Success and Fail Factors in Battery Electric Vehicle Adoption

A comparison between Norway and Sweden

Master of Science Thesis

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By

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LIST OF ABBREVIATIONS

BEV	Battery Electric Vehicle
Elbil	Norsk Elbilforening
EV	Electic Vehicle
EVS	Electric Vehicle Symposium
EU	European Union
FCV	Fuel Cell Vehicle
FFV	Flex Fuel Vehicle
FIS	Functions of Innovations Systems
GDP PPP	Gross Domestic Product – Purchasing Power Parity
ICEV	Internal Combustion Engine Vehicle
HEV	Hybrid Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PIV	Personal Independent Vehicle
PIVCO	Personal Independent Vehicle Company
NGO	Non-Governmental Organisation
NTNF	Royal Norwegian Council of Scientific and Industrial Research
SKF	Svenska Kullagerfabriken AB (Swedish ball bearing factory AB)
SMAB	Swedish Methanol Development Company
TØI	The Institute of Transport Economics (Norway)
USA	United States of America

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This thesis project is the final part of the Management of Technology master program at the Delft University of Technology. Eight months ago I started this research into the diffusion of Battery Electric Vehicles. The idea of this thesis topic came up during my masters, as I learned more and more about how innovations fight against incumbent regimes and start creative destruction. Combined with my interest in transportation and vehicles in general, and the rise of electric vehicles, the contours of the thesis idea became apparent for me. The contrast between clean silent zero emitting vehicles could not be greater as my own motorcycle barely drives without losing some drops of oil and produces lots of noise.

I would like to thank the graduation committee for their guidance and supervision during my thesis project. To my first supervisor Jan Anne Annema, who I would like to thank for all his thorough guidance during my thesis research. Your honest opinion about the chapters that I discussed with you really benefitted me, and gave me the opportunity to take this thesis to the next level. Furthermore thank you for your support during the months of my thesis. To my second supervisor Udo Pesch, who I would like to thank for his advice on social-technical innovations. Your advice on the management part of the thesis was very valuable, as were our meetings about the Functions of Innovations theory. To my thesis chairman Bert van Wee, thank you for our meeting about the thesis topic. Your expertise has helped me to scope my thesis and detail my thesis topic. I would also like to thank you for your advice and critical thinking for my thesis process.

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EXECUTIVE SUMMARY

In the past 45 years 80% of CO_2 emissions have come from road transport. Battery electric vehicles (BEVs) have the potential to lower greenhouse gas emissions, fossil fuel depletions and urban air pollution. Therefore, wide-spread implementation of durable transport technologies, such as BEVs, is an important factor of high priority in solving these problems.

The world's largest BEV market shares can be found in Norway. In 2015 over 17% of new cars sold was a pure electric vehicle (EV). Interestingly, despite seemingly similar socio-technical conditions to Norway the adoption rate of BEVs in Sweden has been relatively low. In 2015 in Sweden the BEV market share was less than 1%. There are multiple factors that could influence the BEV diffusion difference. Until now, there is an absence of a comprehensive research into why there is such a large BEV diffusion difference and what factors have contributed to this difference. This thesis research focusses on why there is such a difference. The research question is:

Which factors explain the difference in BEV adoption rates in Norway and Sweden?

Findings from the thesis provide societal, managerial and theoretical contributions. Society as a whole can benefit when wide-spread adoption of emission-free vehicles, such as BEVs, is achieved. Managerial contributions include increased knowledge in BEV market formations implementation for BEV policy makers, and also insights in historic BEV diffusion progresses for vehicle industries. The theoretical contributions rely on what factors explain the BEV diffusion difference, and also potential enhancements of the Functions of Innovations Systems (FIS) theory of Hekkert et al. (2007).

The FIS theory is used as a socio-technical lens through which the BEV diffusion is observed. The theory divides the BEV innovation system into system functions. These functions include entrepreneurial activities (F1), knowledge creation (F2), knowledge diffusion (F3), guidance of the search (F4), market formations (F5), resource allocations (F6) and creation of legitimacy (F7). Positive interaction between these system functions leads to momentum gain, which stimulates technology change and increases innovation diffusion. Therefore, the FIS theory is a constructive analysis method, and is used to identify factors and historic events that have influenced the BEV diffusion difference.

Influencing factors and historic events for BEV diffusion are searched through a desk research in scientific and grey literature. Semi-structured interviews are used to gain new knowledge and validate earlier findings from the desk research. The data is structured chronologically per country using a history event analysis. Such a process analysis gives insight into in the sequence of events. The events are categorized on the seven system functions from the FIS theory. BEV diffusion factors and events that do not fit any of the system functions are documented separately. After the history event analysis the FIS theory is used to identify interactions between system function. Motors of change fuel these interactions, where vicious and virtual cycles can arise. These cycles can influence momentum build-up, may cause further function interaction, and consequently affect the rate of BEV diffusion.

