Niche-markets subsidy for effective diffusion of battery electric vehicles in Sweden

Robert van Sloten

Spring, 2015
Abstract
This study suggests an improved policy pathway for a higher adoption of battery electric vehicles (BEVs) in Sweden. By use of Rogers’ Diffusion of Innovations it was shown that Sweden’s current policy is ineffective due to equal incentives on plug-in hybrid electric vehicles and battery electric vehicles. In conjunction with Rogers’ theory, Multi-Level perspective shows that this is the result of the technology neutrality of the Swedish government. Norway, with higher incentives which only focus on BEVs, has a greater adoption rate of BEVs. However, the high incentives in Norway come along with the drawback of disturbing the adoption process. The incentives make adopters use the technology only because of financial reasons without questioning the compatibility and complexity of the technology.

In order for Sweden to reach its goal of a fossil independent car fleet in 2030, this study suggests a policy where focus is put on supporting niche-markets rather than supporting individuals, as Norway does. Within the niche-market the BEV can develop to become a competitive technology. When competitive, BEV can replace the fossil fuel dependent vehicles currently used without disturbing the adoption process.

[Keywords: Electric vehicle, battery electric vehicle, Diffusion of Innovations, Multi-Level Perspective, Niche-markets, subsidy, incentive, Norway, Sweden]
Acknowledgement

I would like to express my gratitude to the following persons.

To program coordinator and my supervisor Associate Professor Anders Jonsson for his support during the programme and during my thesis in particular. His comments and feedback helped me to keep track on my subject while at the same time helped to improve the quality of my research. Also to Professor Inga Carlman and Professor Morgan Fröling for their input during the seminars we had in the last months.

Secondly I want to thanks my fellow students for the support and feedback they gave on different levels, for their open conversation and the sometimes needed off topic discussions. Especially I want to thank Pete Simon for his time and effort to proof read and oppose my work in the course of the thesis.

Last, but not least I want to thank my girlfriend Vera for her time, patience and mental support. For proof reading my thesis with a neutral and non-environmental-science point of view.

Robert van Sloten
# Table of Contents

1 Introduction ........................................................................................................... 1  
   1.1 Goal .................................................................................................................. 2  
   1.2 Hybridisation and Niche-markets .................................................................... 2  

2 Method ..................................................................................................................... 4  
   2.1 Analysis of current system pathways using MLP ............................................. 5  
   2.2 Identify barriers in Norwegian policy using Rogers’ ...................................... 6  
   2.3 Assessing a new pathway for Sweden .............................................................. 6  

3 Results ..................................................................................................................... 7  
   3.1 Norwegian and Swedish policy ....................................................................... 7  
      3.1.1 The Norwegian pathway ......................................................................... 8  
      3.1.2 The Swedish pathway ........................................................................... 8  
   3.2 Policy barriers ................................................................................................... 9  
      3.2.1 Barriers in Norwegian Policy .................................................................. 9  
      3.2.2 Barriers in Swedish policy ..................................................................... 9  

4 Discussion .............................................................................................................. 11  
   4.1 Current pathway ............................................................................................... 11  
   4.2 Policy barriers ................................................................................................... 11  
      4.2.1 Barriers in Norway ................................................................................. 11  
      4.2.2 Barriers in Sweden ............................................................................... 12  
   4.3 Hypothesis ....................................................................................................... 12  
   4.4 The niche-market support .............................................................................. 13  
   4.5 Suggestions for a new Swedish pathway ....................................................... 14  
   4.6 Further research ............................................................................................... 15  

5 Conclusion ............................................................................................................ 16  

6 References ............................................................................................................. 17
1 Introduction

Governments in all parts of the world have various policies to increase the adoption rate of battery electric vehicles. Grants, fuel excises, tax benefits, free parking, free charging and toll exemptions are a few of the many incentives given to boost battery electric vehicle (BEV) sales (Bakker & Trip, 2013; Green, et al., 2014; Holtsmark & Skonhoft, 2014; Nykvist & Nilsson, 2015). Each government has its own reasons to promote electric vehicles. Carbon dioxide (CO₂) emissions reduction, urban air quality improvement and energy security could be among those reasons. Regardless of the type of incentive or reasoning, governments put resources aside to reach their set goals, assuming that it is the most effective way.

In the end of 2014 the global total electric vehicle stock was estimated to be over 665,000 vehicles, which represents 0.08% of total passenger car share. Ninety-five per cent of the global EV stock was within the countries of the Electric Vehicle Initiative (EVI, 2015). From those 16 member countries¹, only four had a market sale share greater than 1% in 2014. Namely, Sweden and the USA with both about 2%, the Netherlands with about 4% and Norway with almost 13%. The figures used by the EVI are for both Plug-in Hybrid Electric Vehicle (PHEV) and Battery Electric Vehicle (BEV). In Sweden, 39% of the ‘chargeable cars’ were BEVs bringing the sales of pure electric vehicles under 1% (Power Circle, 2015). In Norway, on the other hand, 94% of the EVs were BEVs (Grønn bil, 2015). Hence, in 2014 Norway sold 1 pure electric vehicle for every 7 Internal Combustion Engine (ICE) passenger cars it sold, a huge contrast to Sweden’s BEV new sale.

This raises the questions, why Norway is so far ahead of other countries in adopting BEVs. Or maybe better, why Sweden is so behind Norway when it comes to the adoption of BEVs?

This major gap in BEV adoption between Norway and Sweden could be due to the strong EV policy in Norway, focussed on zero-emission cars. So one might say that in order to increase the sale of BEVs, a government should adopt the Norwegian policy system. However, Holtsmark & Skonhoft (2014) say exactly the opposite: “Our main conclusion is that the Norwegian policy should be ended as soon as possible, and that this policy certainly should not be implemented by other countries. (…) but put more taxes and restrictions on car use.” (p. 167). They conclude that the current policy is ineffective, has unintended consequences and is counterproductive. Despite the high BEV adoption, the policy motivates households to buy a second car and decreases public transport use (Holtsmark & Skonhoft, 2014).

