UiT

THE ARCTIC
UNIVERSITY
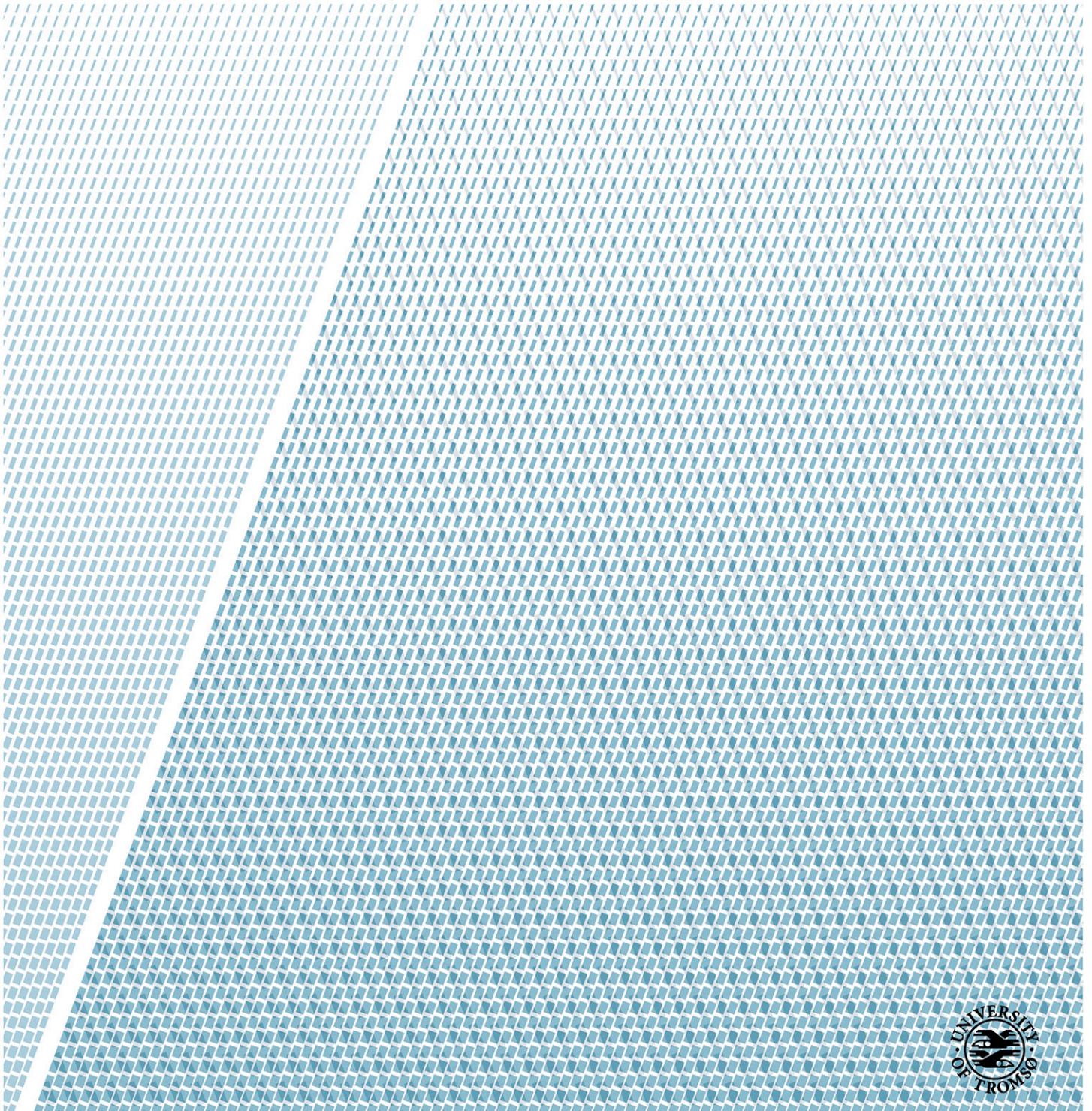OF NORWAY

The School of Business and Economics

Electric vehicles in Norway: a cost-benefit analysis

—

Truls Jarle Johnsen
Master thesis in Economics - June 2015

Preface

The choice of topic for this thesis originates from a genuine interest in cars and a personal curiosity for the recent development of electric vehicles. Writing this thesis has been an enjoyable and challenging journey, and in retrospect I am utmost grateful to be provided with the opportunity to do a comprehensive immersion into such an exciting and complex subject. The whole process has left me with extensive and valuable knowledge regarding all of the aspects about electric vehicles. I found it rewarding to contribute with further findings from a socioeconomic perspective regarding a topic of such current relevance as electric vehicles.

First and foremost, I would like to thank my supervisor, Tapas Kundu, for constructive and helpful input along the way. I would also like to express my appreciation to all the people that have helped me with varying inquiries regarding this thesis, as well as the people that helped me with proofreading. At last, I would like to thank my fellow students for an academic and supportive environment.

Tromsø, 1. June 2015

Truls J. Johnsen

Abstract

Increased global awareness to climate change, global warming and CO_2-emissions, has led to the introduction of new modern electric vehicles in the last couple of years, such as the Nissan Leaf and Tesla Model S. This combined with tax exemptions and incentives have made the sales figures for electric vehicles in Norway to skyrocket.

This research looks at the socioeconomic effects between the procurement and use of an electric vehicle compared to a conventional vehicle under today´s policy measures. In order to get a sufficient comparison between electric and vehicles the cost-benefit analysis was chosen. The cost-benefit analysis was done in three separate scenarios, where each scenario included different variables. This was done in order to see which impact each of the variables had, and in turn evaluate the policy measures and results based on this.

With the assumption that an electric vehicle has a lifetime of 14 years and an annual driving distance of 13.000, the marginal socioeconomic net present value was estimated to be 262.956 NOK for choosing an electric vehicle instead of a conventional vehicle, given today´s policy measures throughout the lifetime. The estimated cost-benefit model showed that the difference in the marginal net benefit in the private costs of owning an electric vehicle compared to a conventional vehicle had a big impact on the results. The greater the difference was the more socioeconomic beneficial the electric vehicle became compared to the conventional vehicle.

For future policies it was recommended that policy measures toward road transportation should aim at making the use of vehicles a more costly choice compared to public transport, walking or cycling than they are today. At the same time make sure that the private costs of electric vehicles are significantly less than for the conventional vehicles.

Keywords: Electric vehicles. Cost-benefit analysis. Incentives. Tax exemption.

Table of Contents

List of tables and figures

List of abbreviations

CO_2	Carbon dioxide
NO_x	Nitrous oxide
PM	Particulate matter
GHG	Greenhouse gases
LDV	Light-duty vehicles
ICEV	Internal combustion engine vehicle
PHEV	Plug-in hybrid electric vehicle
HEV	Hybrid electric vehicle
NEDC	New European Driving Cycle
NPV	Net present value
BE	Breakeven
MNB	Marginal net benefit

1. Introduction

1.1 Motivation and background

Over the last couple of years there has been a significant increase in the number of electric vehicles on the Norwegian roads. The situation today is that the number of electric vehicles on Norwegian roads have passed a total of 50.000, and is close to reaching a 2% share of the car fleet in Norway [1]. Further, in 2014, 12,5% of the passenger vehicles sold in Norway were fully electric vehicles [2]. The increased number of electric vehicles in Norway can be explained by the introduction of multiple new electric vehicles such as the Nissan Leaf and Tesla Model S. The reason for the success of this new generation of electric vehicles can be explained by better driving range and new vehicle design.

The introduction of the new generation of electric vehicles combined with increased global awareness to climate change, global warming and CO_2-emissions has also resulted in a global growth in the electric vehicle market. In 2014, approximately 70 million new passenger cars were sold in the world [3]. Out of these 70 million new vehicles, 320.000 (ZSW 2015) were plug-in electric vehicles, equivalent of 0,5%. The biggest importers were USA, China and Japan and with Norway as the fourth biggest importer of electric vehicles (ZSW 2015). Although Norway was the fourth biggest importer, when comparing the share of electric vehicles with the total car fleet or per capita, Norway is the market leader and considered a pioneer in the field. The main reason Norway has such a high market share of electric vehicles compared to other countries are related to the Norwegian policies towards electric vehicles. In Norway electric vehicles are given tax exemptions and incentives associated with procurement and use. Other countries also give incentives and have taken measures to increase the use of electric vehicles. According to the International Energy Agency (IEA, 2013) it is mostly a form of tax credit received with procurement of an electric vehicles, and it is not considered to be comparable to the Norwegian policy measures.

The last year's drastic increase in the number of electric vehicles has truly caught the attention of the public eye in Norway, with substantial media coverage and discussions about the measures. This has raised some interesting questions such as:

- How much has the Norwegian government lost in tax revenues by giving tax exemptions and incentives to electric vehicles?

- Are electric vehicles better for the environment than conventional vehicles?
- When should the policy measures be removed?

In order to evaluate the incentives and tax exemptions given to electric vehicles in Norway a cost-benefit analysis was chosen. The main reason for this is that the cost-benefit analysis identifies and describes all the positive and negative effects of a given measure. All the effects should be evaluated in a monetary unit as far as possible, which will help make for a solid foundation for further decision-making (NOU, 2012).

1.2 Problem formulation

The objective of this thesis is to evaluate the socioeconomic effects of the Norwegian governments policies towards the procurement and use of electric vehicles compared to conventional vehicles in Norway. In order to find out if electric vehicles are a socioeconomic beneficial choice compared to conventional vehicles we will be using a cost-benefit analysis.

Electric vehicles come in many different forms and shapes and we usually distinguish between three types of EVs. It is the fully battery electric vehicle (BEV), which is driven solely by electric power. Second is the hybrid electric vehicle (HEV), which has both an electric and combustion engine. Last is the plug-in hybrid (PHEV), which also has an electric and a combustion engine as the HEV. The difference is that the PHEV can charge its electric engine from an external electric power source. The fully battery electric vehicle is given different policy measures than both of the hybrid electric vehicles, and since this research will be comparing the fully battery electric vehicle with the internal combustion engine vehicle, both HEVs and PHEVs are excluded from the estimation. For simplicity here on out, EV will refer to the fully battery electric vehicle alone. The internal combustion engine vehicle, which essentially petrol- and diesel driven vehicles in Norway, will be referred to as ICEVs.

1.3 Literature

There exists a substantial amount of literature associated with cost-benefit analysis. Multiple reports and guidelines are prepared by different governmental agencies, such as the guidelines from the Treasury of Norway (Finansdepertement, 2014)**.** The Norwegian directorate of financial management has also published a guideline on how to conduct an economic analysis (DFO, 2014) with the use of NOU (1998), NOU (2012) and Finansdepertement (2014). The Institute of Transport Economics published a report about the marginal external costs of road transportation (Thune-Larsen, Veisten, Løvold Rødseth, & Klæbøe, 2014), which include

estimates for the marginal damage of local air pollution caused by road transportation. To find the cost of climate change associated with road transportation I use "Update of the Handbook on External Costs of Transport", see Korzhenevych et al. (2014).

There are limited studies regarding socioeconomic analysis of electric vehicles in Norway. Carlsson and Johansson-Stenman (2003) did a cost-benefit analysis about electric vehicles in Sweden. In this one of the purposes was to find out if it was beneficial to promote the introduction of electric vehicles by subsidizing them.

1.4 Disposition/outline

This thesis is outlined in the following way: chapter 2 is a presentation of theory about the topic. That includes everything from climate change to the Norwegian policies that are considered relevant for this thesis. Chapter 3 is about the cost-benefit analysis, containing general information about socioeconomic and cost-benefit analysis. Further, the derivation of the cost-benefit model and a description of data are presented. In the last section of this chapter, different assumptions will be taken and the valuation of the cost and benefits will be explained. In chapter 4 the results will be presented, followed by an uncertainty analysis regarding the cost-benefit model. After that, non-monetized side effects of the policy measures and other external effects regarding the policymaking are discussed. Chapter 5 is the last chapter, and it contains a discussion of results and a recommendation on future development of the policy measures, based on the results from the CBA and the external effects.

2. Background

This chapter contains background information of climate change and global warming, and how this has affected and formed the policy measures that are valid for electric vehicles in Norway today.

2.1 Climate change and global warming

Climate change and global warming have become increasingly more discussed in the public debate over the last decade, and have become important topics to consider for the policy makers around the world. Climate change refers to all changes in the climate, from sea level rise, warming oceans, shrinking ice sheets, declining arctic sea ice, glacial retreat, extreme weather, ocean acidification, decreased snow cover and global temperature rise. Global warming is a part of the climate change, and it basically indicates the average temperature rise for the Earth´s climate system. An important thing to remember discussing climate change and global warming is that it is measured on a global scale. Climate change and global warming cannot be specified to only a state, region or country, it is the average for the whole world that is the correct measurement.

Observations over the last decades and centuries imply that climate is changing. The evidence is based on the increment in sea levels, shrinking glaciers and ice sheet, and rise in temperatures of both air and sea [4]. There are some disagreements if the climate changes are caused by human activities or if they are just a part of earth´s evolutionary process.

However, according to the fifth report from the Intergovernmental Panel on Climate Change (IPCC, 2014) there is at least 95% chance that the human-emitted greenhouse gases (GHG) are responsible for more than half of the Earth´s temperature increase since 1951. A graphical illustration of the temperature anomalies with data from four international science institutions over the last century is shown in appendix 1. From this illustration we can see that there has been significant increase over the last few decades and that the last decade is the warmest on record [5]. According to the European Commission to prevent potential severe climate changes, the average global warming should not exceed 2 degrees Celsius compared to the pre-industrial temperature average [6].

2.1.2 Greenhouse gases and CO_2 emissions

There is reason to believe that these trends of global warming are due to the expansion of the "greenhouse effect" caused by human made activity. The reason it is called the "greenhouse effect" is that the GHG that is released into atmosphere creates a layer inside the atmosphere. When sunlight passes through the atmosphere the first time and hits the earth´s surface, it is radiated back towards space. The outgoing radiation is then trapped in the layer of GHG in the atmosphere and re-emitted towards the earth. This causes the sunlight to warm the earth´s surface two times; hence a good illustration of this layer of GHG is to think of it as thermal blanket covering the earth [7].

The most significant gases that contribute to the greenhouse effect are water vapour (H_2O), nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2). These gases have varying roles in the atmosphere since they have different properties and will react/respond physically or chemically differently to changes in temperature.

CO_2 is, as mentioned, one of the greenhouse gases, and it is emitted into the atmosphere from many different sources, such as natural processes like respiration and volcano eruptions, as well as human made activity such as, burning of fossil fuels and deforestation. From appendix 2 we see the development of carbon dioxide in the atmosphere over the last 400.000 years. The data used to construct the figure is reconstructed from ice cores from the last three glacial cycles [8] and it is clear to see that the levels of CO_2 in the atmosphere have increased drastically during the last century.

2.1.3 Road transportations role

In 2010 road transportation amounted to 10,2% of the global GHG emissions (IPCC, 2014a). Out of EU´s total emissions of CO_2 in 2012, road transportation was responsible for approximately 25%. That was 20,5% higher than the emissions for 1990, and road transportation is the only sector where the emissions of GHG still are increasing [9]. Passenger vehicles are the main contributor to emissions from road transportation, and they amounted to 75% of the emissions. Hence, the total CO_2 emissions from passenger vehicles of EU´s total CO_2 emissions are 15%. In Norway road transportation accounted for approximately 19% of the total GHG emissions, behind the oil- and gas sector and the industry- and quarrying sector in 2014 [10].

The road transportation sector is not the most polluting sector in the world, EU or in Norway, but the main concern regarding emissions from road transportation is the growth in the global transport sector. The global vehicle fleet is estimated to double or even triple in the coming decades according to United Nations Environment Programme (UNEP, 2013). 90% of the growth is from non-OECD countries. The main problem with this big growth of vehicles in non-OECD countries is that the average fuel efficiency is worse than in OECD countries as well as the fuel economy policies in these countries are few and poorly regulated compared OECD countries.

