Transportøkonomisk institutt
Stiftelsen Norsk senter for samferdselsforskning

Summary:

Electromobility in Norway - experiences and opportunities with electric vehicles

TØ report 1276/2013
Authors: Erik Figenbaum and Marika Kolbenstvedt
Oslo 2013 134 Pages, Norwegian language

Electrification of vehicles is an important measure to reduce environmental impacts and climate gas emissions from transport. Electric propulsion is energy efficient, does not cause local emissions and reduces noise. The main challenges with electric propulsion is related to range, price and the production of batteries. A long lasting broad interaction between private enterprises, public authorities and non government organizations, have resulted in Norway being home to the largest per capita electric vehicle market in the world. The electric vehicle share of the total vehicle market was around 3% in the first half of 2013 and the share of the fleet reached 0,5%. From the 1990s electric vehicles have been high on the political agenda resulting in the introduction of incentives necessary to meet market challenges, and encourage the early adopters to test the new technology. Economic incentives such as exemption from vehicles taxes (registration tax, VAT) have secured the potential to sell electric vehicles competitively. Reductions in the annual circulation tax on vehicle ownership and exemptions from toll road charges, reduce the owner costs compared to conventional vehicles. The public investment support for charging infrastructure reduces the range issue in daily transport activities. The access to bus lanes has only been available for the electric vehicle owners. The combined effect of these and other incentives, has made electric vehicles popular with increasingly larger shares of car buyers in Norway. The electric vehicle market in Norway is expected to continue to grow as more models are coming on the market, and given the government decision to extend the economic incentives through 2017. Further into the future the market will depend on future incentives, market- and technology developments, and the competitiveness of electric vehicles compared to other technologies.

Electric vehicle evolution through five phases

The Electric vehicle (EV) development has been through five distinct phases in Norway, concept development, testing, early market, market introduction and finally from 2013 entering the market expansion phase.

In the concept development phase (1970-1990), prototypes of EVs and propulsion systems were developed by private enterprises such as Bakelittfabrikken (forerunner of Think), Strømmens Verksted and ABB with financial support from the research council of Norway.

In the test phase (1990-1999), the first vehicles were tested in public test programs, and the first serious efforts to commercialize Norwegian made EVs were launched (Think). The first users were enterprises and organizations. The wish to establish Norwegian EV production was a driving force, and local air quality, energy efficiency and increased use of Norwegian electricity were presented as the main advantages.

Lobbying activities were launched and the Norwegian EV association, Norstart, was established. This resulted in the introduction of the first EV incentives, exemption from the registration tax and the annual licence fee, and the exemption from toll road charges. The vehicle registration tax at that time was levied on the value of the car and this became prohibitively high on the first expensive electric vehicles. Later in this phase free parking on parking lots owned by the municipalities, and reduction in the imposed benefit tax on company cars, were introduced as measures to make EVs more attractive. Kewet electric vehicles were imported from Denmark. This phase ended with Think and the small Danish producer Kewet going bankrupt.

An early market phase was introduced with Ford Motor Company buying Think in 1999, soon launching the first model. Ford initiated development of a new model better suited for the US market, targeting reduced cost and improved quality. Kollega Bil established production of the Kewet in Norway after buying the assets from the Danish bankrupt estate. In the Grenland region the big industrial conglomerate Norsk Hydro scaled down activities, resulting in business development aids given to the region, some of which was found its way to Miljøbil Grenlands EV leasing business. A Norwegian electric vehicle industry cluster was thus developing and it became important to support the development of a home market. New incentives were launched, the exemption from VAT from 2001 (25% in Norway) and test of bus lane access in the larger Oslo Region from 2003 (permanent and nationwide from 2005, with minibuses being banned from 2009) and reduced rates on main road coastal ferries (2009). But it seemed that the technology was not sufficiently developed, and Ford Motor Company pulled out of Think in 2003, also as a result of changing ZEV-regulations in California. This meant that few vehicles were available to Norwegians, and a second hand import of French EVs manufactured between 1998-2002 filled the demand. The Norwegian Kewet producer faced an expired type approval, and new type approval requirements having outpaced the concept. They reverted to redesigning the vehicle to the L7e type, a vehicle category with a much simplified type approval procedure. The main EV-market was in the greater Oslo/Akershus region where users could save time driving in the bus lanes, and in areas with high toll road charges. Think was bought first by an Indian investor living in the UK, which during a couple years of ownership did not achieve much and the company was again bankrupt in 2004. This time Think was bought by Norwegian investors with a serious intent to launch the new model developed in the Ford ownership period.