In harmony with Holtsmark & Skonhoft is Greens et al. (2014) conclusion that EV policies are ineffective because they focus on the mass market in what they call the “mainstream market bias”. Nykvist & Nilsson (2015) confirm that “current [Swedish] incentives to select BEVs are not sufficient for mass-market acceleration, (…)” (p. 41) but point out that (local) governments have little to no effect on the global car market to reduce EV production costs. Nevertheless, both local and national governments should send out a stronger signal that this development has a high priority (Nykvist & Nilsson, 2015).

So, on one hand the Norwegian BEV policy has had a huge impact on the sale of BEVs but on the other there is critique on the policy and its effect. Sweden has set the ambitious goal of a fossil fuel independent car fleet in 2030. BEVs could play an important role in achieving this goal due to Sweden’s low fossil fuel energy mix, only 6.5% (IEA, 2013). There should be a way to achieve higher BEV adoption in Sweden without the barriers that Norway encounters. This study attempts to increase the knowledge of this subject.

The commission of the European Union (EU) has set regulations for the average CO₂ emission of new cars sold within its member states (European Commission, 2015). This regulation No 443/2009 states, that in the year 2015 the average emission of all the new passenger cars sold in a country should not

¹ Members or the EVI: Canada, China, Denmark, France, Germany, India, Italy, Japan, Netherlands, Norway, Portugal, South Africa, Spain, Sweden, UK and US
exceed 130 gram CO$_2$/km. For 2021 the emissions should be 95 gram CO$_2$/km maximum. Car makers are encouraged to produce and sell vehicles that are under the limit and get punished when the fleet of sold cars exceeds the maximum average value. Norway, not being part of the European Union, does not have to obey this regulation and EU car manufactures will not get punished for exceeding the emission limit in Norway.

The difference in BEV adoption and the fact that Norway is not part of the EU, while Sweden is, makes a good ground for comparing the BEV policies of both neighbouring countries, to see how Sweden should and should not implement BEV policies. Both countries have a similar geography and climate, which makes for a more direct comparison. In this study the comparison is made only between BEV policies. BEVs are fossil fuel independent and have zero tailpipe emissions, which fits with Sweden’s transportation goal. This is in contrast to PHEV.

The purpose of this study is not to show that BEV is superior to other zero emission or bio-fuel vehicles but to show how the diffusion of BEV in Sweden could be made more effective. Eventually these policy improvements could also be used to make the diffusion of other technologies, such as hydrogen or bio-fuel, more effective.

The EVI divides governmental spending for electric cars into three categories: Infrastructure, fiscal incentives, and R&D (EVI, 2015). In this study the focus is solely on the second category: fiscal incentives. Between the year 2008 and 2014 the 16 members of EVI spend an equivalent of about 5 billion US dollars on this category.

1.1 Goal

The goal of this study is to suggest a more effective policy to accelerate BEV adoption in Sweden. The hypothesis is that this should be done by putting a larger focus on supporting specific niche-markets rather than supporting individuals with grants. The focus on niche-markets will give the niche-innovation, the electric drivetrain, better grounds to grow on to become a competitive alternative to the current drivetrains used. The niche-innovation can become competitive through technology and production development as well as through scaling. Niche-markets take more advantage to new technologies and at the same time perceive fewer shortcomings due to specific application of the technology. Section 1.2 will go into the use of niche-markets as shown in peer-reviewed research.

In order to suggest an improved policy for Sweden the following three objectives are needed.

1. Describing the current Swedish BEV policy and compare it to the policy of neighbouring country Norway, who has stronger incentives for BEV adoption.

2. Finding barriers in the Swedish and Norwegian policies in order to avoid those barriers in future policies.

3. Suggesting an improved BEV policy for Sweden to increase adoption on a more effective way.

In chapter 2 the method used is explained and the results of the findings are presented in chapter 3. In chapter 4 the results are discussed and suggestions for an improved policy for Sweden are presented. In chapter 5 the findings are concluded.

1.2 Hybridisation and Niche-markets

The method of niche-markets is well described in research. Geels (2002) wrote a well-known empirical case study about steamships. His research shows how in the past innovations evolved and developed. The steam ship niche-innovation replaced the sail ship regime by both niche-markets as well as via hybridisation. In the beginning sail ships only used steam engines for harbour movements and in time

---

The abbreviation BEV is used in favour of EV. The term EV is used for both (plug-in) hybrid electric vehicles (PHEV) and full electric vehicles (FEV) and even for fuel cell electric vehicles (FCEV). To avoid confusion the term battery electric vehicles is used to describe a vehicle with only an electric drivetrain and that stores all the energy in a battery pack.
of low winds to win time, but carrying around too much coal would limit the amount of trade that could be carried leading to less income despite the gain in time. The use of a new innovation within older practices is known as hybridisation and can also be seen within the electric vehicle development with (plug-in) hybrid electric vehicles.

The steamship niche market showed the real power of the steam engine in shipping, for which sailing ships were not functional (Geels, 2002). River and canal shipping as well as ocean postal ships and harbour tugs for manoeuvring bigger ships were niche-markets for the steam ship. For the river and canal shipping resupplying of coal was easy because of the short distance to land which omitted the extra weight of the coals. Postal ships used steam engines because of the independency of wind and currents, which increased speed and predictability, those ships were used to send mail to harbours with information about incoming shipments. Since information was shipped rather than goods, the weight and size of the coals did not influence the capacity. Tug ships used steam engines to manoeuvre the bigger ships from and to the harbour. Eventually the steam ships replaced the sailing ship regime, bringing along other innovations in shipping too. On a similar way the BEV can replace the ICE by first developing in a niche-market, as well as through hybridisation.
2 Method
This study presents an approach to analyze and compare policies for technological transitions, by using two tools that describe technological transitions from different perspectives. These two different perspectives might add to the understanding of technological transitions. This in turn will lead to a better understanding of how policies work, and how barriers that prevent transition can be dealt with. However, the policy should not lead to new or delayed barriers.

