where the social benefit of selecting another alternative are known to be greater. In this paper we consider the Electric Vehicle to be a better option, which will create greater social benefit to the society. In the next section, we will take a deeper look into socio-technical transition, and explain factors and actions that can lead to a shift from ICE technology to EV technology.

4.2.2 Socio-technical transitions

Contemporary environmental problems such as climate change present major societal challenges. Addressing these problems requires improvements in environmental performance, which may be realized by deep-structural changes, and includes the transition from one technology, to a more environmental and sustainable technology. Geels (2011) refer these deep structural changes as STT. STT entails technology, policy, markets, consumer practices, infrastructure, cultural meaning and scientific knowledge (Geels, The Multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011). These elements are reproduced, maintained and transformed by actors such as firms and industries, policy makers and politicians, consumers and society. In other words, transitions are complex and long-term processes compromising multiple actors (Mah, van der Vleuten, IP, & Hills, 2012). Why have in social transitions caught our attention?

The first point to address is that technological innovations that contribute to solving environmental problems distinct from other types of innovations. They cannot necessarily develop into a large market without changes in economic, policy and wider socio-cultural conditions (van den Bergh, Truffer, & Kallis, 2011). This is caused because most sustainable solutions do offer obvious user benefits. They will often score lower on price/performance dimensions than established technologies (Geels, 2011). It is therefore unlikely that environmental innovations will be able to replace existing systems without changes in economic frame conditions such as taxes, subsidies or regulatory framework. These changes will therefore require changes in policies (Geels, 2011). The term ”socio-technical” refers to the interaction between society’s complex infrastructures and human behavior. In other words, socio-technical does not only entail new technologies, but also changes in markets, user practices, policy and cultural meanings. A socio-technical conversion do not favor social and technical elements as two separated entities, but see these as stabilized linked (Dijk, Orsato og Kemp, 2011). This approach is based on a structuralistic and actor-based view, and the core focus is on the close alignment of both technical and social elements such as technology, industry, markets, consumers, policy, infrastructure, spatial arrangements and cultural meanings (Dijk, Orsato og Kemp 2011, p. 135). The socio-technical view is conductive for explaining that change is not forced by single factors such as price, but typically involves co-evolution between multiple developments.

Transition towards sustainability

A related concept we would like to explain is “transition towards sustainability”, which concerns systemic changes that involve improvements in environmental performance.

Geels (2011) has studied the concept of transitions towards sustainability and suggests that this transition bear some particular characteristics. Environmental problems such as climate change, bio diversity and environmental issues have gained more attention on the political agenda in the 1990’s and early 2000s. These problems differ in scale and complexities. Some may be addressed with incremental clean technologies, however Geels (2010) states ”*responses to the new environmental* *issues require more substantive transitions in the upcoming decades like major changes in energy and transport"* (Geels, The Multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011, p. 496). The transition from ICE to EVs is a difficult and complex process that goes beyond technological challenges. The challenges of electric vehicle development are numerous including realigning the interest of manufacturers, government and consumers resistance to change. A potential barrier is that many existing (unsustainable) systems are locked in to mechanisms such as scale economies, sunk investments, infrastructures and competences. Additionally, consumer lifestyles and preferences may have become adjusted to existing technical systems. These lock-in mechanisms create path dependence and make it difficult to dislodge existing systems. The core analytical challenge is therefore to understand how environmental innovations emerge and how these can replace, transform or reconfigure existing systems (Geels, The Multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011). Nilsson et al. (2012) argues that the main barrier in the transition from ICEs to EVs is caused by confined access to knowledge and suppliers within new fields such as batteries and power electronics, how to integrate this knowledge and supply chains in existing production systems and new requirements for industry standards and regulations (Nilsson, Hillman, & Magnusson, 2012).

The notion of socio-technical systems emphasizes that transition of the automobile industry are embedded in a broader context that goes beyond technological change. Geels (2011) suggests, *"Such system innovations not only involve new technological artifacts, but also new markets, user practices, regulations, infrastructures and cultural meanings".* This notion emphasizes the importance of co-evolution of technological, social and environmental systems (Mah, van der Vleuten, IP, & Hills, 2012).

Government subsidies to sustainable innovations

There is a wide agreement among researchers that policy makes plays in important role in sustainable technology transitions (Nilsson, Hillman, & Magnusson, 2012; Aalbers, Shestalova, & Kocsis, 2013; van den Bergh, Truffer, & Kallis, 2011). The question is however, which approach is the best, and for how long will the government need to subsidies environmental friendly technological innovations? Various challenges in the transition process require different methods for governance. Nilsson et al. (2012) argues that EV governance processes focus more on cognitive modes and network building.

They consider network building and cognitive modes to be key processes where regime-external processes are developing. They further argue that according to theory on socio-technical regimes, technology interacts with governance through positive feed-back in both directions. In other worlds, as technologies get introduced, the must be driven by governance, they turn ignite in the emergence of new governance arrangements which leads to the institutionalization and self-reinforcement of a regime. (Nilsson, Hillman, & Magnusson, 2012, p. 64). We will further explain the concept of regime in the next section.

Aalbers et al. (2013) suggests that innovation policy instruments that may boost clean innovations for more environmental friendly technologies includes; providing public R&D to innovations in clean technologies, modifying patent protection and raising the price of carbon emissions above its first best levels (Aalbers, Shestalova, & Kocsis, 2013). Further, Nilsson et al. (2012) suggests that given the urgency to resolve unsustainable trends in the transport sector both industry and policy makers agree that innovation in these technologies require more active governance. They distinguish between government at the international, national and local level. At the international levels, agreements and regimes related to climate change mitigation such as “The greening Transport Package in the EU” is important to set goals that further can be solved at national levels. At the national level governments may use different instruments to facilitate the deployment of sustainable transport technologies such as taxation/licensing fees of vehicles, differential taxation of fuels, investment subsidies and R&D programs for alternative fuel vehicles. They suggest that Local authorities can implemented measures including differential parking fees and congestion charges, as well as developing infrastructure and charging stations for vehicles (Nilsson, Hillman, & Magnusson, 2012).

The question is however; who is best suited to govern sustainable innovations in transport, and what is the appropriate level of governance? These governments’ related issues had not been addressed much and the lack of knowledge within this field is not unique to the transport sector; it concerns a wide range of technological innovations. Nilsson et al. (2012) points out: *“Just how governance should be best arranged to achieve both momentum and sustainable direction in technological innovation system is not well understood*” (Nilsson, Hillman, & Magnusson, 2012, p. 51). Sustainable technological innovation systems emerge internationally, are taken up by national markets and put to use locally. They may further be constrained or promoted by local authorities and infrastructures. Existing research points out that it is vital to understand actor involvement (the relative involvement of private and public actors), the level of governance and the mechanisms of government (Nilsson, Hillman, & Magnusson, 2012).

Van den Bergh et al. (2011) claims that policy and management aimed at stimulating sustainability transitions involves environmental and technological-specific policies. Furthermore, sustainability policies are confronted with problems regarding long-term orientation. Long-term policies are usually based on time horizons of two to three decades, which extend beyond the usual span of political processes as governments are driven by electroal cycles. In order to support long-term structural-shift policies have to interact over the time horizon and the electoral cycles.

Incentives or dis-incentives?

One way of conducting transition policies is to increase the cost of ”dirty” technologies and products. This will lead to better conditions for adopting for new and cleaer technologies (van den Bergh, Truffer, & Kallis, 2011). Alternatively one may implement incentives, rather than dis-incentives. Tran, et al. (2013) has studied which factors that might trigger wide spread adoption of alternative fuel vehicles, (in particular EVs) to support energy policy. They find that transitions from ICEs to EVs depends on commercialization strategies such as; financial benefits i.e improved fuel efficiency or policy related advantages (Tran, Banister, Bishop, & Malcom, 2013).

To provide incentives to encourage innovations, government can step up in two ways. Direct subsidies are best suited to encourage high-risk projects and to meet specific policy goals. The other major subsidy comes indirectly through the tax system. There are two primary forms of indirect taxation today – Value-added taxes (VAT) and customs and excise duties. Within these two major tax types it exists thousands of rates, rules and regulations. Both sales tax and VAT are primarily designed to tax the final customer and may be a suitable incentive for customers to adapt to new technologies (PricewaterhouseCoopers, 2010).

In the broad literature on innovation, we generally find a positive attitude towards innovation. Innovations are considered to be good, and will contribute to economic growth. In transition thinking, we are stepping away from such view, on economic growth and technological change. Transition policy is defined as “*the effort to guide or facilitate sustainability transitions, that is, to influence the* *speed and direction of the evolution of a socio-technical system*" (Alkemade, Hekkert, & Negro, 2011, p. 126). Innovation policy on the other hand rather focuses on facilitating innovation with the purpose of stimulation economic growth. Alignment between transition policy and innovation policy can only be expected in the case where policy seeks to create new profitable industries that contribute to a more sustainable society (Alkemade, Hekkert, & Negro, 2011). In environmental and economic science there has for several years been disagreement regarding environment-versus-growth.

The Multi-Level Perspective

The link between technology and society is well conceptualized in the framework provided by the Multi-Level-Perspective. To bring about the social and technological changes essential for a sustainable future, we need a richer understanding of how these changes occur. Geels (2011) presents a framework called the Multi-Level Perspective (MLP), which provides us insights to how one technology may transition to a radically new technology to fulfill an environmental need. The Multi-level perspective (MLP) has emerged as a framework for analyzing socio-technical transitions to sustainability. This framework distinguishes three inter-related levels of change: *The landscape, Regime and Nice levels of socio-technical systems.*

Socio-technical regime (Meso)

The regime forms the deep structure that accounts for the stability of an existing socio-technical system. Because existing regimes are characterized by lock-in, innovation occurs incrementally (Geels, 2011). It refers to the semi-coherent set of rules and activities of the social groups that reproduce the various elements of socio-technical systems. Examples of rules are routines, beliefs, competences, regulations and legally binding contracts. From a socio-technical perspective, the positioning of the emerging technology, either inside or outside the socio-technical regime may explain governance patterns. EVs are currently operating outside the regime as ICEs is considered to be the Dominant design. In other words, EVs are a radical innovation that has the potential to threat the existing regime. The adoption of EVs requires changes in infrastructure, ownership models driving behavior. Nilsson et al. (2012) points out that the main problems of the regime-level change is access to knowledge and suppliers within new fields such as batteries and power electronics, how to integrate knowledge, supply chains in existing production systems and new requirements for industry standards and regulations.

EVs represents changes in the vehicle supply chain towards batteries and electricity and new suppliers are thereby needed. The manufacturers mainly conduct R&D and production of batteries and EVs. However, it is pointed out that automotive manufacturers need long term and coordinated steering to motivate the necessary investments. (Nilsson, Hillman, & Magnusson, 2012). In other words, theory on socio-technical regimes suggests that technology interacts with governance through positive feedback in both directions, from manufacturers to government, and vice versa.

Niches (Micro)

Niches refer to protected space in which innovations takes place. This includes R&D laboratories, subsidized demonstration projects or small market niches where users have special demands and are willing to support emerging innovations. Niche actors work on radical innovations that deviate from existing regimes. The development of these innovations is not easy because the existing regime is stabilized by many lock-in mechanisms. Niches are crucial for transitions because they provide the seeds for systematic change. Although industry is willing to make sizeable investments required to move forward, policy support is necessary a products will be sold at a loss in this phase because of investment costs. (van den Bergh, Truffer, & Kallis, 2011).

The socio-technical landscape (Macro)

The landscape consists of a range of contextual factors that influence technological development. The landscape is a wider context, which influences niche and regime dynamics. The landscape is seen as an external backdrop to the interplay of actors at the regime and niche level. Changes may occur in the socio-technical landscape, but more slowly than in the regime level. One such change is the increase in Environmental awareness. Increased environmental awareness (socio cultural process) leads to a pressure on several regimes (transport favoring ICE technologies) and open doors for new technologies to establish themselves (Geels, The Multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011).

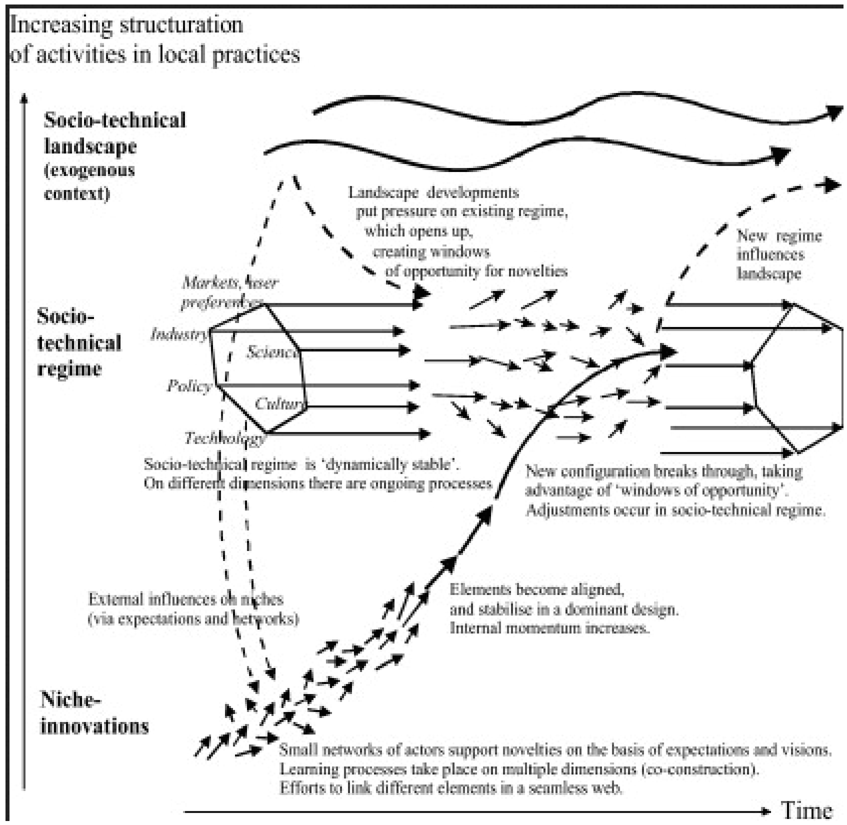


Figure 5 – The multi-level perspective. Source**:** Geels (2011).

Figure 5 gives an example of how the three levels interact in the unfolding of a socio-technical transition. Each transition is unique, however transitions results because of interactions between different processes at different levels. Changes in the landscape create pressure on the existing regime while leads to that the destabilization of the regime and creates windows of opportunities for nice-innovations (Geels, The Multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011). The niche innovations contribute to new encouragements.

This literature on MLP is in particular helpful to put shed on the drivers of change and what interactions should be created at the three inter-related levels to drive change. Mah, et al. (2012) explains how government policies, business incentives and consumers motivations have to converge to overcome barriers such as the problems of "lock in" (Mah, van der Vleuten, IP, & Hills, 2012).

They state that governments, business and consumers are all important players who interact in new kinds of relationships and that the three inter-connected levels of landscape, regime and niche can drive changes in socio-technical systems. The government will have an important role in formulating policy and regulatory framework and enhancing market certainty for innovation processes. The business sector needs to collaborate with government to develop new business models such as charging providers and service contracts that put business incentives and consumers motivations in place to drive towards changes in infrastructure. Consumers who have access to better information can play an active role in micro generation investments. This framework suggests that the interactions of these key actors would create important forces of change at and between landscape, regime and niche levels.

It is however important to note that like all societal and technological changes, transitions involves both winners and losers. Transitions are party governed by economic and political power, which may generate resistance to change or even social conflicts (van den Bergh, Truffer, & Kallis, 2011). Such conflicts can creative inputs and may open up to new trajectories, however they may also be destructive. It is important to understand the existence of potential winners and losers because it may affect political positioning and lobbying resistance.

5. Analysis and results

In this section, we will include three parts. First, we will explain the automobile market using PD. This provides insights to understand the evolution of the automobile industry, why the ICE is still the preferred vehicle, and how this market can be changed in a global and Norwegian context using PD.

In the second part we will assess the policy incentives for EV end users and possible customers. More specifically, how the incentives have affected the purchase price, the battery costs, and operating costs and convenience. We will investigate which of the incentives are perceived as more important to EV end users, possible customers and other actors in the market. This reveals the significance of the different incentives and creates a basis for understanding the third part.

Lastly, in the third part, we will address challenges we have identified in the development of the charging infrastructure, including EV end users charging demands, charge pricing, standard points and plugs, the development of battery technology in relation to driving range, and the responsibility/discrepancy issue between CCIPs and the Government.

5.1 Path dependence and the evolution of the automobile market

In this section we use PD in order to explain the development of the automobile industry. Furthermore, we clarify why the ICE is still the preferred vehicle in the industry and how it can be changed using PD.

In the late 18th century and in the starting phase of the automobile industry there was a competition between steam, electric and gasoline vehicles. At that time, it was not clear who would win the competition in the long run (Asphjell, Asphjell, & Kvisle, 2013). Today it is clear to us who won the battle, but before the ICE became the dominant design of the automobile industry the EV was the one with the upper hand. Ferdinand Porsche's first car was an EV, Henry Ford's wife drove an EV, and in 1899 EVs were the most used car in the United States and accounted for nearly 40 percent of the total sale (Asphjell, Asphjell, & Kvisle, 2013). The EV had a superior infrastructure compared to the two other alternatives. Electricity was available in people's garages and like today it was based on direct current (DC), which made it easy to charge, and the EVs were convenient to operate. Gasoline was only accessible at drugstores and one had to be a mechanic to operate the first ICE. The question is, how did the industry change, and why did the ICE win the battle of the dominant design in the automobile industry?

As mentioned in the theoretical framework, Arthur (1996) explains that markets under conditions of increasing returns can be affected by small "historical accidents" being magnified, which can tip the market towards a certain technology. However, this technology may not be the one with the best technological structure. Explained differently, a technology might be locked-in to a sub-optimal technological structure due to small "chance events". The basic notion of David (1985, 1986) and Arthurs' (1983, 1989, and 1996) models challenge two main assumptions in neo-classical economics (Simmie, 2012). The central assumptions are, first, that market forces will ensure the success of the most efficient technological solutions available. Second, that the reversibility of the market decision-making, in principle, is possible and will be changeable if and when superior technologies are offered (Simmie, 2012).

First of all, if we take a closer look at the example of the early phase of the automobile industry we find that the ICE, which is arguably the sub-optimal technology, became locked-in as an industry standard. This regime has persisted for considerable period of time, more accurately reigned for more than 100 years despite the fact that an alternative, more optimal and environmental friendly technology was available, the EV. Thus, David (1985, 1986) and Arthur (1983, 1989, and 1996) argue that lock-in is one of the key characteristics in path dependence. Another core concept of path-dependent processes is "non-ergodicity". This means that path-dependent processes arrive at outcomes that develop as a consequence of its own history. The history is not reversible. This means that insignificant events and choices can repeat itself through history and close off other paths and confirming a particular path with the consequence that the result may not be the optimal technological solutions (Simmie, 2012).