The market introduction phase from 2009 started with the launch of new Think and Pure Mobility (known as Buddy or Kewet) models. In 2010/11 the big car manufacturers Mitsubishi, Peugeot, Citroën and Nissan launched their vehicles. The EV-market expanded rapidly to about 3% of new vehicle sales at the end of 2012. A hefty price competition broke out with rapidly falling prices causing the Norwegian manufacturers to go bankrupt. A substantial part of the 2 500 Norwegian EV owners in 2009, and probably many in their social networks, were ready to buy a new EV when the big automakers launched their products from 2010. These factors could have contributed to the rapid market growth from 2010. The Electric vehicle association developed into an important organization in this period. They supported their members efforts to get the most out of the vehicles, by compiling and making available information on charging facilities, they recruited new EV drivers through test drives, and other dissemination activities, and they facilitated knowledge transfer on an internet user forum.

The government organization Transnova was established in 2009 to support testing and expansion of new technologies to reduce climate gas emissions from the transportation sector. This new organization has made it possible to finance the establishment of charging stations on a larger scale and to start various test- and demonstration activities. Transnova also supports Grønn bil, an organization promoting EV usage in municipalities and fleets. The energy industry sector have become economically involved in business development related to EV charging.

The first Plug-in hybrid vehicles (PHEV) were launched at the end of 2012, but a lack of incentives has limited sales to low numbers. These vehicles have slightly lower registration tax than traditional hybrid vehicles. Studies of the usage of PHEVs indicated that they run on electricity from the mains 44-68% of the time, driving somewhat more yearly than EVs, but the drivers do not get any of the EV incentives. In 2013 they have been allowed access to public charging stations.

Figure S1 shows the development of EV-sales from 2000 to 2012 and some important events in the Norwegian EV history. During 2012 the number of EVs in the car park reached 10 000 (0,4% of the total fleet of passenger vehicles).

In 2013 *the market expansion phase* is entered with an increasing number of car dealers offering electric vehicles. The number of EVs passed 13 000 in first half year of 2013. The Norwegian EV market is a very competitive market with most vehicles being sold to private buyers. Different business models are tested, amongst these the free of charge loaning of ICE-vehicles for 20 days the first 3 years of EV ownership offered by Nissan. This enables some single car households to opt for EVs. Renault tries out battery leasing without success. Norwegians seem to prefer owning the entire vehicle. In 2013 the fleet market is waking up with municipalities among the more active purchasers. Oslo is leading the way, planning to buy up to 1000 EVs the next years.