The tools used in this study are two theories, Rogers’ Diffusion of Innovations (Rogers, 2003) and Multi-Level Perspective (Geels, 2002). These two theories about innovation diffusion and technological transition are chosen because of their use for technology change, both with different perspectives as explained below. Because of this distinction the two different approaches will be used in this study. While both theories can be found in many other research papers, the use of the two in combination has not been found in prior research.

Rogers’ Diffusion of Innovations is seen as the first all-purpose innovation theory (Rogers, 2003). The theory was first written in 1962 in the book of the same name. The fifth edition of the book is the latest iteration of the theory. This theory is written from an adopter’s, an individual or a decision-making unit’s, point of view. The theory describes why someone adopts or rejects an innovation and when. The suggested adopter categories are widely used these days and described in the theory with category characters.

Increasing structuration of activities in local practices

![Diagram of Multi-level perspective on transitions](Image)

*Figure 1 Multi-level perspective on transitions (Geels & Schot, 2007, p. 401)*
Perceived attributes of innovation are described as a variable that influences the rate of adoption. Those perceived attributes are relative advantage, compatibility, complexity, trialability, and observability.

Multi-Level Perspective (MLP) is a theory younger than Rogers’. It originates from Nelson & Winter (1982) but is developed to its current state by, among others, Geels. (Kemp & Rip, 1998; Geels, 2002; Geels & Schot, 2007; Vries, 2013). MLP approaches technological transition from a sociotechnical point of view. It describes how a new technology, niche-innovation, can enter or replace the current sociotechnical regime which is situated in the sociotechnical landscape. Table 1 shows four different scenarios or pathways that describe how a niche-innovation enters or replaces the regime. Figure 1 by Geels & Schot illustrates the interaction between the three sociotechnical levels in MLP.

The tools are used to complete each other. MLP is used to get an overview of a policy within the sociotechnical regime and landscape; the system. The method is borrowed from Mazur, et al. (2015) where the same is done between the BEV policy of the UK and of Germany. In addition to that, this study adds Rogers’ theory to describe current and possible barriers to the policies in both countries. With the following steps the Norwegian and Swedish policy will be examined and an improved policy for Sweden will be presented.

1. Analysis of current system pathways using MLP
2. Identify barriers in current policies using Rogers’
3. Assessing a new pathway for Sweden

The three steps are explained in section 2.1-2.3.

Before the analysis and identifications are made, the two policies are compared at user incentives level, the benefits for the BEV user. First the overarching goal of the policies is presented as set by the governments. The policies have the intention of reaching this goal.

To compare the incentives, six aspects have been highlighted; the aspects show the benefits that BEV users get in one or both countries compared to users of internal combustion engine (ICE) cars. The first aspect is grant; what a person or company directly or indirectly receives after purchasing a BEV. The second aspect is to see whether or not road tax needs to be paid. The same goes for toll and/or congestion charge, when applicable. Use of bus lanes, free public parking and free public charging are the last 3 aspects considered.

2.1 Analysis of current system pathways using MLP

The first step is analysing the current socio-technical system of both countries. This is done using the five transition pathways as described by Geels & Schot (2007). They describe how landscape pressure influences both regimes and niche-innovations in different scenarios, all with different outcomes. Policies can be seen as landscape pressure, hence taking their influence sheds a light over the current situation. For both nations the extent of landscape pressure (policies), the current regime and the niche-innovations are identified to a compatible pathway.

Table 1 presents transition pathway 1 to 4, pathway 0 indicates no transition and pathway 5 indicates an increasing landscape pressure leading from transformation to reconfiguration to de- and re-alignment when landscape pressure keeps increasing. The data used in this study comes mainly from governmental organisations, governmental publications and governmental agencies, a small part of the data is secondary data from peer-reviewed articles.
<table>
<thead>
<tr>
<th>TRANSITION PATHWAYS</th>
<th>MAIN ACTORS</th>
<th>TYPE OF (INTER)ACTION</th>
<th>KEY WORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TRANSFORMATION</td>
<td>Regime actors and outside groups (social movements)</td>
<td>Outsiders voice criticism. Incumbent actors adjust regime rules (goals, guiding principles, search heuristics)</td>
<td>Outside pressure, institutional power struggles, negotiations, adjustment of regime rules</td>
</tr>
<tr>
<td>2. TECHNOLOGICAL SUBSTITUTION</td>
<td>Incumbent firms versus new firms</td>
<td>Newcomers develop novelties, which compete with regime technologies</td>
<td>Market competition and power struggles between old and new firms</td>
</tr>
<tr>
<td>3. RECONFIGURATION</td>
<td>Regime actors and suppliers</td>
<td>Regime actors adopt component-innovation, developed by new suppliers. Competition between old and new suppliers</td>
<td>Cumulative component changes, because of economic and functional reasons. Followed by new combinations, changing interpretations and new practices</td>
</tr>
<tr>
<td>4. DE-ALIGNMENT AND RE-ALIGNMENT</td>
<td>New niche actors</td>
<td>Changes in deep structures creates strong pressure on regime. Incumbents lose faith and legitimacy. Followed by emergence of multiple novelties. New entrants compete for resources, attention and legitimacy. Eventually one novelty wins, leading to re-stabilisation of regime</td>
<td>Erosion and collapse, multiple novelties, prolonged uncertainty and changing interpretations, new winner and re-stabilisation</td>
</tr>
</tbody>
</table>

2.2 Identify barriers in Norwegian policy using Rogers’
Secondly, the barriers in the policy of both countries are described with Rogers’ five attributes that influence the rate of adoption of an innovation. All attributes are positively or negatively related to the rate of adoption; complexity is negatively related while relative advantage, compatibility, trialability, and observability are positively related. Those attributes could be barriers that need to be dealt with when they are not taken into account or when too much emphasis is put on it in the policy. To what extent does the Norwegian policy take away the barrier or does the policy just postpone the barrier according to Rogers’ theory?

