The explosion of electric vehicles use in Norway – Environmental consciousness or economic incentives?

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1.1. Short Abstract

The use of Electric Vehicles (EVs) has exploded in Norway where Oslo is now thecapital city of EVs. From a transportation research point of view, there are two questions that lend themselves from the observations above: (1) are the Norwegian car user more environmentally conscious than others in the western world and/or, (2) are there economic incentives in place that encourage the use of EVs in Norway more than in other countries?

In this paper we examine the two questions posed above in the case of Oslo where a toll ring has been in place since 1989 and where 60% of funds collected are used to improve the road network while the rest are used to improve both public transportation and cycling. In this paper we also estimate the loss of income to the government due to the exemption of tolls. Further we examine a first-best scenario where EVs pay the external cost of their road use versus those of conventional vehicles. We find that it is due to economic incentives rather than Norwegians being more environmentally conscious.

1. INTRODUCTION

There is currently an Electric "Car Fever" in Norway. Tesla S and Nissan Leaf which are electric driven vehicles are on the top of car sales statistics in Norway. As a matter of fact, the sales of electric vehicles (EVs) in the Oslo area have more than doubled from 2012 to 2013 and the increase is expected to continue also in the coming years.Norway has probably the world's best incentives for Zero Emission Vehicles, and correspondingly the world's highest number of electric cars per capita by a wide margin. In the second half of 2013, EV sales are booming. Tesla started deliveries of the Model S and this vehicle became the bestseller in the statistics of new vehicle sales in Norway for September month. Nissan Leaf was the best seller in October.

From a transportation research point of view, there are two questions that lend themselves from the observations above: (1) are the Norwegian car user more environmentally conscious than others in the western world and/or, (2) are there economic incentives in place that encourage the use of EVs in Norway more than in other countries?

In this paper we examine the two questions posed above in the case of Oslo where a toll ring has been in place since 1989 and where 60% of funds collected are used to improve the road network while the rest are used to improve both public transportation and cycling.In this paper we also estimate the loss of income to the government due to the exemption of tolls. Further we examine a first-best scenario where EVs pay the external cost of their road use versus those of conventional vehicles, and the effect on greenhouse gas emissions.Figure 1 illustrates the increased share of EVs since 2009.

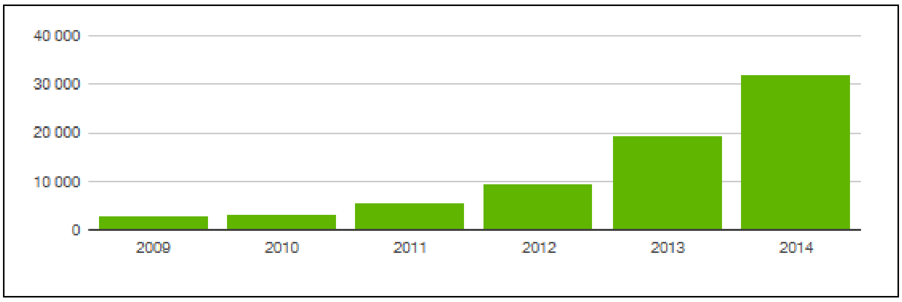


Figure 1: Registered EVs in Norway, http://www.gronnbil.no/statistikk?lang=en_US

There are pros and cons by having the economic incentives for buying EVs in Norway. The political decision should be the one in which the socioeconomic benefits (pros) are greater than the socioeconomic costs(cons).

Electrification is an important factor when attempting to reach the goal of reducing greenhouse gas emissions and local pollution. For example, Figenbaum et al. (2013) show that not only Norwegian, but also European climatic goals for average emissions from new cars, can be reached with increased electro-mobility. To limit greenhouse gas emissions, reduce environmental effects of transport, as well as help to meet national objectives and international obligations on human health and the environment a number of different types of measures or packages of measures will be required. It is not only necessary to reduce the need for transportation, but also to influence the distribution of transportation, so that people and goods are transported in the environmentally best way possible, ensuring that the means of transportation uses the best environmental technology possible, e.g. the electrification of the vehicle fleet. If petrol and diesel cars are replaced by EVs, there can be substantial savings made in energy consumption and emission of the greenhouse gases (Figenbaum et al. (2013)).