From the research four main factors are identified which have influenced the BEV adoption rate difference. First, the institutional difference between Norway and Sweden results in

different vehicle taxations. Norway's larger number and higher vehicle taxations have led to the possibility to introduce more effective tax exemptions for BEVs than in Sweden. Second, the early introduction and selection of BEVs in Norway has contributed to a higher level of BEV knowledge in society, industry and government than in Sweden. This translates into lower switching costs in Norway than in Sweden. Third, available energy supplies direct the technology selection. Norway's hydro power supplies provide inexpensive electricity and channel towards electromobility as the only alternative option to fossil fuels. Swedish biofuel reserves have guided the search for fossil fuel independency towards biofuel technologies. Four, the incumbent vehicle industry in Sweden legitimizes incremental innovations, and therefore the selection for biofuel and hybrid technologies, instead of radical innovations such as BEVs. In Norway such manufacturers are not present, and BEVs can be selected more easily.

The scientific contribution of the research includes the found factors and the FIS theory. The combination of the desk research, interviews and FIS have indicated what factors explain the BEV diffusion difference. The factors were unknown before the research, and thus are the first scientific contribution of the thesis. The second theoretical contribution concerns potential enhancements to the FIS theory. The history event analysis and FIS were very helpful in the thesis research. The history event analysis created a clear picture from the events that have occurred in the diffusion process. The FIS theory was very constructive to find system function interactions which influence the BEV diffusion. Concerning only this research case, three aspects came up that can provide potential enhancements to the FIS theory.

The first enhancement to FIS would be the externalities to the innovation system. Externalities do not receive a system function allocation, but do affect system function processes within the theory. Second, the contextual nature of the factors creates challenges in comparing BEV diffusion. For instance, the institutional differences between Norway and Sweden are difficult to quantify within the system functions. Third, threshold effects cause system functions to be fulfilled and to interact. The level of these thresholds is difficult to map. One example are the number of BEVs on the road, as these can cause changes in knowledge creation and knowledge through interaction. These three points could potentially enhance the FIS theory.

The managerial contribution consists out of lessons learnt for policy and industry. Market formations rely on the respective institutional system for incentive implementation possibilities. Through Norway's high vehicle taxation a lot of incentives can be offered. Policy makers willing to adopt similar incentives have to view this case with care, as certain incentives are not transferable. Import taxation and toll road fees a specific to Norway, and may become difficult to implement in institutional systems with low vehicle taxations. Another lesson for policy is the availability of energy resources. The biofuel selection was influenced by the biofuel resources in Sweden, and after the deselection of biofuels the focus shifted to other technologies. The selection of one single technology includes high levels of risk. Externalities such as the fall of biofuel interests had a decisive influence on biofuel deselection. Policy makers could focus on multiple technologies to spread risks in deselection. A lesson for vehicle industry is the identification of available energy sources and shifting trends. Early strategy formation can be used to capitalize on opportunities, and attain high market shares in the respective countries.

1. INTRODUCTION

This chapter contains the introduction to the thesis research. The research problem will be presented first. From there the knowledge gaps and the problem statement are stated, and accordingly the research objectives and research questions. Thereafter, the scientific and managerial relevance are made clear. The research scope and thesis structure are presented at the end of this chapter, including a flow chart on how the thesis progresses.

1.1 Research problem

As an answer to greenhouse gas emissions, fossil fuel depletion and urban air pollution, the demand for new durable transportation technologies is growing. Electric powered vehicles are one of the possible innovations to help overcome many of these problems (Nykvist & Nilsson, 2015; Sierzchula, Bakker, Maat, & Van Wee, 2014). 80% of increases of CO_2 emissions in the past 45 years have come from road transport, so widespread implementation of electromobility in transport is an important factor of high priority in reducing the amount of emissions (Bjerkan, Nørbech, & Nordtømme, 2016).

Electric vehicles (EVs) are vehicles powered by electric motors. Over the years EVs have evolved in Battery Electric Vehicles (BEVs) and hybrids such as plug-in hybrids (PHEVs) (Bjerkan et al., 2016). These technologies emit less CO_2 compared to internal combustion engine vehicles (ICEVs). The emission difference is even greater when the electricity generated for the EVs is taken from renewable energy sources.

Since 2010, the amount of electric vehicles (EVs) sold globally has been increasing (Figenbaum, 2015; Hannisdahl et al., 2013; Sierzchula et al., 2014). This growth differs per region in the world. One place where EV use is relatively successful is Norway, especially in the BEV area. The market share of BEVs in Norway has been the highest in the world for the last couple of years (Bjerkan et al., 2016).