For Sweden, are the barriers similar to the Norwegian ones and are they being dealt with by use of incentives? Does the policy not take away the barriers and/or does the policy add barriers when it comes to promoting BEV sales.

2.3 Assessing a new pathway for Sweden
The last step is to determine whether Sweden should stay on their pathway, take the same pathway Norway has or take another pathway in which the EV sales and use will increase. For that, the results of the latter two steps are used. This step will be discussed in the discussion section of this study.
3 Results

From the three steps to examine the Norwegian and Swedish policy, as mentioned in chapter 2, the first two steps are presented in this chapter. The third step will be presented and discussed in the discussion section, this section will use the results from the other steps to determine the pathway Sweden should take. First the comparison between the two policies will be presented. This comparison will be the base of the analyses and discussion.

3.1 Norwegian and Swedish policy

Table 2 shows the Norwegian and Swedish policy by goal and the six aspects of the policy. The goal set by the EU is not considered Sweden’s goal, however it might have an influence on the incentives in Sweden. Later this regulation will be considered.

Table 2 Norwegian and Swedish BEV-policy compared on incentives for users and goal set by government

<table>
<thead>
<tr>
<th></th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOAL</td>
<td>&lt;85 g CO₂/km emission for new-car fleet by 2020</td>
<td>Fossil fuel-independent vehicle fleet by 2030</td>
</tr>
<tr>
<td>GRANT</td>
<td>Personal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No VAT or import tax</td>
<td>40,000 SEK (&lt;50 gram CO₂/km emission)</td>
</tr>
<tr>
<td></td>
<td>Company</td>
<td>50% tax benefit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35% tax benefit up to 40,000 SEK (&lt;50 gram CO₂/km emission)</td>
</tr>
<tr>
<td>ROAD TAX EXEMPT</td>
<td>Yes</td>
<td>Yes (first 5 years)</td>
</tr>
<tr>
<td>TOLL/CONGESTION CHARGE EXEMPT</td>
<td>Yes(500 roads)/Yes</td>
<td>Yes(2 roads)/Yes(2 city centres)</td>
</tr>
<tr>
<td>USE OF BUS LANES</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>FREE PUBLIC PARKING</td>
<td>Yes</td>
<td>Limited</td>
</tr>
<tr>
<td>FREE PUBLIC CHARGING</td>
<td>Yes</td>
<td>Limited</td>
</tr>
</tbody>
</table>

The Norwegian BEV policy is put in place to achieve the goal of having a new-car fleet CO₂ emission average of less than 85 gram CO₂/km in 2020, 10 grams less than EU regulation has set for the same year for its member states (European Commission, 2015). In 2012 the cars sold had an average of 130 gram CO₂/km (EV Norway, 2015). The Swedish goal differs from the Norwegian goal on two parts: time and intention. Sweden has given itself 10 more years to achieve their set goal: Fossil fuel independent vehicle fleet in 2030 (IEA, 2013).

BEVs in Sweden get the “Supermiljöbilspremie” (environmental vehicle bonus) as part of reaching the goal set by the government. The supermiljöbilspremie is for all road-going cars with a CO₂ emission of maximum 50 gram CO₂/km, this is in compliance with the regulation 443/2009 from the EU to reward car manufactures that sell vehicles with an emission of 50 gram CO₂/km or less. The vehicles within the bonus scheme, including all BEVs, receive a grant of 40,000 SEK at new sale. For companies this is 35% tax benefit up to a maximum of 40,000 SEK. The Norwegian government has high incentives for car owners to use a BEV or any zero emission vehicle in order to achieve their goal. A grant, as Sweden has, is not given but instead BEVs are exempted from the 25% value added tax (VAT) that is on regular cars. Next to that there is no import tax on BEVs. For companies there is tax benefit of 50% when purchasing a BEV. In both countries the cars are exempted from road tax, in Norway as long as the policy is in use and in Sweden for five years after the first registrations. Again, in both countries cars don’t need to pay tolls, for Norway tolls are collected on 500 roads compared to Sweden that has only
2 toll bridges. In both countries the cars are free from congestion charges. Besides, BEVs in Norway do not pay for road ferries but the price per person is still applicable. Norway offers free public charging and free public parking in all cities while in Sweden this differs from one municipality to the other. In Norway BEVs can use bus and high-occupancy vehicle lanes at any time, Sweden’s BEV drivers do not have this privilege (Hannisdahl, et al., 2013; Transportstyrelsen, 2015; EV Norway, 2015).

The Swedish bonus scheme for environmental vehicles is planned until December 2015 (Transportstyrelsen, 2015). The Norwegian policy is in place until the next parliament elections in 2018 or when 50,000 vehicles are registered (Hannisdahl, et al., 2013). On April 20th 2015 the 50,000th BEV was registered in Norway (Norsk elbilforening, 2015). The revision of the policy by the government is expected later this year, until then the current policy stays in place.

3.1.1 The Norwegian pathway

Tax exemptions on zero emission vehicles in a country with high taxes on vehicles suggest much landscape pressure (Holtmark & Skonhoft, 2014; Geels & Schot, 2007). The current regime - which consists of the car industry and the user preferences - changes. The cost of ownership of a BEV is significantly lowered by the subsidy scheme, making it compete with the regime’s technology of ICE. User’s preferences change to zero emission cars upon which new and current car manufacturers adopt. The hydrogen vehicles and infrastructure are not fully developed hence manufactures start to develop BEV. Both established manufacturers such as Nissan, BMW and Volkswagen as well as new manufacturer Tesla reacted to this by offering BEVs. By March 2015 only 17% of the BEVs in Norway are from a new actor, Tesla. The lion’s share of BEVs sold in Norway are from actors within the current regime, adopting new components to integrate them in current car making practices.