We however, also find some drawbacks with the Norwegian economic incentives for the use of EVs and which no country whatsoever, should copy. The first is that EVs are only socioeconomically beneficial in the sense that they lead to a reduction in greenhouse gas emissions. To that end, the only reasonable tax exemption for EVs should have been the gasoline tax which, presumably are set to account for emissions (NOU 2007:8). Exempting EVs from tolls meant to finance road infrastructure is counter-intuitive; EVs need as much road space as all other traditional vehicles and therefore should pay tolls. We find that the external cost of EVs are much less than the conventional vehicle since they produces less air pollution and consumes less energy than conventional vehicles. However, they increase travel time and congestion on transit lanes of which they are allowed to use. This is an additional external cost that EVs impose on the society and that must be accounted for.

In the literature we find disagreements on the topic. Holtmark(2012) address the question if the EV policy in Norway does work as intended. He concludes that the electric vehicle owners should pay for use of roads, parking fees and the energy they use, and that it is difficult to see why EVs shouldhave access to bus lanes. He writes that with the right policy instruments will the least environmentally damaging alternatives prevail. Figenbaum (2012) answer Holtsmark (2012) and concludes that Electric vehicle policy work as intended. Hultkratz (2012) made a before–after comparison that indicate the impact of the road toll in Stockholm on traffic volumes was smaller when the system was re-opened in 2007, compared to the effect during the trial in 2006. They find that the growth of the share of exempted ‘‘green’’ cars and the decision to make charges deductible from the income tax was about to considerably reduce the positive welfare effect of the toll at the time when the ‘‘green’’ car exemption was abolished.

The paper proceeds as follows. Section 2 describes methodology and data. Section 3discusses if the Norwegian car user are more environmentally conscious than others in the western world. Section 4describes the loss of income to the government due to the exemption of tolls. Section 5describes the reduced greenhouse gas emissions with EVs. Section 6describes the first-best scenario where EVs pay the external cost of their road use versus those of conventional vehicles. In section 7, concluding remarks are provided.

2. METHODOLOGY AND DATA

We use relatively simple statistical procedures to examine the impacts of increase in EVs on the society. For instance, to calculate the revenue loss for the Oslo toll ring, we multiply the number of EVs crossing the toll by the toll rates they would have paid. Furthermore much of the message that this paper conveys is by comparing data on costs between conventional vehicle and EVs.

The data that we use derives from several different sources. Data on traffic were mainly gathered from the Oslo toll ring company. The data included toll rates, number of vehicles crossing the tolls divided by different vehicle categories e.g., EVs, non-EVs, heavy passenger vehicles etc. Data on congestion costs are calculated by Rekdahl et al. (2012), and then multiplied by the number of EVs in the tollring to find the external cost of EVs road use.

3. THE DRIVERS FOR THE PURCHASE OF EVS – ECONOMIC OR ENVIRONMENTAL CONSCIOUSNESS?

To examine why Norwegians are purchasing EVs it is interesting to compare the motives that drives them to do so. Two particular motives are that the Norwegian are environmental friendly and/or there are economic incentives that drives them to do so.

There are several reasons to believe that environmental friendliness is not the driving force behind the increased purchases of EVs. The first argument is that Norway care less about the environment than for example Sweden and Denmark (Michelin 2013). See figure 2: reasons for wanting to buy an electric car at next vehicle purchase in Sweden, Denmark and Norway.