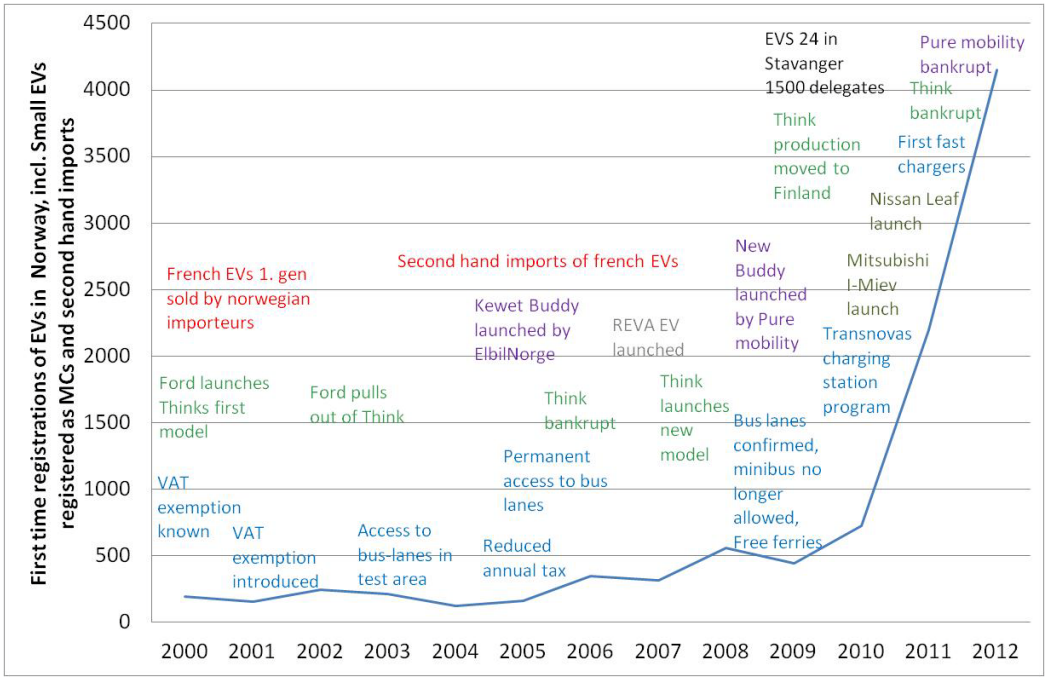

Figure S1: Estimate for EV-sales in Norway 2000-2012 and timeline for the introduction of incentives. Source: TØI, based on vehicle stock statistics from Grønn bil and OFVAS. Sales figures in the early years are uncertain. (EV=Electric Vehicle).

Electric biking is in its infancy

Electric biking is another important measure to achieve climate goals because of its potential to contribute to increased biking. Norwegians are barely familiar with electric bikes (Pedelecs), and are far behind other European countries. Pedelecs are ideal in areas with large altitude differences, and makes longer distance biking accessible for more people. There are currently no incentives for pedelecs in Norway. The price increase compared to traditional bikes seems to be around 600- 1 800 €. Test programs are under way to increase the knowledge, supported by amongst others Transnova and the province of Akershus.

EV policy to reach national targets through incentives

Climate policy is the major driving force in the Norwegian politicians commitment to EVs. Also a renewed interest in local air quality the latest years is apparent. During the period from 2000-2010, industrial development was also a political driving force, as it seemed possible to establish a national EV-industry. Electrification involves replacing conventional vehicles with EVs and Plug-in Hybrid Vehicles (PHEVs). Electricity is considered CO_2-emission free in Norway as more than 98% of Norwegian electricity is produced in hydro-electric power plants. In addition it should be noted that the Norwegian electricity production is part of EU Emission Trading Scheme for CO_2-emissions. Every conventional vehicle replaced with an EV results thus in about 100% reduction in CO_2,-emissions. PHEV emission reduction is estimated to be 44-68%, the same as the share of electric driving, depending on type. In a life-cycle perspective, taking into account emissions for extracting, preparing and distributing energy, using average European electricity mix, including emissions for producing the vehicles, the CO_2,-emissions of EVs would still be lower than for conventional vehicles of the same size.

Incentives for EVs can be targeted at making the purchase cost comparable to conventional vehicles, removing barriers to usage, giving the buyer an advantage that compensates for the EVs disadvantages, thereby reducing the risk of buying and using EVs early in the development phase. Table S1 contains the writers assessment of the effectiveness of the most important incentives.

The Norwegian EV policy has made EVs possible to buy and attractive to use. The incentives have been added one at the time until the market finally responded with increased sales. The prolonged EV interest, and lobby organizations that have battled for better incentives, have resulted in Norway having the largest EV incentives in the world in 2013. As a result Norway has the largest EV fleet and yearly sales per capita.

EVs are small and used to have lower comfort and poor safety level compared to conventional vehicles. Early owners apparently traded comfort and safety for access to the bus lanes and to drive free of charge on toll roads. A few may have been motivated by technological interest. It is obvious that the bus-lane access has been a profound factor influencing EV sales in Asker municipality outside of Oslo, as commuters here face the largest rush hour delays in Norway. Some places the exemption from toll road charges has been important, especially places with yearly toll road charges in excess of 2 500 €. In 2012 and 2013, sales are spreading to areas where these incentives cannot be the only or the most important explanation.