The main actors in Norway are the carmakers making zero emission cars due to the economic benefits for users. For this they use new components, drivetrains, in current practices. This is in accordance to the reconfiguration pathway’s key words; cumulative component changes, because of economic and functional reasons. Therefore it can be said that the current Norwegian pathway is corresponding with the reconfiguration pathway (Geels & Schot, 2007).

3.1.2 The Swedish pathway

In comparison with Norway, Sweden seems to have little to no landscape pressure. The incentives in place currently do not have a specific focus on BEVs or zero emissions vehicles in general. The no-transition pathway ‘Reproduction process’ might be the Swedish pathway because of the low landscape pressure. However, the wide focus of the Swedish subsidy scheme, due to EU regulation, could also indicate a transformation pathway. The transformation pathway occurs when landscape pressure is moderate but niche-innovations have yet been developed, suggesting that Sweden does not see BEV as a fully developed niche-innovation.

This represents a contrast to Norway where the electric drivetrain niche-innovation is considered developed enough to replace the currently used ICE drivetrains. Geels & Schot point out that whether or not a niche-innovation is developed enough is subjective. This disagreement could be between niche and regime level, but also on landscape level (Geels & Schot, 2007). Nykvist & Nilsson (2015) confirm this weak support of BEV with their arguments that the Swedish government express “technology neutrality” due to poor experiences with Sweden’s ethanol policy in the last decades.

This also comes back in Sweden’s transportation goals. Here Sweden wants to phase out the use of fossil fuel, but does not put a certain technology forward to do so. Biodiesel and biogas technology could do this, but so can electric vehicles such as BEVs and hydrogen vehicles. Here again it differs from Norway, since the Norwegian policy rules out biodiesel- or gas due to their CO2 tailpipe emissions. This shows that Sweden’s policy does not, either directly or indirectly, accept BEV as developed niche-innovation, indicating again a transformation pathway as shown in table 1.
Swedish policy seems like an implementation of the regulations set by the EU rather than an implementation of its own goals. The EU does not share Sweden’s goal of becoming fossil fuel independent, hence something that the EU regulation does not aim for.

3.2 Policy barriers

3.2.1 Barriers in Norwegian Policy

The five attributes of innovation mentioned in the method section all influence the rate of adoption, but that does not mean that all have to be addressed when it comes to speeding up the adoption rate, as Norway shows. The Norwegian policy solely focuses on relative advantage, it gives the car users strong economic reasons to change to BEV. With this high relative advantage complexity, compatibility and trialability do not need to be addressed to speed up the adoption. Observability is in Norway addressed by allowing BEVs to make use of bus lanes and by starting the registration plates on cars with the letter ‘EL’ which indicates elbil, Norwegian for electric vehicle (EV Norway, 2015). Relative advantage is seen as the most important attribute of innovation, possibly the reason why Norway chose to increase adoption by use of incentives and not by addressing the other attributes (Rogers, 2003).

Rogers’ theory concludes that only increasing relative advantage comes with two downsides (Rogers, 2003). Those two downsides could turn out to be barriers for the Norwegian policy. The first is the argument that incentives disturb the natural diffusion process. The second argument is that incentives increase the quantity of adoption but not the quality of adoption in the same rate.

In the diffusion process different adopters categories or groups come along, each with their own time of adopting and reasoning. The first group are the innovators and early adopters, often seen as separate groups but with many similarities. The second group is the early majority and is followed by the late majority and the last group is the laggards. The innovators and early adopters have the characteristics to adopt new innovations first. They can cope with the high uncertainty that comes with the early adoption; they understand the risks better and have more resources to absorb the losses when an innovation gets rejected. They also have a higher understanding of complex systems and practices and can better handle product flaws, which might occur in the early stage of a product’s development. The other adopters have a lower degree of these characteristics. Incentives lead to an increased number of adopters who solely adoption of monetary reasons without being to cope with the uncertainties that come with the early adoption of a technology, which leads to Rogers’ second argument.

Adopters adopt an innovation when the five attributes, as mentioned in the method section, are in harmony, when incentives come in to play the perceived advantage rules out the other attributes. This could make adopters only adopt for economic reasons, without arguing the compatibility and complexity of the innovation. The adopter does not support their choice with beliefs or values but solely on monetary reasons. When incentive discontinues, the motivation of the adoption could discontinue with it.

The two downsides of the Norwegian policy lead to the following two barriers. Adopters do not make an educated decision which leads to an increase in two cars households (Holtsmark & Skonhoft, 2014) and further to a possible rejection of the innovation when incentives cease (Rogers, 2003).

3.2.2 Barriers in Swedish Policy

Again the barrier in the policy can be described with the relative advantage attribute. In Sweden’s case this is too low because of the following. The wide focus of the policy, mentioned in section 3.1, does not only give incentives to buyers of BEVs but also on buyers of PHEVs, all vehicles get the same grant and driving privileges when emitting less than 50 gram CO2/km. How this is a problem shows when looking at compatibility. Both BEVs and PHEVs are rather expensive due to the new technology used (Zhang, 2014). But where BEVs are only powered by batteries and therefore need different practices in ‘fuelling up’, charging and trip planning. PHEV’s can also charge the battery via the electricity grid.
but have an additional ICE drivetrain to extend the range of the vehicle, ruling out range anxiety and extended trip planning. When a car buyer wants to invest in a new car, the complexity is higher and compatibility is lower for BEVs than it is for PHEVs, but the increased relative advantage of the incentives is equal between the two different types of vehicle. This explains why in Sweden only 39% of the EVs are BEVs, while Norway has 96% BEV in the total EV fleet.