In Norway a BEV friendly policy including incentives lowers the purchase and operational costs of BEVs. Despite seemingly comparable conditions the adoption of BEVs in Sweden has been relatively small (Nykvist & Nilsson, 2015) compared to Norway. The market share of BEVs in Sweden compared to Norway is much lower (EAFO, 2017). In 2015 in Norway BEVs counted for over 17% of market share, against less than 1% in Sweden in that same year. Among other things, a difference in BEV favouring policies can be seen between Norway and Sweden (Hannisdahl et al., 2013). Furthermore, there are other differentiating factors such as Swedish domestic car manufacturing industry, and BEV related events in history leading up to the BEV diffusion difference. This thesis elaborates on what factors explain the differences in BEV diffusion in Norway and Sweden.

1.2 Knowledge gaps

Information about the BEV diffusion difference between Norway and Sweden is scattered and incomplete. Historic analyses of why and when such a difference has occurred are incomplete. A detailed explanation for a BEV adoption difference between Norway and Sweden over time is lacking in literature.

Furthermore, Aasness and Odeck (2015) and Holtsmark and Skonhoft (2014) have different opinions compared to Bjerkan et al. (2016) and Vergis (2014) on the matter of transferability of the Norwegian BEV policies and incentives to other countries. There seems to be no consensus if the BEV policies are transferable. What determines the transferability of these BEV policies to other countries, such as Sweden, is lacking in literature.

1.3 Problem statement & research question

Continuing from the identification of the knowledge gaps, the problem statement can be addressed. There are multiple factors that could influence the BEV diffusion difference that is apparent. Until now, there is an absence of a comprehensive research into why there is such a large BEV diffusion difference between Norway and Sweden, and what influencing factors have contributed to this difference. This thesis investigates the reasons behind this difference.

1.4 Research objective and added value of the research

The research objective is to contribute to the existing knowledge base concerning why there is a high BEV market share in Norway and not in Sweden. This is done by identifying the influencing factors and contributing historic events leading up to the BEV adoption difference between Norway and Sweden. Sections 1.5.1 to 1.5.2 discuss the relevance of the thesis and also who could benefit from the lessons learnt in this thesis. Chapter 6.5 concludes on this.

1.4.1 Societal relevance

As already discussed in chapter 1.1, road transport accounts for a large portion of the total amount of emitted emissions. EVs are one possible technology that could potentially replace fossil fuel based passenger vehicles, or internal combustion engine vehicles (ICEVs). From the factors and historic events that are identified in this thesis, lessons can be learnt on what influences BEV adoption increases. These lessons may provide insight into how higher BEV adoption rates can be reached. A result from higher BEV diffusion are less greenhouse gas emissions and a lower dependence on fossil fuels. Society as a whole can benefit from technologies that solve these problems.

1.4.2 Managerial relevance

The managerial relevance consists out of two things. First, what factors influence BEV adoption in Norway and Sweden in combination with the used BEV policies and incentives. Second, what determines the transferability of Norwegian BEV policies and incentives to other countries, such as Sweden? Lessons learnt from these two points can benefit policy makers who want to use BEV policies and incentives, and vehicle manufacturers in forming their strategies for BEV introduction.

1.4.3 Scientific relevance

The thesis research has two scientific relevance's. First, historical analyses of BEV diffusion process differences between Norway and Sweden are not found in scientific literature. Partial historical analyses have been made, but much information is scattered and incomplete. Vergis (2014) has conducted a FIS analysis of Norway using, among other theories, the theory of Hekkert et al. (2007). Since the analysis of Vergis (2014) was conducted in 2012, new insights have come up such as the immense accelerated growth of BEV market share between 2014 to 2016 (EAFO, 2017). The number of BEVs in Norway exceeded the prospected amount, by the Norwegian government (Norsk elbilforening, 2012), of 50.000 in 2018 already in 2015. In 2016

there were already more than 100.000 BEVs in Norway (Frydenlund, 2016). Furthermore, this thesis uses the 'motors of change' and system function interaction (Hekkert et al., 2007), which are not used in the Vergis (2014) paper. A more up to date and comprehensive analysis of the BEV adoption difference between Norway and Sweden will contribute to the existing scientific knowledge base concerning BEV adoption.

Second, the Functions of Innovations Systems (FIS) theory (Hekkert et al., 2007) is used as a lens to apply structure and get an insight into the factors and historic events that have influenced BEV diffusion in Norway and in Sweden. Potential enhancements to the FIS theory concerning the research case can benefit the FIS theory, and can be applicable and useful for future scientific research using FIS.

1.5 Research scope

In order to maintain an quality in-depth study, within the proposed time frame set by the Delft University of Technology, for a Management of Technology master thesis, the research scope is limited by the criteria below.