Tabell S.1: Authors assessment of the effectiveness of measures and incentives to promote EVs in Norway.

Incentive	Importance	Evaluation
VAT exemption	++	EVs are more expensive to produce than traditional vehicles causing VAT to be higher. A 12 500 € price increase of the vehicle results in a 3125 € increase in VAT making the vehicle 15 625 € more expensive to the consumer. This would actually increase government income unless the VAT is exempted. The Exemption in Norway has evened out the price difference between EVs and conventional cars.
Access to bus lanes	++	Very efficient in regions with large rush-hour delays in the traffic. The disadvantage is that only a limited number of vehicles can use the bus lane before buses are delayed. There is a risk of increased vehicle ownership if people drive an EV in the bus lane rather than taking the bus.
Exemption from registration tax	+	The exemption from the registration tax was introduced temporarily in 1990, and permanently from 1996. It was based on the value of the car and the exemption was very important to initiate test programs in the 1990s. Today this tax is totally changed and most EVs with a weight below about 1540 kg would anyway get a zero tax, given the way the tax system works. Example tax on gasoline vehicles: VW Up 2 600 -3 600 €. VW Golf typical taxes: 5 600-9 400 €.
Free parking	+	Effective where parking space is limited. A limited number of places are available and many have a time limit. Little influence on the total number of EVs unless parking spaces are converted to EV parking on a larger scale.
Free toll roads	++	This measure has a large impact when the toll roads are expensive. This is the case many places in Norway. In the Oslo-area the costs are 600-1 000 €/year for commuters. Some places in Norway there are tolls exceeding 2 500 €/year, resulting in EV sales in unexpected and waste areas such as small Islands with underwater tunnels to the mainland.
Reduced annual tax	+	Three rates apply for private cars. EVs and hydrogen vehicles have the lowest rate of 52 € (2013-figures). Conventional vehicle rates: 360-420€.
Reduced rates on ferries	0	Not important up to now, few use it and the value of the incentive is limited.
Reduced imposed taxable benefit on company cars	0	This incentive had little impact up to 2012 but might be more important from 2013 for the sales of Teslas Model S. This should be an attractive company car given its long range and the free of charge supercharger network.
Financial support for charging stations	+	Reduce the economic risk for investors establishing charging stations and the range issue for EV owners that get to charge the vehicles during a longer trip. Contributes to expansion of the EV market and aids in get more EV miles out of every EV. The EV alternative becomes more visible to the population.
Fast charge stations	+	Fast charging increases the EV miles driven and the total EV market. It becomes easier for fleets to use EVs and is a premise for using EVs as Taxis.

Incentives have triggered early adopters

Innovation is not just about developing or manufacturing new technologies, items or new ways of doing things. When it comes to taking innovations in use, the innovation process must be understood as a communication process where success presupposes that:

- The "new" has specific characteristics; such as being compatible with user needs, has relative advantages compared to other similar offers, can be observed and tested before decisions on use are taken.
- The knowledge about the innovation is distributed in suitable channels, from producer to media and various networks the users are parts of.
- Those who decide to use the new, have qualities that enable them to take risks. This is the case both for individual users, and for decision makers on different levels that are influencing the framework surrounding an innovation.

Studies of diffusion of innovations shows that the first 2-3% that adopt or take an innovation into use are risk taking, young, educated, well off and in contact with

scientific communities. The risk tolerance enables them to test new technologies and their high income means they can take a loss. The next wave of early users, that can make up around 13% of total users, are also well off, educated with higher status and younger than those that takes the technology into use later. They are often opinion leaders and important for the further market introduction process. They are more cautious than the first users, which aids the communication with those that follows.