The barrier in the Swedish policy is that the relative advantage for BEV does not make up for the higher complexity and lower compatibility compared to the equally subsidized PHEV.
4 Discussion

4.1 Current pathway

Sweden’s transformation pathway and Norway’s reconfiguration pathway might seem like just a label put on a country’s technological transition, but there is a consistency within European countries. Mazur et al. (2015) write in their article about the German and UK policy pathways, how the policy is in harmony with the nation’s transportation and industry goals. Comparison can be made between their findings and the Norwegian and Swedish pathways found in this study.

Like Sweden, Germany has the lower incentives of the two countries in the studies and also has a pathway most corresponding with the transformation pathway. According to Mazur et al. Germany’s big car industry (1/5 of the total industry in revenue) is protected by the low incentives to give the German carmakers time for the transition (Mazur, et al., 2015). Instead German regime actors are subsidized for R&D of BEV. In Sweden the same is present with the Swedish car industry, however not as big as the German (Nykvist & Nilsson, 2015). Swedish carmaker Volvo does not have a production BEV, only PHEVs. Since PHEVs get the same support at BEVs in Sweden, the policy indirectly supports PHEVs over BEV for regime actors.

On the other hand, Norwegian and UK policy show similarities. First of all, both their policies show a lot of corresponding with the reconfiguration process. Second, both countries have a limited car industry. Mazur et al. (2015) conclude that the UK has set higher goals and corresponding policies to strengthen the UK as original equipment manufacturer (OEM) for the electric car industry. Norwegian policy has had a similar path when it had BEV manufacturers Think and Buddy until they got bankrupt in 2011 (EV Norway, 2015). The Norwegian policy helped these manufacturers to get started, possible with the assumption that consumers would start buying Norwegian BEV’s, as Sierzchula, et al. (2014) finds “a strong relationship between consumer adoption of EVs and their being manufactured by native firms” (p. 190).

There seems to be a connection between a country’s car industry and the support for BEVs. The Swedish government does not want to choose a new technology to replace ICE and Germany relies on current regime R&D to develop cars with lower CO₂ emissions, both countries not wanting to risk their important industry (Nykvist & Nilsson, 2015; Mazur, et al., 2015). Aside from the OEMs and one minor carmaker, the UK supports BEV more in order to increase current original equipment manufacturer (OEM) industry and Norway, with the strongest policy towards car buyers, has no significant car industry anymore. Conclusion from this is that the presence of a car industry has influence on the attitude of a government towards BEVs.

As stated earlier in this report, the regimes consist, among others, of the car industry and car buyers (Geels & Schot, 2007). That could lead to a conflict within a country. When car buyers are persuaded to change to BEVs but the car industry does not offer such cars, the car industry could suffer from sales drop and hence influence the nation’s economy. The same could happen when the industry is persuaded to produce BEVs but the car buyers do not want such cars. Hence, they will get their cars from foreign carmakers. It is essential for a nation’s economy to keep harmony between carmakers and car buyers. Norway does not have this conflict due to their lack of a car industry.

4.2 Policy barriers

4.2.1 Barriers in Norway

In the results section of this study, it has been shown that Norway faces two barriers, both related to the relative advantage as described by Rogers (2003). Holtsmark & Skonhoft (2014) argue that the Norwegian policy has too many negative side effects and could potentially lead to a rebound effect, also outside Norway when other governments adopt such incentives. In accordance with findings in this study they conclude that the policy encourages households to purchase a second car. They mention another barrier in the Norwegian policy, the encouragement of transportation use. A drop of about 80 per cent of public transport use for commuting was found after users purchased a BEV. Also,
driver privileges such as free public parking and use of bus lanes encourages people to use BEV over public transport on one hand. On the other hand, busses will have more congestion with other traffic on the bus lanes, discouraging public road transport. Hirte & Tscharaktschiew (2013) call this subsidy overcompensating, where the subsidy not only encourages BEV use but also encourages car use in general potentially leading to more traffic and emissions. Besides they found subsidies for BEV likely to cause distortion, hinting on the natural diffusion process as described by Rogers (2003).

The second barrier in this study for Norway is the possibility of the BEV to get rejected when incentives weaken. Although it is very dependent on external factors such as BEV prices, oil prices and time. When a critical mass is not yet reached, rejecting of the technology is likely. It can be argued that the policy already increased the trialability and observability, but the first only holds true for early adopters, the majority is reached after the critical mass is reached. Only the experience of the BEV users could lead to an increase in adoption when they convince others to make the switch, this opinion leadership is a characteristic of early adopters. The disturbed adoption process might cause a lower amount of opinion leaders.

4.2.2 Barriers in Sweden

The barrier in the Swedish policy is the fact that there is no distinction between a PHEV and BEV, favouring the fossil fuel consuming PHEV currently sold above the pure electric BEV. While this is within the emission reduction targets of EU regulation No 443/2009 (European Commission, 2015), it does not support Sweden’s goal to have a fossil fuel independent car fleet by 2030 (IEA, 2013). Nykvist & Nilsson (2015) identify this barrier as governmental ambivalence, which results in a “(...) weak signal and uncertainty for both industry and consumers (...)” (p. 19); the earlier mentioned technology neutrality of the Swedish government. This ambivalence causes a negative image for adopting BEV in the long term because governmental support of the technology is not guaranteed.

Geels (Geels, 2012) states in one of his articles that government policies are the main driver of transition, next to public awareness. Because of the attitude of the Swedish government, the biggest barrier to the adoption of BEV might not lay within the policy but within the government itself. So, first of all the Swedish government should make an opinion towards BEV, this should be visible in new policies and incentives for BEV. But what should those new policies look like?