Considering that burning of fossil fuel is one of the biggest contributors to CO_2-emissions and that almost 95% of all the energy that is used for transportation comes from petroleum-based fuels, such as petrol and diesel [11]. A logical approach to a reduction of CO_2 emissions in the transport sector will be to make vehicles that are not based on the usage of fossil fuels. The production of modern EVs is a direct result of this.

2.2 The Norwegian policies towards electric vehicles

As a result of climate change and global warming, reducing CO_2 emissions have become a central part of politics, and an important aspect to consider for policy makers around the world. Climate change is as mentioned above, not specified to a specific region or country, it is a global event. The United Nations (UN) is aware of this and is trying to put together an international climate change agreement that will involve all countries [12].

In addition to global climate agreements, the Norwegian government has agreed on different climate goals for the future. The agreement is called "Klimaforliket 2012" and the following points are the most relevant to transportation and electric vehicles. First, Norway as obliged to reduce 30% of GHG emissions equivalent to 1990 emissions by the end of 2020. Out of these emission reductions, 2/3 has to be taken in Norway, implying that only 1/3 of emissions can be reduced with buying carbon offsets. As part of an ambitious global climate agreement Norway has a binding target of climate neutrality latest in 2030. It means that Norway must ensure emission reductions equivalent to Norwegian emissions in 2030. Last, Norway is going to be carbon neutral in 2050 (Energi- og Miljøkomiteen, 2011).

Some of the general principles of the Norwegian transport policies are to stimulate use of more environmentally friendly fuel and energy sources, get a faster turnover of the car fleet

by reducing taxes, secure long-term transparency regarding the tax policies for vehicles and when it comes to average emissions of passenger vehicles it should be less than 95g CO_2/km by 2020, the same goal as EU (Energi- og Miljøkomiteen, 2011).

As a results of global climate agreements in the 1990´s, such as the United Nations Framework Convention on Climate Change (UNFCC) in 1992 [13], Norway started to implement incentives and tax exemptions for the use and procurement of zero-emission vehicles in Norway. Since the following measures only apply to zero-emissions vehicles, they are only applicable to fully battery electric vehicles, hence the reason for excluding hybrids in this analysis. The governmental measures are as follows (Figenbaum and Kolbenstvedt, 2013):

- Exemption of excise duty
- Exemption of VAT
- Reduced annual fee
- Halved company car taxation
- Financial support to building of charging stations
- Reserved EL number plates

Here are the municipal and local measurers and incentives applicable to EVs in Norway (Figenbaum and Kolbenstvedt, 2013a):

- EVs are allowed to drive in bus lanes in certain selected areas
- Free public parking
- Free passing on toll-roads and ferries

Each of these measures affects the procurement and use of EVs in different ways. The exemption of excise duty and VAT is intended to reduce the purchase price of EVs, making them a less expensive alternative to ICEVs. Other measures reduce the costs of using the EV, in order to make EVs less costly to use compared to ICEVs.

2.3 Revised national budget

In the revised national budget (12.05.15) a complete evaluation policy about passenger vehicles was done, and the future development of policies was presented [14]. The measures

and incentives mentioned above will remain untouched until at least 2017. However, after 2017 the incentives for EVs in Norway are determined to be phased out.

The plan is that the annual fee for EVs will be half of what ICEVs pay in 2018, and from 2020 they will be equal. They are considering replacing the exemption of VAT for a premium that will be scaled down and eventually phased out over time.

The government has started a process that will allow the municipalities to have a bigger influence and saying in what that is going to happen to the local measures such as access to bus lanes, free public parking and access to public charging stations.

The government also wants to change the rates for the different components in the excise duty, in order to stimulate more environmentally friendly choices in terms of vehicles. The goal is to eventually phase out the kW-component as well as reducing the weight-component. At the same time the CO_2-component will progressively increase in conformity with the reduction of the kW and weight. The NO_x-component will also remain, and it will increase in the same way as the CO_2-component. They expect that these changes will lead to lower revenues from the sales of new vehicles, but it will reduce the emissions from the car fleet as well as increase the sales of new vehicles. The Norwegian government will gradually start to implement these changes into the different components from 2016. This will only affect ICEVs at first, since EVs are exempted the excise duty until 2020.

Climate change and global warming has lead to many climate agreements with the main goal of reducing the GHG emissions. A big part of reducing the GHG emissions is to reduce the CO_2 emissions from the transportation sector. This increased climate awareness and focus on reducing CO_2 emissions has resulted in a new generation of EVs from the car industry. The combination of this and the policy measures towards EVs in Norway has resulted in a drastic increase in the number of new EVs on the Norwegian roads. This is vital information in order to understand and evaluate the socioeconomic effect of the policy measures and to compare electric and conventional vehicles in Norway in the following sections.

3. The Cost-Benefit Analysis

This chapter starts with a general review of socioeconomic analyzes and a cost-benefit analysis. This is followed by the derivation of the cost-benefit model, general assumptions and a description of data used in the analysis. The last section of this chapter contains the valuation and estimations of the components used in the cost-benefit analysis.

3.1 Socioeconomic analysis

The intention behind the use of a socioeconomic analysis as a tool is essentially to find out if government measures are socioeconomically beneficial or not. The socioeconomic analysis will help to identify and create visibility for the effects caused by the governmental measures, and how such a measure affects the different groups of the society (DFO, 2014). It can be used to evaluate regulations, investments, reforms, provision of services, or other measures, within all the sectors of the society (Finansdepartementet, 2014). Therefore, by conducting the socioeconomic analysis, it becomes a tool to use as a part of the decision making with other reports and consultative inputs.

A socioeconomic analysis is not limited to only a cost that affects a public sector or public funding. The whole idea is to map out and elucidate all groups of society that are affected by a given measure, like changes in welfare or relocation of resources (DFO, 2014). For this thesis the analysis will be limited to the Norwegian society.

There are distinguished between three types of socioeconomic analysis:
- A cost-effectiveness analysis is usually applicable when a substantial amount of the consequences can´t be measured in a monetary unit. The problem of converting consequences into a monetary unit often comes from the beneficial aspect, and in such cases it will be more appropriate to use a cost-effectiveness analysis compared to a cost-benefit analysis. The main goal for a cost-effectiveness analysis is to find what measure will minimize the costs of reaching a target, given that the benefits of the measurements are the same. (NOU, 1998).
- A cost-effect analysis is applicable when different measures can solve a problem, but the consequences of the measurements are not the same. In a scenario like that, the measure with the lowest costs is not necessary the right option. The costs needs to be measured and compared to the benefits of each measurement in order to create a solid platform for decision-making (NOU, 1998).

9

- A cost-benefit analysis will appreciate the costs and benefits of a given measurement in a monetary unit, such as NOK, as far as possible (Finansdepartementet, 2014). Since this is the method chosen for this thesis, it will be elaborated in the next section.

3.2 The cost-benefit analysis

According to the Norwegian department of treasury, Finansdepartementet (2014), guidelines for socioeconomic analysis a cost-benefit analysis (CBA) is an analysis that is supposed to valuate all the positive and negative effects of measure in a monetary unit as far as possible. The main principle is that a consequence equals the value people are willing to pay in order to achieve or avoid the given consequence. In order for a CBA to be socioeconomic profitable/beneficial, the people's willingness to pay (WTP) for all of the benefits effects must be bigger than the total sum of the costs.

This CBA will be an ex-post analysis, which is done in order to evaluate whether or not the measures that were taken were socioeconomic beneficial, instead of the more usual ex-ante analysis that predict the outcome before measures are taken (DFO, 2014). However, the steps and procedure in both of the analyses are the same.

3.3 The cost benefit model

The cost-benefit model used in this analysis is based on NOU (1998) method of net present value. Since cost and benefits of a measure don´t always occur at the same time, a method for comparing the costs and benefits in monetary units over time is needed. To do so, we can use the following net present value (NPV) formula:

(1) $$NPV = -I_0 + \frac{MNB_1}{(1+r)^1} + \frac{MNB_2}{(1+r)^2} + \cdots + \frac{MNB_n}{(1+r)^n}$$

To simplify:

(2) $$NPV = -I_0 + \sum_{t=0}^{n} \frac{MNB_t}{(1+r)^t}$$

Equation (1) and (2) are the same. Here I_0 is an expense for an investment in year 0. MNB_t is the marginal net benefit, i.e. benefits minus costs that occur in year t, and n is the number of years the project is expected to last. In this equation r is the discount rate, and the idea of including it is to discount the marginal net benefit of year t to the present time (NOU, 1998). In this analysis the discount rate is excluded since the time period, i.e. the lifetime of a vehicle is relatively short. Secondly, the many of the estimates have already occurred, hence they

don´t need to be discounted. It is also mentioned in Fridstrøm and Østli (2014) that discounting futuristic emissions could be wrong since the effect of emissions is independent of when the emissions take place. With the discount rate equal to 0, we get the following net present value:

(3) $$NPV = -I_0 + \sum_{t=0}^{n} MNB_t$$

In the cost-benefit analysis the investment expense, $-I_0$, will be a fixed cost (FC) occurring with the procurement of an EV. The MNB for each year is the marginal difference with the use of an EV compared to an ICEV. This will consist of variable cost (VC), social cost (SC) and private cost (PC). All of these components will be explained in detail from section 3.6. Inserting these components into equation (3), we get the following equation:

(4) $$NPV = -FC + \sum_{t=0}^{n} (-VC + SC + PC)_t$$

From the equation above we can see that fixed and variable cost are negative and will act as the cost side of the CBA. While social and private costs are positive and will represent the benefits in the CBA. Further, in this analysis the MNB, i.e. $(-VC + SC + PC)_t$, will be the same for each year, implying that we can write equation (4) as:

(5) $$NPV = -FC + (-VC + SC + PC) * t$$

In this thesis we will focus on if an electric vehicle is socioeconomic beneficial compared to a conventional vehicle, and in order for an EV to beneficial the marginal net benefit needs to be positive. If:

(6) $$MNB = (-VC + SC + PC)_t < 0$$

then the net present value in (5) will never be positive, i.e. EVs will never become beneficial compared to ICEVs. If:

(7) $$MNB = (-VC + SC + PC)_t > 0$$

the net present value in (5) will be positive and EVs will become beneficial at a given time.

The policy measures towards EVs in Norway can be said to be financed by tax revenues, even though it is referred to as a loss in tax revenues. Since taxes in general are considered to distort the allocation of resources between private households and firms. The effect of such a distortion is considered the marginal cost of public funds, or the socioeconomic cost of publicly funded measures.

According to Finansdepartementet (2014) tax costs will lead to different prices for consumers and producers. These differences will eventually lead to different decision-making among consumers and producers, which leads to an efficiency loss in the economy. Further they state that tax collection is estimated to have a socioeconomic cost of 0,2NOK of each NOK collected in tax (Fridstrøm & Østli 2014), since taxes disturbs the price signal and usually leads to lower creation of value. This implies that 20% of the tax incentives given to electric vehicles are to be considered as a socioeconomic cost. In other words the socioeconomic cost is considered to be 20% of the total loss in tax revenues, i.e. 20% of fixed and variable costs.

There are different opinions about the marginal cost of collecting tax, where Bjertnæs (2015) implies that the marginal cost of public funds should be 5%, while Carlsson and Johansson-Stenman (2003) recommend that public subsidies is something that not should be corrected for excess burden.

Since this analysis has a socioeconomic perspective, the cost in the CBA will be 20% of the total loss in revenue. Hence equation (5) becomes:

(8) $$NPV = -0,2 * FC + ((-0,2 * VC) + SC + PC) * t$$

To figure out at which year the EV becomes beneficial we need to find the breakeven point of equation (8). The breakeven point is the point when the costs and benefits are exactly the same, hence when the NPV equals 0. Inserting NPV=0 into (8) and relocating the equation with respect to time, t, we get the following:

(9) $$t = \frac{0,2*FC}{((-0,2*VC)+SC+PC)}$$

This equation will tells us at what time, t, an EV will become beneficial compared to a conventional vehicle. In order to find out how many kilometers it takes for an EV to breakeven it is just to multiply t with the yearly driving distance in kilometers.

These two equations are the ones that cost-benefit analysis will be based on. Where equation (9) will estimate the NPV of choosing an EV compared to an ICEV, and equation (10) will be used to estimate at what year or kilometer EVs will become beneficial.

3.4 Assumptions and estimations

This section start with some general assumptions before moving on to section 3.5 with a description of data and then 3.6 elaborating around the costs associated with CBA. Section 3.7 is assumptions and estimations about the benefits included in the CBA.

3.4.1 General assumptions

A general assumption with this model is that the total car fleet does not change, implying that if a new vehicle is procured, an equivalent ICEV will be taken out of the car fleet. Keeping the total number of the car fleet constant will not have a significant impact on the results, since the model looks at the cost and benefits at a vehicle-level. Though, if we are comparing the vehicle-based results and don´t include this assumption, the estimated results would be biased.

This cost-benefit model will compare the marginal benefit of choosing an EV over an ICEV, and it is not comparing the choice of procuring an EV with not procuring a vehicle at all. This is important considering the private costs. Because, if a consumer buys an EV, and an ICEV isn´t replaced, that would lead to an additional vehicle on the road. For that scenario, the private costs such as interest rate on the mortgage, annual fee, parking, electricity, etc. would be counted as a cost, making the net benefit of private costs negative. The net benefit from social costs would also become negative. Since the marginal difference in this scenario would be from not having a vehicle, to an additional vehicle on the road, and then all of the seven inputs would have to be included as a net cost. This would lead to a cost-benefit model consisting of only negative inputs; hence, it will never be socioeconomically beneficial with an additional vehicle on the road.

Life-cycle analysis

The whole life-cycle analysis of vehicles is every external effect caused by the production and use by a vehicle and its fuel, and big parts of the whole life-cycle analysis will not be included in this thesis. The life-cycle analysis is usually divided into two phases called the well-to-tank and tank-to-wheel. The well-to-tank phase is essentially all externalities associated with the vehicle production, such as production of bodywork, engine, batteries, etc. The externalities of vehicle production are usually larger for EVs than they are for ICEVs mainly because the production of batteries for the EVs is a difficult and energy-intensive process (Notter et al., 2010), (Majeau-Bettez et al., 2011), (Hawkins et al., 2013).

This part is not included in this CBA and for two reasons. First, according to Carlsson and Johansson-Stenman (2003) the externalities associated with the well-to-tank activities cannot be given to another country, whether or not a country has externality-correcting taxes. Hence, including emissions emitted and regulated in other countries where the vehicle production takes place, and also including the same emissions and externalities in this analysis could lead to inefficiencies since they are included twice. Secondly, getting these specific numbers for all the electric vehicles available in Norway is a tremendously complex task. First you need the externalities associated with the vehicle production, and then you need the externalities associated with the production of the battery packs, which is often manufactured by an external company, such as Tesla and Panasonic [27]. After that, the externalities associated with the production of ICEVs needs to be estimated in order to compare EVs to ICEVs and get the total net effect of vehicle production. Hence, for both the simplicity and scope of this thesis and analysis, externalities of well-to-tank activities will not be included.

The other part of the life-cycle analysis is as mentioned earlier the tank-to-wheel activities. This part is all of the externalities associated with the use of a vehicle. The main components to consider here are the externalities with the production of fuel and electricity, and the emissions caused by the combustion of these fuels when the vehicle is in use. As opposed to the externalities associated with vehicle production, the externalities with the production of fuel and electricity take place in Norway. Considering that more than 96% of the electricity produced in Norway in 2013 came from hydropower [28], there would be few externalities associated with the use of electricity in EVs. The costs and emissions associated with the refining of diesel and petrol used in ICEVs, from the extraction of oil to the transportation of fuels to gas stations, consists of many components and was considered too complex to

14

estimate for the scope of this thesis. The externalities associated with the production of fuel for both EVs and ICEVs was not included in this analysis. The emissions from combustion is included and estimated in the section with social costs in section 3.6.

Annual driving distance

In 2014 the annual average driving distance for passenger cars in Norway was 13.264km, while average annual driving distance for electric vehicles the same year was 7.800km [29]. The reason electric vehicles had so much shorter average annual driving distance can be explained by shorter range and long charging time compared to conventional vehicles. Although there is a significant difference between the averages, the annual driving distance is for simplicity assumed to be 13.000km for both EVs as well as for ICEVs. This is with regards to the assumption that the procurement of an EV will replace an ICEV.