Another study, conducted by Asphjell et al. (2013), points out two "historical events", among others, that might have caused the ICE to prevail over the EV. First, Charles Kettering, an American businessman, invented the electrical starting device (for the ICE). Second, Henry Ford introduced the model T automobile in 1908, which revolutionized the transportation industry. Ford's introduction of the moving assembly belts made the production of the model T more efficient and cheaper (Asphjell, Asphjell, & Kvisle, 2013).
Furthermore, when looking at the evolution of the EV industry in Norway it is interesting to take a closer look at the work of Dijk et al. (2013). They argue that a reason why history cannot be reversed is due to lock-in from the production side. They state that automakers have been reluctant to invest money in new technology that is considered non-competitive in terms of costs (Dijk, Orsato, & Kemp, 2012). In the past decades there has been tough competition between large automakers. As a result, automakers perceive it to be both safer and more economically attractive to invest in current ICE innovation than in other technological opportunities, e.g. EVs, which carry the risk of lower customer acceptance. This means that car producers continue to enhance the environmental performance of the ICEs and consequently improve the dominant design. The development of HEVs can also be seen as an

attempt by car producers to develop without moving away from their core competencies (Dijk, Orsato, & Kemp, 2012).

Second, Dijk et al. (2013) argue that emerging markets, such as China, requests for low-priced ICE instead of other vehicle options add extra lock-in. China is a larger market with a greater increase in sales and earnings than Norway; hence car manufacturers will listen and adapt to the Chinese market rather than the Norwegian market. This will affect car manufacturers to support further supply of ICEs and the lock-in of the ICE. Lastly, uncertainty surrounding other vehicle technologies, which can be seen in connection to the first reasoning, and whether or not they are ready for commercial use, creates further lock-in of the ICE technology.

It is possible to un-lock history. Norwegian governmental policies seem to affect and change the automobile industry in Norway and Norwegian consumers' preferences for cars, which Arthur (1996) argue is one way to shake free from the history and un-lock the market (Arthur B. W., 1996). Dijk et al. (2013) agree to some extent with Arthur (1996), though they phrase it a bit differently. They argue that policies about electric propulsion can be used as a source of CO_2 reduction. This enhances the brand of the EVs. Furthermore, they state that the unpredictability of future oil prices and peak oil expectations have increased the attention to EVs, which do not rely on oil. This unpredictability can contribute to the reversibility of the established vehicle market decision-making. Other contributions that they mention are; the success of the Toyota Prius (show casing electric drive), the development in battery technology (contribute to lower costs of EVs), realization of lower overall driving costs compared to ICEs and car manufacturers adopting a diversified strategy, including EVs. These developments have and still do affect the automobile industry in Norway, from being ICE based to becoming EV based (Dijk, Orsato, & Kemp, 2012).

These initiatives and developments propose that there is change underway in the pathway towards electrification of cars, managed largely by CO_2 reduction policies, an increasing positive image of EVs among policy makers and customers, unpredictability of future oil prices, as well as progress in battery development (Dijk, Orsato, & Kemp, 2012).

5.2 Empirical evidence from a series of actor interviews and secondary data research

We will now outline the outcomes of our qualitative interview process and secondary data research to examine what developments/factors the future of EVs depends on. As outlined in 7 below we have codified our interviewees into different groups.

Table 7– Codification of interview groups for in-text references. Source: Own development.

Grouping	Abbreviation Code	Alias
Policy Makers	PM	Erik
		James
		Kerstin
		Tyler
NGOs	NGO	Michael
		Simon
		Kyra
EV Producers	EVP	Peter
		Earl
		Keith
Commercial Charging Infrastructure Providers	CCIP	Adam
		Peter
		Earl

**Interview subjects will be referenced according to aliases and their interview group code*

5.2.1 Policy incentives for EV end users

The following section assesses the policy incentives given by the Norwegian Government to exposit how they affect the purchase price, operating costs and convenience. Furthermore, we will elaborate on feedback and opinions of EV owners, users, actors from the industry, NGOs and other stakeholders. Additionally, we will address which of the incentives which have had the greatest influence on EV-owners.

The incentives have gradually been implemented and even though they can be seen as a whole package some of them have been, and still are more significant for the development of the Norwegian EV market. We can divide the incentives in two categories; cost incentives and convenience incentive. Cost includes purchase price and operating cost. Convenience includes the incentives that increase comfort and save time. The importance of each incentive is a contingent question of time and geography. In an article by NEVA, based on a survey among their members[29], they state that there is no single common reason as to why people buy an EV. Furthermore, they express that the reason for buying an EV and the importance depend on usage pattern and geography. Within three broad categories; cost savings, environmental savings, and time savings, they found that cost savings were considered the most valuable benefit by 41 percent of the respondents. Environmental savings follows second with 29 percent, while saving time was decisive for 22 percent of the respondents (Haugneland & Kvisle, 2013). If we go more in depth with which of the incentives was most important to respondents, the exemption from toll roads fee was the most important, followed by the purchase price incentives (exemption from registration tax and VAT[30]). Other operating incentives, like low operating costs, free access to public transportation lanes, free parking, and low annual fee were just about as significant. However, ZERO argues that the wide distribution reveal that the various incentives influence EV users differently. Different incentives have different influence in different parts of the country, depending on the benefits it provides, like exemption from toll is relevant only on roads with toll (Thema Consulting Group, 2013).

[29] The respondents are owners of EVs that run fully or partially on renewable energies (Haugneland & Kvisle, 2013).
[30] Technically, it is not exempt from VAT, but rate of zero percent. It is important, as companies still get deduction for output VAT. We still use the term, exemption from VAT, to ease the use of language (Thema Consulting Group, 2013).

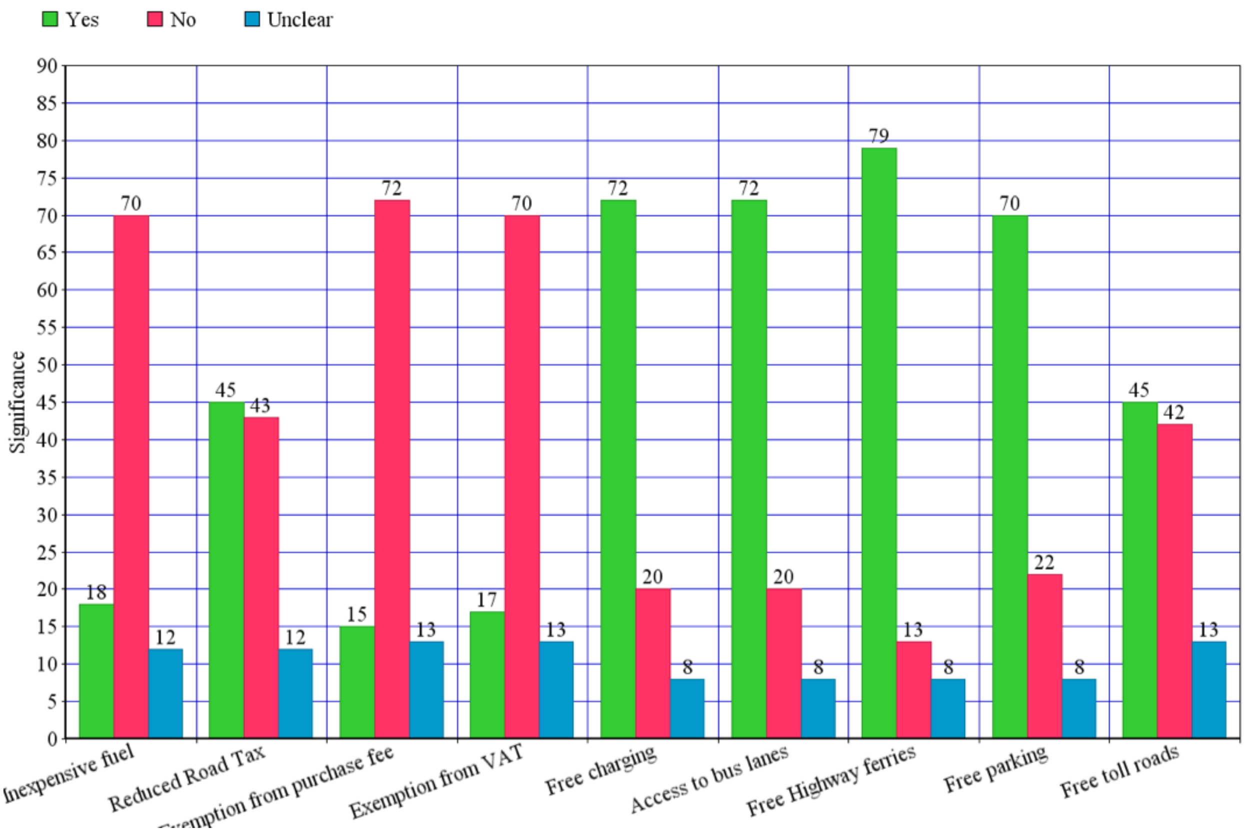


Figure 6 – A graphical representation of the responses that were given when EV owners were asked: Would you purchase an EV without the following benefits/incentives? Source: Own development based on data from Figenbaum and Kolbenstvedt (2013).

We will now examine the significance and effect of each policy incentive more thoroughly based on how each incentive has affected the EV end users, the EV market and society (government cost). Data was retrieved from interviews of EV end users and other actors, surveys made by NEVA and ZERO, and publications.

Table 8 - Overview of the incentives, EV end user benefits and costs/consequences for society and the Government. Source: Own development based on the ZERO report: Development and phase out of rechargeable cars' incentives (2013).

Incentive	**Incentives**	**EV end user benefit**	**Consequence for the Government and the society**
Purchase price	Exemption from Registration Tax	Saving expenses	Reduced government revenue

Operation Costs and Convenience	Exemption from VAT	Saving expenses	Reduced government revenue
	Reduced Annual Fee	Saving expenses	Reduced government revenue
	Access to Public Transportation Lanes	Saving time	Poor traffic flow for buses
	Exemption from Road Toll	Saving expenses	Reduced municipal and government revenue
	Exemption from Ferry Ticket	Saving expenses	Reduced municipal and government revenue
	Free Parking at Public Municipal places	Saving time and expenses	Reduced municipal revenue and destroys the development of bicycle and public transportation lanes
	Free Charging – availability and pricing	Saving time and expenses	Reduced municipal and government revenue, and stagnation of the development of the charging infrastructure
	No Road Usage Fee	Saving expenses	Externalities Reduced government revenue

5.2.1.1 Purchase tax exemption (exemption from registration tax and VAT)

The Government has introduced a comprehensive tax policy that gives EV users substantial economic benefits. Current financial policy incentives include exemption from registration tax and VAT (25 percent). As mentioned earlier in the introduction of this section, 41 percent of EV users perceived cost savings as the most significant incentive (Haugneland & Kvisle, 2013). By going in depth with the purchase price incentive (exemption from registration tax and VAT) we found it ranked as the most important EV benefit by 17 percent of EV owners (NEVA 2013)[31] (Haugneland & Kvisle, 2013) . Exemption from purchase tax reduces the purchase price of EVs and contribute to that EVs are price competitive to equivalent ICE models. To contextualize this we use the Tesla Models S as an example. Tesla Model S has a purchase price of 750.000 NOK. If VAT were imposed, the purchase price would be calculated at approximately 1.000.000 NOK. NEVA claims, *"The competitive purchase price is a prerequisite for the EV success in Norway."* (Haugneland & Kvisle, 2013, p. 2). The Registration tax fee depends on the weight of the Vehicles. Registration tax is made up by the components: Weight of the car, CO_2 g/km, NOx and effect. The significance of this incentive therefore depends on type of EV, and the total weight of the vehicle. The weight of a Tesla Model S is 2100 kg while the weight of a Nissan Leaf is 1139 kg. The exemption from VAT will therefore be of greater importance for a Tesla owner, than for a Nissan Leaf owner. Calculations made by Green Car (2014), shows that the registration tax of a Tesla Model S would sum up to 284,564 NOK. A Nissan Leaf on the other hand, would be charged a minimum rate because of its light weight. The registration fee is calculated to NOK 3,626 NOK (Grønn Bil, 2014).

Eleven interviewees were questioned about which of the incentives that has influenced the EV adoption rate the most. Figure 7 demonstrates the results where the majority of our interviewees perceives exemption of purchase tax as a determent factor and believes that this incentive needs to be preserved by the Government even after 2017.

[31] The respondents consisted of 1858 of their member and other EV users and owners in Norway. This number represents 15 percent of all EV owners in Norway. The owners are mostly located in and around the cities Oslo, Trondheim, Bergen and Stavanger (Haugneland and Kvisle 2013, 2).

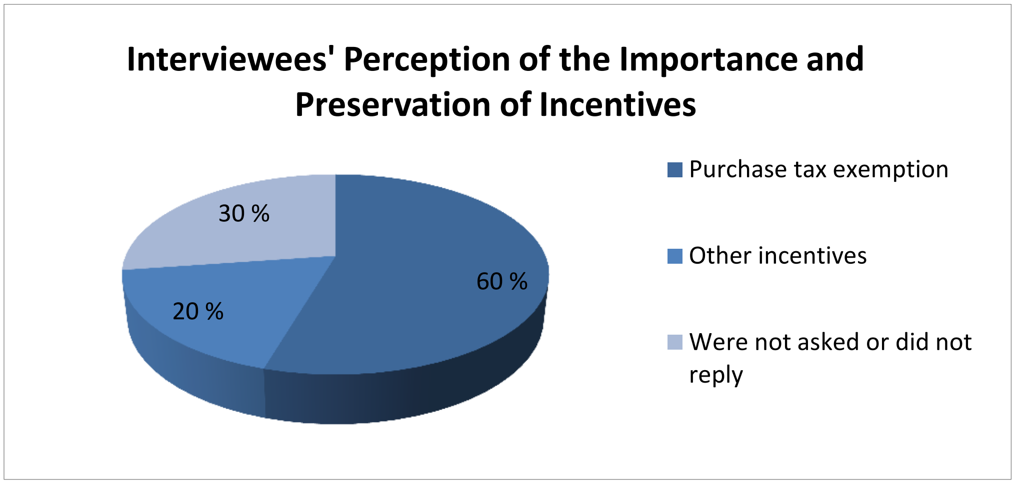


Figure 7 – Interviewees' perception of the importance and preservation of incentives. Source: Own development based on interviews

Six of our interviewees emphasized the importance of the purchase tax exemption and preservation of this incentive. Erik (PM) states that "*VAT exemption has a considerable influence on consumers on a national basis. The exemptions from tax are increasingly the most valuable incentive."* Tyler (PM) agreed by stating "*EVs are still slightly more expensive than ICEs, the exemption from VAT, registration tax and annual fee has had a major impact in providing affordable alternative for consumers*." Additionally, he adds "*the tax benefit has a major impact; however the tax incentives cannot change the industry on its own*." The respondents argue that this incentive has had great influence on the adoption rate of EVs.

Simultaneously there is a broad consensus stating that the exemption from VAT leads to a major loss of revenue for the Government. The Prime Minister in Norway, Erna Solberg has stated that the government needs to find a solution that may offset the income loss. Simon (NGO) suggests that the government can implement a reduced VAT rate for EVs.

Michael (NGO) makes a suggestion to introduce a 6 or 8 percent VAT (compared to the reference of 25 percent) on EVs. Michael (NGO) mostly agrees with the above statements; "*purchase incentives have made EVs an opportunity for a wider section of the population. The tax benefits should be prioritized".*

However, there are not only positive effects related to the implementation of these incentives if we look at it from an economic perspective. The exemption from purchase tax leads to loss of tax income, a cost delegated to the state. This results in increased costs for society, as the income loss has to be compensated in other ways (Thema Consulting Group 2013).

5.2.1.2 Development of battery technology (purchase price impact)

The tax exemption of purchase price has made the EV price competitive compared to similar ICE models. An additional factor with the potential to affect the purchase price of EVs even further is the development of EV battery technologies. Batteries are the most expensive component of the EV. The price of EV batteries makes up two thirds of the total purchase price. Over the last couple of years the battery prices have decreased significantly. From 2010 to 2012 the industry experienced a decrease of 40 percent. The prices are predicted to drop by an additional 50 percent towards 2020 (Transnova, 2013). The development of battery technology is a complex topic, where the factors, price and range, are much intertwined.

New technologies do not just emerge low-priced and fully developed. There is a known path explaining how new and emerging technologies are developed and commercialized. The usual scenario is that they begin with low volumes and high prices, with a rapid development potential. Incremental improvements appear until the technology development reach a point where the price/performance ratio is close enough to the competing technology and consumers switch from an old technology to a new one. The technology reaches the final phase, where economies of scale lead to even lower prices and further refinements. The story is usually the same, whether you look at the past 100 years for automobiles or the past 10 years for cell phones (Richard, 2012). The question is whether battery technology for EVs will follow the same development as ICEs. At the current stage, the price development indicates that this outcome most likely will occur. EVs are still more expensive than the equivalent amount of petrol and diesel, however this is an expected outcome, as the introduction of new technologies always requires huge investment costs in the initial phase.

When we asked about the future EV prices five of our interviewees directly connected battery prices with EV prices. Erik (PM) states that "*the prices on EVs will drop significantly. We believe that the battery prices will drop similar to one third of what the prices were a couple of years ago. We also believe that the range will increase and the weight will decrease. A decrease weight of and reduced cost of batteries will most likely lead to significantly cheaper EV Models*." He further points out: *"The battery technology has stagnated for a long time now, however rapid development on technologies is indicating that the EV industry will experience a "revolution" on battery technology in terms of price and performance*".

Tyler (PM) deviates somewhat from this prediction. He states that: *"the strong competition between different EV models will most likely lead to a further decrease in the prices of batteries. However, we cannot predict the outcome of this competition, it may lead to cheaper cars, or cars with similar prices as today, but with a longer driving range*". In other words, he suggests that it is unlikely that the industry will experience a drop in prices parallel with the development of better battery technology.