- The focus of the research is limited to passenger cars only. Other vehicles are excluded from the research. This is, firstly, because passenger cars make up most of the emissions in the road transportation area (Sierzchula et al., 2014). Secondly, the rise in BEV is for the majority caused by passenger cars (Holtsmark & Skonhoft, 2014; Nykvist & Nilsson, 2015; Sierzchula et al., 2014).
- The research focusses on BEV technology. Although PHEV, HEV, and other EV technologies are discussed, the research focusses primarily on BEVs. This is because of the relative large difference in BEV adoption between Norway and Sweden.
- This thesis focusses on only the countries Norway and Sweden. The reason for Norway is because Norway has the highest BEV adoption rate worldwide. Despite seemingly similar socio-technical conditions in Sweden, Norway's neighbouring country, there is a relatively large BEV adoption difference. A comparison between Norway and Sweden is presented in chapter 4.1.
- No redesign of the Hekkert et al. (2007) framework is created. Possible enhancements, if any, to the framework regarding this research case are presented as recommendations in the thesis.
- The subject of BEV being the correct or better transport technique is not discussed in this thesis. It is too comprehensive to include in this thesis report, considering the limited time. Furthermore, the object of study is the difference of BEV adoption between Norway and Sweden, and not versus another transport technique, i.e. FCV, PHEV, ICEV, FFV, etc.
- The history event analysis time scale runs until the year 2016.

1.6 Thesis structure

Figure 1, on the next page, shows a flowchart of the thesis structure. Chapter 2 starts with the theoretical framework in where socio-technological innovation diffusion is discussed. Following from chapter 1.5, the FIS theory of Hekkert et al. (2007) is used as a socio-technical lens to gain insight into the factors and historic events in where BEV adoption in Norway and in Sweden has taken place. The theory is used throughout the thesis research.

Following from the theoretical viewpoint of this thesis in chapter 2, chapter 3 presents the methodology to collect relevant data. Both the desk research and the interviews will provide the data for the historic event analysis, which is also presented in chapter 3. Chapter 4 includes the history event analysis and the system functions (Hekkert et al., 2007). Chapter 5 continues with the findings from chapter 4, and analyses the system function interactions within the FIS theory. Chapter 6 presents the conclusion to the research question and the discussion of the findings.