Consumption and share of diesel and petrol cars

Out of the total car fleet with internal combustion engines in Norway, the diesel driven vehicles amounted 46%, and the petrol driven vehicles amounted to 54% of the shares in 2014 [30]. This information is necessary since data is provided for both petrol and diesel vehicles. The average fuel consumption in litres/10km is assumed to be 0,55l/10km for both petrol and diesel.

3.5 Data

In this analysis the time perspective is from January 2010 including March 2015. I was provided with data from OFV regarding the yearly sales of new electric vehicles in the same time perspective. In this dataset a total of 39475 new electric vehicles registered spread over the time period as illustrated in figure 1 below.
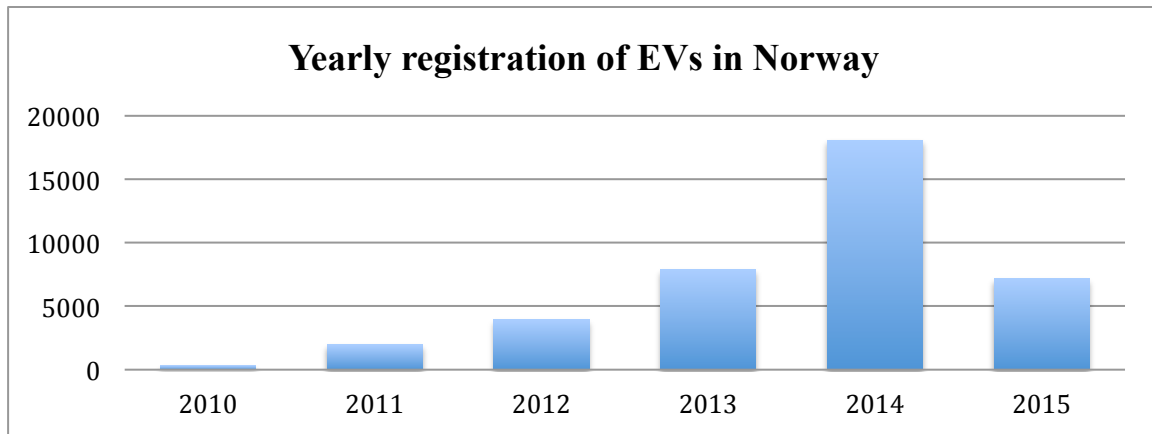
Figure 1: Yearly registration of EVs in Norway. Source: OFV AS.

In table 1 below all of the different EVs sold in the time period are listed in chronological order based on market shares. Purchase prices, power and weight for each EV are collected from the respective website for each brand. This was done for the 12 electric vehicles with the highest market shares. Using prices and technical specifications from 2015 for the whole time period leads to some differences that is further discussed in section 3.6 and in the uncertainty analysis in section 4.3. Considering that the remaining fifteen vehicles amounted 1,3% of the market share together, an average for the purchase price, power and weight from the top twelve was used. In figure 2 a pie chart of the market shares for each of the vehicles for the whole time period are presented.

16

Nr [Source]	Car	Number of cars	MS %	Purchase price	kW	kg
1 [15]	Nissan Leaf	13138	33,3	189000	80	1474
2 [16]	Tesla Model S	7555	19,1	558000	274	2108
3 [17]	Volkswagen e-Golf	4690	11,9	253200	86	1510
4 [18]	Volkswagen e-up!	4036	10,2	196400	60	1139
5 [19]	Mitsubishi I-MiEV	2649	6,7	147620	49	1085
6 [20]	BMW i3	2427	6,1	249900	125	1195
7 [21]	Peugeot iOn	1218	3,1	169000	49	1120
8 [22]	Citroen C-Zero	1189	3,0	139900	49	1120
9 [23]	Renault Zoe	794	2,0	199900	65	1503
10 [24]	Kia Soul	617	1,6	211900	90	1490
11 [25]	Think City	409	1,0	244000	37	1038
12 [26]	Ford Focus Electric	252	0,6	203800	107	1674
13	Nissan NV200	190	0,5	233152	89	1371
14	Mercedes-Benz B-Class	96	0,2	233152	89	1371
15	Think Think	80	0,2	233152	89	1371
16	Tesla Roadster	79	0,2	233152	89	1371
17	Mia Andre	14	0,0	233152	89	1371
18	Volvo C30	10	0,0	233152	89	1371
19	Renault Fluence	8	0,0	233152	89	1371
20	Smart ForTwo	7	0,0	233152	89	1371
21	Fiat Fiorino	6	0,0	233152	89	1371
22	Fiat 500	3	0,0	233152	89	1371
23	Mercedes-Benz SLS	2	0,0	233152	89	1371
24	Tazzari EM1	2	0,0	233152	89	1371
25	Mia VE79	2	0,0	233152	89	1371
26	Tazzari Zero	1	0,0	233152	89	1371
27	Tata Indica	1	0,0	233152	89	1371
Total		**39475**	**100**			

Table 1: Data and technical specification. Source: OFV.
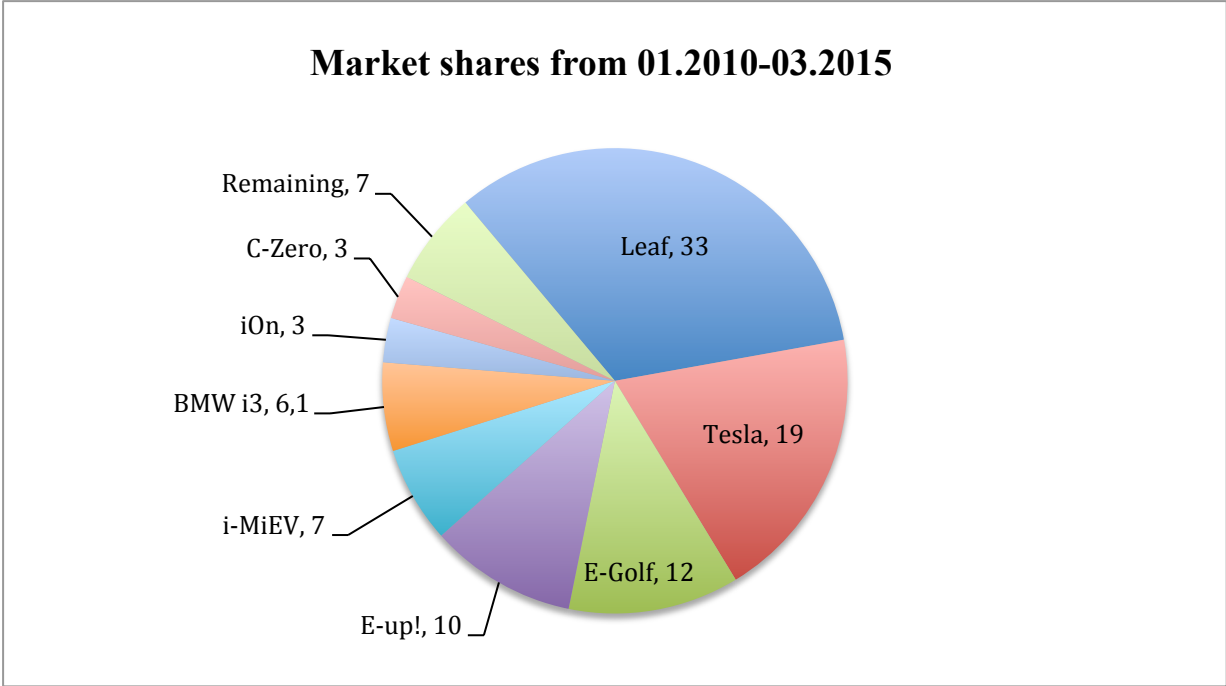
Figure 2: Market shares. Source: OFV AS.

The cost in NOK/km used for estimating the marginal of local air pollution are found in
Thune-Larsen et al. (2014), and are presented in table 2 below. The cost of marginal damage
of climate change associated with road transportation used in this analysis is listed in
appendix 3. Explanation and estimation with these numbers are elaborated in section 3.7.

Type of vehicle	Type of fuel	Area more 100.000	Area between 15.000-100.000	Area less than 15.000	Computed average
ICEV	Petrol	0,27	0,05	0,01	0,18
ICEV	Diesel	0,44	0,08	0,01	0,29

Table 2: Cost of local air pollution. Source (Thune-Larsen et.al, 2014)

In table 2 below, key figures for the estimation of this analysis is presented. These key figures
are used in the estimation of variable, social and private cost.

	ICEV	EV
Average consumption	0,55 liter/10km	0,201 kWh/km (Top 3)
Yearly consumption	715 liter/year	3068 kWh/year
Price per liter or kWh	13,65 NOK/liter	0,837 NOK/kWh
Share of fee and VAT of liter and kWh	6,95 NOK/year	0,271 NOK/kWh
Annual fee	3060 NOK/year	435 NOK/year
Toll booths	3600 NOK/year	0 NOK/year
Public parking	3300 NOK/year	0 NOK/year
Annual driving distance	13.000 km/year	13.000 km/year

Table 3: Key figures.

3.6 Estimating cost

In this section the costs associated with the procurement will be explained. The costs are essentially the loss in revenue for the Norwegian government caused by the tax exemptions and incentives with the procurement and use of electric vehicles. These costs are divided into fixed and variable costs.

3.6.1 Estimation of fixed costs

The fixed costs (FC) of this analysis are the costs associated with procurement of an EV. The FC stems from the one-time loss in revenue from the exemption of the excise duty and VAT on electric vehicles in Norway. The loss in revenue from total excise duty and VAT are then added together, and a total fixed cost for the average electric vehicle is then estimated.

Excise duty

The excise duty is estimated based on four parameters, CO_2, NO_x, weight and kW of each vehicle. Since the estimation of excise duty is based on the loss in revenue from procuring an EV, the factors of CO_2 and NO_x will not be included. The reason for this is that the externalities of producing electricity are excluded, and electric vehicles don´t emit neither CO_2 nor NO_x during the usage phase. This leaves us with weight and kW as the remaining parameters. Each of these parameters consists of different rates in different intervals of a given effect or weight, and the estimation of these parameters for each vehicle is done by using the rates from Toll og Avgiftsdirektoratet (2015). Using the estimation procedure with

the rates for 2015 for all vehicles in the given time period of this thesis will not give the exact, actual loss in revenues for each vehicle since the rates has changed over the years [31]. Even though there have been some changes in the rates during the given time period, the average numbers estimated for each vehicle are considered to be both significant and applicable.

VAT

EVs in Norway are exempted from VAT on the customs valuation of the car. The customs valuation consists of purchase price, shipping- and insurance costs that incur until the vehicle has arrived in Norway [32]. The rate of VAT is 25% of the customs valuation of the vehicle. In the estimated purchase price in table 1, the shipping costs are included for most of the models. Hence, the estimation of the loss in revenue from the exemption of VAT is simply the rate of VAT multiplied with the purchase price. It is worth mentioning that all additional equipment purchased and fitted to any given vehicle during manufacturing and before the cars enters Norway and the local dealership, is also exempted from VAT. Considering that the purchase prices in table 1 are based on the basic model for each brands, i.e. the cheapest models with minimum equipment, the actual purchase price is probably higher than the one used. This is especially related to Tesla, since it is possible to choose extra equipment for over 200.000NOK in addition to the basic purchase price of Tesla Model S 70P [33].

Another concern with the purchase prices is the changes they have had over the time period. Where most of the vehicles have experienced a decrease in the purchase price, Tesla has increased their prices [34]. Since there was no data available on actual average purchase price for each model over the time period, the estimation done is considered to be adequate, but with the notion that the total estimated VAT could be too low. This is reflected further in the uncertainty analysis in section 4.3.

Total fixed costs
The total fixed cost for the period was estimated to be 8,507 billion NOK, making the average fixed cost 215.512NOK for each EV. The variable costs were 2,651 billion NOK and the excise duty was 5,856 billion NOK. Tesla amounted to 4,643 billion NOK of the fixed costs, making the average fixed costs for Tesla 614.457 NOK.

3.6.2 Estimation of variable costs
The difference between the variable cost (VC) and fixed costs is that the VC is dependent of number of years or how many kilometers the vehicle drives per year, as opposed to the FC

that is a one-time cost. The VC is the loss in revenue from the incentives associated with the use of EVs, and is presented below.

Annual fee

EVs aren´t exempted to pay the annual fee, but the fee has been reduced compared to petrol- and diesel driven vehicles. Diesel driven vehicles without a factory installed particle filter has to pay a higher fee then diesel vehicles with the particle filter installed. For simplicity it has been assumed that all of the diesel driven vehicles have a factory installed particle filter, and that the annual fee of ICEVs is then 3060NOK/year and 435 NOK/year for electric vehicles [35]. The difference between the annual fee for ICEVs and EVs, 2625NOK/year, is considered a loss in tax revenue, and is the cost of the annual fee with the procurement of an EV.

Tollbooths and ferries

From Figenbaum et.al. (2014), the value of free passing of tollbooths or driving on toll-roads was estimated to be 3600NOK per EV each year. However, there are big regional differences in terms of costs from using toll-roads and considering the importance of this incentive for EV-owners, the estimate is assumed to be on the low side.

Figenbaum et.al. (2014) also have an value for the costs associated with free use of ferries, and that is estimated to 1200 NOK/year for each electric vehicle. This cost is however, estimated based on the fact that the value of free ferries is 1/3 as important as the free passing on toll-roads and tollbooths. Hence, there is still large uncertainty regarding both of these estimates since no specific data is available. Regardless, the total costs from free passage from tollbooths, toll-roads and ferries used are 4800NOK/year per EV, and this number is considered to be sufficient enough for further estimation.

Parking

According to Fearnley (2014) the average electric vehicle gets incentives equivalent of 3300NOK per year in form of free public parking. This estimate will be used as the yearly parking cost for each vehicle and is consider being a precise estimate.

Public charging

From the chapter about charging behavior among EV owners in Figenbaum et.al. (2014), an assumption was made that approximately 20% of the charging occurs at a public charging station. With this information available as well as the numbers in table 3, we can calculate

that a total of 522,6 kWh/year are charged at a public charging station per EV. With the electricity cost of 0,837 NOK/kWh, this means that the average cost per vehicle from public charging is 437NOK/year. This is considered to be a very rough estimate with high uncertainty, but the total average cost isn´t very high, hence the impact of the uncertainty about the public charging cost is almost trivial. The reason for using this electricity cost and not the cost of fee and VAT of each kWh is the assumption that the Norwegian government has to pay for the electricity in addition to loosing revenues in terms of VAT and fee.

Fees and VAT from fuel consumption

Replacing one ICEV with an EV leads to a decrease in the consumption of fuels such as diesel and petrol. This leads to a loss in revenues since the sale of diesel and petrol is taxed in terms of fees and VAT. Fuel prices and the rates of fees and VAT for each type of fuel were found at Statistics Norway [36]. An average for the fees and VAT per litre of fuel was created for the given time period. It was then multiplied with the average annual consumption from table 1.

With this procedure the total loss in revenue from fees and VAT caused by the decrease in fuel consumption, was estimated to be 5868 NOK/year per ICEV. Since the CBA estimates the net difference between EVs and ICEVs, the government's revenue from fees in the electricity price also has to be included. Considering that EVs are charged at home 80% of the time, this electricity leads to an increase in revenues in terms of 566NOK/year for each EV, and makes the total net cost of decrease in fuel consumption 5302 NOK/year for each vehicle.

Bus lanes

Electric vehicles are also allowed to use the bus lanes in some areas where those exist. According to Figenbaum et.al. (2014), the time saved by using the bus lanes for EV-owners is equivalent of 7800NOK per year. Since this estimation don´t include the cost of the extra time used by the other people traveling by bus, this estimation is not included in the estimation. The total net effect of this incentive is unclear, and we are not able to include this since there are no data available on the total net effect of this incentive.

Public charging stations

The costs for publicly funded charging stations was estimated to be approximately 2.500€ for each regular charging station (Figenbaum and Kolbenstvedt, 2013b). Charging stations for fast charging were estimated to be significantly more expensive, and the cost was in the range

of 62.000-125.000€ for each fast charging stations. However, making these numbers applicable to the average EV for the time period was not feasible due to the lack of precise and sufficient data. Hence, the cost of funding public charging stations was excluded from the estimation.