4.3 Hypothesis

The hypothesis stated in the introduction suggested that the most effective policy for Sweden would be by supporting specific niche-markets rather than individuals, as mostly happens now. But is this hypothesis supported by the theory? Only indirectly; Rogers’ theory does not include niche markets as an entity and MLP does not state that all niche-innovations develop within the niche-markets. A niche-innovation can be developed within the regime.

As shown, Sweden has low landscape pressure on the industry and on users (Nykvist & Nilsson, 2015). Partly because of technology neutrality and economic conflicts within the regime. This indicates that Sweden sees BEV’s not developed enough to replace the current ICE regime. Norway’s high landscape pressure on the current automotive regime indicated a positive attitude towards BEV as replacement of the ICE. But Norway’s policy has some major barriers that might affect the adoption in the near future due to recent changes.

For Sweden it is important to start choosing one or more technologies to achieve their goal set for 2030. Regardless of the outcome, the government should help nurturing and supporting their choice. This calls for a niche-market, where low performing, cumbersome and expensive radical new technologies can be developed through learning processes and price/performance improvements (Geels, 2002; Geels & Schot, 2007; Steinhilber, et al., 2013; Green, et al., 2014). When Sweden, or any other country, wants to make an attitude towards BEV as a new innovation, it should nurture it before accepting or rejecting it. This is in accordance with Roger’s theory where a low trialability causes a lower rate of adoption. How the hypothesis is supported can be read in the next section:
4.4 The niche-market support

In order for Sweden to achieve both the EU’s and their own goals, it is necessary to switch to new technologies for zero emission transport (Steinhilber, et al., 2013). The most important step for the Swedish government is to create an opinion towards BEV despite their technology neutrality (Nykvist & Nilsson, 2015), which in some way is not neutral but focused on the current technology of ICES. To do so the government should award car buyers proportionately to the effect of the technology. In the Swedish example that means making a distinction between BEVs and PHEVs. As shown in the results the Swedish government treats the two technologies in the same way while both have different effects. This policy is in favour of the PHEV, which is still a fossil fuel dependent technology. This does not suggest a negative attitude towards hybridisation, it only suggests a policy that should reward to the gain effects accordingly. A lower effect should lead to lower incentives. The example of hybridisation and niche-markets in the introduction show how those two actions have different goals. For cars nowadays the weight issue is not as it was for the trading ships, and neither was time, but emissions are. While PHEV cuts down on the emissions, it is still based upon the old ICE drivetrain as main drivetrain and like the hybrid sail ships it is still a compromise.

Like the steamship niche-market the BEV should be utilized, creating a market where the limitations, carrying coals for the steam engine, are cancelled out by the gain, speed for mail delivery, of the technology. The biggest limitations for BEV are the driving range and charging time (Zhang, 2014). Besides investment costs for BEVs are higher than for conventional cars while running costs are lower (Hao, et al., 2014). So to create a niche-market for BEVs a market should be found that has limited driving distances and longer non-operation times for charging. Green et al. (2014) see the U.S. postal Service (USPS) as example for a BEV niche-market. In their study they show that 84% of all USPS delivery routes are shorter than 40 km. Their short route in combination with nightly charging makes up for a good market for BEV. But recent development has shown driving ranges over 400 km (Tesla Motors Inc., 2015) makes room for more possibilities. At Schiphol Amsterdam Airport, the Netherlands’ main airport, electric taxis with a driving range up to 500 km are used to bring travellers from the airport to the city and vice versa (Schiphol Group, 2014).

These are just two examples of how niche-markets can be implemented to increase the use of BEV without use of consumer incentives. It is likely there are many more cases where niche-markets could be employed to increase the adoption of BEV.

It can be said that supporting niche-markets is likely a more effective way for Sweden to increase sales and use of electric vehicles. Consumer incentives do have unwanted barriers and side effects (Hirte & Tscharaktschiew, 2013; Steinhilber, et al., 2013; Green, et al., 2014; Sierzchula, et al., 2014; Holtsmark & Skonholt, 2014; Larson, et al., 2014; Thomas & Azevedo, 2014) Besides, the early adopters who buy BEVs now have the extra resources to afford the new technology anyways (Rogers, 2003; Plötz, et al., 2014), they would probably buy the technology without the incentives. Also, Sierzchula, et al. (2014) finds that purchase subsidies have a very low relationship with consumer’s willingness to buy BEVs. To reach the bigger share of the market the prices of the BEV have to drop, increasing the relative advantage. Most of this cost reduction should come from decreasing battery prices (Hidrue, et al., 2011). The smaller variety in BEV models available, compared to ICE models, is also a barrier for adoption of BEV due to the little choice consumers have when purchasing a BEV (Bree, et al., 2010). Niche-market development can increase the variety of vehicles available to cover the entire market. Additionally the range should increase and while charging time should decrease, lowering complexity and raising compatibility. While incentives do lower prices, they come with the earlier mentioned negative effects, but they do not directly address range and charging.

So niche-markets are a more effective way to increase the use, but how can a government support niche-markets without incentives? Green et al. (2014) suggest governments offer funding for organisations to cover the higher investment. Those funds can be paid back, in terms of a bank or governmental loan, when the investments pay off in the lower operational costs of BEV. This way the costs are reduced while the adoption should increase. The resources otherwise put aside for incentives
Niche-markets subsidy for effective diffusion of battery electric vehicles in Sweden

4-6-2015

can on the short term be used for funding niche-market initiatives. In the long run the resources can be used for electric utilities efficiency programs (Thomas & Azevedo, 2014) or to buy CO2 emission rights to be left unused to shrink the quota supply, raising emissions prices (Holtsmark & Skonhoft, 2014). Both methods are found to have a greater effect on CO2 emission reduction. However, this will not directly reach Sweden’s transportation goal, rather the overarching goal of the Swedish government (Naturvårdsverket, 2012). Low cost funding for BEV niche-markets can be offered by the Swedish government as alternative subsidy to user incentives.