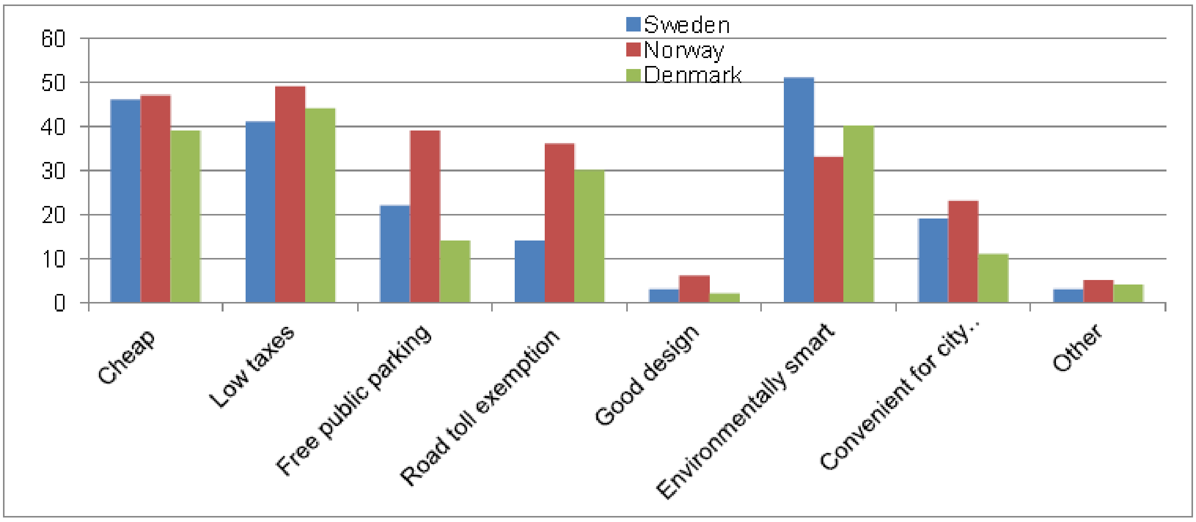


Figure 2: Reasons for wanting to buy an Electric car at next vehicle purchase in Sweden, Denmark and Norway. Source: Michelin 2013.

A Norwegian study conducted in July 2014 shows that over half of the respondents bought EVs because of lower costs. See figure 3.

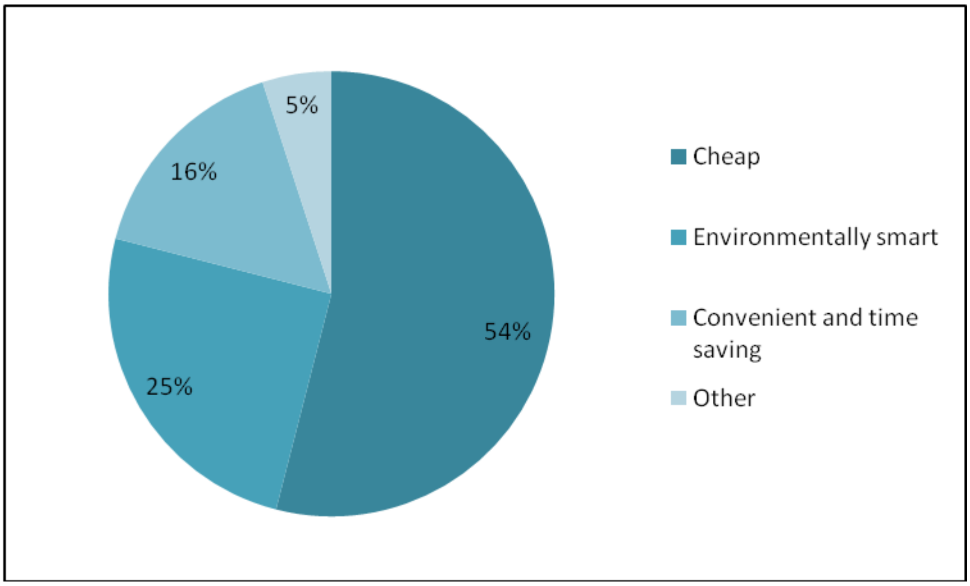


Figure 3: The main reason for buying EVs. Source: Elbil.no

And figure 4 show the rankings of EVs benefits from the same study from July 2014.

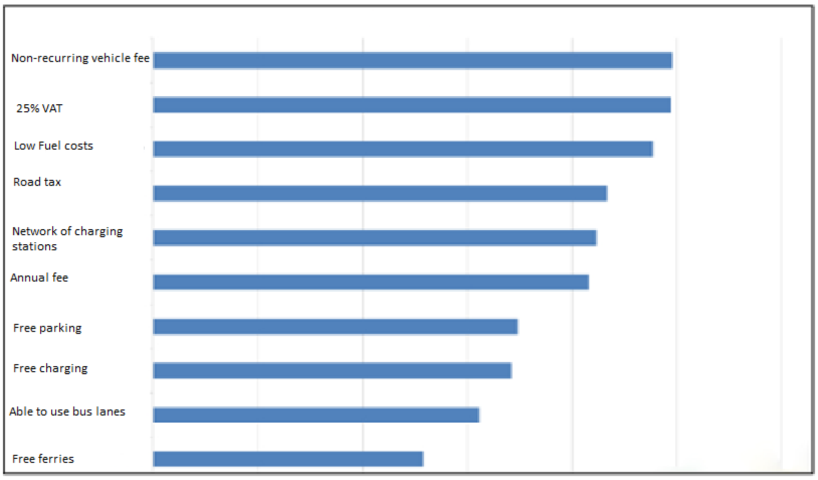


Figure 4: Ranking of EVs benfits. Source: Elbil.no

The economic incentives that lead to increased use of EVs in Oslo are as follows:

1. EVs are exempt in Norway from all non-recurring vehicle fees, including purchase taxes, which are extremely high for ordinary cars, and 25% VAT on purchase, together making electric car purchase more price competitive as compared with conventional cars.
2. EVs are also exempted from the annual road tax, all public parking fees, toll payments which are high, as well as being able to use bus lanes also in the rush hours.

3. EV users do not incur fuel taxes (gasoline tax and diesel tax) and the marginal fuel costs as there are numerous plug-in stations which are free of charge.
4. Judging from previous attitudinal studies from Norway as compared to other cities in Europe, there is no evidence that the Norwegians are more environmental conscious to the extent that it alone can lead to the observed explosion of EV use.

How much does an EV cost over five years compared to a conventional car? Each month you will save around NOK2000 (250 Euro) by driving Nissan Leaf instead of an average conventional car. See the costs over a five year period figure5.

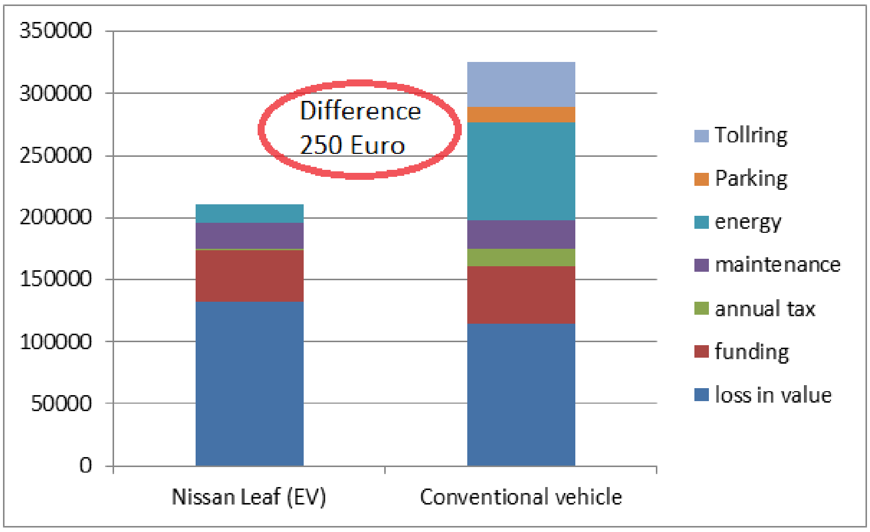


Figure 5: Costs over 5 year, 15 000 km. Data source: grønnbil.no

Halvorsen and Frøyen (2009) compare the travel habits of electric vehicle owners to those found in the population sample. Their study shows that it is clear that those who have purchasedEVs have changed their travel habits. Compared to how they usually travelled to work before they bought the EV, it turns out that they now travel less with public transport and more often by car.

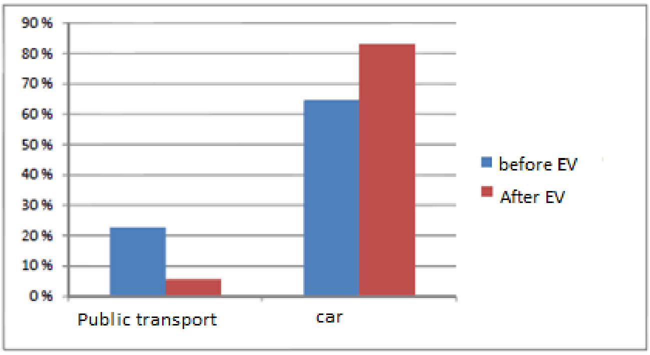


Figure 6: Travel habits before and after they bought an EV. Source: Halvorsen and Frøyen (2009)

Although the number of electric cars is small today, the findings show that the procurement of EVs became at the expense of public transport. If this is the trend that stays in the future transport market, it will produce results that are very adverse for public transport. There is good reason to question whether it is desirable for the urban transport situation and land use in the long term, to maintain these incentives in the form they have today (Halvorsen and Frøyen (2009)).