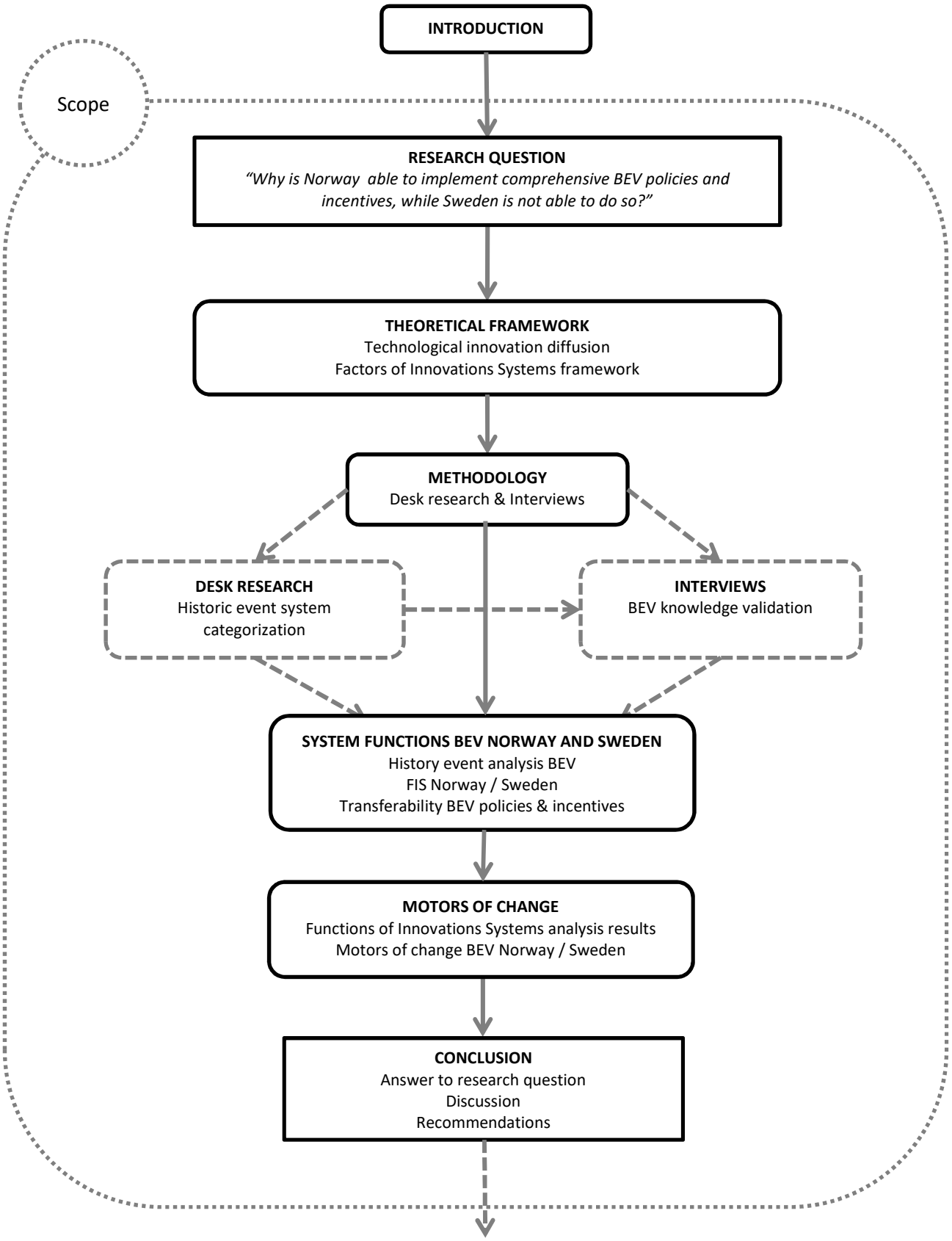

Figure 1: Research framework

2. THEORETICAL FRAMEWORK

In this chapter insights into innovation diffusion theory are presented, as is the theoretical framework which is used for the research. Chapter 2.1 elaborates on how socio-technical innovations diffuse and what factors could potentially have an influence on this process. These factors can be expected in the BEV diffusion case, and are used in this research as a guideline in finding the influencing factors for the diffusion of BEVs in Norway and in Sweden.

Chapter 2.2 presents the socio-technical lens in the form of the FIS theory (Hekkert et al., 2007), which is used to get an insight into the BEV diffusion process in Norway and Sweden. Chapter 2.3 elaborates further on the FIS theory, the system functions and also examples of these functions from empirical data from Hekkert and Negro (2009).

2.1 Technological innovation diffusion

In order to structure the research into the BEV diffusion influencing factors in Norway and Sweden it is important to gain knowledge into what factors can be in place. Diffusion influencing factors from scientific literature are presented in Table 1 at the end of chapter 2.1.

2.1.1 New versus incumbent technologies

During the introduction of a new technology, the technology will have to fight against existing regimes. Regimes are rule-sets, which consist out of organizations which are aligned with societal actors and technical, organizational and social aspects (Rip, 1995), and are built around a dominant design and grant stability (Geels, 2002). Dominant designs emerge due to market demand, market power of a dominant producer or an external player such as a powerful user, industry committee or government influence (Anderson & Tushman, 1990). These groups have their own political, social and economic agendas. The eventual selection of the dominant design occurs through technological or political competition between technological variants (Tushman, Anderson, & O'Reilly, 1997).

The existing regime, and the existing dominant design, is updated to be more efficient and innovative as an answer to new rival technologies. According to Rosenberg (1982) capital goods, at their first introduction, are often inefficient and uneconomical. As time passes, these devices or products are continually improved and adapted to the specific context. The old technology is not substituted immediately, but only when the superiority of the new rival technology is proven (Anderson & Tushman, 1990). It is possible that there is one rival technology that, in technical terms, is better than the dominant design (J. R. Ortt, 2010). A technically inferior product may be of greater value when its complementary products and services are included (J. Ortt & Delgoshaie, 2008). The dominant design that eventually emerges is a combination of technical, social and political constraints (J. R. Ortt, 2010).

The new technology has to convince new consumers, policy makers, investors, and other stakeholders about the potential the new technology holds in order to attain a high chance of wide-spread diffusion. Path dependency within these regimes makes it difficult to convince potential users to switch to the new technology as sunk investments, commitments, established views and habits formation hinder technological transitions (Rip, 1995). Especially radical innovations have a relative high level of uncertainty, since they tend to change existing paradigms and deviate from the technological pathways (Werker, 2003).

BEVs have to compete with the existing ICEV regime. This regime can be changed by influential stakeholders, which can direct the innovation path. This can be in the direction of BEVs, to ICEV technology, or to another alternative technology towards ICEVs. Technological, societal and political factors have an influence into the likelihood of high BEV technology diffusion. Furthermore, path dependency and switching costs influence the attractiveness of BEVs against other technologies. In chapter 2.1.2 technology development and diffusion are further discussed.

2.1.2 Technology development and diffusion

Once a new technology is introduced, the first people who switch towards this new technology are often the visionaries. Bounded rationality and switching costs influence the attractiveness of the new technology. This can be seen for the introduction of ICEVs in the example from Kline and Pinch (1996) in 2.1.1.