Among EV manufacturers we find contending opinions on the future prices of batteries. Earl (EVP) states that; "*The prices will most likely drop as the price development is technology driven".* This is consistent with research by Richard (2012). He uses the mobile phone as an example and explains that the cell phone was much bigger and more expensive 10 years ago and believes the same development will happen with the battery technology. Another EVP representative, Keith, agrees with the latter statement and is convinced that the prices will decrease when the cost of battery production drop. Simon (NGO) disagrees *"I don't think the prices will drop significantly because the driving range will increase. If we look at price relative to range it will be lower, but not much. The manufacturers bear large investment costs in the development of battery technology; I therefore believe it is unrealistic to expect that we will experience a large price drop of EVs".*

Transnova has in collaboration with Institute of Transport Economics (ITE)[32] developed three different scenarios that may reduce the price of EVs:

- Increased production volume

[32] Norwegian Centre for Transport Research

- Learning effects (optimization of design, materials and manufacturing processes)
- Research that can provide technological leaps that decrease the costs and provide better performance for the same cost (eg. more energy out of every kg battery) (Figenbaum & Nørbech, 2012).

5.2.1.3 Main takeaways

The results from the NEVA survey, our interviews and secondary data research indicate that the purchase tax exemption incentive has a major impact on EV adoption rates at a national level. From the result we find that EV-end users and other actors in the network perceive this incentive as the most influential benefit. NEVA takes it a step further by saying this incentive is probably the main reason why Norway is ahead on sales per capita compared to the rest of Europe (Haugneland & Kvisle, 2013). As we highlighted in the theoretical framework, several authors argue that exemption or reduction of sales tax and VAT are effective incentives to promote adaption of environmentally friendly technologies, as sales tax and VAT are primarily designed to tax the final customer. This is consistent with the theory adopted from Nilsson et al. (2012), and Tran et al. (2013) who point out that tax reduction is an effective instrument to facilitate deployment of sustainable transport technologies. Still, Nilsson et al. (2012) points out that just how governance should be best arranged to achieve both momentum and sustainable direction in technological innovation systems is not well understood. A different way is to increase the taxes on “dirty technologies” such as ICEs. However, independent of climate policy considerations, Norwegian automobile ownership and use are subjected to high taxes, and cars emitting over 110 grams of CO_2 per km are subject to progressively increasing tax rates. According to the Taxation Trends in the European Union, the Norwegian VAT and TAX rates on cars are among the highest in Europe, only surpassed by Denmark. On the basis of these numbers, we will argue that the high VAT and Taxation level in Norway is contributing to strengthening the effect of the tax and VAT exemption on purchase of EVs (European Commission, Eurostat, 2013).
ZERO (2011) supports the view of Nilsson et al. (2012) and Tran et al. (2013). They propose that higher fees on fossil fuel will make EVs more attractive because the purchase price and operating cost of EVs becomes lower. An increase in fuel taxes would thus have an indirect effect of the introduction of EVs (ZERO, 2011).

5.2.1.4 Operating costs and convenience

Based on data from the NEVA survey we find that EV users consider the EV to be cheap to operate compared to alternative transportation modes. In particular they value low operating costs and convenience (Haugneland & Kvisle, 2013). 41 percent ranked monetary savings as the most important EV benefit. 22 percent of the respondents ranked timesaving as the benefit with greatest impact. The timesaving is a consequence of the incentive that allows access to public lanes. By going in depth regarding the result concerning operating cost, we find that 94 percent of the EV owners agreed to the statement indicating that EVs are inexpensive to operate, while 64 percent of the respondents agreed that they are saving time by driving EVs. Furthermore, 46 percent of the respondents stated that after they purchased an EV the main advantage is low operating costs (Haugneland & Kvisle, 2013). This indicates that the EV users experience and value both time and cost savings. As Earl (EVP) emphasizes: "*It is of great importance that EV manufacturers become better at communicating total cost of ownership. EVs may be more expensive than other cars in the same segment, however it is cheaper to own an EV compared to owning an ICE. Less maintenance, less costs per km, and cheap electricity are all factors that contribute to low operating costs."* In addition, exemption from toll road payment, access to the bus lanes, free ferry, free parking and charging leads to lower operating costs and convenience. These incentives will now be discussed in detail.

Annual fee

10 percent of the respondents replied that reduced annual fee is the most important incentive. Reduced annual fee leads to lower operating costs for EV owners (Haugneland & Kvisle, 2013). Negative effects of is loss for the Government, and as we previously stated, MF has directed more attention to the total income loss the state experiences as a result of the incentive scheme (Thema Consulting Group 2013). However it is worth noticing that the annual fee for ICEs is 2,995 NOK for cars below 7,500 kg, and 3,490 NOK for cars over 7,500. The Annual fee rate for EVs is NOK 245.The loss of income is therefore relatively low compared to consequences of the exemption from VAT upon purchase.

Government resolution

Before we analyze the incentive that revolves around exemption from toll roads, free ferries, and access to public lanes and free parking we will repeat the Government's resolution on these EV incentives. The Storting Resolution on Norwegian Climate Policy report St. 21 (2011 – 2012), Recommendation 390 S (2011-2012), decision 567 states; The current tax benefit for purchase and use of pure zero-emission vehicles will be maintained in the next parliamentary term (2017), provided that the number of pure zero-emission vehicles does not exceed 50,000. Other measures to promote zero-emission vehicles, such as exemption from toll roads and ferry fees, access to bus lanes and free parking must be viewed in the context of traffic trends in the major cities. In decision about these measures, local authorities' viewpoints weight heavily (The Norwegin Government, 2012).

Toll road

The exemption from charge on toll roads was rated as the most significant incentive by 23 percent of the respondents in the NEVA survey. However, we will highlight that the importance is geographically dependent. The 23 percent probably constitutes respondents that are frequently passing toll roads, such as people commuting to Oslo and other major cities (Oslo has several toll roads surrounding the city). We will therefore specify that this advantage will not have a major impact on those who do not frequently pass toll roads (Haugneland & Kvisle, 2013) . Michael (NGO) agrees with EV end users on the importance of exemption from toll roads. He follows up by saying that "the *exemption from toll roads is a definite incentive that should be maintained"*. However, he points out that EV owners contribute equally to ICEs in tearing up roads and occupying space. It is therefore an equitable transition that EV owners gradually would be charged a reduced rate when passing toll roads. He further points out that it should always be advantageous to drive environmental friendly vehicles. EVs could therefore be charged a reduced fare.

Erik (PM) stated that the exemption from toll is more important on a national basis than access to public transportation lanes. Keith (EVP) adds that exemption from toll is more significant in rural areas. Earl (EVP) expresses that toll roads had more impact in the beginning for the early EV adopters.

Access to public transportation lanes

14 percent of the respondents rank access to public transportation lanes as the incentive that has had the greatest influence. Similar to the toll roads, the incentive is geographically contingent, and this one is of greater importance for people living in areas where there are bus lanes, in particular Oslo, Stavanger, Trondheim and Bergen. Access to public lanes represents a great potential for time saving, in particular in the morning and afternoon in congestions in, and out of the major cities. An informal attempt was conducted on the distance from Sandvika to Oslo which is one of the most common commuter routes[33]. The distance is about 15 km. The EV with access to the public lane spent 12 minutes on the route. A gasoline car used 28 minutes on the distance. In other words, the EV uses half the time compared to regular ICE car without access to public lanes. This attempt illustrates that use of EVs in and out of the major cities involves significant time savings (Honningsøy & Mon, 2014). Thus, even though the acess to public lanes gives benefits to one environmental friendly technology, it constitutes a threath to other types of public transport. EV-drivers without a wide experience in driving in public lanes cause poor traffic flow for the buses (Thema Consulting Group, 2013). Fjellinjen observed that the EV traffic has increased from 2012 to 2013[34], and the number of EVs is still increasing. In July 2014 1340 EVs, 120 busses and 100 taxies was registered in the public lane on the stretch from Blommenholm to Høvik between 07.00 and 09.00. This indicates that nearly 85 percent of the vehicles driving in the public lane are EVs (Tjernshaugen & Ruud, 2014) Lars Harein Sæther, chairman of the Administrative Traffic Association Bus in Oslo and Akershus, states; *many EV drivers throw themselves into the bus lane without thinking about the busses coming. Bus drivers must constantly watch out, which is an increasing problem. We have trouble keeping our schedule in some stretches, especially E18 Drammensveien"* (Løken & Halvorsen, 2013). Another critic that agrees with Sæther, is Arne Veggeland, CEO in Nettbuss[35]. Veggeland explains that he constantly receives complaints from bus drivers who find that queues caused by EVs delay the bus traffic. Furthermore, Veggeland adds; "*the EV growth has accelerated and delay bus traffic, traffic hazard and lower accessibility, especially around Oslo"* (Ertesvåg, 2013). Access to public lanes has caused much public debate around the EV

[33] The attempt was made by the Norwegian media house NRK on a ramdom weekday in April 2014.

[34] From July 2011 to June 2012 registered Fjellinjen nearly 526,000 crossings through the toll. In the same period a year later they registered that the number had doubled to almost 1.2 million. The real numbers are surely higher, since the registration only register EVs with a tag, which is mandatory, but not all EV users necessarily have them.

[35] Nettbus is a Norwegian Bus Operator

incentives. The debate is causing negative repercussions around all of the incentives. This creates uncertainty regarding the incentive scheme and may potentially prevent new buyers from investing in EVs.

The State Secretary, Bård Hoksrud (Frp), in MTC says he is aware of the growing EV queues in the bus lanes, primarily in and around Oslo. NPRA[36] is already underway to assess the eviction of EVs from the bus lanes. Hoksrud states "*specifically, problems occurs at the exit and entry to highways and public transportation lanes"* (Ertesvåg, 2013). Erik (PM) stated that it would be unfortunate if the number of EVs on E18 had caused the Government to remove the whole incentive scheme. "*The value driving in the public transportation lanes was higher a few years ago, when there were fewer EVs on the roads. At this point there are so many EVs that the public bus lanes are starting to fill up".* Kerstin (PM) suggests that a solution to overcome this issue is to set geographical restrictions where access to public lanes is restricted in Oslo, and still legal elsewhere where the problem is not significant. She further points out that the Government will take public opinions into consideration when they revise the incentive package in 2017. Important contributions are lobbyists, such as ZERO and NEVA. There is a broad agreement among our respondents that the EV should not be an obstacle for public transportation. James (PM) says, "*Transport capacity needs to be considered relative to the capacity of the bus lanes".* Michael (NGO) points out that the access to public lanes is a much-debated benefit, and he believes that this incentive will be phased out within a short time. It is however worth noticing that this incentive has both positive and negative sides. On one hand, the fact that EVs can drive in the public lanes reduces congestion in the regular lanes. If 1,000 EV drives the distance from Sandvika to Oslo in the Public lane, this represents a reduction of 5km congestion per hour in the regular lanes (Simon NGO). On the other hand, 1,000 EVs per hour in the public lanes represent a potential danger for congestion, which may hinder the bus in arriving on schedule. Simon (NGO) suggests that the government can set restrictions in the areas where the public lanes are used the most. "*An option is to allow access to public lanes if the EV transports two persons or more. A second option is to set time restrictions, which denies access between 07.00 – 09.00, and 15.00 – 17.00"*.

[36] The Norwegian Public Roads Administration

The majority of our respondents agree that it is necessary to revise this incentive, because it directly affects public transport in a negative manner. Other respondents point out that access to public lanes had a major impact on the early-adopters because congestion is an increasing problem on the way in- and out of the major cities, and says that the EV will become less attractive for consumers if the access to public lane incentive is removed. Peter (EVP) states: "*We noticed at an early stage that access to the public transportation lanes was significant, however today it is less important. The EV has transformed from being a city-car into a regional phenomenon.*"
Keith (EVP) is certain that the access to the public transportation lanes started the EV sales in the capital, then other cities followed. He emphasizes the importance the access to the public transportation lanes had before.

Free ferry ticket

Similar to the toll roads and the public transportation lanes, this incentive is geographically dependent. We base this on the fact that some counties and stretches are dependent on ferry traffic. A ferry is a term for a ship carrying passengers and vehicles over limited distances. Ferry traffic is particular important for many costal dwellers who are dependent on ferries on a daily basis. Free ferries are of greatest importance to less than five percent of the EV-owners. Nevertheless, for the EV users in rural areas, which are dependent on ferries when commuting, this incentive accounts for a significant amount of money saved. As mentioned in the section *Norwegian Governmental and Municipality Incentives* the exemption only applies for ferries connecting highways, and not ferries connecting county roads (Figenbaum & Kolbenstvedt, 2013).

A challenge related to this incentive is that the operations of the ferries are up for tender where private companies are competing for operation. Ticket revenue for ferry traffic is considered income to private companies, which means that the ferry operators bear an income loss because of the Government's provision's concerning free ferries for EVs. The Manager of a ferry Company named Fossen-Namsos SEA which operates the route between Krokeide – Hammar points out; "*No one could predict that EV sales would explode when we won the tender for these routes. We have attended a dialog with the Norwegian Government to discuss compensation for loss of revenue"* (Østerbø 2014).

Calculations made by the County Administration in the county Sør-Trøndelag show that the operators on the ferry over Trondheimsfjorden (The Trondheim Fjorid) bear an annual income loss of two million NOK because the EVs travel for free (Garathun, 2014). The ferry operators have therefore required the government to either compensate for the loss of income, or consider removing the incentive. This issue highlights an important question, who should pay the bill for this EV benefit? Simon (NGO) points out; *“the revenue loss for the ferry operators are increasing parallel to the increasing number of EVs. The Government must either compensate for the loss, or in the worst case, eliminate the incentive”*. Estimates show that about 40,000 EVs travelled for free in 2013 (Stenberg 2014). Peter (EVP) says, "*We observe that in rural areas of Norway, free ferries are the most important incentive."* Based on their calculations of an annual income loss of 2 million NOK the City Council in Trondheim has decided to remove the incentive giving free ferries for EVs in the region of Sør-Trøndelag. They were able to do this based on the Storting Resolution that states “*Other measures to promote zero-emission vehicles, such as exemption from toll roads and ferry fees, access to bus lanes and free parking must be viewed in the context of traffic trends in the major cities. In decision about these measures, local authorities viewpoints weight heavily*” (The Norwegian Government, 2013). As previously pointed out, the incentives of free ferries are essential for EV owners in coastal areas of Norway. It is therefore a negative trend that some counties are implementing measures to eliminate this incentive, which may lead to fewer car owners in the districts choose to drive EVs. Another point to notice is that access to charging stations are limited in rural areas compared to the major cities. It is therefore less convenient to operate and EV, because it requires more planning as a result of limited charging access. The free ferry incentive can be used as a subsidy to compensate for the lack of charging stations. Erin, EV end user, pointed out in the interview “*I choose to drive an EV because I rely on ferries on a daily basis and thus save on major expenses because of the free ferry benefits we have by driving EVs*”.

Free municipal parking

11 percent of the respondents to the NEA survey considered free parking as the third most important incentive. Erik (PM) considered free parking as one of the third most important incentive, when we asked the question about which incentive that has the most impact on the EV sales numbers. Tyler (PM) and Simon (NGO) agree with the statement, however Simon (NGO) believes that the incentive

will be passed out after 2017. The impact of this incentive depends on the demand for parking and will be more important for users who do not have access to free parking in the workplace. A negative consequence of this incentive is mainly that it reduces municipal revenues.

Free public charging

This is an important aspect of convenience. We will discuss this incentive in detail in the next section, *Charging infrastructure*.

Cost savings

Even though there are operating expenses to save when buying and driving an EV there is wide disagreement regarding how much EV owners actually save by driving an EV. Numerous of calculations of the operating savings by going from ICEs to EV has been done, however what the EV owners save depends on several factors. If EV drivers live or work in one of the major cities they will most likely be able to save major expenses. The same applies to those who live along the cost and depend on ferry connections. Furthermore, driving patterns, use of municipality parking, toll roads, access to free charging at home and at work are all factors that have a major impact on savings cost. One of the EV producers has estimated how much their customers save by driving EVs. *"The operating costs of EVs are much lower than on ICEs. We have calculated that the operation cost of the EV is 1 NOK per 10 km, and the equivalent cost for an ICE is 14 NOK per 10 km. EV owners may save up to 4,000 NOK per month by driving EV compared to fossil fuel car".* However, calculations made by other instances have a different outcome than the EV producer. VG[37] claims that EV owners will save 2,500 NOK per year, NRK[38] reported that EV owners will save 10,000 NOK per year, and BT[39] reports that EV owners could save up to 72,000 NOK annually. This indicates that there is wide disagreement about the actual savings of EVs, which depends on the operating factors mentioned above. We will now go more in depth with the importance and preservation of each of the operation costs and convenience incentives.

[37] VG is The major national newspaper in Norway
[38] NRK is a shortening of the Norwegian Broadcasting Corporation
[39] BT is a local newspaper in the Hordaland county

5.2.1.5 Main takeaway

As Geels (2011) points out, most sustainable innovations do not offer obvious user benefits and often score lower on price and performance than similar non-environmental friendly technologies (Geels, 2011). This is clearly reflected in the EV. A major challenge with the EV is that current modes available at the Norwegian Market are not able to compete on price with ICE models. Christensen (2012) points out that the EV is not able to fully replace the ICE until the price decreases. As the EV is considered to be a more environmentally friendly alternative to the ICE, national and local policy makers may promote the adoption of EV technology through two possible options: by using incentives or disincentives. Furthermore, Nilsson et al. (2012) suggest that incentives given at national and local level are a way of promoting the transition towards adoption of EVs. At the national level, government may use different instruments such as taxation, different taxation of fuels and by subsidizing R&D programs. At the local level the authors suggest to implement measures including different modes of fees, free parking and congestion chargers.

It remains clear to us that the Norwegian Government has chosen the incentive mode. In the US, focus has been directed disincentives. The US made an attempt to promote the adoption of EVs through restrictions on the car manufacturers. A representative from the Norwegian Government points out that the EU has chosen a similar approach, where they set restrictions for the average emission caused by each manufacturer. However, this is not an effective approach in Norway, since Norway does not produce their own EVs. The Government has therefore developed an incentive scheme that gives extensive benefits to the EV end users rather than producers. In the incentive scheme we may distinguish between two different levels of incentives – purchase incentives that reduce the purchase price of the EV, and operating and convenience incentives, which reduce the operating cost. We also find that there are incentives similar to those Nilsson et al. (2012) suggest at the local level. EVs are exempted from paying toll roads, ferry tickets and parking, and at some public charging stations they may also recharge for free. The only disparity we can find from Nilsson et al. (2012) is the support of R&D programs. The Norwegian Government cannot see this purpose as EVs are mainly imported to Norway from foreign manufacturers who mainly finance their own research and development.