From these results we conclude that it is the economic incentives that have led to the observed explosion of EV use in Norway. Ultimately, the difference in generalised cost of EV use is insignificant as compared to a conventional vehicle.

4. LOSS OF INCOME TO THE GOVERNMENT DUE TO THE EXEMPTION OF TOLLS

Sales of electric vehicles (EVs) in the Oslo area have more than doubled from 2012 to 2013 and the increase is expected to continue also in the coming years.Until at least 2017 the government have planned to keep the good economic incentives for EVs. In the following calculations we assume that the increase will continue, and that the numbers of EVs will double every year until 2017. However, EVs will probably always be cheaper so we assume a less convex curve from 2017. The technology will be better, and we can expect a greater supply for EVs in the future. Revenue loss (RL) equals number of EVs that does not pay the toll today times the price in the toll ring today.

$$RL_t = EV_t * p_t$$

We assume the price is NOK30, which is the toll in the Oslo tollring today. We do not take into account that the toll in Bærum is less, but most of the tollring is inside Oslo toll zone.

Revenue loss in 2012:

$$RL_{2012} = EV_{2012} * p_{2012} = 814047 * 30 = 24421410$$

Revenue loss 2012	NOK 24 millions
Revenue loss 2013	NOK 50 millions
Expected revenue loss 2014	NOK 99 millions
Expected revenue loss 2015	NOK 199 millions
Expected revenue loss 2016	NOK 398 millions
Expected revenue loss 2017	NOK 796 millions
Expected revenue loss 2020	NOK 836 millions

5. REDUSED GREENHOUSE GAS EMISSIONS WITH EVS

Average CO_2 emissions for all new passenger cars in April was 114 g / km, it is 13 g / km less than in April 2013. In April, the average CO2 emissions for new cars with petrol engine 121 g / km, while for diesel cars was 134 g / km. In April 2013, they had gasoline powered passenger cars 126 g / km in CO_2 emissions, while the diesel powered passenger cars had 137 g / km.Among the new passenger cars that have CO2 emissions between51 to 110 g / km, it is a significant increase in the interval from 51 to 110 g / km. In 2012 had 17.2 percent of the new cars CO_2 emissions between 51 and 110 g / km. In 2013 22.2 percent of the new passenger cars were within this range (ofvas.no). Emissions from EVs are unsure. Some says that from the electric car, there are no emissions of CO, NOx, HC and particulates that are harmful to people's health and no emission of greenhouse gasesif you use Norwegian water power (naf.no). The figure below illustrates emissions for different types of cars per km, when we assume no emissions from EVs.

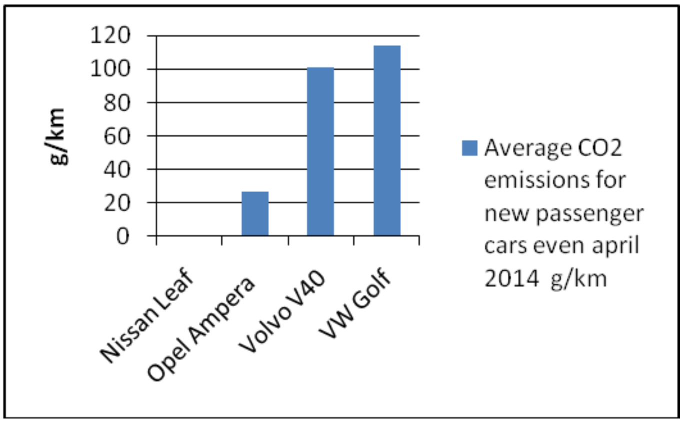


Figure 7: Average Co2 emissions for new passenger cars. Source: http://ofvas.no/co2_utslippet_1/co2_utslippet_2014/co2_utslippet_i_april/

Based on the Norwegian travel survey (RVU 2009) an average car will be driven around 13300 km during the year. If we assume that an EV will be driven 13300 km each year the table below illustrates how much CO_2 emissions we do not emit when buying an EV instead of another vehicle. Some examples are illustrated below. Furthermore we assume a CO_2 price of NOK 210. This is the price the Norwegian Public Roads Administration uses in their cost benefit model(SINTEF (2011)).