In the early 20th century, the ICEV made its entrance in rural America. Early car owners perceived the car as a usable transportation device. Besides the acceptance of early car owners, the ICEV also encountered great resistance from farmers, who were unfamiliar with the machinery. Cars were not accepted, characterised as the “Devil wagon”, and sometimes motorists were attacked. It took several years before the car became more common in rural areas. With a larger concentration of vehicles and motorists, the car was accepted by the farmers as they saw the benefits of motorized vehicles (Kline & Pinch, 1996).

In the case presented by Kline and Pinch (1996), the early car owners are the visionaries. Initial adopters of innovations are innovative and often visionary, and are willing to adopt high-tech products that are not fool-proof yet. The majority of customers, especially the farmers, were somewhat hesitant in adopting non-proven and not mass-adopted technologies. The difference between the early adopters and the remaining majority creates a gap in the diffusion path, affected by the interaction between the technology and society (J. Ortt & Delgoshaie, 2008). Only after a certain time in rural America a certain threshold was reached and the ICEV got accepted by the majority of society and started to diffuse further into society.

The diffusion of a technological innovation refers to the gradual adoption of an innovation into the market or society. This diffusion is often characterized by a classic S-shaped curve (J. R. Ortt & Schoormans, 2004). Before the S-curve starts, there are pre-diffusion phases where the technology has to go through a process of innovation, adaptation and improvement (J. R. Ortt, 2010). During the innovation phase the product is introduced to the market in its initial form. Governmental intervention can be used to increase the chances of a new technology against other technologies. Governmental influence, in the form of incentives or environmental regulations, may force technological change and make the new technology more attractive than incumbent or competing technologies (Schot, 1992).

The length of the adaptation phase may vary considerably, as the product has to be adjusted to contextual factors within the technological landscape. Often, a critical mass of interested customers has to be reached, in order to move from market adaptation to market stabilization. This may prove difficult, since potential customers may not know of the technology, do not understand the technology potential or perceive the technology as one that will not last or for fill their needs. Due to this uncertainty and also bounded rationality, situations occur of

introduction, withdrawal and reintroduction of the technology in the adaptation phase (J. R. Ortt, 2010; J. R. Ortt & Schoormans, 2004).

Technological development is a research process involving social, political and economic factors (Markham, Ward, Aiman-Smith, & Kingon, 2010). These factors co-evolve with the technology itself (Schot, 1992). According to Abernathy and Clark (1985), innovations of a given type may appear in clusters, and the innovations are closely linked to the overall evolution of the industry. The development comes along with uncertainty, and this uncertainty spreads to the co-evolving domains. These areas have to co-evolve with the technological development (Correljé, Cuppen, Dignum, Pesch, & Taebi, 2015). Reverse salients hamper the growth of the entire system (Mulder & Knot, 2001). If some domains in the socio-technical system lack development growth, or have a degree of uncertainty of successful co-evolution, the new technology will likely diffuse less into the socio-technical regime.

The perception of BEVs in Norway and Sweden is an important factor in the attractiveness of the technology. Familiarity, bounded rationality, threshold and network effects all may influence the diffusion rate. Governmental intervention in the form of BEV policies and incentives may stimulate the attractiveness of BEVs and therefore the diffusion. The entire BEV socio-technical system, consisting out of technological, societal and political aspects, has to evolve in order to attain wide-spread diffusion of BEVs. These factors provide guidelines in what to expect in the BEV diffusion difference between Norway and Sweden.

2.1.3 Potential diffusion influencing factors

Chapter 2.1.1 and 2.1.2 have introduced factors which could potentially influence the diffusion of BEVs in Norway and in Sweden, and explain the BEV adoption difference. Certain factors may appear in Norway, and not in Sweden, or vice versa. Table 1 presents these potential influencing factors, which could be expected in the BEV diffusion research case. Following from these factors, chapter 2.2 continues with the appropriate socio-technical lens through which the BEV diffusion is observed in this thesis.

Table 1: Potential influencing factors in BEV diffusion in Norway and Sweden

Potential influencing factors
• Incumbent socio-technical regimes • Technological, societal and political constrains • Influential stakeholders and regime players • Path dependency • Switching costs • Familiarity and bounded rationality • Governmental intervention • Contextual factors and circumstances • Historic events influencing BEV diffusion

2.2 Socio-technical lens

Chapter 2.1 has shown that the path of a technological innovation is strongly shaped by society itself, through culture, politics and regulatory mechanisms (Kline & Pinch, 1996). A process between technology and society defines how a technological innovation diffuses into the technological regime. BEVs in Norway and Sweden have followed a different diffusion path resulting in the BEV diffusion difference. In order to get an accurate understanding into the BEV diffusion difference, a socio-technical lens is used to observe BEV diffusion influencing factors and historic events in Norway and Sweden. The socio-technical lens has to be able to give accurate insights into the BEV diffusion processes within Norway and Sweden. A number of theories on socio-technological innovation diffusion can be used for this research case.