Van den Bergh et al. (2012) suggest increasing the cost of “dirty” technologies and products as a way of encouraging the transition to more environmentally friendly options. We find that this may be a future possibility. There has been much debate about the incentive package in Norway, and different opinions are covered daily in the media. This lobbying activity has led to the MF stating that the revenue loss of the state is getting so big that it is necessary to re-consider the incentive package after 2017. This comes as a result of the sales figures increasing and the income loss to the state thus increasing proportionally. As pointed out in the theoretical framework, transition policy is not necessarily associated with economic growth. The focus lies on developing transitions towards innovations that give benefit to the environment or the society. Economic growth will only occur if the policy makers are able to create profitable industries that contribute to a more sustainable society. We find that this is one of the central challenges that the Norwegian EV market faces. There are currently a wide number of free services for EV users, and the operating costs of the EV are very low compared to the operating cost of an ICE. The question is whether it is actually necessary to offer free services to EV users.

5.2.2 Charging infrastructure

In this section, we will go more in depth with the development of charging infrastructure. We will assess factors affecting the development of the charging infrastructure that we have identified through our research process: EV end users charging demands, charge pricing, and standards points and plugs.

Development of charging infrastructure

EV producers have chosen to apply a model for charging, where the network of charging stations is built on demand (Tesla, 2014). This model has also been applied to the Norwegian EV market. As the policy incentive for EVs has been introduced and new EV models have emerged, more people have shifted from ICEs to EVs and the demand for charging infrastructure has increased. The Norwegian Government saw the need to initiate actions to meet the need for charging infrastructure in Norway and plays a major part in the development of charging technology through the organization Transnova. The Government founded Transnova as an organization to establish charging infrastructure for EVs. In the first year Transnova received 50 million NOK by the Norwegian Government to establish the organization, an additional 50 million NOK in funds to build charging stations. This support has subsequently increased. The budget is 50,000.000 NOK for 2014, 80,000.000 for 2015, and 50 percent of the annual budget of Transnova (approximately 90.000.000 NOK) will be used for developing charging infrastructure and charging technology in 2016 (Transnova, 2014). The delegation of this financial support from the Government is assumed to contribute to achieve the 85-gram target in 2020[40]. Additionally, Transnova collaborates with the industry and supports innovation and development projects within charging infrastructure and technology (Transnova, 2014). The NGOs we interviewed are positive towards the work Transnova does and emphasized that it is important that the Government focuses on strengthening Transnova. As Kyra (NGO) stated "*Transnova needs more funding to develop charging stations that keeps pace with the development of EVs. We wish that they will have an expanded mandate*".

The National Strategy and Finance Plan for Infrastructure

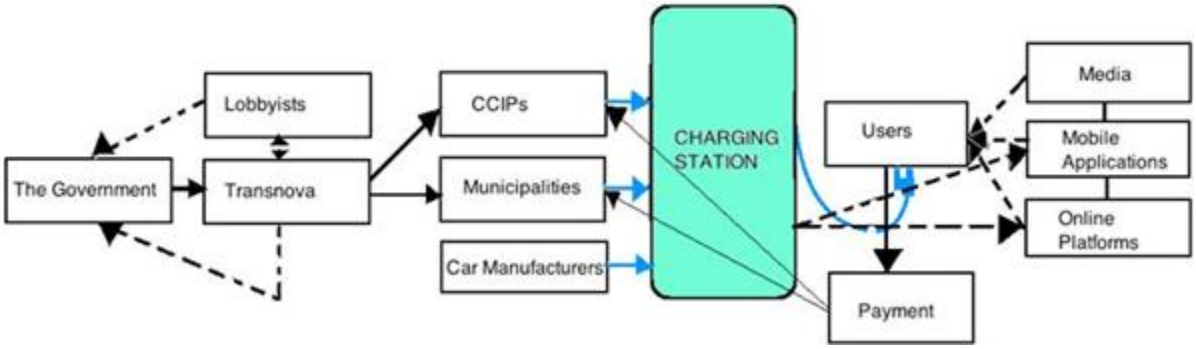
The National Strategy and Finance Plan for Infrastructure by Transnova provide an estimate of how much the Government must invest in order to develop adequate charging infrastructure in Norway. The goal is that it should be as easy to charge as it is to refuel gas for ICE and it is based on a funding plan that applies to the end of 2016 (Transnova, 2014). However, a challenge is that the development is rapid and it is difficult to predict what will happen in the future. As one of the policy makers, Erik, emphasized "*we are heading towards a "blind spot" and we are therefore careful about predicting what will happen in the long term. We are experiencing a major evolution in charging technology and automotive technology, which will have a major impact on the need for charging infrastructure and we have therefore set a short time horizon".* Another challenge is in order to establish an adequate supply there must be a balance between CCIPs[41] wishing to establish charging stations and consumers who want to purchase EVs and pay for charging. We will discuss the challenge of pricing in the section, *Charge pricing*.

The development of charging infrastructure has in the recent years reduced the demand for charging and decreased the range anxiety to some extent. However, there is still a long way to go. We will now elaborate on our findings and address the challenges we have identified. We will assess EV end users

[40] Average emission from new cars sold in 2020 will be a maximum of 85g CO_2/km.
[41] CCIPs = Commercial Charging Infrastructure Providers

charging demands, charge pricing, standard plugs and points, and the development of battery technology (range aspect), which are all connected to charging infrastructure.

5.2.2.1 Model for charging infrastructure



Dashed arrow – information flow -------
Solid arrow – Money/subsidies ____
Blue arrow – provides charging ____

Figure 8 – **Model for charging infrastructure.** Source: Own development

Our model is a simplified representation of the relevant actors affecting the development of charging infrastructure. The model does not take into account the technical development of the charging station; instead we focus on funding, interest and information. The Government delegates support to Transnova. The MF is responsible for delegating earmarked funds, while the MTC manages Transnova as an organization. Transnova and lobby organizations provide information and recommendations to the Government regarding size and scope of the financial support needed for development. CCIPs and municipalities can apply to Transnova for financial support for the establishment of charging stations, however Transnova requires that all actors that receive financial support must establish a payment solution for charging. The charging station must be accessible to a wide number of users. Transnova also sets standard for payment, number of charging points and availability. There are also a number of private operators such as companies, retailers and car manufacturers that offers charging stations regardless of support from Transnova. They have their own system of standards and payment where some offers subscription packages or free charging. Media, apps and information platforms provide information to EV end users about new developments of charging stations and availability, and in use at the current time. The charging stations send information back to the apps and information platforms regarding availability, user data and statistics.

Table 9 – Conceptual clarification – Charging. Source: Transnova: National Strategy and Finance Plan for Infrastructure for EVs

Term	Explanation
Charging Point	Power socket where EVs can plug in and charge the battery
Charger	Technical installation with one or more charging points
Charging Station	Location with one or more chargers
Basic Charging	Charging at a low current (up to 3.6 kW). Duration four to eight hours.* Expected to be the typical solution where EVs are parked for longer periods of time, for example, at home, at work and on long term parking spaces.
Flexible Charging	Charging with a higher current than basic charging (up to 22 kW) based on AC or DC. Duration two to ten hours.* (AC charging is currently the most common and cost-favorable).
Fast Charging	Charging at a higher current than flexible charging (between 22 kW and 50 kW) based on AC or DC. Duration ten minutes to two hours.* The most common charging is with a minimum of 43 kW, which charges a battery from 20 percent to 80 percent power between 20 to 50 minutes (depending on the temperature). (AC has an upper power limit of 43 kW).
Super Fast Charging	Charging with the highest current (above 50 kW). Only DC-charging, usually based on Combo. Duration 10 minutes to one hour.* Tesla has its own solution which is also based on DC.
Mode 1	Charging method where one only uses regular power supply and regular electrical socket (Schuko socket and plug).
Mode 2	Charging method where one only uses regular power supply and the charging cable is mounted on an EVSE.
Mode 3	Charging method where an EVSE is integrated into a charging post, which provides higher level of security and reliability. Will normally provide faster charging than with Mode 2.
Mode 4	DC charging where the power is converted from AC in an external charger. Has a fixed cable attached to the charger and can transfer more power than possible with Mode 1-3.
Type 1	Charging plug with mechanical lock. Compatible with Mode 3-charging.
Type 2	Charging plug with magnetic lock. Compatible with Mode 3-charging.
Type 3	Charging plug with a cap for protection against the weather. Compatible with Mode 3-charging.
Alternating Current (AC)	AC is an electric current that periodically change direction.
Direct Current (DC)	DC is an electric current of constant direction.
Schuko Socket and Plug	Schuko socket and plug is the regular electrical socket and plug people have in their homes. Used for regular charging Mode 1. This was the only charging option for the first generation of EVs. It is also used for charging Mode 2.
CHAdeMO	Fast charging based on DC. Established by Japanese automotive industry.
Combined	Combined basic and fast charging system. Characterized by the fact that both basic and

Charging System (CCS or Combo)	fast charging is connected to the same point on the vehicle.
Electric Vehicle Supply Equipment (EVSE)	Monitoring the security of the connection between the EV and the charging station, and tells the EV how much power is available.
On Board Charger (OBC)	The charger in the EV

Charging patterns and EV end user preferences

The NEVA survey shows that the typical EV owner has a charging outlet at home or at work and uses these as the main source of daily charging. When consumers purchas an EV it is used for the majority of the rides, such as daily travel to work, grocery shopping and delivery of children. Nine out of ten interviewees support this statement. 85 percent of the EV end users can charge in their own garage or parking lot. In addition, 10 percent have access to charging in a shared apartment building, while 59 percent have access to charging where they work. 48 percent have access to public charging stations in the area where they usually use the EV, but these public charging stations are used less frequently (Haugneland & Kvisle, 2013). However, these, and especially fast chargers, are important to extend the range of the EV for longer and unexpected trips, and work as a precaution if the battery runs empty by accident. Thus, there is a growing demand for fast charging stations.

5.2.2.2 Limited driving range and shortcoming of charging stations

In a survey conducted by ITE[42] the respondents replied that a major disadvantage with EVs is limited driving range. This is considered to be a problem mainly by consumers who consider buying an EV as opposed to those who already drive an EV (Figenbaum & Kolbenstvedt, 2013). However, our interviews with EV end users show that too short driving range is also a disadvantage for EV end users. In a reply to the question, what is the main disadvantage with an EV, five of ten of our respondents answered that limited driving range was the major disadvantage. Limited driving range is also connected to the capacity of the battery. We will assess the issue of battery range in the section, *Development of battery technology (range aspect)*.

[42] The Institute of Transport Economics (ITE) is a national institution for transport research and development.

Another survey, conducted by ZERO, supports these findings. The survey reveals that access to charging stations is ranked as one of the major disadvantages with EVs. Furthermore, it demonstrates that the lack of availability of charging stations is considered to be of greater disadvantage among women than among men, and in particular those who live outside the major cities (Zero Emission Resource Organization, 2014). One of our interviewees, Erin, expressed it in this way*: "It requires much planning as the charging stations in the cities are often occupied. I live in a rural area, and I have to charge when I drive to the nearest major city because of limited range of the EV. I see the need for more charging stations".* As the next section demonstrates, limited access to charging stations is also one of the biggest obstacles for EV end users and customers who are considering buying an EV.

The NEVA[43] survey reveals the percentage demand for charging between cities vs. within cities. 64 percent of the respondents demanded charging possibilities between cities, while 40 percent of the EV end users wanted increased access to public charging stations in the cities (Figenbaum & Kolbenstvedt, 2013). This shows that majority of the EV end users thinks the charging network is not yet sufficient, especially fast charging. They wish to use the EV for longer trips between the cities; however this is in many cases not possible due to the lack of charging stations between cities. Moreover, 11 percent of the EV end users use public charging stations on a daily basis, 28 percent on a weekly basis and 35 percent of the respondents' replied less frequent. 26 percent did not use public charging. The survey disclose that there are few EV end users that use fast charging, however one explanation to the relative low usage is the lack of fast charging points in Norway compared to the number of EVs with fast charging capabilities (67 fast charging points and about 7,800 EVs with CHAdeMO charging solutions). Our EV end users also replied that the charging infrastructure is a major drawback. Erin stated *"the charging stations are often busy in the city"*. Oliver and Max agree and point out that there is a lack of access to charging stations. Furthermore, there is general agreement among our NGO and EVP respondents that charging infrastructure is one of the EV industry major challenges. They support the EV end users. As Simon (NGO) expressed it *"one of the major challenges for the EV market in Norway is that it is growing too fast relative to the development in charging infrastructure. Municipalities, electricity companies and other providers must speed up the establishment of charging stations."* Kyra, a

[43] The Norwegian Electric Vehicle Association has 7000 members. 1858 users contributed with their experiences and opinions.

representative from another NGO, stated that the development of charging stations is a policy instrument that is likely to have large effect because it will reduce the disadvantages of limited range. Keith (EVP) and Peter (EVP) agree with Simon (NGO). Peter adds *"we need more available charging stations so that people can drive longer distances".*

This indicates that the level of charging stations for daily usage is more or less sufficient; however the development of charging infrastructure needs to keep up with the increased sale of EVs and the usage patterns. We will not address charging at work, since this is outside the scope of this thesis. The fast chargers extend the range of the EV, which makes it possible to make longer trips, and they are important to prevent range anxiety. The fast chargers are not frequently used; however they still have an important function both for existing EV users and for potential new users who consider buying an EV.

5.2.2.3 Free charging

As we mentioned in the section, *Policy incentives for EV end users*, free charging is an aspect of operating costs and convenience. In this section, we will address the challenge of free charging offered by municipalities and EV producers in detail. We will not further look into the aspect of charge pricing since this is outside our scope.

The NEVA survey identified that only four percent of the respondents perceived free public charging as the most important incentives (Haugneland & Kvisle, 2013). There are two reasons why these respondents identified this incentive as the most important one. First of all, in some cases free public charging increases the convenience for the EV end users. The reason is that this incentive is usually connected to free parking and parking is often scarce, especially in larger cities. It becomes a time saver for EV end users. Second, as briefly mentioned, there are cost savings associated with free public charging. First of all, the EV end users do not have to pay for the charging. Additionally, they save a large parking expense, since parking is very often expensive in larger cities and is closely associated with free public charging. However, it is central to note that the cost of basic charging, which is usually the charging type in public stations, is not a significant factor. Roughly estimated, an EV has a charging cost between 0,15 NOK and 0,25 NOK per kilometer. Compared to ICE, which has a fuel cost of one NOK per kilometer, this is very low (Ringen, 2013). Despite the cost and time saving benefits there are some disadvantages with free public charging. It can create dissatisfaction among EV end users. In many cases, because it is free, the public parking spaces are used by EVs beyond the charging time. This causes inconvenience and range anxiety for other EV end users that need to charge their EV. In order to prevent this, Transnova has stated that in the future they will only support public and private charging stations that charge their EV end users. We will address the challenge of free private charging from EV producers in the section *EV producers as commercial charging infrastructure providers.* Another disadvantage is the loss of revenue for municipalities and the Government. Even though the yearly amount of money paid for charging is not significant for the EV end users, the consequence of free public charging for the municipalities and the Government is foregone charging and parking revenue. This means less money in the treasury and will lead to stagnation of the development of charging infrastructure. We will explain why it will lead to stagnation in the next section.

From our ten interviews with EV end users it became clear that most of them supported the perception identified in the NEVA survey. Our interviewees recognized other incentives than free public charging as being of greater importance. Furthermore, the interviewees pointed out that they are willing to pay for charging. This is supported by the NEVA survey conducted in June this year where 64 percent of the respondents replied that they are willing to pay for charging[44] (Skogstad, 2014). We realized that there is a discrepancy between the opinion of the municipalities (the Government) and EV end users in relation to free public charging. The municipalities offer free public charging for EVs, which probably was of great importance in the early phase of the Norwegian EV market. However, based on the NEVA survey and our interviews with EV end users, we identified that free public charging is now of less importance and also indicate that EV end users are actually prepared to pay for this service. Thus, it is now an unnecessary expense for the municipalities and the Government. Additionally, free public charging destroys competition because it makes CCIPs reluctant to invest in charging infrastructure, which, as previously stated, leads to delays in the development of charging infrastructure. As Adam (CCIP) emphasized *"there are conflicting aspects in the charging infrastructure since the municipalities offer free charging"*. He argues that this suppresses the creation of fast chargers from

[44] It is important to note that the premises of the answers in the NEVA survey is that payment for charging goes to set up more charging stations

CCIPs and refers to an example where they (ICCP) had established a fast-charging station in central Oslo. In the same area there are 8 to 10 free basic charging stations provided by the municipality of Oslo. He says *”we can cover the need for charging in this area. However, EV end users do not use our fast chargers since the free chargers are available. This is not right. The municipality uses tax payers' money on free charging in places where there is established paid charging. This undermines the market for establishing paid charging”.* Additionally, he elaborates that they have the possibility to establish chargers ranging from South to North and fill the corridors from Oslo to Stavanger, Bergen, Trondheim and Bodø with few exceptions. However, he argues that this requires support from Transnova because it is a competitive and very expensive market, and a market where the EV end users are willing to pay for charging.

5.2.2.4 EV producers as commercial charging infrastructure providers

EV producers participate in the development and establishment of the charging infrastructure. Most CCIPs obtain part of the large establishing costs (the fixed costs) (see Table 10) and the operation costs (variable costs) of a fast charger from EV end users through two different systems, a subscription and “drop in” system. Different CCIPs provide different subscription systems and prices. One CCIP, EV Power, has a monthly subscription price of 299 NOK. This corresponds to a total energy cost of 6,500 NOK for an EV driving 15,000 kilometers per year, if the EV is charged 80 percent at home and the rest by fast charging. The electricity in Norway is fairly cheap, so the energy costs are minimal compared to the fixed costs. Therefore, the amount to pay in the “drop in” is linked to the time EV end users use the fast charging station and not the cost of energy (Kvisle, 2012). The prices for “drop in” fast charging is between 50 to 120 NOK for 15 (partly charged) to 30 minutes charging (80 percent charged) (Skogstad, 2014).

In addition to the coverage from EV end users, most CCIPs need subsidies from Transnova, support from counties, municipalities and other actors.