Total variable costs

Adding all of the variable costs presented and estimated above, the total average variable cost per vehicle is 14.665 NOK per year. This cost is for simplicity assumed to be constant over the whole lifetime of the vehicle. Any changes in the current policy measures will make the estimations not applicable to model.

3.7 Estimating benefits

This section describes the benefits of replacing an electric vehicle with a conventional vehicle. These benefits are divided into two variables, social costs and private costs. The reason these benefits are referred to as costs, is the fact that cars, an EV as well as an ICEV, will create costs associated with road transportation, both marginal damage and private ownership. The reason they will be included as benefits in the CBA is the costs of owning and using an EV is much lower than the cost of owning and using an ICEV. Hence, there will be a decrease in marginal damage and private costs of replacing an EV with an ICEV.

3.7.1 Estimation of social costs

According to the update of the Handbook on External Costs of Transport (Korzhenevych et al., 2014) there are seven external costs associated with road transportation. Below, each of the external cost and other effects are presented, and those that are included in the estimation are valued in NOK/km.

Congestion costs

Congestion costs is essentially the willingness to pay for avoiding the utility loss associated with spending time on the road, and it is estimated from road users. In this estimation EVs and ICEVs are considered equal, and given the assumption that one EV replaces an ICEV, there will be no net change in congestion costs.

Accident costs

External accident costs are the social costs associated with traffic accidents, and no literature indicates that the external accident costs are higher for the new electric vehicles than the

equivalent ICE vehicles are found. Thus, EVs and ICEV are assumed equal with regards to accident costs, making the marginal net benefit from accident cost equal to zero.

Air pollution costs

The external marginal cost of local air pollution is related to the emissions of environmentally harmful substances from the use of vehicles. This pollution occurs through different aspects with the use of a vehicle, such as combustion of fuel from the vehicles with combustion engines, road damage, tire damage, damage from brake linings, as well as the wind from vehicles moving causing dust and dirt on the side of the road to swirl up again (Thune-Larsen et.al. 2014). Since many of these aspects mentioned will have the same polluting effect with the use of an EV as well as an ICEV, we will focus on the emissions associated with combustion engines. Considering that electric vehicles don't have an internal combustion engine, the estimated emissions from vehicles with an internal combustion engine will be the net effect. To compute the external costs coupled with the emissions from the internal combustion engine, we used the estimated cost from the Thune-Larsen et.al. (2014), see table 2. Here the emissions are estimated in NOK/km caused by each passenger car, depending on fuel type, and divided into urban areas (>100.000), town (<100.000<15.000), and rural (<15.000). The emissions associated with the external effects of local air pollution are NO_x (nitrous oxide) and PM10 (particulate matter). The costs of CO_2-emissions from combustion are estimated in the climate change costs.

Most of the EVs in Norway are located in or close to urban areas. Using Grønn Bil Norge´s overview [37] of EVs registered in each municipality and Statistics Norway [38] as the condition for how many inhabitants each area has, it was estimated that 60% of the EVs were located in urban areas with more than 100.000. While 30% were located in areas with more than 15.000 but less than 100.000 inhabitants, and the remaining 10% of the EVs were located in rural areas with less than 15.000 inhabitants. These vectors were then used with the numbers found from Thune-Larsen et.al. (2014), which lead to an average emission cost for a diesel and a petrol passenger car. These were then multiplied with the share of diesel and petrol cars in Norway, resulting in an average marginal external cost associated with the local emissions from a combustion engine of 0,2502 NOK/km.

Noise costs

The noise caused by the use of vehicles is also an external effect to consider in the estimation of the social costs. According to Marbjerg (2013) there is a difference in noise between

electric vehicles and vehicles with an internal engine. However, this is at low speed. After a given speed the noise from the tires will be the loudest component of a vehicle, hence making the noise costs for EVs equal to ICEVs. At what speed that this scenario occurs is rather unclear. In the report from Thune-Larsen et.al. (2014) external noise cost were estimated for light duty vehicles and heavy-duty vehicles in specific scenarios. Since no specific data of the difference in noise from an EV and an ICEV in the given scenarios was found, the external noise costs had to be excluded from the estimation.

Climate change costs

The marginal external costs of climate change associated with road transportation are essentially the emission of CO_2 during the combustion from an internal combustion engine. The report (Thune-Larsen et.al. 2014) didn´t include any specific climate change costs. However, the update of the handbook on external costs of transport (Korzhenevych et al., 2014), did include a climate change cost, see appendix 3. The climate change costs in this table was estimated for diesel and petrol as well as engine size and EURO-class, and the numbers where given in €ct/vkm. EURO-5 was used as the given EURO-class for both diesel and petrol since it was the newest class available. There were three types of engine sizes, and engine size of 1,4-2 litres was chosen based on a search on finn.no.

The climate change costs were divided into three categories, urban, rural, and motorways, where I estimated an average of these consisting of one third each. I then multiplied this average with the same percentage share of diesel and petrol, 46% and 54% respectively. The following number was given in €ct/vkm, and it was divided by 100, and multiplied with an exchange rate of 8,5 €/NOK (23.04.15) [39]. This gives us a cost of 0,1545 NOK/km.

Costs of up- and downstream processes

The costs of up- and downstream processes are the well-to-tank aspects associated energy production, vehicle production and infrastructure construction. It consists essentially of the same factors mentioned in section 3.5.1 about life-cycle analysis, and it will be excluded for the same reasons as well. It is worth mentioning that EVs and ICEVs are not considered equal regarding the well-to-tank aspect, but all input factors needs to be taken into account in order to estimate these figures and that is beyond the scope of this thesis. However, it is recommended to include this in future research in order to get a better picture of the whole life-cycle costs.

Marginal infrastructure costs

The marginal infrastructure costs are the aspects corresponding to higher traffic levels on the roads, such as road maintenance and repair expenditures. Since we early on assumed that one EV replaced one ICEV, keeping the total car fleet constant, marginal infrastructure costs will not affect the social costs. However, the increased axel weight of EVs compared to ICEVs may cause the marginal infrastructure costs to increase as well. The effects of this increase are not well documented, and the general marginal infrastructure damage done by light-duty vehicles are very small compared to heavy-duty vehicles (Thune-Larsen et al., 2014). Hence, the net effect on marginal infrastructure by replacing an EV with an ICEV is assumed to be insignificant in the estimation of the social cost.

Other costs

Thune-Larsen et.al. (2014) mentions other aspects that might influence the external costs of road transportation, such as barrier effects, other health effects and nature- and landscape effects. Without further elaboration, the impact done by light-duty vehicles on these effects are considered to be the same for EVs as for ICEVs. Hence, these effects are not considered in the estimation of the social costs.

Total social costs

Out of all these marginal external costs associated with road transportation, the local air pollution and climate change are the ones that are included in the social cost of replacing an electric vehicle with an ICEV. The average social cost by the use of an ICEV are estimated to be 0,3898 NOK/km. Since EVs is assumed to not emit anything during use this is also the net difference of replacing an EV with an ICEV. Using an annual driving distance of 13.000km, the net social cost was estimated to 5068 NOK/year per vehicle.

3.7.2 Estimation of private costs

The procurement of a new vehicle would imply reduced liquidity for the car owner, since he would most likely have to take a loan, and his personal fixed costs would increase. However, procuring an EV or an ICEV at the same purchase price will lead to no net difference in this car owners fixed cost in terms of mortgage and interest rate. Assuming that the exemption of excise duty and VAT are making EVs in the same price range as ICEVs.

For simplicity the secondhand value and interest rate are assumed equal between EVs and ICEVs. The same goes for insurance, service, maintenance and tires. Since the new generation of electric vehicles haven´t been on the market for a long time, it is still a big uncertainty about actual costs. The remaining private costs are then fuel expenses, annual fee, toll booths/ferries and parking. Fuel expenses are estimated to be the difference between the costs for fuel and electricity of driving 13.000km a year. Annual fee, toll booths/ferries and parking will be the same as the estimates included in the variable costs. Making the marginal net benefit of owning an EV instead of an ICEV 18.737 NOK per year.

The assumption of including private costs is that the money that are not spent on the different costs of owning an EV compared to an ICEV, will eventually be spent on other things, making the socioeconomic net effect positive.

3.8 Estimated costs and benefits

Below, in table 4, all of the costs and benefits estimated above are presented.

	Rate	Yearly costs each vehicle	Total lifetime each vehicle	Lifetime cost all vehicles in dataset (billion)
FC	215.512	0	215.512	8,507
VC	14.665	14.665	205.310	8,112
SC	0,3898	5.068	70.952	2,801
PC	18.737	18.737	262.318	10,036

Table 4: Costs and benefits

If we assume that the average vehicle in this dataset has been on the road for 1,5 years, the total VC for all of the vehicles would be approximately 870 million NOK. That combined with the total FC for all vehicles makes the Norwegian government´s loss in revenue approximately 9,376 billion NOK for these EVs so far.

4. Results from the cost-benefit analysis

In this chapter the results from the cost-benefit analysis will be presented and discussed. Further, there will be a discussion about certain side effects from the policy measures, as well as a section about other aspects with the electric vehicle that affects the policymaking.

4.1 Baseline

The baseline in a cost-benefit analysis is to describe how the situation is today and what is to be expected if the measures aren´t implemented (DFO, 2014). Since this is an ex-post analysis with the aim of evaluating the policy measures over the last years, and that the model computed in chapter 3 looks at the net marginal difference with procuring an EV to an ICEV, the baseline or alternative with this model would be to compare an ICEV to an EV without today´s policy measures. That would leave only the social costs, and only the difference in fuel consumption from the private costs. However, removing the tax exemptions would make the EVs more expensive, which would reduce the private costs. By using a 35% (25% VAT and 10% excise duty) increase in purchase price, the estimated NPV for the baseline scenario is 102.620 NOK. It is worth mentioning that in a scenario like this, the recent development of EVs in Norway would not have been the same.

4.2 Presentation of results

The results are estimated in three scenarios that include different sets of costs. The fixed and social costs are included in all of the scenarios, and in scenario A they are the only ones used. In scenario B, the variable cost is also included, and in scenario C all of the components are included. The reason for including these different scenarios is to see how each of the parameters affects the result, which allows us to see how the political decisions can be made in order to improve the results. Scenario C will be the main results since all parameters are included.

The cost-benefit analysis is estimated for three different averages as well, and they are all included in each of the scenarios. The first one is the total average, and that is for all the cars in the dataset. The second one is the total average without Tesla, and the third average is for

Tesla only. The reason why the CBA is divided into different averages is related to the fact that the total fixed costs for all of the vehicles in the data was estimated to 8,507 billion NOK, and the Tesla´s sold in this time-period amounted to 4,642 billion NOK, approximately 55% of the total fixed costs, although they only had a market share of 19%, see figure 2.

All of the components are estimated based on net difference per vehicle. The fixed cost is as mentioned earlier a one-time fee, and it is also the starting point for each averages in the figures presented below. The average lifetime of each vehicle is assumed to be 14 years or 182.000km based on Hawkins et.al. (2013), implying that if one of the averages breakeven in less than 14 years it will be socioeconomic beneficial to choose an EV over an ICEV.

4.2.1 Scenario A

In this scenario only fixed costs and social costs are included, implying that variable and private costs are set equal to zero in equation (9) and (10). We can see from table 5 that the FC for the average vehicle, i.e. the average loss in revenue for the government for each EV, is estimated to be 215.511 NOK, while the socioeconomic cost of this is estimated to be 43.102 NOK.

In this scenario the total average and the average without Tesla breakeven before the end of the lifetime and is considered to be socioeconomic beneficial. Tesla only, does not breakeven before the end of the expected lifetime, hence it is not considered socioeconomic beneficial.

A	FC in billions NOK	FC each vehicle	20% of FC each vehicle	SC each year	Years before BE	KM BE	NPV in NOK
Total Average	8,507	-215.511	-43.102	5068	8,50	110.554	27.850
Without Tesla	3,865	-121.087	-24.217	5068	4,78	62.116	46.735
Only Tesla	4,642	-614.457	-122.891	5068	24,25	315.207	-51.939

Table 5: Scenario A
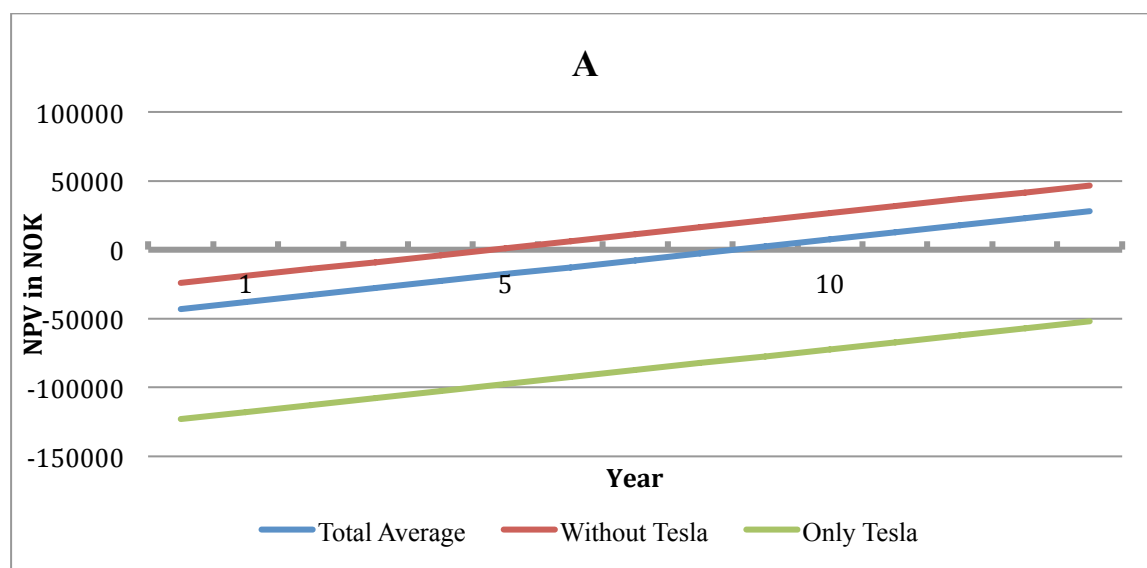
Figure 3: Scenario A.

4.2.2 Scenario B

This scenario is the same as A in addition to including the variable costs. The variable costs are reducing the yearly marginal net benefit with almost 60% compared to scenario A. The effect of this is making the results in scenario B 2.37 times higher than the results from scenario A. Hence, making only the average without Tesla to breakeven before the expected lifetime.

B	20% FC	20% VC	SC	Net benefit	Years before BE	KM before BE	NPV in NOK
Total Average	-43.102	-2933	5068	1775	24,28	315.613	-18.247
Without Tesla	-24.217	-2933	5068	1775	13,64	177.330	638
Only Tesla	-122.891	-2933	5068	1775	69,22	899.860	-98.036

Table 6: Scenario B.
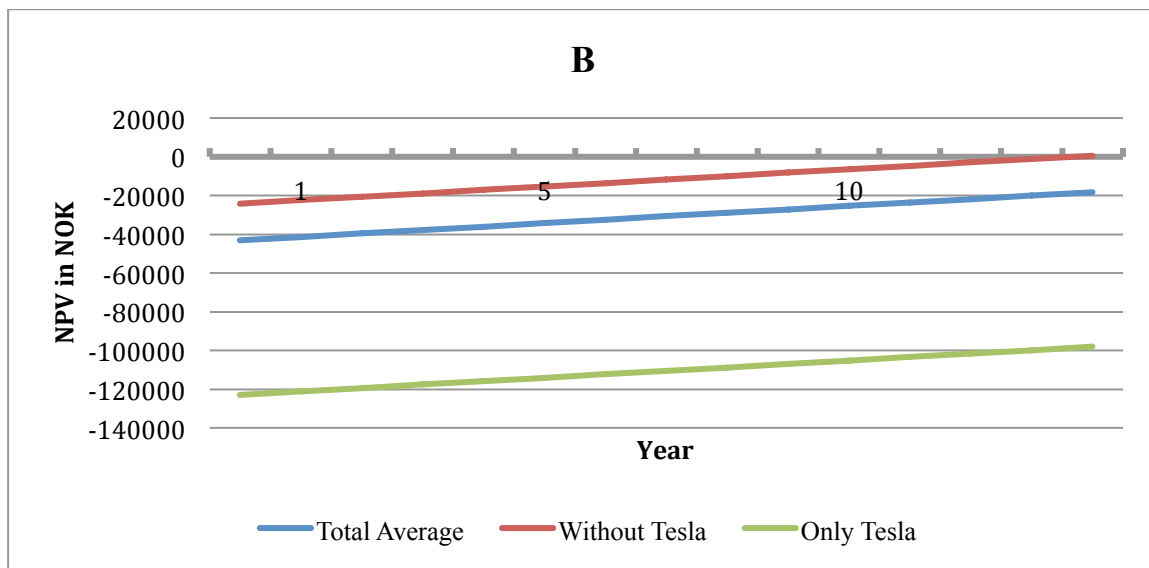
Figure 4: Scenario B.