The Political Economic Transport Innovation Framework of Feitelson and Salomon (2004) is one such theory. Their theory focusses on what conditions have to be fulfilled to have a high chance of widespread technological diffusion in society. The four pillars of perceived feasibility, namely technical, political, financial and societal, have to be fulfilled to receive a high change on wide-spread technological diffusion. Though these feasibilities give a good insight when innovation can diffuse in society, the effect through time becomes troublesome. The theory of Feitelson and Salomon (2004) is a representation on how factors influence innovation adoption in a time static environment. Events that have occurred in the past are difficult to analyse in comparison to current events within the theory. Furthermore, contextual factors influencing innovation diffusion are not easily implemented into the proposed perceived feasibilities in the model. The need for a more dynamic theoretical model for this research is necessary to get a good insight in how the BEV diffusion difference came about.

Geels (2002) presents an evolutionary theory on technology transitions. Historic events can be seen as technology shifts. Geels (2002) describes a multi-level perspective, where technology is divided into niches, sociotechnical regimes and the sociotechnical landscape. From these levels, successful innovations rise up. At first this theory seems to suit the research case, since a number of events have taken place that have caused a technology shift. But actually the subject of study are factors and events surrounding BEVs. The diffusion of the BEV has followed a different path between Norway and Sweden, but the innovation itself is not the subject of study.

In the paper of Hekkert et al. (2007), innovation systems are determined as being very important within the process of technology change. The emergence of a new innovation system and changes in existing innovation systems co-evolve with the process of technological change. Since technological change is a dynamic process, a dynamic innovation approach is needed to better understand the direction the technological change is going. Hekkert et al. (2007) propose a method for systematically mapping the activities within the innovation process. Within the mapped processes, the functions are embedded in a theoretical framework, to show the important processes within well-performing innovation systems, which result in technological change. These processes can be seen as the 'Functions of Innovation Systems' (Hekkert et al., 2007) or FIS. This method can be characterized as a process analysis or history event analysis. This is where the model of Hekkert et al. (2007) becomes suitable for analysing the BEV adoption difference for Norway and Sweden.

A dynamic analysis, such as in Hekkert et al. (2007), shows how regulations come into place. It may also show renewable energy lobbies, opposition, and external events influence the emergence of renewable energy regulations. A dynamic analysis can also show the co-evolutionary process of regulations adaptation and learning experiences from previous institutional arrangements (Hekkert et al., 2007). As these aspects are also of importance in the BEV adoption research case, the FIS theory suits the research case.

Hekkert et al. (2007) ask the question what the conditions are that foster growth of an emerging innovation system in such a way that it becomes entrenched in society. Another subject mentioned is the ability to compete with or even become part of the existing innovation systems. This can be answered by using FIS. A drawback from the dynamic analysis method is that many different relations occur within the innovation system. Mapping all these relationships is simply not feasible. Only the relevant relationships, which influence the goal of the innovation system, will be mapped (Hekkert et al., 2007). A history event analysis is used to map all the events that have occurred around BEVs in Norway and Sweden, which is further elaborated upon in chapter 3.3. The history event analysis fits within the FIS theory, which is used in this research. Chapter 2.3 goes into more detail about the theory itself.

2.3 Functions of Innovations Systems

In the FIS theory, there are 7 system function categories. The list below presents these functions, including a description, following from Hekkert et al. (2007) and Hekkert and Negro (2009). Examples of case studies from Hekkert and Negro (2009) are presented in Table 2.

F1: Entrepreneurial activities

Entrepreneurs are essential for a well-functioning innovation system. Their presence is a first and prime indication of the performance of the innovation system. When entrepreneurial activity lags behind, causes may be found in the other six functions.

F2: Knowledge development

Mechanisms of learning are at the heart of innovation processes. Learning by doing and learning by searching fit within this function. Entrepreneurs rely on knowledge bases from where they take action. Knowledge development can also be seen as technology variation creation.

F3: Knowledge diffusion through networks

The exchange of information is the essential function of a network. This is especially important in heterogeneous context where R&D meets government, competitors, and market. Policy decisions should be consistent with the latest technological insights, norms and values. Network activity is a precondition for learning by using and learning by interacting.

F4: Guidance of the search

Since resources are limited only certain technologies are selected to invest resources in. This selection function can be fulfilled by industry, government and/or the market. Knowledge creation (F2) is regarded as technological variety creation, while guidance of the search (F4) means the process of selection. Furthermore, F2 and F3 refer to mechanisms of learning where the direction of the learning process is not included. Guidance of the search (F4) indicates that technological change is not autonomous. Changes in preferences in society (if strong and visible) can also influence he direction of the technological search. As a function, guidance of the search refers to activities that positively affect the visibility and clarity of specific needs among technology users. Technological expectations are important here, since they can guide the search through the system.