Earl (EVP) emphasizes the importance of EV producers in the development of charging stations and says *“we have an important role regarding building charging infrastructure. It is all about facilitating our customers and making the charging infrastructure as good as possible, so that more consumers can choose EVs”.* However, not all CCIPs charge their customers. Both Nissan and Tesla have their own free chargers, which they set up and operate. As with free public charging, free private charging leads to costs savings and enhance convenience for EV end users. On the one hand, this can suppress the development of fast chargers from new CCIPs, as Adam (CCIP) argued, in relation to free public charging. On the other hand, it can increase the development of charging infrastructure. Nissan is one EV producer who has seized the opportunity to increase the development of charging infrastructure, while lowering the costs and enhancing the convenience. Along with the Norwegian grocery chain, Kiwi, Nissan launched a project called "Green Parking" April 1st 2014. The collaborative project will establish between 50 and 75 multi-standard fast chargers at Kiwis' grocery stores all over the country during 2014. The chargers are developed and delivered by Nissan, and support both the CHAdeMO-standard (used by Nissan LEAF, Citroën C-Zero, Mitsubishi i-MiEV, Peugeot Ion), AC-standard (Renault ZOE) and the Combo-standard used by Volkswagen (e-UP and e-Golf) and BMW (i3). The fast chargers can recharge a normal battery up to 80 percent in 20 minutes, according to the press release. This is if the EV end user has some battery power left, because it will normally take half an hour to charge from zero to 80 percent. Kiwi has set a limit of 20 minutes to reduce the inconvenience of EVs using the parking space beyond the charging time. They do not want customers to wait too long before the charger is available, and customers, on average; never use more than 20 minutes inside the store (Hattrem, 2014). In relation to the launch The Minister of Climate and Environment, Tine Sundtoft, stated *"by combining the use EVs with something most of us do every day, Nissan and Kiwi are now removing a major obstacle to using EVs"*. It was Nissan who initiated the collaboration. As Country Manager in Nissan Norway, Pål Simonsen, says *"In order to obtain a further increase in the EV segment, we need more charging infrastructure. This collaboration makes it easier for EV owners to combine recharging the EV with grocery shopping, without having to do anything extra".* It is not yet been determined which of the Kiwis' stores who will get fast charging. However, the fast charging will be free to use until the end of 2014, what the price of fast charging will be in the long term is yet to be determined. Though, Jan Paul Bjørkøy, CEO of Kiwi, points out that he is certain that the price will fit in with Kiwi's concept of fast, safe and cheap (Garathun, 2014).

5.2.2.5 Standard points and plugs

This section assesses the lack of standard points and plugs and which challenges the Norwegian Government, EV end users and CCIPs face in relation to the lack of standard. We will not address the lack of standard within the payment system, since this is outside our scope.

Overview of the types of charging points and plugs[45]

Internationally and historically there have been many different kinds of charging plugs. The amount of different plugs is created by the fact that it has been difficult to standardize the regular household plugs from country to country. Another factor that has affected the selection is competition. Various charging plugs suitable for EVs have been developed due to competitive reasons. In addition, there are some interesting industry plugs that are also well suited for EVs (Ladestasjoner AS, 2014). Here is an overview of the charging plugs EV end users can expect to find over the next few years in the charging station database, Nobil:

- Schuko CEE 7/4
- Industry points IEC 60309 3-pin and 5-pin
- Type 1
- Type 2
- Tesla
- CHAdeMO
- Combo Charging (CCS)
- Charging point with a fixed cable

(Ladestasjoner AS, 2014)

The costs of investment and operation of charging stations

A survey of the costs of establishing basic charging points, made by Transova in the period 2009 to 2011, showed an average establishment cost of approximately 20,000 NOK. Based on applications for support for fast charging stations, Transnova estimates the cost of establishing fast charging stations of the type CHAdeMO (DC) to be between 500,000-700,000 NOK, except for establishments where one develops large reserve capacity for the future. This includes the charger, digging, foundation work,

[45] For the sake of simplicity we will call this standard of plugs

signs and the like. Currently there are no data on maintenance costs, but the CCIPs predict that costs may be around 30,000- 40,000 NOK per year based on information provided by the funding applications. The establishment of AC-flexible chargers has been significantly cheaper than the CHAdeMO (DC) fast chargers (Solem, Jonsen, & Nørbech, 2014).

Table 10 provides an estimate of the cost of establishing different types of charging points. The costs include charging points, charger, foundation work, disclosure of electricity, installation and commissioning. The costs will vary considerably and do not include construction (Solem, Jonsen, & Nørbech, 2014).

Table 10 – An excerpt of the costs for different types of charging points.[46][47] Source: Transnova: National Strategy and Finance Plan for Infrastructure for EVs

Type of Charger	Charging Power	Standard	Price of Charger	Other Establishment costs	Annual operating costs excluding energy costs
Basic Charger	< 3,6 kW	Mode3 Type 2	NOK 8,000-15,000	NOK 3,000-8,000	< NOK 1,000
Flexible Charger AC*	< 22 kW	Mode3 Type 2	NOK 50,000	NOK 7,000-40,000	NOK 1,000-5,000
Multi-Standard Fast Charger	< 50 kW	CHAdeMO, Combo, Mode3 Type2	NOK 300,000	NOK 200,000-400,000	NOK 40,000-50,000
Super Fast Charger	> 50 kW	Combo	NOK 250,000	NOK 200,000-400,000	NOK 40,000-50,000

* Implies establishing charging stations with two charging points

[46] For complete Table of the Costs for Different Types of Charging Points see Appendix 2

[47] The price of chargers in Table 1 reflects the pricing currently obtained from actors in the market. It is possible that the prices will fall as a result of technological development and increased production volumes. Price reductions of any such are not included in the cost estimates (Solem, Jonsen, & Nørbech, 2014).

As shown in Table 10, the costs of buying a charger and the establishment costs vary because of the complexity of the charging station. A fast charger is more complex than a basic charger. Additionally, for the establishment costs, the conditions as to where the charging stations are to be placed are a varying factor. For example, for flexible chargers, the establishment costs can be low if the chargers are mounted on a wall and the wiring of the electrical panel is simple. However, if the flexible charger has to be mounted on the foundation and the cable has to be buried, the establishment costs increase a great deal (Solem, Jonsen, & Nørbech, 2014). Thus, there are many factors that influence the total cost and it is important that the numbers in the table are considered as guiding only.

Lack of standard design plugs and how to fast charge the EV

There is no global standard for fast charging plugs, as seen in the table 11. As previously mentioned, Citroën C-ZERO and Berlingo, Mitsubishi i-MiEV, Nissan e-NV200 and LEAF, Peugeot iOn and Partner Electric use the CHAdeMO plug, BMW i3, Volkswagen e-UP and e-Golf use Combo plug, while Renault ZOE uses the Type 2 (AC) fast charger plug. Then there is Tesla, which makes its own charging stations. Their EVs are at the moment only compatible with Teslas own DC fast charger and plug.

Table 11 - An excerpt of the types of charging different EVs can use.[48] [49]Source: Transnova: National Strategy and Finance Plan for Infrastructure for EVs (2014)

Brand and Type		Point AC	AC 3,6 kW	AC 7,2 kW	AC 11 kW	AC 22 kW	AC 44 kW	CHAdeMO	Combo
BMW i3		2	S	A	-	-	-	-	A
Citroën C-ZERO		1	S	-	-	-	-	S	-
Ford Focus Electric		1	S	S	-	-	-	-	-

[48] For a complete table see Appendix 3
[49] S=Standard, A= Additional/ Extras, 1=Type1 and 2=Type2

Mitsubishi i-MiEV		1	S	-	-	-	-	S	-
Nissan LEAF II	From June 2013	1	S	A	-	-	-	S	-
Peugeot iOn		1	S	-	-	-	-	S	-
Renault ZOE	Norway 2014	2	S	S	S	S	S	-	-
Smart fortwo electric		2	S	A	A	A	-	-	-
Tesla Model S		2	S	S	S	A	-	-	-
VW e-Golf	Spring 2014	2	S	-	-	-	-	-	S

There are mainly two specific issues that create challenges for the Norwegian Government, Norwegian EV end users, and CCIPs. First of all, there exists no standard as to how to fast charge the EV. Charging an EV involves mainly converting AC from the power grid to DC. One of the main discussions between stakeholders in the automotive and power industry has been whether the transformation from AC to DC should be in the EV or in the charging station. If the inverter is in the EV, it is AC-charging. If the inverter is in the charging station, it is DC-charging. The second issue is that there exists no standard on the design of the charging plugs (Grønn Bil, 2011). The EU and Norway are currently working to implement a fast charging standard plug that meets the conditions in the various markets. However, there is controversy about the standard. On the one hand, EU prefers Combo for DC fast charging. The Combo is the fast charging plug that has the broadest support among European car manufacturers. On the other hand, Norway favors the Japanese CHAdeMO plug for fast charging. One challenge for the Norwegian Government is whether they should go ahead and legislate a standard plug or wait for the EU (Grønn Bil, 2014; Solem, Jonsen, & Nørbech, 2014). Another challenge is which standard plug the Government should choose: CHAdeMO, Combo or Type 2 (AC). For now, the Norwegian Government emphasizes, through Transnova, that accessibility for all EV end users is important. The Norwegian Government highlights this by stating that everyone receiving funding for charging stations must have all three standard plugs and that this would normally discourage monoplies.

As of August 3rd 2014 Norway has a total of 219 fast chargers, 104 CHAdeMO, 30 Combo, 13 AC Type 2 and 72 Tesla super fast chargers. This means that there are four different fast charging plugs, CHAdeMO, Combo, Type 2 (AC) and Tesla. Erik (PM) also emphasized the issue of lack of standard plug and pointed out that there are too many different plugs for fast charging. As well as creating challenges for the Government this creates challenges for EV end users. Tesla is the only EV producer, at least to our knowledge, which is currently developing adapters so their EV end users can charge at all stations with CHAdeMO plugs. The adaptors should have been released in the second quarter of 2014, but there is no information as to when these are offered in Norway, or at what price (Hattrem, 2014). NEVA points out that adapters for fast charging are in conflict with norms for electrical installations and thus not desired and prohibited. This means that EV end users cannot recharge at other fast charging stations than the one their EV is fitted to. Firstly, this may result in range anxiety since there is a limited amount of fast charging stations, especially Combo and AC Type 2. The second consequence is planning. The EV end users need to plan their trips more carefully due to longer range between fast charging stations. In our interviews we found that four out of ten of our EV end users perceived planning as one of the major disadvantages of driving an EV. However, if it were possible to use all charging stations the EV end users would be forced to carry with them four different plugs if they want to use the different chargers. This may not be a major problem per se, but charging cables with plugs are expensive. The price range vary for a five meter long charging cable with plug, from 2,800 NOK for cheapest one, Ford Focus Electric, to 7,604 NOK for the most expensive one, Citroën C-ZERO (Marcussen, 2014). Additionally, the chargers also have different charging and payment systems, which makes it even more disadvantageous for EV end users. This is beyond the scope of our paper, but Transnova is looking into this standard issue (Solem, Jonsen, & Nørbech, 2014).

As stated previously in the section, *Background: Understanding the EV market*, Transnova has determined that all actors, companies, municipalities and organizations, that receive financial support from Transnova must have at least three charging points, Combo, CHAdeMO and AC Type 2, so that the charger can be used by as many EVs as possible (Transnova, 2014). In other words, this means that CCIPs, who apply for funding from Transnova, are required to have the three charging points. As a result of lack of a standard plug, this also stagnate the development of charging infrastructure because some actors that have received funding from Transnova delay the installation of the charging stations. They have decided to defer the installation of charging station due to the lack of standard plugs and to avoid the expense of establishing and operating three charging points. The applicants hope that there will be clarifications, about which plugs that become standard, which will significantly reduce the installment price.

We find that it is difficult to anticipate when the standard plug will appear. The EU is actively working to establish a standard for charging plugs, and the development in Norway depends on the outcome of the research the EU performs. At present time the Norwegian Government does not engage actively in promote standards plugs. It will be necessary to implement actions towards establishing standard plugs so that EV end users do not have the expenses and inconvenience of having to bring several different charging plugs, CCIPs and municipalities do not delay the charging infrastructure.

5.2.2.6 Important takeaways

We identified charging challenges which affect the Norwegian EV market: shortcoming of charging stations, free charging, and lack of standard points and plugs. In this section, we will go more in depth with these challenges and assess what the Norwegian Government do or can do to overcome these challenges.

Most EV end users have the possibility of charging their EVs at home. We determined that the level of charging stations for daily usage is more or less sufficient. Still there is a demand for more charging stations, in particular fast chargers. They are important to extend the range which is considered to be a problem by consumers who want to buy an EV. We acknowledge that few EV end users use fast charging, but argue that this is due to lack of fast chargers since the surveys clearly show that there is a demand for charging both between cities and within cities. As Simon (NGO) pointed out, the EV market is growing too fast relative to the development in charging infrastructure. The development of charging infrastructure needs to keep up with the increased sale of EVs and the usage patterns. Djik et al. (2011), as previously mentioned in our theoretical framework, emphasize that the commercial success of the EV widely depends on the charging infrastructure (Dijk, Orsato, & Kemp, 2012). According to Djik et al. (2011) it is essential that the Norwegian Government continue its support of the development of the charging infrastructure through Transnova. Furthermore, Djik et al. (2011) point out that an extensive charging infrastructure initiated by collaboration between national government, local government and electricity companies is necessary. At the moment there exists no collaboration between the Government and electricity companies.

Consumers' lifestyles and attitudes have co-evolved with the evolution of the ICE, as it is the dominant means of transport. In other words, car owners are used to being able to drive long distances without having to plan where to recharge or worrying about running out of power, and they expect to still be able to do so. As pointed out in *Theoretical framework,* Geels (2011) emphasizes that consumer lifestyles and preferences are adjusted to existing technological systems, such as the ICE. "*The core process for transition is a shift in belief systems, ideologies and public opinions. Such shifts do not only influence consumer preferences and values, but also create credibility, pressure and legitimacy for policy makers to introduce regulations*" (Geels, The Multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011, p. 32). According to Geels (2010) The Norwegian Government should do more to change the attitudes of consumers, in order to shift the consumers to drive EVs. Media and culture have created symbolic associations with the car, and it represents the ability to go wherever we want, at any time. Furthermore, even if consumers would want to change to another transport option, their habits are hard to break. Consumers develop habits and routines connected to the car, which are hard to break. For example, it is very convenient for car owners that they only have to refuel once a week, like you can do with ICEs. With EVs however, one must plan to recharge. Therefore, the Government should continue with its development of charging infrastructure that meets the customers' demand. However, there are major costs connected with the development of charging infrastructure so the Norwegian Government is dependent on CCIPs taking their share of the development. As mentioned earlier, we will address this issue later in the thesis.

We found that the EV end users perceived free public charging as an incentive that is not so important and that most of our EV end user interviewees are willing to pay for the service. Additionally, we identified a discrepancy between the opinion of the Government/municipalities and EV end users in relation to free public charging. First of all, this incentive is an unnecessary cost for both for the municipality and the Norwegian Government, since the EV end users are willing to pay for charging. Second, it destroys competition. Municipalities still offer free charging, which may result in CCIPs being reluctant to invest in charging stations. EV end users will naturally choose free charging over paid charging. Some CCIPs are therefore requesting a joint claim for payment for charging, and a payment solution will be a positive contribution to the competition. Consequently, the incentive leads to a delay of the development of the charging infrastructure.

Investment in charging stations is costly. However, based on the analysis by Transnova, it is possible to establish a profitable industry. This requires, however, that the sale of EVs will increase, and that more people will use the paid charging stations. The Norwegian Government has pointed out that it is crucial for the future of the EV industry that CCIPs take more responsibility for the development of charging infrastructure. Since the investment in EV charging infrastructure is related to large costs and high uncertainty, and the lack of information concerning investment in EV charging infrastructure, Transnova can have a major impact on the development. We discovered that there are too many different points and plugs, and the lack of standards generates a bottleneck in the development of the charging infrastructure. Transnova is partly, unwillingly, involved in this because they require three charging points from CCIPs and municipalities, and other actors who want support. The consequence is postponement of the installation of the charging points, a policy loophole, which again results in stagnation in the charging infrastructure development. On this basis we argue that the Government, through Transnova, should introduce a restriction, which says that the charging station must be established within a certain period after the CCIPs have received funding. Another challenge in relation to standard plugs is whether Norway should go ahead and establish the CHAdeMO standard, wait for what the EU decides or let the market decide. Whether mandate standards, standards imposed by National Standard Bodies (NSBs), are more beneficial than market based standards is a whole different research. However, Gandal et al. (2003) argue, based on research within standards in wireless telephone networks, that when a government mandates a standard it will achieve coverage usually faster than a market based standard. However, this could be a disadvantage for customers in the long run, if the standard technology is inferior to one used elsewhere. In respect to de facto standards, the authors points out that this creates more technological and price competition. Farrell and Shapiro (1992) note that mandate standards forego benefits of competition in R&D (Gandal, Salant, & Waverman, 2003).

5.2.2.7 Development of battery technology (range aspect)

"Range anxiety" is a new expression that emerged as a result of the influx of EVs in Norway. The term is defined as: *"A fear of running out of electricity before one reaches the next charging station"* (Solem, Jonsen, & Nørbech, 2014, p. 13).

It is possible to overcome range anxiety by improvement in two areas:

1. Charging infrastructure (as elaborated on the latter section)
2. Development of battery technology

1. Development in charging infrastructure implies that charging station providers need to build enough charging stations to satisfy the demand for charging so that EV owners can drive their desired distances without having to fear that they will run out of power.
2. Development in battery technology means that the technology behind EV batteries is improving, and EVs are not dependent on charging frequently.

We will focus on improvement in area 2 in this section (battery technology).

The development in the EV industry is rapid, however according to research conducted by Transnova, all producers are facing one major challenge: A whole new type of vehicle must be developed, and the high cost of batteries limits their ability to produce cars with a sales price that the EV market will accept (Transnova, 2014).

Christensen et al. (2012) and Transnova (2014) argue that limited driving range is the major weakness of today's EVs. The very simple solution to this problem is to install a large battery. However, large EV batteries are expensive and require much space. The result will therefore most likely be an expensive car where most of the space is dominated by carrying the battery. To make EVs competitive, it is necessary with a decrease in prices as well as broadened range (Christensen, 2012). The batteries in EVs are expensive partly because the development of battery technologies requires major investment costs, and have been produced in relatively small batches. The EV market is still immature and EV Providers are working to find various technical solutions that optimize mileage and create commercial opportunities in the future. We acknowledge that the development of battey technology is a major challenge for the EV industry. However research and development of EV batteries are mainly conducted by foreign manufacturers and not directly affected by the actions of the Norwegian Government. Therefore, we consider the technological development of EV batteries to be outside the scope of our thesis.

Instead we will focus on how the driving range affects the Norwegian EV market.