4.2.3 Scenario C

In this scenario all of the components are included, making the yearly marginal net benefit 20.512 NOK. This results in a breakeven after only 2,10 years or 27.317 km, and a net present value of 224.071 NOK for procuring a EV compared to an ICEV. Even the average consisting of only Tesla breakeven before halfway through its expected lifetime, and has a net present value of 164.282 NOK.

C	20% FC	20% VC	PC	SC	Net benefit	Years BE	KM BE	NPV in NOK
Total Average	-43.102	-2933	18.737	5068	20.512	2,10	27.317	244.071
Without Tesla	-24.217	-2933	18.737	5068	20.512	1,18	15.348	262.956
Only Tesla	-122.891	-2933	18.737	5068	20.512	5,99	77.884	164.282

Table 7: Scenario C.
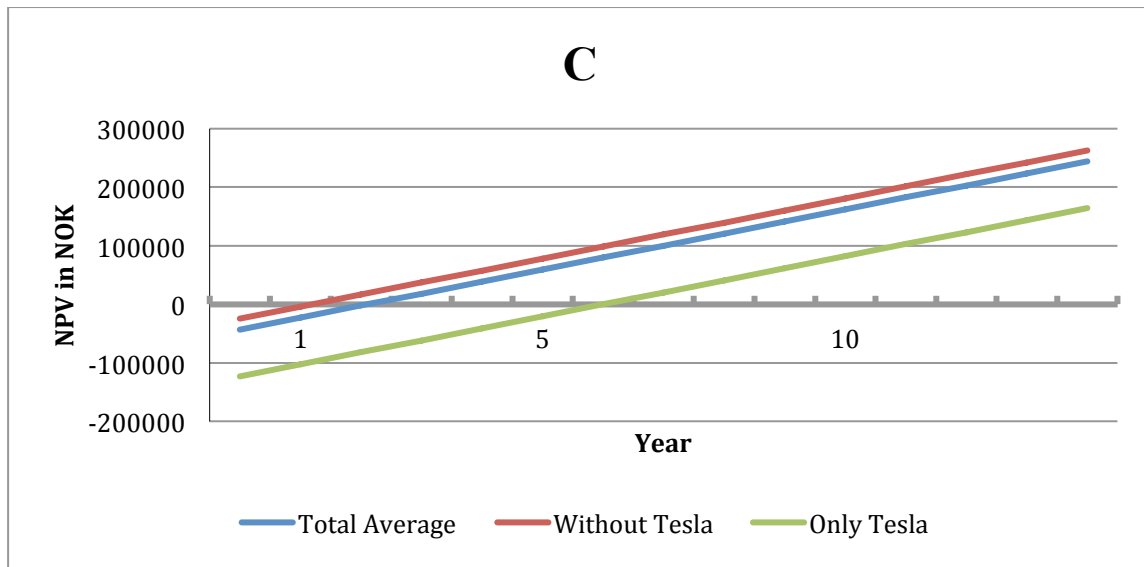
Figure 5: Scenario C.

4.3 Uncertainty analysis

This section will elaborate and create visibility around the uncertainty within the different parameters in the cost benefit analysis (DFO 2014). The reason for this is to give an impression of the potential change in the results if changes are done in the parameters. The total average from scenario C is the result used when discussing the impacts uncertainty has on the parameters, and how this affects the results.

4.3.1 Fixed cost

The total fixed cost for this time period are estimated to be 8,507 billion NOK where 2,651 billion NOK are from VAT, and the remaining 5,856 billion NOK were from excise duty. In figure 6 we can see each vehicles share of the total fixed cost over the time period.
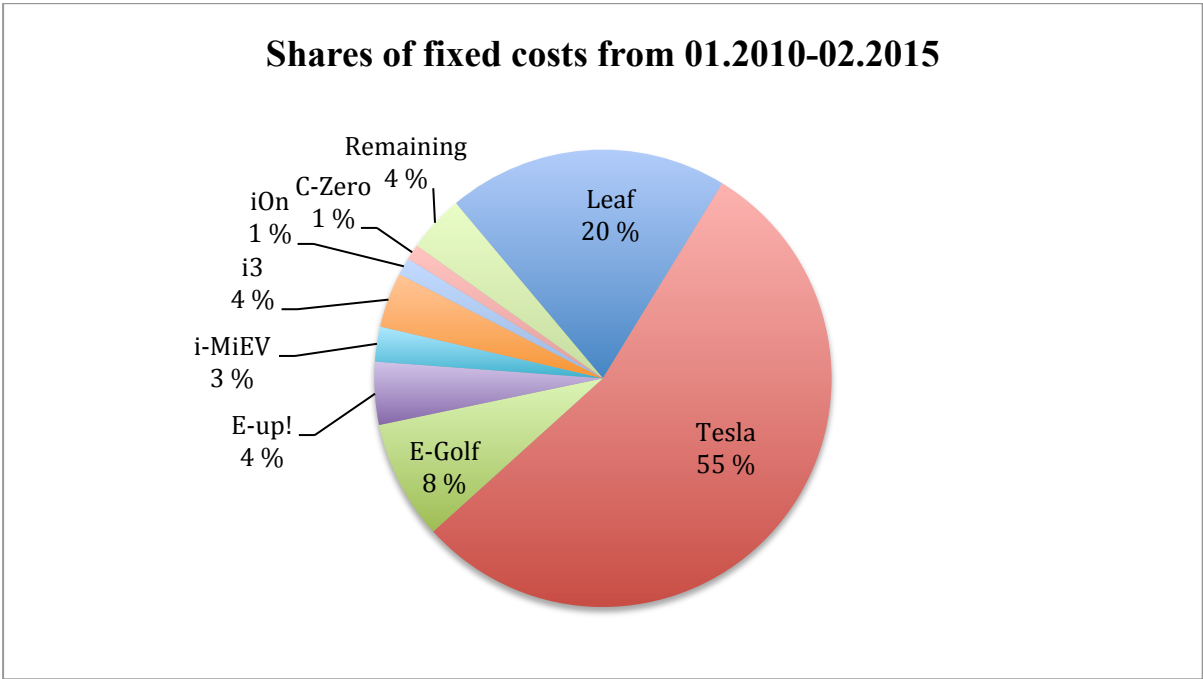
Figure 6: Share of fixed cost

As we can see from figure 6, Tesla accounts for 55% of the Norwegian government´s loss in revenue from excise duty and VAT. Considering that Tesla only had a market share 19% over the same time period, see figure 2, it is safe to assume that Tesla has a negative impact on the results on the total average. There are multiple factors causing uncertainty about the fixed costs for Tesla, since the purchase price can vary a lot depending on exact model and extra equipment that is chosen. One of Tesla´s models also has 315 HP more and weighs 200kg

more than what is used in the estimation [16]. Even though the purchase price for Tesla has increased over the years, there is no reason to assume that the estimated fixed costs for Tesla are too low [34].

Most of the remaining EVs have experienced a decrease in the purchase price [34] due to the increased competition in the segment. Hence, the purchase prices used in the estimation are considered to be too low for the whole time period. The estimated excise duty for these EVs is considered to be a rather precise estimate.

Overall, most of the inputs in the estimation of fixed costs are considered to be too low estimates. So if we are assuming a worst-case scenario with 5% increase in excise duty and 25% increase in VAT for the rest of the car vehicles. And all Tesla´s purchased cost 970.000NOK, with additional power and weight. The total fixed cost would then be 12,589 billion, a 48% increase, resulting in a breakeven after 3,11 for the total average with all parameters included. This scenario above is considered to be an illustration on how much the fixed costs move with changes in Tesla specifications and the average of the rest of the vehicles, and is considered an worst-case scenario. While the used estimate of a total fixed cost of 8,507 and breakeven after 2,10 years is considered a best-case scenario.

4.3.2 Variable cost
The variable cost is composed of many different variables in it is a complex parameter with many assumptions. Though, some of these are considered to be quite reliable numbers, such as the annual fee and parking. The valuation of tollbooths, ferries, public charging, fees and VAT from fuel consumption on the other hand, is more uncertain. It is a very difficult task to get the exact figures on all of these variables, but we have estimated an uncertainty parameter for the variable costs as well. Considering all of the inputs, variables and changes over the time period the uncertainty parameter is the variable cost of 16465 NOK $\pm$ 25%. With this uncertainty parameter in use the number of years it takes for the total average to breakeven in C would lay between 2,02 and 2,12 years.

4.3.3 Social cost
The social cost of electric and conventional vehicles is essentially the net different in the costs of emissions for the vehicles over a lifecycle. Since only the tank-to-well aspect are included in this cost-benefit, the social cost or social net benefit used in the estimation are not representative for the whole lifecycle cost.

If we look away from the assumptions given in section 3.5 and include the well-to-tank aspect, according to Hawkins (2013) an electric vehicle with a lifetime of 150.000km will have a potential of reducing the global warming with 10% to 24% on the European electricity mix compared to the conventional diesel and petrol car. Implying that the social costs will always be positive, i.e. considered a benefit in the CBA, especially if running on Norwegian produced electricity. It is worth mentioning that this is under European energy mix, and under Norwegian electricity mix the emissions would be even lower for an EV. This would lead to a higher social benefit for EVs, than for ICEVs.

According to Hagman et al. (2015) the new Euro 6 classified diesel driven ICEVs emits between 4-20 times as much NO_x in city-traffic and on cold days than the certified emission limits for Euro 6 vehicles. While Franco et al. (2014) estimated that the average on-road emissions of NO_x to be 7 times higher than the certified emission limit for Euro 6 vehicles. Hagman et al. (2015) have also estimated that new ICEVs has a CO_2-emission that is 20-95% higher with actual use, than what is measured from the New European Driving Cycle (NEDC) and is the certified emissions limit. Hence, if every new ICEV emits more CO_2 than what is actually stated it is going to emit, it is reason to believe that social cost estimated in this model is too low.

With all this included, the social cost is estimated to have an uncertainty of 50% in both directions. Hence, the current social cost of 5068 NOK $\pm$ 2534 NOK, making scenario the total average in C breakeven between 1,87 and 2,40 years.

4.3.4 Private cost

It is an underlying assumption for this model that if an EV isn´t bought, an equivalent ICEV would have been bought. The private costs of owning an EV compared to an ICEV are not well documented yet, since the new generation of EVs haven´t been on the market for a very long time. There is reason to believe that maintenance costs for EVs would be lower than they would for ICEVs, since the drivetrain and engine on EVs is much less complicated than it is in ICEVs. However, if an EV would have to replace the battery pack during its lifetime, the average maintenance costs would most likely be similar of the average maintenance costs for ICEVs, or worse.

The biggest input in the private cost is the fuel savings. Using $\pm$ 0,25 litre/10km as a best and worst scenario, and $\pm$ 50% of the public charging. The remaining inputs affecting the private costs are the ones included in the variable costs. Including all of the uncertainties above the private costs is estimated to be 18737 $\pm$ 4684 NOK. Which results in a breakeven after 1,71 and 2,72 years in the best and the worst-case scenario, respectively.

4.3.5 Best- and worst-case scenarios

In order to get a total best-case scenario and a total worst-case scenario we add all of the different uncertainty scenarios for each input. By doing so the following breakeven are applicable for the total average in scenario C:

A total best-case scenario: 1,51 years or 19.624km. NPV: 356.642 NOK.
A total worst-case scenario: 5,12 years or 66.490km. NPV: 110.807 NOK.

Even in a worst-case scenario with the cost-benefit model, the EV is still socioeconomic beneficial compared to the ICEV, with today´s policy measures. The best-case scenario would make EVs socioeconomically beneficial after just 1,51 years or 19.624km on the road.

4.4 Non-monetized side effects

In this section the non-monetized side effects of the policy measures towards EVs in Norway will be discussed.

4.4.1 Increased use of vehicles

One of these side effects is the increased use of vehicles caused by the benefits of the incentives. A survey done about EV-owners in Norway (Figenbaum et.al., 2014), revealed some changes in the travel pattern, see appendix 4. From the appendix we see that 23% of the EV-owners in Norway said that they drive more than they did before they had an EV, while only 7% drive less. 16% said they use public transport less than before, while only 4% uses it more. These results indicate a slight increase in the use of a vehicle that may be correlated to the benefits with the incentives.

In addition to a slight increase in the use of EVs after buying one, the incentives and tax exemptions also leads to an increase in the number of vehicles on the road. This increase is in addition to the average yearly growth in the vehicle fleet. According to Figenbaum et.al. (2014) 28% of EV-owners bought an EV in addition to owning another vehicle, while 3% of

the new EV-owners didn´t have a vehicle before procurement, see appendix 7. Tesla is the electric vehicle that replaces an ICEV most often. The reason for this is presumably the range and size of the vehicle compared to the other EVs.

Figenabaum et.al. (2014) also found that one-third of EV-owners are a part of an EV-only household, and that this is a higher share than before. Implying that improvements of EVs in terms of range, purchase price, etc. makes more people replace their ICEV with an EV. Another factor to consider is that people that didn´t own a vehicle before, have bought an EV and making them a part of the statistics. Though, they amounted to only 3% of EV-owners.

The positive effect of increased number of electric vehicles in addition to other ICEVs is the increase in the used EV market. This will result in a higher number of EVs for sale, which will help make EVs available at all price ranges, hence more people will have the opportunity to procure an EV.

4.4.2 Electric vehicles in bus lanes

EVs are as mentioned allowed to use the bus lanes in certain areas where they exists. This has resulted in more vehicles traveling in the bus lanes, causing public transport like buses to get stuck or delayed in traffic more frequently [40]. In spite of this the Norwegian automobile association NAF concludes that the bus lanes are capable of handling more vehicles, it is the on-going ramps to the bus lanes and highways that are the ones causing the traffic jams [40]. It is also reason to believe that the increased number of vehicles in bus lanes, are resulting in fewer vehicles travelling in the other lanes causing the overall effect to be socioeconomic beneficial in the terms of reduced local air pollution from ICEVs.

4.4.3 Reduced oil consumption

Replacing EVs with ICEVs leads to a reduced oil consumption. Considering that the oil industry in Norway stood for the biggest share of greenhouse gas emissions in 2014 [10], the increase in the use of EVs instead of ICEVs, can help reduce both the demand for oil and future emissions from the oil industry.

This increased use of EVs will also increase the demand for electricity and this will lead to an increased load on the electricity grid in Norway. However, EVs are very energy efficient and wouldn´t sequester that much energy over a year. To illustrate this, consider a Tesla Model S with an efficiency of 0,2367 kWh/km, driving 13.000km a year, this equals a little more than

3070 kWh a year. If we now, hypothetically, replaced all ICEVs in Norway today with a Tesla Model S, the total electricity needed for all cars to drive 13.000km each would be approximately 7,7 tWh for all cars each year. Considering that Norway produced 142,3 TWh and had a total net export of 15,6 TWh in 2013 [41] the increase in the number of EVs in Norway is not expected to have a big impact on neither electricity production nor grid capacity in the next decade.

4.5 Other considerations regarding policymaking

According to the research and interviews done by Nyborg (2012), some politicians do not consider the cost-benefit analysis alone to be a sufficient enough tool for policymaking. With this in mind, the rest of this section will be a discussion involving external effects not discussed in the CBA, but still concerning the policymaking of EVs in Norway.