Average CO2 emissions for new passenger cars even april 2014					
	g/km	average km per car	gram per car	tonn per car	price per car
Nissan Leaf	0	13300	0	0	0
Opel Ampera	27	13300	359100	0.36	75
Volvo V40	101	13300	1343300	1.34	282
VW Golf	114	13300	1516200	1.52	318
Volvo V60	118	13300	1569400	1.57	330

If we instead assume that an average EV will be driven 7500 km each year, see for example Holtsmark(2012). The calculations below illustrate how much we will save by driving an EV instead of other vehicles.

Average CO2 emissions for new passenger cars even april 2014					
	g/km	average km per car	gram per car	tonn per car	price per car
Nissan Leaf	0	7500	0	0	0
Opel Ampera	27	7500	202500	0.20	43
Volvo V40	101	7500	757500	0.76	159
VW Golf	114	7500	855000	0.86	180
Volvo V60	118	7500	885000	0.89	186

The tables below illustrate the same calculations as above, but from 2012-2020 in NOK mill. We use the same assumptions as in section 2, when we double the number of EVs until 2017.

Average costs with 13300 km/year							
	2012	2013	2014	2015	2016	2017	2020
Number of Evs	814047	1657819	3315638	6631276	13262552	26525104	27851359.2
Nissan Leaf	0	0	0	0	0	0	0
Opel Ampera	61	125	250	500	1000	2000	2100
Volvo V40	230	468	935	1871	3741	7483	7857
VW Golf	259	528	1056	2111	4223	8446	8868
Volvo V60	268	546	1093	2185	4371	8742	9179
Average costs with 7500 km/year							
	2012	2013	2014	2015	2016	2017	2020
Number of Evs	814047	1657819	3315638	6631276	13262552	26525104	27851359.2
Nissan Leaf	0	0	0	0	0	0	0
Opel Ampera	35	70	141	282	564	1128	1184
Volvo V40	129	264	527	1055	2110	4219	4430
VW Golf	146	298	595	1191	2381	4763	5001
Volvo V60	151	308	616	1232	2465	4930	5176

Holtsmark (2012) estimates CO_2 emissions combined city and highway driving gasoline car Toyota Prius (hybrid) Opel Ampera (plug-in hybrid) and electric vehicle Nissan Leaf, based on consumer tests conducted by the U.S. Department of Energy. A global electricity mix is assumed to consist of 40 percent coal, 25 percent gas and 5 percent oil power, the rest CO2-free