The early EV adopters have characteristics that fits well with the picture outlined. There is a higher share of married men aged 30-50 years with higher education, full time job and high income among EV users, than in the average population. They live in or near the largest cities and 91-93% belong to households with more than one vehicle. However, one cannot take for granted that the future EV owners will have the same characteristics as the first owners. EV-ownership is socially more like multicar ownership in general. The national travel survey from 2009 shows that 42% of the population belongs to households with two or more vehicles. Among multicar owners the share of men, couples living together, employed and households with high income is far larger than among those that have none or only one vehicle.

Most new technologies in the car industry are expensive and most often in the initial phase introduced in large and expensive luxurious vehicles. EVs have not (until Tesla Model S appeared) been available in the luxury segment. The EVs properties have thus been more advantageous to society than to consumers. Incentives have been used to make EVs more attractive to the consumers. One could say that access to the bus lanes has replaced status as a reason to buy the new technology in Norway. It is a necessity that some try out new things especially when it comes to environmental technologies. Buyers today contribute to making better performing EVs more affordable and available in wider choices in the future. The Norwegian incentives have made buying an EV within reach of most vehicle buyers. 2013-surveys shows that EV-owners now are more like the average car owner. A survey from September 2013 shows that more young people with lower income consider EV as an alternative when buying a new car the next couple years, compared to previous surveys.

Users are motivated by economy and environment

Results from 19 Norwegian surveys on the perception of the EVs advantages, and disadvantages, and the reasons why consumers would consider buying an EV, have been analyzed. Figure S2 shows representative answers from one of the surveys. The EV buyers are mainly motivated by the comparative economical and practical advantages that EVs offer, compared to conventional vehicles, as a result of the incentives offered. All the incentives are seen as important advantages for an EV. Age, sex, income and family situation influence the motivation profile.

The EV is foremost used for daily trips, especially work trips. After buying the EV it is used for a large share of the households trips. This results in a benefit to the environment but can increase car use in general. The biggest disadvantage of EVs as it is seen in the surveys, is that the range is too short. Data on trip chain lengths from national travel surveys indicates, however, that most daily travels can be covered with the range EVs have today.

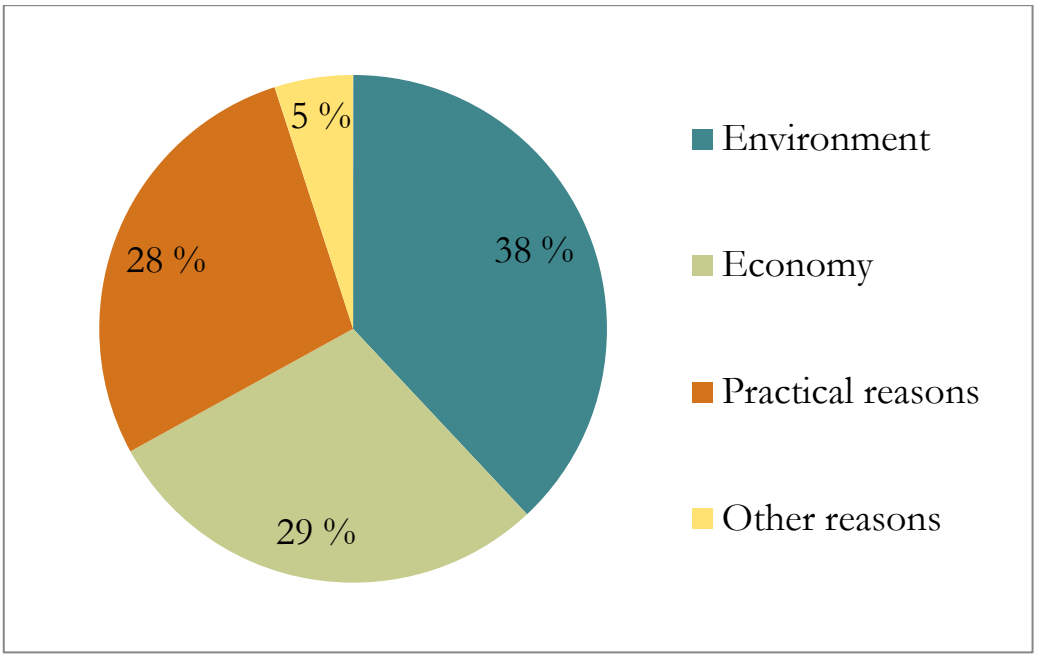

Figure S.2: Share of EV-owners reasons for selecting an EV. Percentage. (EV=Electric Vehicle). Source: Haugneland 2012.