4.5.1 Sustainability

One of the aspects to consider regarding policymaking towards EVs is the sustainability. If electric vehicles available on the market were not considered to be sustainable in comparison to conventional vehicles, a change or removal of the tax exemptions and incentives would most likely result in a decrease in the sales of EVs.

Despite the recent years increase in the number electric vehicles in Norway, more than 80% people still choose to buy an ICEV [2]. A possible reason why more people isn´t purchasing an EV is the lack of certain qualities compared to ICEVs, where some of these also are key factor to sustainability. A survey discussed in NAF (2015), see appendix 6, revealed that the biggest obstacle of procuring an EV was the uncertainty about the maintenance costs, followed by the uncertainty about the second hand value, and third was that people preferred combustion engines over electric engines.

Over the last couple of years there has been an increase in the number of EVs in the market and different segments, but there are still many segments where the EV isn´t represented yet. Some of these segments are among the most popular segments in Norway, and those are estate cars and SUVs. From using the biggest sales site for cars in Norway, finn.no, and including all 58030 cars, 20436 (approximately 35%) of the cars for sale are in the segments of combined 3-doors/5-doors (Buddy/e-Golf) and sedans (Tesla). Implying that only 35% of

the car market has competitive substitutes with an electric engine. Although there is a large uncertainty about the quality of these numbers, they still provide a certain amount of insight in the market and trends. In addition, none of the EV manufactures offers EVs with extra equipment as tow bar or ski carrier. The reason for this is that the aerodynamic of a ski carrier and extra weight of towing will reduce the range, battery capacity, etc. For many potential EV-owners the right segment and equipment are key components, which cannot be omitted with the procurement of a new vehicle, especially if it´s intended to replace an ICEV.

The purchase price and the secondhand value are important aspects affecting the implementation of EVs. The purchase prices have decreased for almost every electric vehicle over the last years, except for Tesla Model S [34]. The main reason for this is the competition in the small electric vehicle market, while Tesla Model S don´t have any competition from other electric vehicles in the same segment. Electric vehicles without the exemption of excise duty and VAT would be more expensive than a conventional vehicle to day. The reason for this is that the prices are closely correlated to cost of manufacturing, where the cost of manufacturing batteries is high (Oslo Economics, 2015).

Two things mainly affect the secondhand value of electric vehicles in Norway, and that is the incentives and tax exemptions and the development in the battery technology. While the secondhand value itself doesn´t have a direct effect on the sustainability it affects the secondhand market. A big secondhand market with multiple EVs at different price ranges is important in order for everybody to have the opportunity to buy an EV.

4.5.2 Future potential

The internal combustion engine vehicle has been on the market for over a century, and it has evolved a lot over that time period. The new generation of electric vehicles has only been on the market in less than a decade. Hence, the future potential for EVs is considered to be much higher than it is for ICEVs, and below some of the components with the biggest potential is discussed.

Batteries

The battery technology affects the electric vehicle in multiple ways, from production costs and emissions to range and capacity. The technology is still considered to be in the early stages in terms of mass-production for use in EVs. Hence, there is an uncertainty for the

expected lifetime and range of the different batteries. To cope with this uncertainty among users and potential buyers, the different manufacturers have a warranty on the batteries and/or driving distance. These warranties help with both the uncertainty among users and buyers about the battery as well as the secondhand value.

A sudden breakthrough in the battery technology, for example a new way to store more electricity, would most likely lead to a drop in the secondhand value of EVs. This fear of a breakthrough in battery technology causing the secondhand value to drop is listed as the second biggest obstacle of procuring an EV (NAF, 2015), see appendix 6.

Another demur evolving the batteries is the environmental aspect of disposing the batteries when they are no longer useful in the EV. When the capacity of the batteries has decreased to a certain amount so that the range and power is no longer fulfilling the needs, the batteries are not necessarily "dead" or no longer useful in other areas. One of the most promising areas of reusing the batteries is energy storage and reserve power supply in housing and industrial sector [42].

There is a high confidence that the largest potential for reducing emissions in the short term is from improving the energy efficiency from both vehicle and engine design (IPCC, 2014b). The report further implies, with medium evidence and agreement, that this is dependent of large investments by vehicle manufacturers, and in order for this to work and reduce emissions, it will require strong incentives and regulatory policies.

Induction

Another potential regarding batteries and range anxiety with the use of EVs is induction charging [43]. Induction charging is simply explained wireless charging, and the ideas behind using induction to charge EVs is to implement chargers into the road making the EV able to charge while driving [44][45]. This would help cope with the range anxiety, since it will increase the range of EVs. However, this technology would require a substantial amount of resources in terms of time and money to implement, but the potential is significant. This technology would also make the battery technology less important.

Changing the car fleet

Changing the entire Norwegian car fleet, or any car fleet for that matter, takes time. In 2012 in Norway the average car is 10,5 years old. [46]. Fridstrøm and Alfsen (2014) predict that changing the whole car fleet would take around 35 to 30 years considering that the car fleet is a slow mass. In other words, the effects of new EVs in the Norwegian car fleet will not be noticeable right away. A problem with this long turnover of the car fleet is that the costs are biggest now and in the near future, while the direct results are not significant until further ahead.

Even if EVs and ICEVs were to be considered equally as environmentally harmful today, the future potential of improving EVs in terms of manufacturing, emissions, and greener electricity production are considered to be greater. The ICEV also have room for improvement both in production and fuel efficiency, but not to the same extent as EVs, especially considering that they have been on the market a very long time, and at the same time reaped the benefits from the economies of scale.

4.5.3 Norway´s impact on the world

The Norwegian car fleet amounts to less than 0,3% of the global car fleet, hence any particular changes in Norway would have small impact on the global car fleet [36][47]. However, out of all Tesla´s sold in 2014, 12,7% was imported to Norway [47]. The indirect effect of purchasing a high share of the EVs produced is that it helps the manufacturers with the economies of scale. Building new production lines for EVs are costly, and purchasing EVs in the early stage of production will lead to higher revenue for the manufacturers. An increased revenue and demand will eventually result in a higher production of EVs at a lower cost, which can lead to new models in different segments. The result of increased production of EVs from the different manufacturers is a decrease in the retail price, i.e. making EVs more competitive against ICEVs. When EV manufacturers reap the benefits of economy of scale, the emissions associated with production will also be reduced.

Another impact Norway will have on the world is the policy measures given towards electric vehicles. These policy measures can be evaluated to see which of the incentives were most efficient. In other words, use Norway to learn from, and in turn make assessments of what is the best alternative for the given country. However, Holtsmark

and Skonhoft (2014) concluded that the Norwegian policy measures should not be implemented by other countries. The reason for this is that in order to reduce GHG emissions, they suggest that the best way to do this is to reduce the overall road traffic volume with imposing more taxes and restrictions on car use in general.

It is worth considering that Norway has good prerequisites for electric vehicles, in terms of environmentally friendly electricity production, and high taxation on passenger vehicles, compared to other countries. Hence, the usage of EVs becomes very environmentally friendly compared to ICEVs, and the exemption of certain taxes and incentives have big impacts on the purchase and usage costs of EVs compared to ICEVs in Norway.

5. Discussion

5.1 Results

With today´s policy measures the results from the cost-benefit analysis in scenario C shows that all the averages have a positive NPV after a lifetime of 14 years, i.e. all of the electric vehicles are a socioeconomic beneficial choice compared to ICEVs.

The total average breakeven after 2,10 years, implying that after 2,10 years or 27.317km, the total marginal net benefit from procuring and using an EV instead of an ICEV is bigger than socioeconomic cost of the policy measures towards EVs. From a socioeconomic perspective the NPV of procuring an EV instead of an ICEV is estimated to be 244.071 NOK, given that today´s policy measures lasts the whole lifetime. For Tesla, this happens after approximately 6 years or 80.000km, while the NPV was estimated to be 164.282 NOK. It is clear to see that the average for Tesla has a negative impact on the total average. However, each of this estimated averages in scenario C are more beneficial than the baseline.

From the changes in the result from scenario A-C it is safe to say that the private costs have the biggest beneficial impact on the results, while the fixed and variable costs are more or less the same over a lifetime of 14 years. The biggest component in the private costs is the marginal benefit from fuel costs. The reason why the marginal net benefit of the fuel costs is so high stems from the combination of lower prices for electricity compared to the high petrol and diesel prices, and that EVs are more energy-efficient. Hence, keeping a significant price difference between electricity and petrol and diesel will keep the private costs high. The second biggest component is tollbooths and ferries, which helps explain why this is valued as such an important factor for buying an EV.

Other research using a cost-benefit analysis to evaluate the Norwegian policies towards electric vehicles has not been found in the literature search. The only research found that might be comparable is Carlsson and Johansson-Stenman (2003) who does an ex-post CBA in order to figure out if it would be socially profitable to subsidize EVs in Sweden. They concluded that it wasn´t socially profitable, because the loss in tax revenues would be too high.

It is important to remember that an EV is a socioeconomic beneficial choice compared to an ICEV, given the specific assumptions in the model. If the alternative is to purchase a new EV to replace the old ICEV or not to buy a new vehicle at all, it will not be socioeconomic beneficial to buy an EV. The reason for this is that mortgage and interest rate would make the private costs negative, and the model will never breakeven over a lifetime of 14 years. However, replacing a used ICEV with a used EV would most likely be socioeconomic beneficial given that the price difference is minimal, since the marginal net benefit from private costs would increase. Though, this would vary from each individual vehicle and specific data on purchase prices and emissions for each of the vehicles would be needed in order to know for certain.

These results does not imply that the procurement of an EV is socioeconomic beneficial compared to the use of public transport, walking or cycling. If the alternative for a person is to buy an EV or don´t buy a vehicle at all, i.e. an additional vehicle to the car fleet. This would not be socioeconomic beneficial, since all of the marginal external effects with the use of that EV would become a cost instead of benefit. In addition, all of the private costs that occur by owning a vehicle would also count as a cost in the model.

This research and these results does not estimate or imply that the total socioeconomic effect of the policy measures is beneficial, i.e. that the socioeconomic effect of all vehicles in the data is beneficial. To estimate this, specific data on how many EVs were replaced with ICEVs and how many EVs became an additional vehicle in the household is needed. This was beyond the scope of this thesis, but is recommended for further research in order to provide insight in the total socioeconomic effect of the policy measures.

5.2 Recommendation

The current policies measures towards electric vehicles in Norway are to be considered a success by the results from this thesis, in the way that they have made EVs a more socioeconomic beneficial choice than ICEVs. Further, they definitely meet some of the general principles of the Norwegian transport policy, such as to stimulate use of more environmentally friendly and energy sources, and reduce the emissions from passenger vehicles.

The planned change in excise duty with increased focus on CO_2 and NO_x, and reducing the rates of weight and kW will help to make EVs more cost-effective and more socioeconomic beneficial compared to ICEVs. The reason for this is that by reducing the rates of weight and kW, the cost for excise duty in the model will be reduced. It is important that the components have been reversed so much that when the excise duty becomes applicable to EVs in 2020 it doesn´t lead to a drastic increase in the purchase prices.

The suggestion to replace the exemption of VAT with a premium that is set to phased out over time correlating to the technology development, will make the purchase price for Tesla´s higher, given that the premium is the same for every vehicle. A higher purchase price will reduce sales, and considering that Tesla is the only alternative for many potential EV-owners and that it is the vehicle that replaces most ICEVs, this will have a negative impact on the implementation of EVs in Norway. Hence I recommend that this suggestion is postponed at least until Tesla got some other competitors in the segment. An alternative could be that all of the extra equipment chosen in addition to the basic model was not exempted of VAT. However, to implement and control this could be time-consuming and create an inefficient tax system.

An alternative to consider, instead of removing the incentives for tollbooths and ferries at a given time, could be to phase them out and replace them with rates based on each vehicle´s emissions, in the same way the excise duty is planned. For example, a minimum fee that every vehicle have to pay to pass and in addition to that each vehicle have to pay a certain amount relative to the CO_2-emissions.

There are some concerning evidence about the real emissions of CO_2 and NO_x from new ICEVs compared to the stated emissions. Hence, having multiple important tax components

mainly depending on the stated CO_2-emissions would lead to lower revenue and higher emissions of GHG than what is estimated. Here further research is needed in order to make sure that the stated emissions are the same as the actual emissions from driving under Norwegian conditions. I strongly suggest that this is sorted out before multiple tax components for vehicles solely rely on vehicle emissions, especially such an important tax as the excise duty.

The private cost is an important parameter in making the electric vehicle socioeconomic beneficial compared to the conventional vehicle. The dilemma here is that the same incentives are also making electric vehicles so cheap to use that some EV-owners choose it instead of public transportation. Given the increased number and use of EVs, the policy would eventually have to change in order to make EVs a more costly choice than public transportation than it is today.

Passenger transport with the use of cars is inevitable in this elongated country, and in order to fulfill certain climate agreements and reach planned reduction of GHG-emissions a more environmentally friendly car fleet is needed. Considering the time it takes to change a car fleet and the future potential of EVs, the implementation of electric vehicles needs to happen sooner rather than later in order to reduce emissions from road transportation. Further, considering the sustainability of EVs today, policy measures are still needed. From a socioeconomic and environmental perspective, the future policy measures should aim at making the use of vehicles a more costly choice compared to public transport, walking or cycling than they are today. At the same time make sure that the private costs of EVs are significantly less than for ICEVs.

References

Bjertnæs, G. H. M. (2015). "Samfunnsøkonomiske kostnader av å kreve inn skatteinntekter – en generell likevektsanalyse av den norske økonomien", 2015/15. Retrieved from: https://www.ssb.no/nasjonalregnskap-og-konjunkturer/artikler-og-publikasjoner/_attachment/222358?_ts=14c50249cd8

Carlsson, F., and Johansson-Stenman, O. (2003). "Costs and benefits of electric vehicles: a 2010 perspective". Journal of Transport Economics and Policy, Vol.37, No.1, January 2003, pp. 1–28. Retrieved from: http://www.jstor.org/stable/20053920

DFO. (2014). "Veileder i samfunnsøkonomiske analyser". Oslo: Direktoratet for økonomistyring. Retrieved from: http://dfo.no/Documents/FOA/publikasjoner/veiledere/Veileder_i_samfunns%c3%b8konomiske_analyser_1409.pdf

Energi- og Miljøkomiteen. (2011). "Innst. 390 S". Meld. St. 21 (2011-2012). Stortinget: energi- og miljkomiteen. Retrieved from: https://www.stortinget.no/globalassets/pdf/innstillinger/stortinget/2011-2012/inns-201112-390.pdf

Fearnley, N. (2014). "Kommunenes inntektsbortfall ved at elbiler har betalingsfritak på avgiftsbelagte kommunale parkeringsplasser". 1340/2014. Institute of Transport Economics, Oslo. Retrieved from: https://www.toi.no/getfile.php?mmfileid=40465

Figenbaum, E., and Kolbenstvedt, M. (2013a). Elbiler i Norge. Arbeidsdokument 50347. Institute of Transport Economics, Oslo.