Pattern of use

In the section, *Charging infrastructure*, we explained how EV users perceive range as one of EVs major disadvantages. The EV is today marketed as a city car, however if the EV is to compete with the ICE, EVs must be able to drive long distances, such as between cities. This is particularly vital in Norway, since the country is elongated with long distances, especially in the northern counties and along the coastlines. Furthermore, in Norway there is as strong tradition for travelling to the cabins over the weekend. There exist approximately 400,000 cabins in Norway. On average, 56 percent of the population has access to cabins, and Norwegians spend 36 nights at the cabin every year (Stene 2010). In particular inhabitants of large cities frequently wish to escape the city for weekend trips to the mountains. As we mentioned in the section, *Charging infrastructure*, one way to overcome this distance problem is to set up more charging stations in areas where it is needed, such as in the mountain areas. Another possibility to overcome this problem is to increase the battery capacity of the EV. One of our interviewees (an EV user) stated *"a major disadvantage with the EV is the battery capacity"*. There is a demand for increased battery capacity in order to use EVs also for weekend trips. If the EV is to sustain on its own it will therefore be necessary to increase the range of the batteries so that it also covers requirements beyond everyday use. Tesla is at the moment the best EV for trips beyond everyday use. Tesla Model S has a range of 500 km, which makes it possible to use for longer trips. James (PM) said *"I am from a rural area in the mountains, which is a popular cabin area for people who live in Oslo. Before, BMWs and Range Rovers were parked outside the cabins, but now it is quiet. All I see is Teslas".* Erik (PM) confirms this view.*" Lots of people buy the EV as car number 2, however it turns out to be used as car number 1, because they see that it can be used for almost everything"*. However, it is important to note that the battery power Tesla offers entails a high cost. The purchase price of Tesla Model S (as of 06.2014) ranges from 580,000 NOK – 780,000 NOK, without additional equipment (Teslamotors, 2014).

Nissan LEAF is the second most sold EV in Norway. The price is approximately 228.600 NOK (as of 06.2014), and the range of a new Nissan LEAF is 199 km (Nissan Norway, 2014). Nissan has chosen a different model to overcome the challenge of driving longer distances. Nissan is making a great effort to get more people to opt for the EV solution. They offer a limited period of what they call "full mobility throughout the country for the days you need to drive really far". Nissan has signed an agreement with Hertz (a car rental business) which provides access to free ICEs in the same category as Nissan LEAF for up to 20 days (Dinside, 2013).

This indicates that at the present time it is possible to purchase EVs with a range that to some degree satisfies trips beyond everyday use; however it comes at a high price. It is therefore vital that other EV manufacturers focus on battery technology that can increase the range at an affordable price that suits the income basis for the rest of the population.

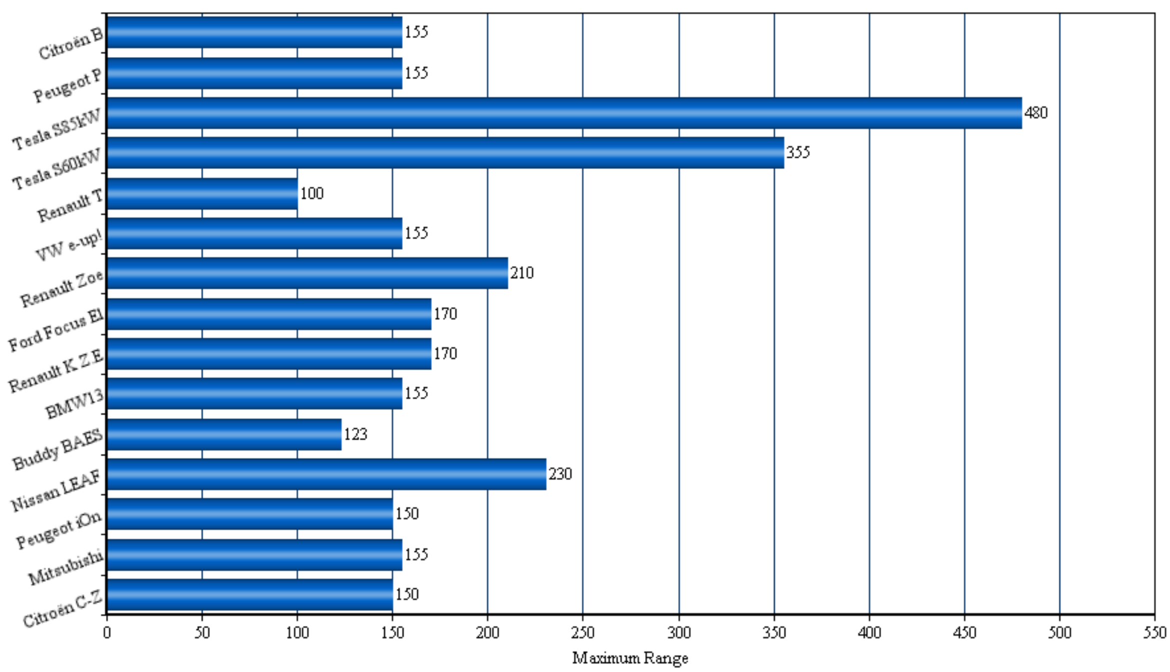


Figure 9 – Maximum mileage of selected EV models. Source: Own development based on numbers from NEVA (2013).

Local conditions

When we discuss the development in battery technology, we will continue by arguing why this development is particularly important in Norway. The driving range of EVs is being seriously reduced in cold winter weather, and today's battery technology cannot handle cold inequalities without compensating for the driving range.

It is therefore important to take local climate conditions into account. As winter weather arrives we find that EV owners are worrying about what the cold will do to the range of their vehicles. Forum threads like "winter driving warning" and "another way to stay toasty on long trips without running heat" are appearing on customer forums run by Tesla Motors (Ulli-Beer, 2013). The average temperature in Oslo during winter is approximately -3C, while some regions in Norway experience average temperatures of -17 degrees during wintertime. In the summer months the average temperature varies from 16 to 18 degrees in Oslo (SNL, 2014). Batteries can be optimized for either high or low temperatures. However it is challenging to engineer them to function over a wide range of temperatures without incurring performance (The Boston Consulting Group, 2010). Cold weather presents two main challenges for EVs: Cold air limits battery performance and running the heater drains the battery (Ulli-Beer, 2013). Considering the various climates in Norway, a range of 160 km during summer can decrease by up to 50 percent during wintertime. The range is further reduced by 20 percent after 8 years because of aging, and an additional 20 percent in range buffer, which the EV end users usually calculate with. This means that the range of the EV will be approximately 50 km during wintertime, if the EV that is older than 8 years. Drivers living in an extreme climate might see the range decrease even more. There are some measures drivers can take to improve a EVs range, but with today's battery technology, some loss of range is inevitable. Ulli-Beer (2013) argues that researchers are currently working on technological fixes that will not be ready for years.

The role of the Norwegian Government in the development of battery technology

We have previously described how the development of battery technology has a major impact on the purchase price of EVs and the demand for public fast charging stations. Improved battery technology can lead to EVs that are less dependent on financial subsidies from the Government. Further, it can lead to EVs that need less frequent charging, which requires less investment in public charging stations. Improved battery technology can thus lead to a number of benefits and financial savings for the

Norwegian Government. It is therefore in our interest to elucidate what measures the government takes to improve the development of battery technology. James (PM) states: *"The Norwegian Government does not collaborate directly with the industry. However, Transnova is collaborating with the industry as they provide financial support to innovation and development projects. The Government delegates financial resources to Transnova, which opt for the research and development projects they find it useful to support".* Transnova does not support EV manufacturers in the development of battery technology, however they do support pilot and demo projects, such as the development of the Zemantic project. The overall objective of the Zemantic project is to help extend the life and lower the operating costs of EV batteries. Another goal is to lay the foundation for reuse and valuation of battery leasing, sales and re-use in other applications than the EV. Examples are storage of renewable energy such as solar, wind and tides, in ships/ferries, in the power grid, in fast charging stations and backup systems. In the project there will be particular emphasis on being able to predict and analyze battery range and residual value in Norwegian and Nordic climate conditions (Nørbech T. E., 2011). From Erik's perspective, *"foreign companies, working on technology for batteries, are interested in cooperating with Norwegian companies (supported by Transnova) to test their technology on the emergent EV market in Norway"*. Norway is as previously mentioned a pioneer in the EV industry and through our interview process we have identified that major EV producers are using Norway to observe trends and developments in the EV market. NEVA works as a communication portal to convey trends and knowledge about the need for further development of battery technology. A representative from an NGO, Simon, confirmed this by stating "*the EV producer had not even heard of Norway before they started the production of EVs. Now they want to find out what the Norwegian market demands in terms of further development and new products"*. Norway is not a major player in the production of batteries or the development in battery technology. However Norway is an important source for conveying information about user behavior, opportunities and obstacles of today's battery technology.
Even though the Government is supporting some pilot and testing projects we find that the Norwegian Governments approach to address the battery performance issue is to primarily support widespread public charging stations to provide greater range potential. In 2011 Oslo installed 400 public charging stations, and since then has been installing 100 each year. The direction of search outside Norway has been more focused on innovating electric drive technologies like motors, controllers and battery systems. Political pressures and government incentives have supported advancing the state of these EV

technologies in other major EV manufacturing countries. Partially as a result of these pressures for major manufacturers to innovate improved technologies the EVs in Norway are predominately from Japanese, French and American manufactures. While government policies in other countries may have been pushing EV manufactures towards advancing the state of EV technologies, Norwegian efforts have been focused on providing consumer-based solutions such as providing publicly available EV stations to address the technological bottleneck of limited EV range (Vergis, 2014).

5.2.2.8 Main takeaways

As pointed out in our theoretical framework, sustainable innovations tend to score lower on price and performance than other unsustainable innovations. Price and driving range are the major challenge for EVs and in this section we have argued that battery technology is essential to improve the performance of EVs.

As elaborated on in our theoretical framework the Multi-Level Perspective can be used as a framework for analyzing socio-technical transitions to sustainability. The perspective distinguishes between three inter-related levels of change; the landscape, regime and niche level. We find that the development of battery technology fits at the niche level, which refers to "protected space in which innovations takes place" (Geels, 2011). This includes R&D laboratories, subsidized demonstration projects or small market of emerging innovations. Geels (2011) argues that niches are crucial for transitions because they provide the seeds for systematic change. As we have pointed out, the Norwegian Government does not subsidize or collaborate directly with R&D projects on battery technology. The main reason is because the research is conducted by the major international automakers. We will however point out that the government supports research and development through Transnova, which provides financial support to research and development projects. Furthermore, we have identified that most of the projects that receives funding from Transnova involves research on charging technology, and not development of battery technology.

We have identified that there is considerable uncertainty about the future evolution of price and battery technology among different actors on the EV market. There is some disagreement about how long range the EVs will hold in the future and at what cost. Furthermore, we find that Scenario A (a decrease in price and longer range) is the optimal scenario for an increase in the adoption rate of EVs. Scenario B represents cheaper EVs with similar range as today. Trends in the EV market reflect a development in this direction. As several of the automakers who we interviewed expressed, the challenge is that bigger batteries with longer driving range are expensive, and as a result they find it necessary to install batteries with lower range to keep prices competitive. It is however still necessary to conduct research on battery technology. Gover (2014) points out that a research breakthrough in battery technology that causes major cost reductions in battery technology and result in a major reduction in the cost of EVs will cause the market for EVs to grow in the future. A key question is whether this is a fortunate development in relation to the Norwegian Market. Due to the climate and usage patterns in Norway, which often place demands on long journeys in cold weather, consumers are often dependent on cars with long range. Tesla is the only car on the market, which satisfies the Norwegian Climate. Tesla obtained a driving range of 500 kilometers. However, the Tesla model S comes at a high price compared to other EV models, and the purchase price allows a limited range of consumers to purchase the car. We therefore find that the market will largely depend on developments in battery technology. Since Norwegian conditions are particularly challenging because of the cold climate during winter we find it appropriate to initiates research that contributes to battery technologies that are better adapted to Norwegian conditions. Gover (2014) suggests that research at technological universities will be an effective measure for a rapid and sustainable development of battery technologies. These findings are also consistent with research conducted by Mah et.al (2012) who suggests that the government must collaborate with key actors to create important forces of change between landscape, regime and niche levels.

5.2.2.9 Public and private communication

This section explores the relationship between the Government’s objectives for development of charging infrastructure and the CCIPs investment in charging infrastructure. By CCIPs we mean commercial operators such as power utilities, car producers, gas stations, hotels, shopping malls etc. offering charging stations for free or against payment. We find a discrepancy between the Government and CCIPs, which implies that the Government aims at more CCIPs to provide, charging stations, while the CCIPs call for a long-term steering plan for the Government´s commitment to EVs that extends beyond 2017.

Before diving into the discrepancy between the two actors, we will start by explaining the relationship between them.

The relationship between the Government and CCIPs

The Government has set a target that multiple CCIPs shall offer charging stations for EVs. It is thus in our interest to investigate the relationship between the Government and the CCIPs. We find that the Government is not cooperating directly with CCIPs per se; however they attempt to influence potential CCIPs through financial support which Transnova delegates. James (PM) states *"the industry and other interested parties request meetings with us and we are making an effort to meet as many as possible to gain insight into the viewpoints of the industry*." Furthermore, we find that NEVA and NGOs act as important intermediaries in the communication between CCIPs and the Government, as these organizations is in close collaboration with industry, EV end users and the Government. Peter (EVP) states that there are no official or coordinated collaboration between the Government and CCIPs, however they participate and communicate with each other within forums such as debates and seminars. Additionally, CCIPs can apply for financial support from Transnova. The purpose of the financial support is to ensure that the market for charging operates on commercial principles after the establishment phase. We find the financial support to be an efficient measure to promote investment in charging infrastructure. Adam (CCIP) points out that the contribution from Transnova has been decisive for their investment in charging stations. He says *"It is out of the question to establish charging stations without the financial support from Transnova".* They have received 200,000 NOK from Transnova, which contributes to one third of the total investment cost in the charging station. With financial support from Transnova, they consider it will take less time before the charging station may be regarded as profitable. The Government is responsible for overall coordination of establishing charging infrastructure. The task is performed by supporting testing of new technology and deployment of charging infrastructure where the market does not work purely on commercial principles. In Transnova's framework for charging infrastructure, CCIPs are responsible for selecting which solutions to focus on and where, and how it is appropriate to make establishments from commercial considerations (Figenbaum & Nørbech, 2012). However, it is also critical that the CCIPs develop business models that enable the development that Transnova proposes for the first phase of the financing plan, 2014-2016. The grant should also ensure that commercial operators, who would not otherwise invest in charging stations, are interested in this and actually investing in the charging capacity and offers charging with a fee.

We find a discrepancy in relation to the responsibility issue between the Government and the CCIPs. When the Government drafted the State Budget (2013 – 2014), one of the initiatives was to submit a strategy and financing plan for charging stations and infrastructure for EVs. One of the main tasks was to identify and map the responsibility between private and public sector. Transnova was awarded this task and developed the report "National Strategy and Financing plan for Charging Infrastructure" (Transnova, 2014). In this report, Transnova emphasized that the CCIPs must take greater responsibility in order to facilitate charging infrastructure in partnership with the Government. One of the measures that were implemented was a scheme where CCIPs can apply to Transnova for financial support for the establishment of charging stations. The challenge with this strategy is that there is no long-term plan for the financial support. Transnova states; *The Government support for the development of charging infrastructure is a measure to realize investments that commercial operators would not otherwise implement. Our mission is to avoid charging access becomes an obstacle to increased adoption and use of EVs. The market for EVs and charging equipment is developing rapidly, and it is not easy to predict what kind of charging the market will demand, where the demand will occur, what kind of charging equipment that will be most cost efficient in the future and finally where the bottlenecks may be greatest. The first phase of the development and financing plan are limited to the period 2014 – 2016"*(Solem, Jonsen and Nørbech, 2014, p 11).
CCIPs argue that they need more predictability before investing in charging stations. Peter (EVP) says; "*if the Norwegian Government's demand for CCIPs to invest in charging stations the CCIPs needs long-term objectives and steering from the Government. We call for long-term steering as we need longer investment horizon."*

In other words, the Government states that the industry, e.g. CCIPs, must take greater responsibility while the CCIPs stress the need for further predictability in order for them to invest in charging stations. Erik (PM) agrees with Peter and emphasizes that the industry is not ready to invest in charging infrastructure. He points out that there is a need for a longer timeframe of the incentives so that the

CCIPs will be willing to invest in charging infrastructure. James (PM) is not supportive of the latter statement. He argues that the Government needs to hold the industry (car manufacturers) accountable to take more responsibility in the development of charging infrastructure independent of financial government support. He justifies this statement by arguing that the EV sale has soared and is becoming a profitable industry.

In the survey conducted by NEVA, EV end users was asked about which measures they considered to be appropriate to implement in order to convince more consumers to purchase EVs. 23 percent of the respondents ranked a predictable long-term EV policy as the most important measure (Haugneland & Kvisle, 2013). This supports the opinion of CCIPs who request greater predictability.

When the Norwegian Government released the revised National Budget in May 2014, they communicated mixed signals to CCIPs. *”EVs contribute to lower global and local emissions. However, emission reduction represent a major cost, e.g. in the form of loss of tax revenue. There is broad political consensus that tax benefits for EVs should not be removed now (until 2018), see box 5.3 for further details.”* (Finansedepartementet, 2014). This statement demonstrates a willingness from the Government to retain the incentives. NEVA is positive towards this development. Snorre Sletvold, Technical and Project Manager in NEVA, expressed: *“The announcement from the MF implies that the Government will not change the established EV taxation benefits before 2018. This is a positive announcement that creates predictability and hinders the uncertainty about the incentives that have flourished in the media”* (Frydenlund, 2014). However, the Government also stated that they are postponing the implementation of the exemption from VAT for leasing of EVs and sales of batteries for EVs indefinitely (Finansedepartementet, 2014). The indefinite delay of the exemption from VAT was based on projection that the decision could lead to EEA legal issues, and that one had to determine the legal technical aspects of the regulations (European Economic Area, 2014). Even though we are not focusing on corporate users in our thesis, the postponement of the implementation of exemption from VAT for leasing of EVs is significant for the collaboration between the CCIPs and the Government. We find that it sends unclear steering signals to the CCIPs.

Based on our interviews, it appears the establishment of basic chargers and to some extent flexible AC chargers in central areas are closest to sustain on its own without the Government investment grants. The emergence of a commercially viable market will probably come first in urban areas. In that case it will be natural that Transnova gradually withdraw the investment subsidy and turn a greater proportion of the funds to the charging infrastructure in rural parts of the country that are less interesting from a commercial standpoint.

5.2.2.9 Main takeaways

We have identified that there is no direct or official cooperation between the Government and CCIPs. We find that this may have led to a controversy between the different actors in relation to development of charging infrastructure. As elaborated on in our theoretical framework, socio-technical regimes suggest that technology innovation interacts with government through positive feedback in both directions. This includes from manufacturers and CCIPs to government, and vice versa. We find that the Government has not succeeded in communicating a long-term strategy, which motivates CCIPs to invest in charging infrastructure. Mah et.al (2012) argue that the business sector needs to collaborate with government to develop new business models such as charging providers that put business incentives and consumer motivations in place to drive towards changes in infrastructure. The Government has to some extend succeeded. Adam pointed out that they have invested in charging stations as a direct effect of the support Transnova has granted. Furthermore, the CCIPs demand a long-term steering plan and increased predictability in relation to the EV incentives. In terms of Socio Technical Transitions and the Multi-Level-Perspective our findings are consistent with the theory by Nilsson et al. (2012), which suggests that in order to change a regime, manufactures and infrastructure providers need long term and coordinated steering to motivate necessary investments. We have identified a set of reasons way the absence of a long-term plan prevents CCIPs from investing in charging infrastructure. The first point we would emphasize is the uncertainty it creates regarding the adoption rate of EVs. If the incentives are removed and the sales of EVs stagnate, the demand for charging will decrease.