This study has great similarities with a recent study about BEV adoption in Sweden’s capital Stockholm (Nykvist & Nilsson, 2015). The authors of this study point the lack of governmental support for BEV and lack of niche-markets as major barriers, but also the lack of support within the regime. This last point seems valid but it must be noticed that most of the actors, if not all except for users, work according to the market mechanism; they supply what the users want. It is up to the landscape and niches to change the user’s and regime’s behaviour. Nykvist & Nilsson also argue that incentives in Stockholm are ineffective because it will not influence the cost reduction of BEV on the global market. While this is true, they could have emphasized more on the cost reduction that comes with the use of BEV rather than the cost reduction of purchasing a BEV. Not to undermine their work, which shows on a clear way what is wrong with the Swedish BEV policy.

Their conclusions, to promote demonstrations and pilots as well as to increase the signal from (local) government, are in line with this study. This study can also be seen as their call for more investigation on how to spend resources more effectively for BEV adoption.

4.5 Suggestions for a new Swedish pathway

With the knowledge gained in the study, it should be possible to determine whether Sweden should stay on their current transformation pathway, follow Norway in their reconfiguration pathway or if they should pursue a different pathway. It has to be noticed that the pathway does not determine whether an innovation gets diffused or not, it only determines how an innovation gets diffused. The different pathways have different principles and different time spans. Transition pathways can only be fully described with empirical studies after a certain transition has taken place, but with past empirical studies and research of transitions theories a better understanding of the transitions of new technologies are gained.

In Sweden’s case, it has been shown that their current transformation pathway is not effective. The Swedish government sees BEV as an insufficiently developed niche. This holds back the diffusion of BEV while this technology can help Sweden reaching its transportation goals. A pathway should be where the landscape sees the niche as sufficiently developed to replace the regime. The transformation pathway does not fit in this. Norway’s reconfiguration pathway seems to send a stronger signal to the regime, however it seems that their policy is based on financial rather than functional reasons. Besides it has been shown that financial reasons can dissipate when incentives phase out. Therefore Sweden should focus on the functional reasoning of the reconfiguration pathway. But Sweden can do more; once niche markets develop further they can be ready to replace the regime.

This only happens when a shock occurs in the landscape. Oil or economic crisis as well as governmental pressure could call for a replacement of the regime; the technological substitution. This pathway is described as high landscape pressure when the niche-innovation is sufficiently developed (Geels & Schot, 2007). This pathway has a higher, more sudden shock in the landscape than the reconfiguration pathway and therefore a higher adoption rate.

What Sweden needs is what Geels & Schot (2007) call a sequence of transition pathways. Here the landscape pressure is disruptive, meaning that in the beginning the pressure is low and gradually builds up. It starts with a transition pathway, in which Sweden is right now. With the increase in pressure the niche develops further to the point of a reconfiguration pathway. When the pressure keeps on rising, it can cause a shock, which opens the opportunity for the niche to replace the regime. Even if the shock
from the landscape occurs before BEV has fully developed, the de-alignment and re-alignment pathway can create the opportunity for BEV to develop as (part of) the new regime.

A reconfiguration pathway should be the next step for Sweden in which landscape pressure comes from niche market support and increased tax on emissions (Steinhilber, et al., 2013; Holtsmark & Skonhoft, 2014; Massiani, 2015). This reconfiguration pathway could take up to 20 years to change the current regime (Geels, 2012). Landscape pressure on the regime can increase with the development that BEV makes in the niche-markets to the point that a technological substitution is reached.

4.6 Further research

Besides the implementation of the new policy suggested in the study, further research is needed. It is essential that during the implantation the policy is monitored. This data could be used to see the policy’s effect. More research on technology transition is needed where a higher focus is put on the advantages and disadvantages of niche-markets. This research could potentially show what the long term effects of both niche-market support and user incentives are.

There is also a need for more research on the electric drivetrain to increase the range of BEVs and decrease charging times. Research on new battery types is needed to improve this. This research can in turn help the BEV to accelerate the adoption process. Also research on production technology could lead to cost reduction for BEV.

It is likely that BEV is not the only technology to replace ICE on the long term (Steinhilber, et al., 2013), research is needed to find a technology that can complement BEV in reaching a more sustainable transportation.
5 Conclusion

While Norway has an increasing rate of adoption of BEVs due to its high landscape pressure on the current regime, Sweden’s adoption of BEVs is lagging behind in comparison. Sweden does not put the same pressure on the regime as Norway does; the Swedish incentives are substantially lower than Norway’s. To increase the adoption of BEV in Sweden, the Swedish government should increase the pressure on the landscape. In their current policy towards BEV Sweden subsidizes BEVs and PHEVs equally while the effects on emissions from PHEVs are lower than from the zero tailpipe emission of BEVs. Adopting Norway’s BEV policy would lead to the same barriers that Norway encounters. First of all, the high incentives on BEV leads to an increase in two-car households. Secondly the policy is based on the financial benefit gain with the incentive ending or lowering, the incentives could lead to rejection of the BEVs.

Norwegian policy focuses on speeding up the adoption rate for individuals by disturbing the natural adoption rate as described by Rogers (2003). Instead focus should be put on supporting niche-markets, those markets help develop the BEV in a controlled environment to compete with the regime in the future. The advantage of supporting niche-markets rather than hybridisation, as Sweden currently does, is that niche-markets exploit the advantages of the new technology. Hybridisation uses the new technology as a compromise with the current regime technology.

To increase the effect of the Swedish policy and therefore increasing the adoption of BEVs, the Swedish government should increase pressure on the current regime and at the same time support niche-market initiatives to develop a new fossil fuel independent regime of which the BEV takes part in, fully or partly. When the niche is developed to replace the ICE regime, landscape pressure by legislation should trigger a shock to make regime actors to lose faith in the current technology (Geels & Schot, 2007).
6 References