Figenbaum, E., and Kolbenstvedt, M. (2013b). "Electromobility in Norway - experiences and opportunities with Electric vehicles". 1276/2013. Institute of Transport Economics, Oslo. Retrieved from: https://www.toi.no/getfile.php/Publikasjoner/TØI rapporter/2013/1281-2013/1281-2013-elektronisk.pdf

Figenbaum, E., Kolbenstvedt, M. And Elvebakk, B. (2014). "Electric vehicles – environmental, economic and practical aspects". 1329/2014. Institue of Transport Economics. Retrieved from:

https://www.toi.no/getfile.php/Publikasjoner/T%C3%98I%20rapporter/2014/1329-2014/1329-2014-el.pdf

Finansdepertement, D. K. (2014). "Prinsipper og krav ved utarbeidelse av samfunnsøkonomiske analyser mv.". R-109/14. Retrieved from: https://www.regjeringen.no/globalassets/upload/fin/vedlegg/okstyring/rundskriv/faste/r_109_2014.pdf

Franco, V., Sanchez, F. P., Germ, J., and Mock, P. (2014). "Real-world exhaust emissions from modern diesel cars". ICCT, Part1. Retrieved from: http://www.theicct.org/sites/default/files/publications/ICCT_PEMS-study_diesel-cars_20141010.pdf

Fridstrøm, L., and Alfsen, K. H. (2014). "Vegen mot klimavennlig transport". 1321/2014. Institute of Transport Economics, Oslo. Retrieved from: https://www.toi.no/getfile.php?mmfileid=40122

Fridstrøm, L., and Østli, V. (2014). "Ressursøkonomisk regnskap for elektrifisering av bilparken". 1350/2014. Institute of Transport Economics, Oslo. Retrieved from https://www.toi.no/getfile.php?mmfileid=37984

Hagman, R., Weber, C., and Amundsen, A. H. (2015). "Utslipp fra nye kjøretøy – holder de hva de lover?". 1407/2015. Institute of Transport Economics, Oslo. Retrieved from: https://www.toi.no/getfile.php?mmfileid=40122

Hawkins, T. R., Singh, B., Majeau‑Bettez, G., and Strømman, A. H. (2013). "Comparative environmental life cycle assessment of conventional and electric vehicles". Journal of Industrial Ecology, Vol. 17, No.1, pp. 53–64. Retrieved from: http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2012.00532.x/epdf

Holtsmark, B., and Skonhoft, A. (2014). "The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries?" Environmental Science and Policy, Vol. 42, pp. 160-168. Retrieved from: http://www.svt.ntnu.no/iso/anders.skonhoft/Environmental Science and Policy 814.pdf

IEA. (2013). "Global EV Outlook". International Energy Agency, April 2013. Retrieved from: https://www.iea.org/publications/globalevoutlook_2013.pdf

IPCC. (2014a). "Introductory Chapter". Fifth Assessment Report, Intergovernmental Panel on Climate Change. Retrieved from: http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter1.pdf

IPCC. (2014b). "Summary for Policymakers". Fifth Assessment Report, Intergovernmental Panel on Climate Change. Retrieved from: https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., Varna, A., and Cox, V. (2014). "Update of the Handbook on External Costs of Transport". European Comission Vol. 2. Retrieved from: http://ec.europa.eu/transport/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf

Majeau-Bettez, G., Hawkins, T. R., and Strømman, A. H. (2011). "Life cycle environmental assessment of lithium-ion and nickel metal hydride batteries for plug-in hybrid and battery electric vehicles". Environmental Science and Technology, Vol. 45, No.10, pp. 4548–4554. Retrieved from: http://pubs.acs.org/doi/pdf/10.1021/es103607c

Marbjerg, G. (2013). "Noise From Electric Vehicles – a Literature survey". WP 3, COMPETT. Retrieved from: http://www.compett.org/documents/wp_3_report_noise_from_electric_vehicles_a_literature_survey.pdf

NAF. (2015). "NAF Elbilrapport". March 2015. Retrieved from: https://www.naf.no/globalassets/dokumenter/politikk/elbilrapport.pdf

Notter, D. A., Gauch, M., Widmer, R., Wäger, P., Stamp, A., Zah, R., and Althaus, H. J. (2010). "Contribution of Li-ion batteries to the environmental impact of electric vehicles". Environmental Science and Technology, Vol. 44, No.17, pp. 6550–6556. Retrieved from: http://pubs.acs.org/doi/pdf/10.1021/es903729a

NOU (1998). "Nytte-kostnadsanalyser". Norges offentlige utredninger 1998: 16. Retrieved from:

https://www.regjeringen.no/contentassets/665d0f4312f545f18b4028694a003412/no/pdfa/nou199819980016000dddpdfa.pdf

NOU (2012). "Samfunnsøkonomiske analyser". Norges offentlige utredninger 2012: 16. Retrieved from:

https://www.regjeringen.no/contentassets/5fce956d51364811b8547eebdbcde52c/no/pdfs/nou201220120016000dddpdfs.pdf

Oslo Economics (2015). "Elbilens konkurransedyktighet i Norge". 2015-13. Retrieved from:

http://osloeconomics.no/wp-content/uploads/2015/03/Rapport-2015-13-Elbilens-konkurransedyktighet-i-Norge-12-mars-2015_OPPDATERT.pdf

Thune-Larsen, H., Veisten, K., Løvold Rødseth, K., and Klæbøe, R. (2014). "Marginale eksterne kostnader ved vegtrafikk". 1307/2014. Institute of Transport Economics, Oslo. Retrieved from: https://www.toi.no/getfile.php?mmfileid=38978

UNEP (2013). "OWG Issues Brief on Sustainable Transport". United Nations Environment Programme. Retrieved from:

http://www.unep.org/Transport/sharetheroad/PDF/OWG_brief_Final.pdf

ZSW (2015). "Press Release 06/2015". Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, Stuttgart. Retrieved from: http://www.zsw-bw.de/uploads/media/pi06-2015-ZSW-E-Mobility.pdf

Web-sites:

[1]   Statistics on plug-in vehicles. Grønn Bil. Website: http://www.gronnbil.no/statistikk/. Published 11 April 2015. Date: 14.04.15

[2]   Car sales in 2014. Opplysningsrådet for veitrafikk AS. Website: http://www.ofvas.no/bilsalget-i-2014/category648.html. Published January 2015. Date: 17.04.15

[3]   Global passenger car registrations. The International Organization of Motor Vehicle Manufacturers. Website: http://www.oica.net/category/sales-statistics/. Published: 2015. Date: 17.04.15

[4]   Climate change: how do we know? NASA. Website: http://climate.nasa.gov/evidence/
        Updated: 27 May 2015. Date: 11.03.15

[5]   Consensus: 97% of climate scientists agree. NASA. Website:
        http://climate.nasa.gov/scientific-consensus/ Updated: 27 May 2015. Date: 11.03.15

[6]   Keep global warming below 2 degrees Celsius. European Comission. Website:
        http://ec.europa.eu/clima/citizens/eu/index_en.htm Updated: 20 May 2015. Date:
        21.05.15

[7]   A blanket around the world. NASA. Website: http://climate.nasa.gov/causes/ Updated:
        Date: 11.03.15

[8]   Carbon dioxide. NASA. Website: http://climate.nasa.gov/vital-signs/carbon-dioxide/
        Updated: 27 May 2015. Date: 14.03.15

[9]   Road transport: Reducing CO2 emissions from vehicles. European Comission.
        Website: http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm Updated:
        08 May 2015. Date: 11.03.15

[10]   Greenhouse gases. Statistics Norway. Website: https://www.ssb.no/natur-og-
        miljo/statistikker/klimagassn/aar-forelopige/2015-05-07 Published: 07 May 2015.
        Date: 19.05.15

[11]   Global GHG emissions data. United States Environmental Protection Agency.
        Website: http://www.epa.gov/climatechange/ghgemissions/global.html Published: 09
        September 2013. Date: 23.04.15

[12]   The 2015 international agreement. European commission. Website:
        http://ec.europa.eu/clima/policies/international/negotiations/future/index_en.htm
        Updated: 29 May 2015. Date: 05.05.15

[13]   EU climate action. European Comission. Website:
        http://ec.europa.eu/clima/citizens/eu/index_en.htm Update: 20 May 2015. Date:
        21.05.15

[14]   Review of vehicle taxes. The Norwegian government. Website:
        https://www.regjeringen.no/nb/aktuelt/helhetlig-gjennomgang-av-kjoretoy--og-
        drivstoffavgiftene/id2411426/ Published: 12 May 2015. Date: 12.05.15

[15]   Pricelists Leaf. Nissan Norway. Website:
        http://www.nissan.no/etc/medialib/nissaneu/_NO_no/_Other_pdf/_pricelists.Par.1031.
        File.dat/LEAF_Kundeprisliste__01-05-15_0665.pdf Published: 01 May 2015. Date:
        04.05.15

[16]   Vehicle options. Tesla Motors Norway AS. Website:
        http://my.teslamotors.com/no_NO/models/design Published: 2015. Date: 23.04.15

[17]   Price and information Golf. Volkswagen. Website:
        http://www.volkswagen.no/no/models/golf/brosjyrer-og-priser.html Published: 2015.
        Date: 23.04.15

[18]   Price and information e-Up!. Volkswagen. Website:
        http://www.volkswagen.no/no/models/up-/brosjyrer-og-priser.html Published: 2015.
        Date: 23.04.15

[19]   iMiev. Mitsubishi Motors Corporation. Website: http://www.mitsubishi-motors.no/i-
        miev/#!: Date: 23.04.15

[20]   i3. BMW Norge AS. Website:
        http://www.bmw.no/no/no/newvehicles/i/i3/2013/showroom/index.html Date:
        23.04.15

[21]   iOn. Peugeot Norway. Website: http://www.peugeot.no/oppdag/ion/kombi-5-dorer/
        Published: 2015. Date: 23.04.15

[22]   C-Zero. Citroen Norway.Website: http://www.citroen.no/biler/citroen/c-zero.html
        Date: 23.04.15

[23]   Renault Zoe. RBI Norge AS. Website: http://www.renault.no/ze/zoe Date: 23.04.15

[24]   Soul. Kia Bil Norge AS. Website: http://www.kia.com/no/modeller/soul/ Published:
        2015. Date: 23.04.15

[25]   Think City. Wikipedia the free encyclopedia. Website:
        http://en.wikipedia.org/wiki/Think_City Updated: 23 May 2015: Date: 23.04.15

[26]   Ford Focus Electric. Ford Motor Norge AS. Website: http://www.ford.no/Biler/Focus-
        Electric/Oversikt Published: 2015. Date: 23.04.15

[27]   About Tesla. Tesla Motors. Website: http://www.teslamotors.com/about Published:
        2015. Date: 23.04.15

[28]   Electricity, annual figures. Statistics Norway. Website: http://www.ssb.no/energi-og-
        industri/statistikker/elektrisitetaar/aar/2015-03-25#content Published: 23 March 2015.
        Date: 27.03.15

[29]   Driving distances. Statistics Norway. Website: http://www.ssb.no/klreg/ Published 30
        April 2015: Date: 02.05.15

[30]   Registered vehicles. Statistics Norway. Website: http://www.ssb.no/bilreg Published:
        25 March 2015. Date: 27.03.15

[31]   Excise duty. Toll- og Avgiftsdirektoratet. Website:
       https://www.toll.no/no/bedrift/bilavgifter/engangsavgift/rundskriv-om-
       engangsavgiften/ Published: 2015. Date: 30.04.15

[32]   VAT with import of vehicles. Toll- og Avgiftsdirektoratet. Website:
       http://www.toll.no/no/bil-og-bat/import-av-bil/innforsel-av-bil/merverdiavgift-ved-
       import-av-bil/ Published: 17 December 2014. Date: 30.04.15

[33]   Equipment choice. Tesla Motors Norway. Website:
       http://my.teslamotors.com/no_NO/models/design Published: 2015. Date: 13.05.15

[34]   Purchase prices new vehicles. Skattetaten. Website:
       http://www.skatteetaten.no/no/Person/Selvangivelse/tema-og-fradrag/Bil-og-andre-
       kjoretoyer/Bil/Bilpriser/ Date: 28.04.15

[35]   Annual fee vehicles. Toll- og Avgiftsdirektoratet. Website:
       https://www.toll.no/no/bil-og-bat/arsavgift/satser-og-frister/ Published: Date:
       13.05.15

[36]   Transport statistics. Statistics Norway.Website:
       https://statbank.ssb.no/statistikkbanken Date: 05.05.15

[37]   Location EVs registered. Grønn Bil. Website:
       http://www.gronnbil.no/ladbarebiler/?zr=1&region=0&p=t&lat=65.16500897619129
       &lng=12.938616699218755&z=4&y=2015&m=3&ct=elbil&ts=q&lang=no_NO&flist
       = Published: 2015. Date: 10.04.15

[38]   Population density of cities in Norway. Statistics Norway. Website:
       http://www.ssb.no/223508/tettsteder.folkemengde-og-areal-etter-kommune.1.januar-
       2014 Published: 2014. Date: 20.04.15

[39]   Exchange rates. Norges Bank. Website: http://www.norges-
       bank.no/Statistikk/Valutakurser/valuta/EUR/ Updated: 29 May 2015. Date: 23.04.15

[40]   Increased pollution without EVs in bus lanes. NAF. Website:
       https://www.naf.no/om-naf/nytt-fra-naf/lengre-koer-og-okt-forurensing-uten-elbil-i-
       kollektivfelt/ Published: 8 September 2014. Date: 23.04.15

[41]   Electricity. Statistics Norway. Website: www.ssb.no/elektrisitet Published: 6 May
       2015.Date: 20.05.15

[42]   Co-operation to recycle batteries from Nissan Leaf. ABB.
       http://www.abb.no/cawp/seitp202/6fcd6c82dbc25934c125798b002aa762.aspx
       Published: 20 January 2012. Date: 24.01.15

[43]   Leber, J. Wireless charging – has its time finally arrived. MIT Technology review.
       Website: http://www.technologyreview.com/news/429163/wireless-
       charging%E2%80%94has-its-time-finally-arrived/ Published: 11 September 2012.
       Date: 17.01.15

[44]   Qvale, P. Tarmack charging EVs. Teknisk ukeblad. Website:
       http://www.tu.no/samferdsel/2015/03/19/denne-asfalten-lader-elbilen-mens-du-kjorer
       Published: 19 March 2015. Date: 04.04.15

[45]   LaMonica, M. Someday your EV charger may be the roadway itself. MIT Technology
       review. Website: http://www.technologyreview.com/news/521761/someday-your-ev-
       charger-may-be-the-roadway-itself/ Published: 19 November 2013. Date: 23.04.15

[46]   Vehicle registrations, sorted by age and brand. Statistics Norway.Website:
       http://www.ssb.no/107749/registrerte-personbiler-etter-bilens-alder-og-
       fabrikkmerke.gjennomsnittsalder-p%C3%A5-registrerte-personbiler Published: 2015.
       Date: 27.04.15

[47]   Loveday, E. Top 10 Global electric car sales 2014. Inside EVs. Website:
       http://insideevs.com/top-10-global-electric-car-sales-2014/ Published: 05 February
       2015 Date: 27.02.15

Appendix 1: Temperature anomaly
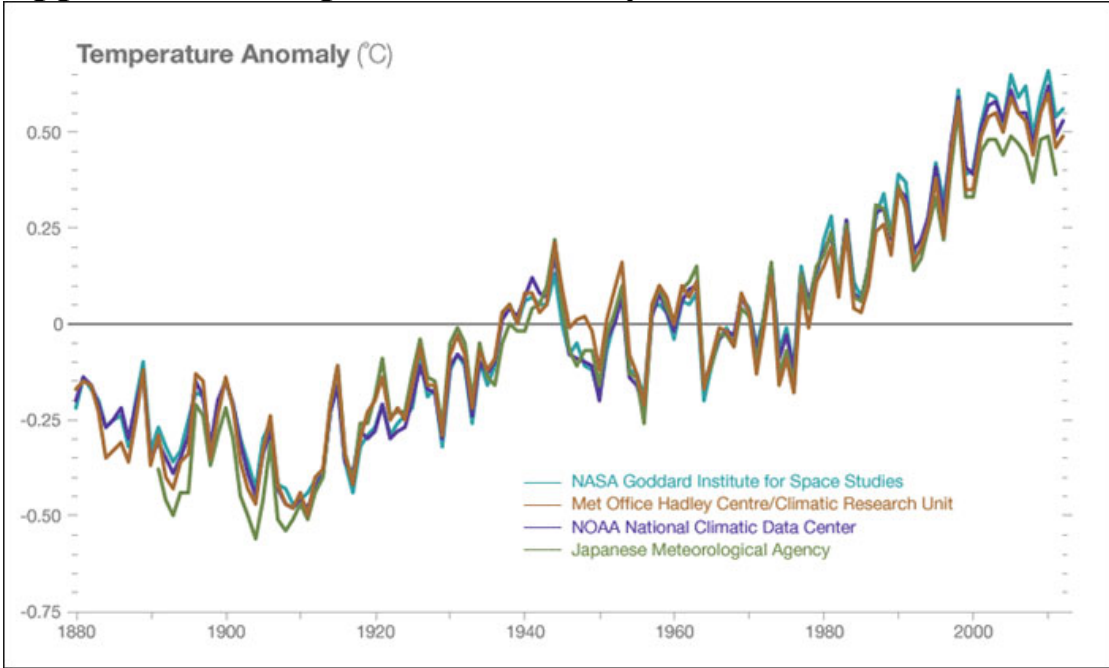
Temperature anomalies. Source: NASA [5].