A second point is that an unclear steering plan creates uncertainty about the further development of the EV market. Uncertainties can cause the CCIPs to choose to postpone planned investments in charging stations until the government have formulated a long-term strategy.
The revised National Budget ensures more predictability in the sense that the infrastructure providers know that the Government stated they will keep the financial incentives until 2018, however we find that the CCIPs demand even longer predictability.

A barrier is the postponement of the implementation of the exemption from VAT for leasing of EVs and sales of batteries for EVs indefinitely. This indicates that the Government is somewhat reluctant in their policy and sends a negative signal to the infrastructure providers.

As pointed out in our theoretical framework, a high level of commitment by the Government is necessary in order to promote adoption to EVs. However, Tran et al. (2013) state that it is of great importance that actors from the industry follow and invest in the development of charging infrastructure in order to create a competitive market (Tran M. , Banister, Bishop, & Malcom, 2013).

6. Discussion

In this section we would like to summarize our empirical findings and research. We will connect our findings with the theoretical framework applied in this thesis. More specifically, we will structure our findings in the MLP framework, and apply theory on STT by Geels (2011). We will present our key empirical findings, allowing us to make recommendations for the Norwegian Government. Since the object of our research is to identify what the Government can do to create a sustainable EV market, our recommendations will be concentrated on what the Government should do. Furthermore, we will reflect on what contributions our research has made to research on the development of the EV market in Norway. Lastly, we will present our suggestions for further research within the existing field of EVs in Norway.

6.1 Our findings in the multi-level perspective

The MLP to STT suggest how a new technology can emerge to fulfill an environmental need. As problems related to automobile use grow more urgent the case for radical innovations builds and the large-scale adoption of such alternatives become more likely (van Bree, Vergong, & Kramer, 2010). Based on our findings we will present which measures we consider to be significant drivers to increase the adoption rate of EVs. We will present how our findings fit in the MLP framework. Additionally, we will address unexploited opportunities, which we have identified.

Table 12 – Our empirical findings incorporated into the multi-level perspective. Source: Own development.

MLP levels	Measures by the Norwegian Government	Recommendation
Landscape	- *The Kyoto Protocol* - *The Climate and Energy Package* - The EEA Agreement - *The Norwegian Climate Agreement* - *The White Paper (2007 and 2012)*	We find that the climate objectives are satisfactory. The challenge is to maintain the initiative and to further strengthen the climate targets.
Niche	- Transnova subsidizing research and development projects - NGOs conducting research on EVs - Sharing experiences to foreign car manufacturers to contribute to research and development	- Increase financial support to R&D of battery technology - Increase financial support to research on standardization of charging technology - Establish a market for re-use of used batteries so that the duration of batteries is not a threat to impairment loss of EVs
Regime	-The incentive scheme - High taxes on fossil fuel - Providing financial support to charging infrastructure	- Long-term steering and commitment from the Government to motivate CCIP investments in charging infrastructure - Long-term steering and commitment from the Government to encourage consumer adoption of EVs - Increase the support to public procurement of EVs and company cars - Develop a long-term steering plan for the incentives that goes beyond 2017. - Conduct a thorough analysis of the impact of each inventive and eliminate redundant incentives

Theory on MLP proposes that the governments must support research programs to promote radical innovations. A challenge we have found in relation to development on the niche level is that Norway is not involved with production and development of EVs. A key issues, not covered by the theory, is therefore how governments can support development on the niche level when the country is not involved with production and development of new technologies. In this case, we suggest that the Government should share experiences with governments in foreign countries that produce EVs. We argue that it should be in the Norwegian Governments interest to contribute to increased sales of EVs abroad. Increased demand will lead to increased production of EVs and thus lower purchase prices because of economies of scale.

6.1.1 Assessment of the policy incentives

We consider the incentive scheme to be an effective measure to increase the adoption rate of EVs in Norway. As we already pointed out in Table 12, there is lack of more thorough assessment of the effect of the incentives. In table 13, we will provide our assessment of the impact and significance of each incentive. The significance will be assessed with the categories of high, medium, low and negative, where low means that the incentives should be changed or removed, and negative indicates that the incentive should cease.

Table 13 – Our evaluation of the effect and importance of the policy incentives. Source: Own development

Incentive	Significance	Evaluation
Exemption from registration fee	High	Of major significance to reduce the purchase price and equalize the prices between EVs and ICEs. Of major significance to make EVs price competitive and it is of great importance for potential new buyers. In particular for heavy EVs such as Tesla.
Reduced annual fe	High	We find it to be a major contributor to reducing annual operating cost of the EVs.
Exemption from VAT	High	Because of the high tax rates in Norway we find this incentive to have considerable influence. Of major significance to make EVs price competitive and it is of great importance for potential new buyers.

Exemption from toll on toll roads	Medium	The significance is locally justified. This incentive have a major impact on sections where toll road rates are high and traffic is dominated by commuters, i.e around the major cities (Oslo, Trondheim). We suggest that a reduced fee can be implemented over time, but has it has to be cheaper for EVs than ICEs.
Free parking	Medium	Provides a great effect where parking is scarce. However there are a limited number of parking spaces available and thus, we find that this benefit have limited impact on the total EV scope. However, we find that it is an effective way to demonstrate the benefits of EVs and the incentive should therefore be maintained.
Access to Public Lanes	Low	Effectively to increase EV use in areas with large congestion delays. Our findings indicate that the effect of this incentive is diminishing lately because the public lane fills up during peak hours (Oslo). On certain routes the EV is an obstacle for public transport. We suggest that the Government should set restrictions on access to the public lanes during peak hours for EVs.
Free charging	Negative	Our findings indicate that this incentive is an obstacle for the development of charging infrastructure.
Free use of highway ferries	Medium	Effective in coastal areas where transport is dependent on ferry connections. A challenge we have identified is the dispute regarding who should bear the bill for this incentive since private companies operates the ferries and ticket revenue accrues to private operators.
Financial support to charging infrastructure	High	Transnovas support for the establishment of charging stations is of major significance to build up charging infrastructure. We have identified that access to charging stations is one of the most important instrument for limiting range anxiety. At the present time it is difficult to make profit without financial support to establishing charging stations. We suggest that the Government, through Transnova, should set stricter guidelines for those receiving financial support. Furthermore, the Government should strengthen Transnova as an organization and delegate more funding to Transnova the coming years.

6.1.1.1 Purchase price incentives

Policy incentives may be the dominant factor in driving Norway's leading position in the EV market. In the NEVA study the survey participants indicated that the financial incentives were significant factors in driving their purchase decision.

In addition to the direct subsidies that are provided through reduced taxes and fees, we identified another factor that may affect the future price of EVs. Development of battery technology has the potential to reduce the purchase price because EV batteries are currently the most expensive component in the EV. We have identified three factors that may affect development in battery technology: Research and development, mass production and learning effects including optimization of design, material and operations.

We find that it is in the Governments interest that the prices on EVs drop. If prices on EV batteries drop, the purchase price of EVs will drop, and the EV will be less dependent on financial subsides from the Government. At present time there is considerable uncertainty surrounding the development of battery technology, therefore we claim that long-term, consumer-oriented incentives are crucial to succeed regardless of which situation the battery technology is in. These findings are consistent with theory from Geels (2011) on socio-technical transitions, which claims that sustainable innovations cannot necessarily develop into a large market without changes in economic, policy and wider socio-cultural conditions. However, our search in the literary landscape of socio-technical transitions shows that there is a lack of theory on how long the government should subsidize new environmental friendly technologies. Historical events such as the EDF project in France[50] and EV1 in California are examples where attempts to commercialize the EV has been successfully until the government has withdrawn its subsidies. Consumers lost interest and the sale of EVs stagnated. It is important that this does not happen in Norway. Geels (2011) argues that technological innovations that contribute to solving environmental problems cannot develop into large market without support from policy makers because most sustainable innovations do not offer obvious user benefits. They often score lower on price and

[50] See section 2.1 – History of the EV in the global context for more information about the EDF project in France and EV1 in California.

performance and consumers needs incentives to adopt these technologies. We have identified that the major obstacle with EVs is limited range and high purchase price. We find that the Government can step up in two ways: 1. Support research and development so that the EVs obtain longer range and over time, lower price. 2. Give benefit related financial and operating incentives to eliminate high purchase prices and range anxiety. Since Norway no longer is involved in production of EVs we find it most effective to focus on incentives and development of infrastructure. Our recommendations means that the Norwegian Government must expand the financial incentives until the EV is competitive on price to similar ICE models. We cannot predict when this will happen, however according to research from Transnova it is estimated that prices on EV batteries will drop by 50 percent in 2020. Based on these calculations and responses from the interviews we have conducted we argue that the financial incentives should be extended until at least 2020.

6.1.1.3 Operating incentives

We have made various findings concerning the operating incentives. Some corresponding with the government's initial plan, while other findings indicate that the incentives may be a hindrance to the development of the EV Market. In this section we will discuss the findings we have made in a matter of courtesy to each incentive.

Exemption from toll

We find that the significance of the incentive giving exemption from toll is geographically dependent. Our research indicates that it is most significant for commuters who daily pass toll roads. 23 percent of the EV owners consider this incentive to be most influential as it represents a potential for significant financial savings for those who frequently pass toll booths. This is also an important incentive given that it accrues to users who are driving in major cities, where the challenge of pollution from transport is greatest. It is however important to note that EVs also contribute to worn paths. We therefore consider it to be appropriate that EVs have to pay for the use of roads. In the longer term we propose the introduction of a reduced rate for EVs. We want to emphasize that it should pay off to drive EVs. On the basis of this we suggest that the discounted rate should represent at least 50 percent lower price than the tariffs for ICEs. In sum this implies that the incentive should be maintained, but with reduced scope.

Access to public lanes

Access to bus lanes represents a potential of major time savings for those who commute to major cities like Oslo, Trondheim, Bergen and Stavanger. We consider this incentive to be an important driving force in the establishment phase, however we have identified an increasing problem because at current time there are so many EVs using the bus lanes that the bus lanes are filling up. Furthermore, a significant issue is that EVs are an obstacle to public transport, which leads to difficulties and irritation among commuters using public transport. A key question is therefore weather this incentive leads to more problems than benefits for traffic. EVs driving the bus lanes create irritation among commuters and bus drivers, which have led to a public debate in media. It can thus lead to a negative attitude towards EVs in general. Given that the government takes public debates in to account when they re-consider the incentives, we find that these debates may have a negative impact on the outcome of the entire incentive scheme. However, another factor to consider is that if all EVs loose access to drive in the bus lanes, it will lead to even more congestion in the regular lanes. We therefore propose a solution, which includes restrictions on driving in the public lanes. One alternative is to introduce a rule, which allows EVs to drive in public lanes if there are at least two people in the car. Another possibility is to place restrictions on certain routes, or hours. EVs may for example be denied access between 07-09 and 15 – 17, on the most heavily trafficked stretches.

Free ferries

Exemption from ferry tickets proves to be an effective incentive to promote EV adoption in coastal areas in Norway, where commuters are dependent on ferries. Numerous islands characterize the coastal areas, and ferries are a major expense for commuters. Our research indicates that free ferry has been a crucial factor, which has led to many “islanders” purchasing EVs. However, there is much uncertainty about how long this incentive will continue. We find a great potential in that more people will invest in EVs if a clearance on the extent of this incentive appears. As we previously have pointed on, it is an ongoing debate about who should take the bill for the free ferry incentive, as private companies operates the coastal ferries. We therefore propose that the state either must compensate for lost ticket income to the ferry operators. Another option is that the Government must clarify a long-term decision on this incentive so the ferry operators can calculate transport of EVs in their tenders. We consider free ferries will not be a determined factor for the overall EV stock, however we find it crucial to consider overall cost in relation to the number of EVs in the coastal areas.

Free parking

Our findings indicate that free parking is an effective measure in areas where parking is scarce such as in city centers. In particular for EV owners who does not have access to parking at work. An important factor is however that there are limited EV parking spaces available and this incentive has thus little impact on the total EV stock. Free parking is a good, which is visible to the public, and we find it to be an effective tool to demonstrate the benefits for driving electric. All ICE cars have to pay for parking, while the EV parked beside on the parking lot parks for free. We find that this is an incentive that should be extended to last even after 2017, however it is not of great importance for the overall EV stock.

6.1.2 Charging infrastructure

We have identified that there is a need for more fast charging stations to overcome range anxiety. The development of charging infrastructure is a crucial factor to increase the adoption rate of EVs in Norway. Broad access to charging stations limits range anxiety, which is ranked as the major disadvantage of EVs.

The key question is; what does the ideal charging infrastructure look like?

The majority of EV owners charge their EVs at home. We therefore find that the major demand for public charging involves fast charging stations where EVs can be charged to 80 percent of full capacity within 20 minutes. Fast charging is primarily needed for trips that go beyond everyday use, such emergencies or long distances. This suggests that fewer charging stations are needed per vehicle than ICEs, or that each charging station will serve fewer customers, which will raise the total cost of charging. The question if therefore whether the market is large enough to support multiple providers with competing stations? In order to answer this question we find that the demand for charging depends on several factors. We would like to emphasize three factors, which we consider as most significant:

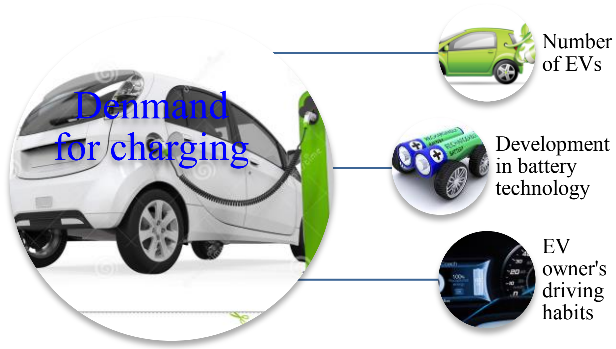


Figure 10 – Factors that constitute the demand for charging. Source: Own development

1. Number of EVs: The quantity of EVs depends on the future of the incentive scheme. The quantity of EVs sold in Norway is also dependent on access to charging stations. In this case we identify the "chicken and egg problem", what comes first? If the incentive scheme persists and Transnova maintain financial support for charging stations our findings indicates that the demand for charging will rise.

2. Development in battery technology. As our findings indicate, Norway has chosen to focus on development of infrastructure rather than research on battery technology to overcome range anxiety. This factor will therefore depend on research and development from foreign manufacturers. On the one hand, development in battery technology will lead to that the EVs can drive longer distances without charging. On the other hand, we find that if the EVs obtain longer range, more consumers will adapt EVs, which further will increase the demand for charging.

3. EV owner's driving habits. If the EV can replace ICEs the demand for charging will increase. This will occur if the EV is used for longer trips extending outside everyday use. By this we mean that the EV is the household's only vehicle. To promote this development, charging infrastructure is an important factor, and we can once again draw parallels to the "chicken and egg" problem.

A key challenge we have identified is that the EV market is growing too fast relative to the development of charging infrastructure. To develop sufficient charging infrastructure we argue that it is of great importance that CCIPs offers charging. By encouraging private operators to establish charging stations, the market is less dependent on public funded charging stations. We find a market potential in providing fast charging, and we argue that within a few years, it is possible to establish a profitable industry for fast charging. However, in an early-phase we find that the market for fast charging depends on financial subsidies from the Government. Interviews with CCIPs and NGOs shows that Transnova play a significant role in the development of charging infrastructure.

6.1.2.1 Standards

Our findings points out that there are too many different points and plugs, mainly within fast charging, and this creates a bottleneck in the development of the charging infrastructure. EU is currently favoring the Combo for DC fast charging, while Norway is favoring the Japanese CHAdeMO plug for fast charging. A challenge is whether or not Norway should establish a standard, wait for EU to legislate a standard or let the market decide. There are advantages and disadvantages with both, however there are little research on policy in regards to standards within the EV market and this would require a thorough analysis. Therefore, we recommend the Norwegian Government to investigate this area before making a decision on which one is the best. As a temporarily solution to overcome this challenge Transnova requires that all charging stations must be installed with three different charging points to reach out to the critical mass. However, we are critical to this solution as our findings indicates that this requirement may lead to that charging providers postpone the establishment of charging stations in anticipation of a default standard. Three charging points is more expensive to install than one, and leads to increased investment costs. We identify this as a political loophole. To overcome this we suggests that Transnova should set restrictions on the financial support, which requires the charging providers that receives funding to install the charging station within a certain time after they have received funding.

6.1.3 Suggestions for further research

Certain findings and realizations during our research of the Norwegian EV market led to thoughts around interesting topics and fields for further research. The first suggestion for further research is to research at the regional level and examine the differences between municipalities. Furthermore we argue that since Norway is a pioneer in EV development it is interesting to investigate whether the Norwegian incentive scheme is applicable to other countries. By utilizing our methods (emphasis on semi-structured interviews) when carrying out the research would allow the researcher to identify similar challenges and solutions. Alternatively, our methods to study the Norwegian EV market could be applied to investigate other parts of the EV market, such as the standard issue of the payment system. We realized during our research that there exists only a limited amount of evaluation reports and that there is no systematic research on the effects of the financial incentives of the EV policy. Through our research process another realization emerged as possibility for further research. It would be particularly interesting to investigate the potential for increasing the share of EVs in the public vehicle fleet and the corporate segment. Through our research process we find that there is a major potential for increasing the adoption rate of EVs in public car fleet.

7. Conclusion

We have conducted research through mainly interview driven investigations and the use of second-source qualitative data. Our findings are based on an empirical research of the Norwegian EV market, focusing on the involvement of the Norwegian Government.

To identify areas of interest and to answer our research question we have used theory on path-dependence (PD) and socio-technical transitions (STT). Furthermore, we applied the multi-level perspective (MLP), which is a framework for analyzing STT to sustainability. The MLP allowed us to systematize our findings on three levels (landscape, niche and regime), as presented in section 6, *Discussion*.