The surveys shows that a large share of EV and Hybrid Electric Vehicle (HEV) owners are committed to their choice. 35-60% will buy EVs also in the future but more people consider buying a HEV than an EV. This could be influenced by the limited level of range and comfort on early EVs. Given that the price is equal about 19% would consider buying an EV. When comparing survey results from the latest couple of years, it becomes apparent that the share of potential EV customers is increasing. From 2012 to 2013 the share that considers buying an EV as the primary car has increased from 13% to 21%. The environmental benefits are not on the top of the list of reasons to buy an EV. Price, safety and efficient time saving transport is more important to the population. The EVs share of new vehicle sales is so far much lower than the positive attitude expressed in surveys. The real market potential and the real environmental effects are therefore lower than stated in surveys, roughly 10-15% with the current EV technology. With longer range vehicles that could become available in the future, the market share assessment would be more optimistic

Potential for EVs in Norway

Many of the conditions for a successful diffusion of EV's in Norway have evidently been present. Given that the EV fleet in the summer of 2013 passed 13 000 EVs and that this increases by 3 000 per half year, Norway has more EV's per capita than any other nation. Authorities and organizations have countered objections, developed solutions for problems, and communicated them to potential users. Early adopters with financial ability to take risks, and social capital to influence others, have bought the first EVs. This has led to an expansion of the customer base.

Our review of the population's assessments of the EV's advantages and disadvantages and actual data on the population's travel behavior form the national travel survey of 2009, leads us to believe that there still is a large potential for EV's in

the private market in Norway. Especially in the cities and suburbs around the cities and in multicar households. Range is sufficient for most daily travels, including travels to and from work. The potential is larger among multicar households, and for those who have access to parking facilities at work. 42% of the population in Norway have access to two or more vehicles, so the theoretical potential for replacing conventional vehicles with EV's is large.

Price reductions have been substantial enough to give EVs a competitive price regardless if the user can utilize local incentives or not. This should result in sales also in areas without local incentives, and indeed evidence to this can be found in the Norwegian market last year. The second hand market, where many secondary vehicles for multicar households are bought, is less developed, but should pick up gradually as more new EVs are sold. Second hand value is however still uncertain.

The expansion of the charging infrastructure the last years has reduced range- and charging challenges reported in EV owner surveys from earlier years. The development is likely to go on, both improving batteries and an expansion of the charging network. Further market opportunities can be created by spreading more information on EVs, exemplified by the fact that they nowadays fulfill safety requirements, but also information on what range the user can expect in different driving situations, what different types of charging means and the impact it can have on battery life. The facts point at increased potential for sales of EVs in Norway.

It is early in the diffusion process and there is a risk of setback unless the EV sales speed up in other more populous countries than Norway or if competing technologies achieve major advances.

An obvious focal point for Norway and other countries is to encourage fleets to use EVs. Especially those operating in larger cities. Vehicles in fleets are used for specific tasks that cannot be solved by public transport. They drive medium long distances per day, making fleets an interesting EV market. In Norway today the fleet share of EVs is merely 25% of EVs sold and in use.

EVs are important to reach national environment targets

The 2012 Climate policy settlement in the Norwegian parliament contains a target for emissions from new passenger vehicles. The average emission should not exceed 85 g/km (related to emissions measured in type approval testing). The target can be reached if either EVs or PHEVs or both types of vehicles achieves significant market shares, in parallel with substantial emission reductions from conventional vehicles. EV shares up to 20% are deemed necessary if PHEVs fail in the market, and a share of 30% PHEVs is needed if EVs fails in the market. The main measure to reach the 85 g/km target will be to increase the CO_2-part of the registration tax, making high emitters more expensive. At the same time this makes EVs and PHEVs more competitive against higher emitting conventional vehicles. The consumers will over time get an increased selection of low emission vehicles to chose from. The proposed tax increase is phased in over time at roughly the same pace as the expected availability of low emitting vehicles increases.