Appendix 2: CO2-levels
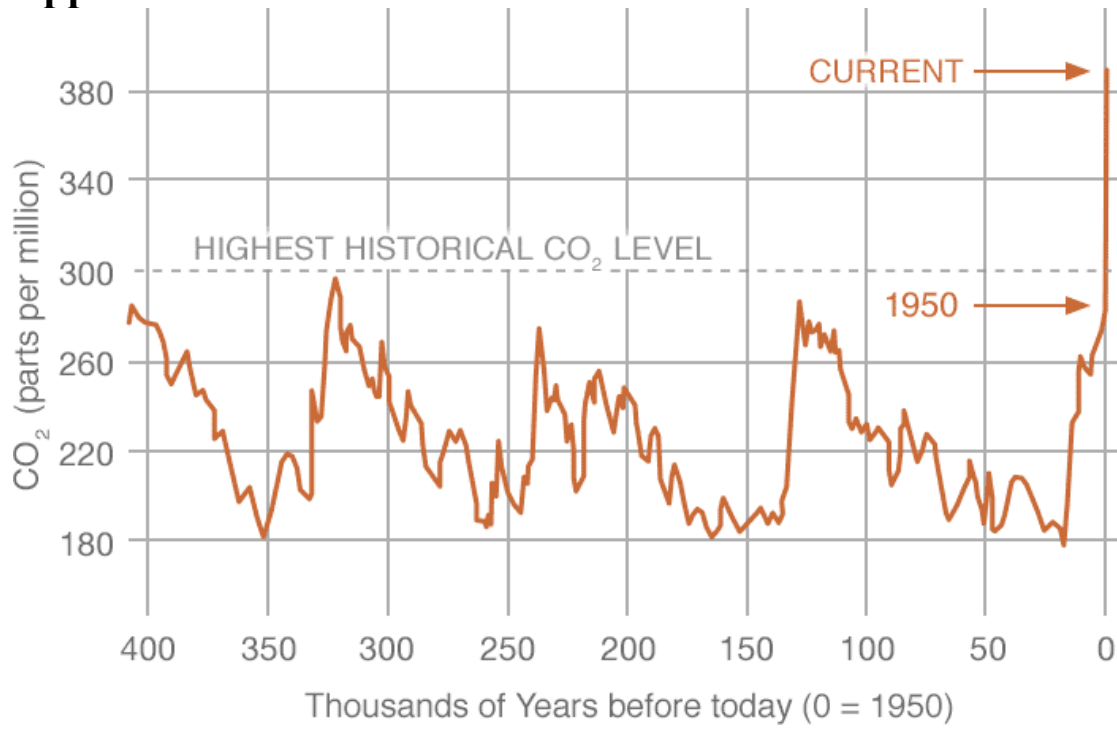
CO2-levels. Source: NASA [8].

Appendix 3: Marginal external costs of climate change

Table 35: Marginal climate change costs for road transport (cars and light commercial vehicles), EU average (prices of 2010).

Vehicle	Size	EURO-Class	Urban	Rural	Motorways	Average
			(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)
Passenger Car - Petrol	<1,4L	EURO-0	2.8	1.7	1.8	2.0
		EURO-1	2.6	1.5	1.7	1.8
		EURO-2	2.5	1.4	1.5	1.7
		EURO-3	2.4	1.4	1.5	1.7
		EURO-4	2.4	1.4	1.5	1.7
		EURO-5	2.4	1.4	1.5	1.7
	1,4-2L	EURO-0	3.4	2.0	2.1	2.3
		EURO-1	3.1	1.8	1.9	2.1
		EURO-2	3.0	1.7	1.7	2.0
		EURO-3	2.9	1.7	1.7	2.0
		EURO-4	2.9	1.7	1.7	2.0
		EURO-5	2.9	1.7	1.7	2.0
	>2L	EURO-1	3.9	2.3	2.3	2.8
		EURO-2	3.9	2.3	2.3	2.7
		EURO-3	3.5	1.9	1.8	2.4
		EURO-4	3.5	1.9	1.8	2.4
		EURO-5	3.5	1.9	1.8	2.4
Passenger Car - Diesel	<1,4L	EURO-2	1.7	1.1	1.2	1.3
		EURO-3	1.6	1.1	1.2	1.3
		EURO-4	1.6	1.1	1.2	1.3
		EURO-5	1.6	1.1	1.2	1.3
	1,4-2L	EURO-0	2.4	1.7	1.9	1.9
		EURO-1	2.2	1.5	1.8	1.7
		EURO-2	2.2	1.5	1.6	1.7
		EURO-3	2.1	1.4	1.5	1.6
		EURO-4	2.1	1.4	1.5	1.6
		EURO-5	2.1	1.4	1.5	1.6
	>2L	EURO-0	3.3	2.3	2.7	2.6
		EURO-1	3.0	2.1	2.4	2.4
		EURO-2	3.0	2.0	2.3	2.3
		EURO-3	2.9	1.9	2.1	2.2
		EURO-4	2.9	1.9	2.1	2.2
		EURO-5	2.9	1.9	2.1	2.2
Light commercial vehicles	Petrol	EURO-0	4.0	2.5	2.8	2.7
		EURO-1	3.6	2.3	2.5	2.5
		EURO-2	3.7	2.2	2.4	2.5
		EURO-3	3.7	2.2	2.4	2.5
		EURO-4	3.4	2.1	2.3	2.3
		EURO-5	3.4	2.1	2.3	2.3
	Diesel	EURO-0	2.9	2.0	2.9	2.4
		EURO-1	2.8	1.8	2.6	2.2
		EURO-2	2.8	1.8	2.6	2.2
		EURO-3	2.8	1.8	2.5	2.1
		EURO-4	2.8	1.7	2.4	2.1
		EURO-5	2.8	1.7	2.4	2.1

Source: (Korzhenevych et al., 2014)

Appendix 4: Survey among EV-owners

Legend:
- ■ I drive more than before
- ■ I drive less than before
- ■ I use public transport less than before
- ■ I use public transport more than before
- ■ I walk or cycle less
- ■ I walk or cycle more
- ■ I have done other changes
- ■ No change
- ■ Do not know/no answer

	I drive more than before	I drive less than before	I use public transport less than before	I use public transport more than before	I walk or cycle less	I walk or cycle more	No change	Do not know/no answer
EV OWNERS NORWAY	23%	7%	16%	7%		5%	60%	3%
EV OWNERS OSLO KONGSBERG	28%	7%	24%	9%		6%	53%	4%

Figure 5.13 Changes in the travel pattern among EV owners in Norway 2014 (n = 1 722). Percent

Legend: ■ More ■ Less

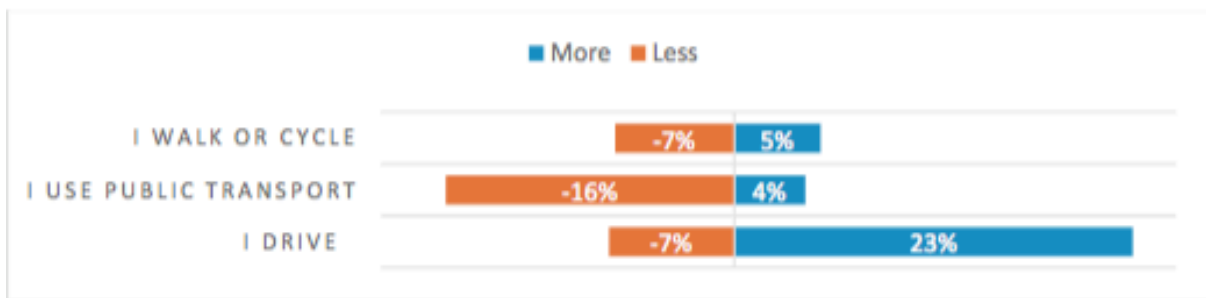|	Less	More
I WALK OR CYCLE	-7%	5%
I USE PUBLIC TRANSPORT	-16%	4%
I DRIVE	-7%	23%

Figure 5.14 Changes to walking, cycling, public transport use and driving after buying the EV. EV owners in Norway 2014 (n = 1 721). Percent

Legend: ■ More ■ Less

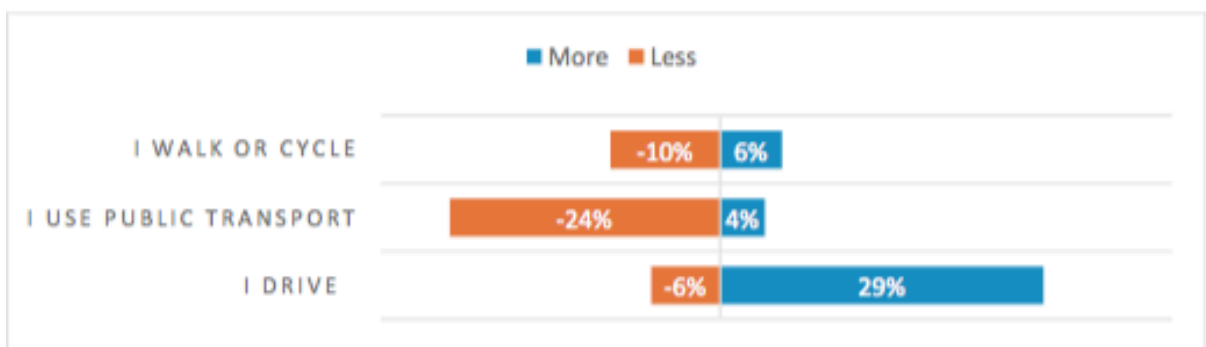|	Less	More
I WALK OR CYCLE	-10%	6%
I USE PUBLIC TRANSPORT	-24%	4%
I DRIVE	-6%	29%

Figure 5.15 Changes to walking, cycling, public transport use and driving after buying the EV. EV owners in Oslo-Kongsberg region 2014 (n = 527). Percent

Source: Chapter 5.9 in Figenbaum et.al. (2014).

58

Appendix 5: Replacing EVs with ICEVs

Legend:
- Yes, the EV replaced another car
- No, the EV came in addition to other vehicles.
- Yes the EV replaced two or more vehicles
- No, did not have a vehicle before

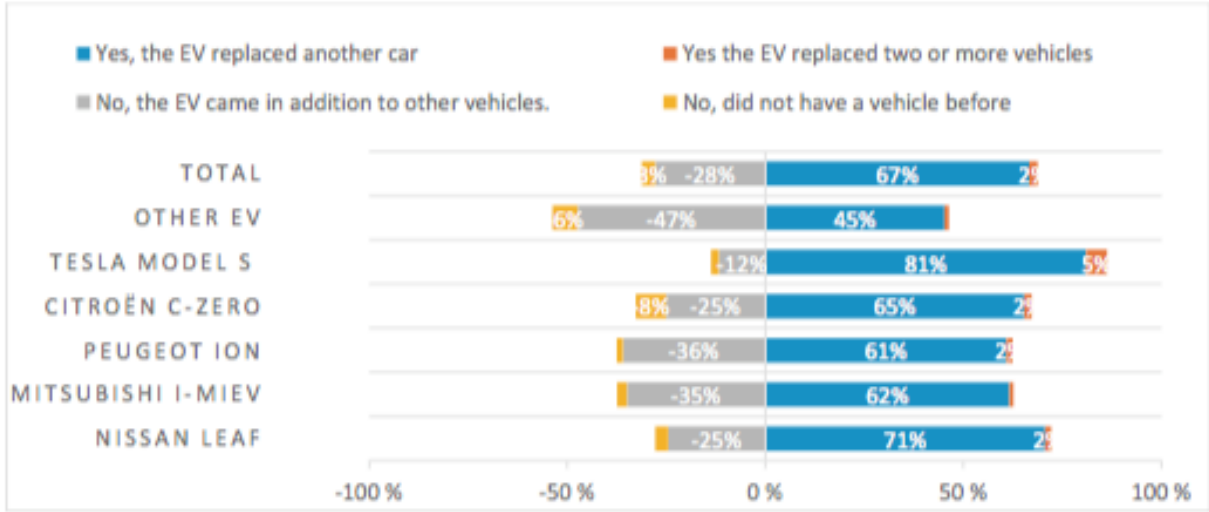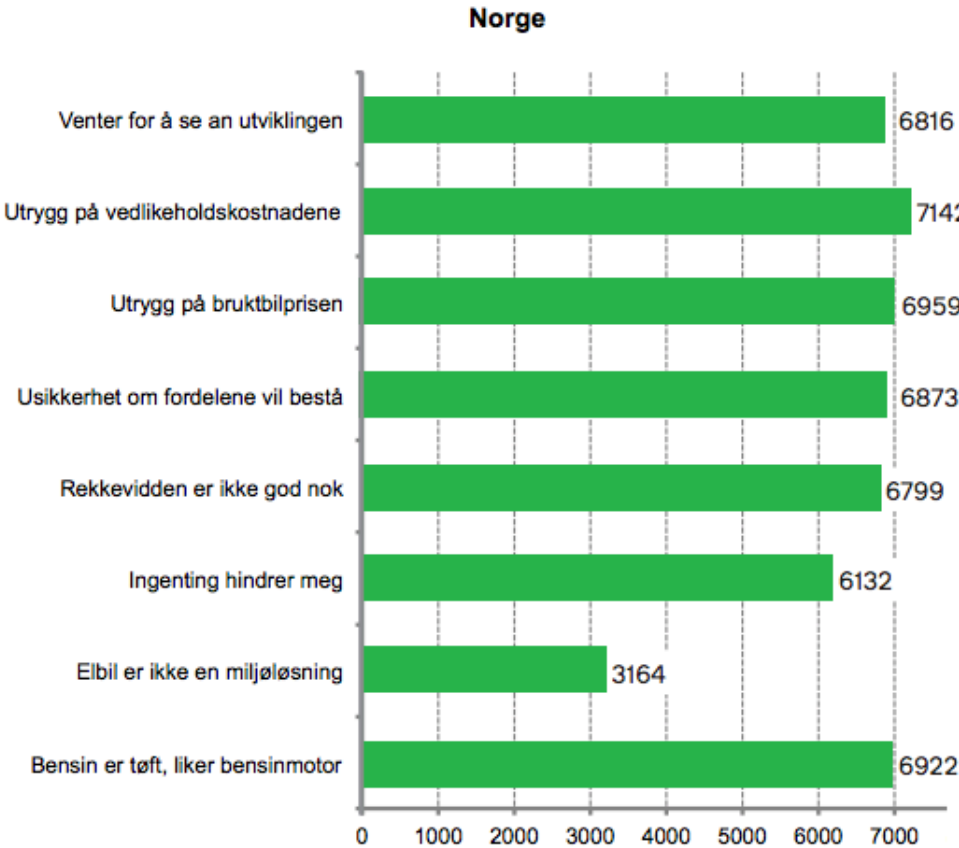|	
TOTAL	3% -28% 67% 2%
OTHER EV	6% -47% 45%
TESLA MODEL S	-12% 81% 5%
CITROËN C-ZERO	8% -25% 65% 2%
PEUGEOT ION	-36% 61% 2%
MITSUBISHI I-MIEV	-35% 62%
NISSAN LEAF	-25% 71% 2%

Figure 4.11 Change in number of vehicles in the household after buying the EV by brand, among EV owners in Norway 2014 (n = 1 721). Percent

Source: Chapter 4.5 from Figenbaum et.al (2014)

Appendix 6: What is preventing people from buying an EV

Figur 14: Hindringer for å kjøpe elbil

Norge

Kategori	Verdi
Venter for å se an utviklingen	6816
Utrygg på vedlikeholdskostnadene	7142
Utrygg på bruktbilprisen	6959
Usikkerhet om fordelene vil bestå	6873
Rekkevidden er ikke god nok	6799
Ingenting hindrer meg	6132
Elbil er ikke en miljøløsning	3164
Bensin er tøft, liker bensinmotor	6922

Source: Chapter 2.2.4 in NAF (2015).