The Multi-Level Perspective

The Norwegian Government has set an ambitious climate goal, the 85g CO_2 target. To meet this target the Government depends on an increased amount of EVs in the vehicle fleet. This objective can be placed in the landscape level, and provides the basis for changes at the niche level and at the regime level. We have identified challenges at the niche level, which include how the Government should promote development of EV models even when Norway is not involved with the production. We identify that there is a lack of theory on this area. To do so the Government should make an effort to share experiences and establish a closer communication with foreign manufacturers in order to promote development of EVs, which is better suited for the Norwegian market. This includes EVs with increased range that can withstand Norwegian climate. Furthermore, we identify there is a need for more fast charging stations and a standardization of charging points. We will further elaborate on charging infrastructure and standardization of charging points below. At the regime level we have identified challenges regarding the incentive scheme, charging infrastructure, and long-term steering and commitment from the Government to the EV market. We will now outline our findings regarding these challenges.

The incentive scheme

As we previously explained, the incentive scheme is applicable until 2018. What happens next is hard to predict. However, based on our research, we have identified measures the Government can do to create a sustainable EV market.

On the matter of the incentive scheme we concluded that changes occurring after 2017 should happen in a predictable manner. A long-term steering plan and commitment by the Government reduces uncertainty about the EV benefits, which we have identified as a potential barrier to the EV market. We find that the Government should implement immediate action regarding the future of the incentive scheme. This might prevent customers from postponing the purchase EVs and CCIPs from delaying planned investments in charging stations in pending clearance for what will happen to the EV benefits. Furthermore, we emphasize that they should not consider the incentive scheme as a whole but consider the effect of each incentive individually. It is unfortunate if negative effect of one incentive causes the whole incentive scheme to be removed. We therefore propose a modulation model in which to develop, improve and change single incentives.

In Table 13 we presented our evaluation of the effect and importance of the policy incentives. We find that exemption from registration fee, reduced annual fee and exemption from VAT is of high importance. These incentives reduce the purchase price of EVs and allow the EV to be price competitive to similar ICE models. Our interviews show that the majority of respondents believe that the purchase price of EVs will drop towards 2020. Transnova have calculated that the cost of EV batteries will drop by 50 percent in 2020, and EV manufacturers have announced that they will launch a model, which is significantly cheaper in three to four years. Therefore, we conclude that the Government should maintain the financial incentives, which include exemption from registration fee, reduced annual fee an exemption from VAT, until 2020.

Access to public lanes

Access to bus lanes represents a potential of major time savings for those who commute to major cities like Oslo, Trondheim, Bergen and Stavanger. We consider this incentive to be an important driving force for the early-adopters of EVs. However, we have identified an increasing problem because at current time there is too many EVs using the public lanes that they are are filling up. Furthermore, a significant issue is that EVs delays public transport, which leads to difficulties and irritation among commuters using public transport. A key question is therefore weather this incentive leads to more problems than benefits for traffic. EVs driving the bus lanes create irritation among commuters and bus drivers, which have led to a public debate in media. It can thus lead to a negative attitude towards EVs in general. Given that the government takes public debates in to account when they re-consider the incentives, we find that these debates may have a negative impact on the outcome of the entire incentive scheme. However, another factor to consider is that if all EVs loose access to drive in the bus lanes, it will lead to even more congestion in the regular lanes. We therefore propose a solution, which includes restrictions on driving in the public lanes. One alternative is to introduce a rule, which allows EVs to drive in public lanes if there are at least two people in the car. Another possibility is to place restrictions on certain routes, or hours. EVs may for example be denied access between 07-09 and 15 – 17, on the most heavily trafficked stretches.

Free ferries

Our research indicates that free ferry ticket has been a crucial factor for EV owners living in the coastal areas in Norway. However, there is uncertainty, as with the other incentives, around the future of the incentive. We believe that more people will invest in EVs if a clearance on the extent of this incentive appears. There is an ongoing debate about who should pay for the free ferry ticket incentive, the private companies which operates the ferries or the Government. We recommend that the Government should either compensate for lost ticket income to the ferry operators or clarify the future of the incentive so the ferry operators can calculate transport of EVs in their tenders.

Free parking

Our findings indicate that free parking is an effective measure in areas where parking is scarce such as in city centers. However, this incentive has little impact on the total EV stock due to limited parking spaces. We perceive free parking to be an effective tool to demonstrate the benefits for driving electric and argue that the Government should extend it after 2017, even though it is not of great importance for the overall EV stock.

Exemption from toll

The exemption from toll is geographically dependent. Our research demonstrates that it is most significant for commuters who daily pass the toll. For 23 percent of the EV owners it represented a significant financial saving and they stated this incentive as the most influential. However, it is important to note that EVs also contribute to worn paths. Therefore, we consider it to be appropriate that EVs have to pay for the use of roads in the long run. The Government should in the future implement a reduced rate for EVs, at least 50 percent lower than the tariffs for ICEs.

Charging stations

We find that there is a shortcoming of charging stations, mostly fast charging, in order to overcome range anxiety. Broad access to charging stations limits range anxiety, which is ranked as the major disadvantage of EVs. The fact that the EV market is not growing in proportion with the development of the charging infrastructure, on one of the key challenges that we have identified. We therefore argue that it is of great importance that CCIPs invest in the establishment of charging stations. Due to high investment costs and uncertainty about demand, CCIPs are largely dependent on financial support from Transnova. We therefore argue that the Government should strengthen Transnova by increasing their financial support to development of charging infrastructure, such as investments in R&D.

We discovered that there is a lack of standard points, which generates a bottleneck in the development of the charging infrastructure. Transnova is partly, though unwillingly, involved in this because they require that CCIPs must install three charging points, so the charging station serve as many EVs as possible. This has lead to several CCIPs postponing the establishment of the charging stations. On this basis we argue that the Government, through Transnova, should introduce a restriction that says that the charging station must be established within a certain period after the CCIPs have received funding. Furthermore, the Government should, before deciding on facto de standard or mandate standard, research which of the options are most beneficial for the EV market. In respect to free public charging, we found that the EV end users perceived this incentive as less important and something most of our EV end user interviewees are willing to pay for. Additionally, we identified a discrepancy between the opinion of the Government/municipalities and EV end users in respect to free public charging. First of all, this incentive is an unnecessary cost for both for the municipality and the Norwegian Government, since the EV end-users are willing to pay for charging. Second, it is said to destroy competition. Municipalities still offer free charging, which may result in CCIPs being reluctant to invest in charging stations. EV end-users will naturally choose free charging over paid charging. Transnova has already stated that all actors how apply for subsidizes must charge their customers. In addition, the Government should implement measures to meet this challenge.

8. Acronyms and Abbreviations

BEV – Battery Electric Vehicle

CARB – California Air Pollution Resources Board

CBS – Copenhagen Business School

CCIP – Commercial Charging Infrastructure Providers

CCS – Carbon Capture and Storage

CO_2 – Carbon Dioxide

ECCP – The European Climate Change Program

EDF – French Electric Utility

EEA – European Economic Area

EFTA – European Free Trade Association

ETS – Emission Trading System

EU – European Union

EV - Electric vehicles

GHG – Greenhouse gas

GM – General Motors

HEV – Hybrid Electric Vehicle

ICE - Internal Combustion Engine

KW – Kilowatt

KM - Kilometer

MCE – The Ministry of Climate and Environment

MF – The Ministry of Finance

MLP - Multi-level Perspective

MTC – The Ministry of Transport and Communication

NEDC – New European Driving Cycle

NEVA – The Electric Vehicle Association

NGO – Non-Governmental Organization

NOK – Norwegian Krone

PD – Path Dependence

R&D – Research and Development

STT – Social Technical Transition

ULCV – Ultra Low Carbon Vehicle

VAT – Value-Added Tax

ZERO – Zero Emission Resource Organization

ZEV – Zero Emission Vehicles

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10. Appendices

Appendix 1 – Interview Topics and Questions for EV end users

Advantages/Disadvantages:

- What do you see as the major benefits of having an EV?
- What do you see as the main disadvantages?
- What are the main reasons why you decided to buy an EV?

Incentives:

- Have the incentives from the Government directly influenced you to purchase an EV?
- If yes, what were the most important ones?
- Are any of the incentives less important?
- Are you worried that the government will remove some of the incentives that are important to you?

Usage:

- Is the EV car number 1 or 2? What do you use the EV for? What do you use the ICE for?
- Does the EV cover you transportation needs?
- Why was the EV an option when you bought a new car?
- What was important to you when you bought the EV? (Brand, environment, price, ect.)
- How important is access to charging stations for you? Are you satisfied with the current arrangement?
- How many times per day do you charge your EV?
- How far do you drive on average per day?

- Do you use the EV more in the summertime than during wintertime?

Other:

- How satisfied are you with the EV? Hypothetically speaking, what kind of car will your next car be?
- What do you think about the future of EVs in Norway, based on the Government's action plan?

Appendix 1a – Original Set of Interview Topics and Questions (Translated)

1. **Initial Introductory Questions**

- What is your job?
- What is your connection to the Norwegian EV market?
- Do you own an EV?

2. **EV Specific Questions**

EV Producers/Commercial Charging Infrastructure Providers	Policy Makers	NGOs
What are your views on the future plan for the government incentives for EVs?	Do you have any thoughts about what is the future plan for the government incentives for EVs?	What are your views on the future plan for the government incentives for EVs?
Which changes do you believe will occur after 2017 and how will this affect the Norwegian EV market?	What do you think might happen after 2017, or when the number of EVs reaches 50 000 and in what way do you think this will affect the Norwegian EV market?	Which changes do you believe will occur after 2017 and how will this affect the Norwegian EV market?
Do you see any other changes coming up and how will this affect the EV market?	Is the Government planning to phase out any incentives before 2017 or when the number of EVs reaches 50 000 and which ones?	Do you see any other changes coming up and how will this affect the EV market?
Which incentives do you think will be the first one to be removed? Do you have any thoughts about the priorities?	Which incentives do you think will be the first one to be removed? Do you have any thoughts about the priorities?	Which incentives do you think will be the first one to be removed? Do you have any thoughts about the priorities?
What was your role when the Government made the incentives? Did you collaborate with the Government?	To what extent did the Government take the customers into consideration when the incentives were made?	What was your role when the Government made incentives? Did you collaborate with the Government?

How do you collaborate with the Government in the plan of phasing out the incentives?	How does the Government include EV producers or NGOs in the plan of phasing out the incentives?	How do you collaborate with the Government in the plan of phasing out the incentives?
From a customer perspective - which incentives do you believe has affected the sales numbers the most?	To what extent does the Government include customers in the plan of phasing out the incentives? Which incentive do you think is the most influential on customers? Do you think that is a typical view among your colleagues? Or are there any other perspectives?	From a customer perspective - which incentives do you believe has affected the sales numbers the most?
Are the incentives meeting you expectations? Are there changes you would make in retrospect? Are you satisfied with the development?	Are the incentives meeting you expectations? Are there changes you would make in retrospect? Are you satisfied with the development?	Are the incentives meeting you expectations? Are there changes you would make in retrospect? Are you satisfied with the development?
Do you collaborate with the Government in R&D?	Does the Government collaborate with manufacturers in research and development?	How do you collaborate with EV producers? And whom do you collaborate with?
Were you involved in the process of making the incentives?	How did the Government take the EV producers into consideration when the incentives were made?	Were you involved in the process of making the incentives?
Are there other incentives you think should be implemented? Ex to manufacturers, hotels, ferries etc.	Have you considered giving incentives to others? Ex hotels, producers and ferries?	Are there other incentives you think should be implemented? Ex to manufacturers, hotels, ferries etc.
How do you work to improve the infrastructure to EVs?	How does the Government work to improve the infrastructure for EVs?	How do you work to improve the infrastructure for EVs?
Which organizations do you collaborate with?	Which organizations did you think about when the incentives were made? Ex NEVA?	Which organizations do you collaborate with?

What is your role in the communication between the Government and customers?		What is your role in the communication between the Government and customers?
What are the main challenges for the future of the EV market in Norway?	What are the main challenges for the future of the EV market in Norway?	What are the main challenges for the future of the EV market in Norway?
What would you dream scenario with regards to the EV market look like?	What would you dream scenario with regards to the EV market look like?	What would you dream scenario with regards to the EV market look like?
What kind of connection do you see between people's environmental awareness and buying an EV?	What kind of connection do you see between people's environmental awareness and buying an EV?	What kind of connection do you see between people's environmental awareness and buying an EV?
What do you believe to be the main concern that EV end users? What causes you to think that is an issue?	What do you believe to be the main concern that EV end users? What causes you to think that is an issue?	What do you believe to be the main concern that EV end users? What causes you to think that is an issue?
What is your opinion about the incentives? What should the Government do?	What is your opinion about the incentives? What should the manufacturers/NGO´s be doing?	What is your opinion about the incentives? What should the manufacturers/Government do?
What keeps you awake at night?	What keeps you awake at night?	What keeps you awake at night?
What do you do to overcome the "range anxiety" among current and potential customers? Is there a different between current and potential customers?		What do you do to overcome the "range anxiety" among current and potential customers? Is there a different between current and potential customers?
What kind of positive and negative feedback do you get from your customers?		What kind of positive and negative feedback do you get from your customers?
What do you think about the future pricing for EVs in Norway?	What do you think about the future pricing for EVs in Norway?	What do you think about the future pricing for EVs in Norway?

If the incentives are being phased out, will the EV market crash? Or is this a market that will stay? What does that depend on? What would make it die? What would make it live?	If the incentives are being phased out, will the EV market crash? Or is this a market that will stay? What does that depend on? What would make it die? What would make it live?	If the incentives are being phased out, will the EV market crash? Or is this a market that will stay? What does that depend on? What would make it die? What would make it live?

3. **CCIPs Specific Questions**

- Can you tell us about your investment in charging stations?
- Why have you chosen to invest into this market?
- What has the support from Transnova meant for you? Was the support a determining factor and how much do Transnova contribute with?
- Are you planning to increase the investment on charging stations?
- What role will Transnova play in the possibly development of more charging stations?
- Which income opportunities are there with charging stations?
- What opportunities and challenges are there in connection with the establishment of charging stations?
- What feedback do you get from customers?
- What do you feel about municipalities are offering charging for free?
- What challenges do you see in relation to standardization of charging points and plugs?
- How is your collaboration with NGOs?
- What do EV end users pay for charging?
- The situation has changed for the EV. Now there are an increased number of EVs on Norwegian roads. What impact does this have on future investments?
- Could you tell us about the process of establishing charging stations?

Appendix 1b – Revised Set of Interview Topics and Questions (Translated)

1. **General Questions**

- **Job/role**
- **Relation to the EV industry**

NGO specific questions:

- How does media affect your job?
- In which ways do you work to encourage the media to write more about EVs?
- To what extend have the Norwegian EV policy affected the success in Norway?
- What do you think will happen after 2017, and how do you think it will affect the EV market?
- Are there any other incentives you believe should be implemented?
- How long do you think the incentives should last in order to create a sustainable EV industry?

- Which incentive do you consider to be most important?
- Who do you consider to be the most important actors in the EV industry?
- What do you consider to be the major challenges of the EV market today?
- What do you think about the future prices on EVs?
- What do you think about the future for EVs in Norway?
-

Retailer specific questions:

- Do you find that many of your customers change from ICEs to EVs?
- What is the most important criteria's for your customers when they consider to purchase an EV?
- Which changes do you believe will occur after 2017, and how will these changes affect the EV market?
- Which incentive do you consider to be most important for you as a retailer?
- What do you consider to be the main challenge for the Norwegian EV market?
- What do you consider to be the main challenge for you EV customers?
- What do you think will happen with the EV prices?
- Limited battery range is a challenge for EV owners today. What do you think will happen to the EV batteries the next years?
- What is needed to establish a sustainable EV market in Norway ?
- From a customer perspective – which incentive has affected the sales numbers the most?
- What kind of feedback do you receive from customers that have shifted from ICEs to EVs?
- What do you believe will happen in the future for EVs in Norway? Do you consider the EV market to be sustainable?

Appendix 2 – A Complete Table of the Costs for Different Types of Charging Points[51]

Type of Charger	Charging Power	Standard	Price of Charger	Other Establishment costs	Annual operating costs excluding energy costs
Basic Charger	< 3,6 kW	Mode3 Type 2	NOK 8,000-15,000	NOK 3,000-8,000	< NOK 1,000
Flexible Charger AC*	< 22 kW	Mode3 Type 2	NOK 50,000	NOK 7,000-40,000	NOK 1,000-5,000

[51] The price of chargers in Table 1 reflects the pricing currently obtained from actors in the market. It is possible that the prices will fall as a result of technological development and increased production volumes. Price reductions of any such are not included in the cost estimates (Solem, Jonsen, & Nørbech, 2014).

Flexible Charger DC	< 22 kW	CHAdeMO, eCombo	NOK 100,000-200,000	NOK 7,000-40,000	NOK 1,000-5,000
Multi-Standard Flexible Charger	< 22 kW	CHAdeMO, Combo, Mode3 Type2	NOK 225,000	NOK 100,000-250,000	NOK 40,000-50,000
Fast Charger, Single Standard	< 50 kW	CHAdeMO, Combo,	NOK 120,000-200,000	NOK 200,000-400,000	NOK 40,000-50,000
Multi-Standard Fast Charger	< 50 kW	CHAdeMO, Combo, Mode3 Type2	NOK 300,000	NOK 200,000-400,000	NOK 40,000-50,000
Super Fast Charger	> 50 kW	Combo	NOK 250,000	NOK 200,000-400,000	NOK 40,000-50,000

Appendix 2 – A Complete Table of the types of charging different EVs can use.

Brand and Type		Point AC	AC 3,6 kW	AC 7,2 kW	AC 11 kW	AC 22 kW	AC 44 kW	CHAdeMO	Combo
BMW i3		2	S	A	-	-	-	-	A
Citroën Berlingo		1	S	-	-	-	-	S	-
Citroën C-ZERO		1	S	-	-	-	-	S	-
Ford Focus Electric		1	S	S	-	-	-	-	-
Mitsubishi i-MiEV		1	S	-	-	-	-	S	-
Nissan e-NV200		1	S	A	-	-	-	S	-
Nissan LEAF I	Until June 2013	1	S	-	-	-	-	S	-
Nissan LEAF II	From June 2013	1	S	A	-	-	-	S	-
Peugeot iOn		1	S	-	-	-	-	S	-
Peugeot Partner Electric		1	S	-	-	-	-	S	-
Renault Kangoo ZE		1	S	-	-	-	-	-	-

Renault ZOE	Norway 2014	2	S	S	S	S	S	-	-
Smart fortwo electric		2	S	A	A	A	-	-	-
Tesla Model S		2	S	S	S	A	-	-	-
Tesla Model X		2	S	S	S	A	-	-	-
VW e-Golf	Spring 2014	2	S	-	-	-	-	-	S
VW e-up!		2	S	-	-	-	-	-	S