EV sales are expected to remain high in Norway. The economic incentives will remain in place at least through 2017. At the same time EVs will become cheaper than other vehicles (with incentives) and the selection will be wider. The market for PHEVs have been slow and around 500 were in the vehicle fleet in summer 2013.

There are signs of increased competition which could lead to future price reductions, leading to increased sales.

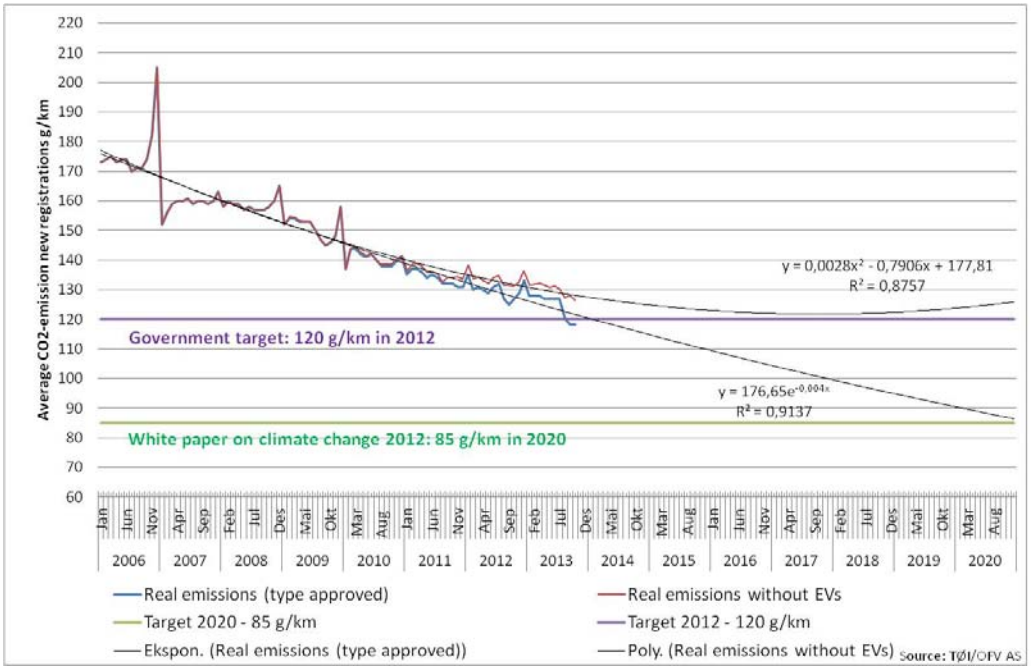

Figure S.3: Status of emissions (actual and estimated) from new passenger vehicles with and without EVs from 2006-2020 relative to national targets. Source: Figenbaum et al 2013.

Phasing out incentives will be challenging. The incentives are so large and wide that to remove all at the same time will cause big disturbances in the market. The most challenging incentive to remove will be the exemption from VAT, which for a car costing 25 000 € will add another 6 250€ to the price tag. The most attractive user incentive, access to bus lanes, will probably be phased out (within the next couple years to make room for the buses.

When EVs are selling well in all parts of the country, a gradual removal of the local user incentives can be initiated without disturbing the market to much. This will be a balancing act in cities. Here EVs are wanted since they can replace conventional vehicles and thus reduce pollution and noise. Fast charge stations will have a bigger market in cities. But if EVs replace public transport, biking or walking rather than conventional vehicles, then targets to reduce congestion can be troublesome to meet. Congestion as a result of urbanization and lack of incentives to increase vehicle utilization, are challenges not being solved by a transition to EVs.

The Norwegian example proves that EVs are attractive when incentives are powerful enough. If this situation contributes to EVs becoming really competitive in the market, or if this market will need permanent incentives at some level, remains to be seen. Another question is if the powerful incentives can be modified to stimulate behavior supporting other environmental goals, such as increased public transit shares in cities.