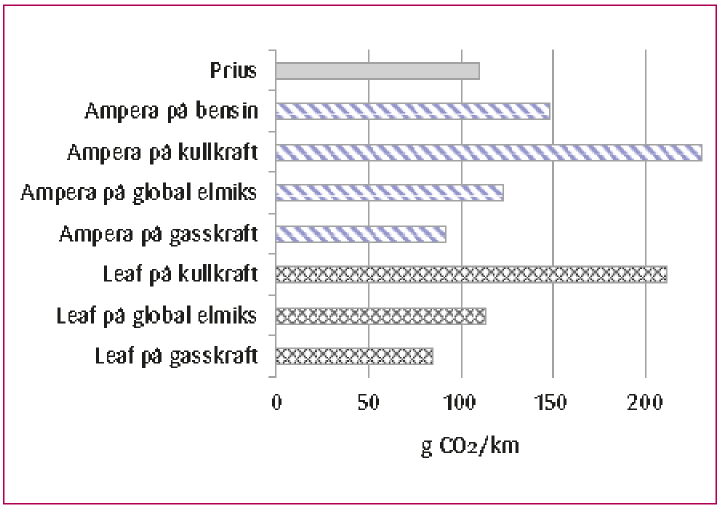


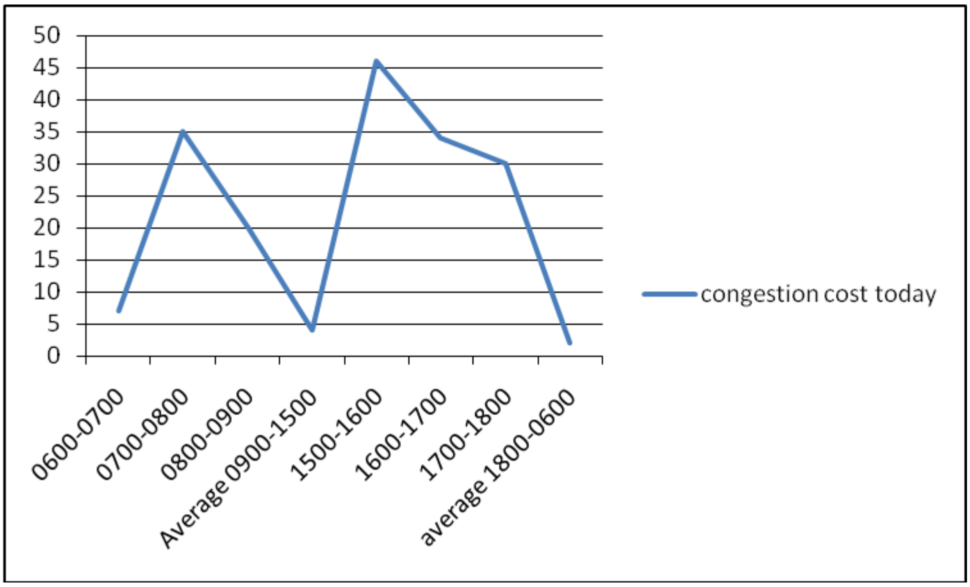
Figure8. CO2 emissions for EVs and conventional cars. Data source: Holtsmark (2012)

In summary, we see that in a world where the power of big degree comes from fossil fuels, we do not necessarily lower CO_2 emissions with EVs than gasoline or diesel vehicles. In areas where coal dominates come EVs poorer than the most fuel-efficient gasoline cars. This picture is confirmed by Ji et al (2012), who studied the effect of EVs in China, where about 85 percent of the electricity is coal based.(Holtsmark (2012)).

6. FIRST-BEST SCENARIO WHERE EVS PAY THE EXTERNAL COST OF THEIR ROAD USE VERSUS THOSE OF CONVENTIONAL VEHICLES

There are only two places in Norway were congestion in public transport fields are a problem: HøvikandMosseveien. Therefore we don't count the congestion in public transport field in the first best payment in the following calculations.

By finding the marginal congestion cost, we can approach the external cost EVs impose on society. Rekdal et.al(2012)calculates the marginal congestion cost. Congestion costs differ with and without congestion charging. Today it is no congestion charge, and the congestion cost is therefor higher than it could have been with a charging system. Like the system is today, the maximum congestion cost in rush hour be NOK 46 compared to evening/night which is NOK 2. EVs should pay the congestion cost, and based on Rekdalet. Al. (2012) calculations should each EV pay max 46 in rush hour and NOK2 in the evening.



Number of EVs passages*congestion cost.
In average an EV should pay 22,5 NOK, but it is social optimal to pay only the external cost, and therefore the price is less in the evening.
814047*46= 37446162 = 37 mill
814047*22,5= 162894

	Averagecost	Maximum cost

Rush hour 2012	NOK 18 mill	NOK 37 mill
Rush hour 2013	NOK 37 mill	NOK 76 mill
Rush hour 2014	NOK 74 mill	NOK 153 mill
Rush hour 2015	NOK 149mill	NOK 305 mill
Rush hour 2016	NOK 298mill	NOK 610 mill
Rush hour 2017	NOK 597mill	NOK 1220 mill
Rush hour 2020	NOK626 mill	NOK 1281 mill

7. CONCLUSIONS

Our results reveal that the major explanation of the explosion of EV use in Oslo, and in Norway in general is explained by economic incentives rather than environmental consciousness among the population.

Our conclusions and recommendations to the Norwegian authorities given that there is an explosion of EV use are that: (1) the economic incentives encouraged the purchase and use of EVs and thereby has helped reduced emissions and, (2) given that the EV usage has increased tremendously, it is time to reconsider whether EV users also should be made to pay the full marginal cost of their road use just as other users of conventional vehicles do. The marginal costs of EV use would stillbe low as compared to conventional vehicles and still encourage the increased use of EVs.

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