F5: Market formation

New innovations can face challenges to fulfil needs and wishes of users, since the innovation may be introduced into an already existing regime. At first, these new innovations may have no significant advantages, or maybe none at all, compared to the existing technology. Diffusion under these circumstances may be slow. These new technologies can be protected by offering them protected spaces. Here actors can learn about the new technology (F2, F3) and expectations can be delivered (F4). This can be achieved by creating (temporary) competitive advantages by favourable tax regimes or incentives, in order to make the new technology relatively more attractive.

F6: Resource mobilization

For a specific technology the allocation of sufficient human and financial resources is necessary to make knowledge production possible. This function can be regarded as an important input to knowledge development (F2). An example for this function may be funds that are made available for R&D programs, set up by industry and government, to develop specific technological knowledge. This accounts also to funds made available to allow testing of new technologies in niche experiments.

F7: Creation of legitimacy / counteract resistance to change

To succeed, a technology has to become part of an incumbent regime or overthrow this regime. This is also called creative destruction. When there is creative destruction, advocacy coalitions of stakeholders can act as a catalyst. They can lobby to put the technology on the agenda (F4), ask for resources (F6) and favourable tax regimes (F5), and by doing so create legitimacy (F7) for a new technological trajectory. If the advocacy coalitions grow in size and strength, they eventually can speed up the rate of creative destruction. The size and strength of these coalitions directly depends on available resources (F6) and future expectations (F4) of the specific technology.

Table 2 shows some examples of system functions out of Hekkert and Negro (2009), in which 5 cases are analysed using FIS. According to Hekkert et al. (2007) and Hekkert and Negro (2009), entrepreneurial activities are the most important indication in what state an innovation system is. A relative large number of entrepreneurial activities resembles a well-functioning and healthy innovation system. The examples in Table 2 are used to identify system functions within the events leading up to current BEV adoption numbers in Norway and Sweden.

Functions can also be negative, since for example the lack of financial resources (-F6) may lead to fewer research activities and knowledge creation (-F2), which can lead to less entrepreneurial activities (-F1). Another possibility can be the introduction of rival technologies (-F1), or governmental focus on another technique (-F4) which can cause the innovation, or in this case BEV, diffusion process to slow down.

Table 2: Functions of Innovations Systems examples from 5 case studies (Hekkert & Negro, 2009)

#	Function	Examples of functions
F1	Entrepreneurial activities	Setting up projects Start-ups Building manufacturing plants
F2	Knowledge development	Research programs User experiences Learning by doing Learning by searching
F3	Knowledge diffusion through networks	Scientists interacting Conferences Knowledge transfer Learning by networking Learning by interacting
F4	Guidance of the search	(Governmental) Goal setting and statements (Governmental) Guidance and stimulation Policy programs Putting cases on the agenda Expectations Selection
F5	Market formation	Introduction of subsidies Tax exemptions Incentives
F6	Resource mobilization	Provision of resources Subsidies for particular research cases Investments
F7	Creation of legitimacy / counteract resistance to change	Lobby activities Exerted influence on policy decisions

Hekkert and Negro (2009) mention that quantitative graphical representations can be used to strengthen the qualitative argument following from the FIS use. In these representations the frequency and summation of system functions over time is plotted. The results from FIS theory are not intended as a statistically valid argument, since analysing correlations between system functions over time requires qualitative insights into these research case specific inter-function relations (Hekkert & Negro, 2009). In this innovation system analysis, graphical quantitative representations will not be used to support the analysis result. The factors influencing the BEV adoption and the incentives and policies used to stimulate BEV diffusion growth are highly context dependent, and comparing these from Norway and Sweden statistically one to one is quite a difficult process, and will not significantly contribute to the qualitative analysis result.

This chapter has presented potential BEV diffusion factors, which can be found in Norway and Sweden. The research will focus on these factors and also historic events that have had an influence on the BEV adoption process in Norway and Sweden. The methods for finding the data is presented in the methodology in chapter 3.

3. METHODOLOGY

The nature of this thesis is a qualitative descriptive study, where the object of study is the difference in BEV adoption between Norway and Sweden. For this study qualitative data is required as input for the Functions of Innovations Systems (FIS) theory. This chapter presents these data gathering methods. Chapter 3.1 presents the desk research method, chapter 3.2 the interviews and interview setup, and chapter 3.3 elaborates on the History Event Analysis.

3.1 Desk research

The first research method is a desk research in scientific and grey literature. By doing so, potential influencing BEV adoption factors are identified from several kinds of sources. Besides scientific literature, which gives accurate theoretical viewpoints, grey literature such as websites and newspaper articles may provide valuable insights in how the BEV technology is perceived. Examples could be entrepreneurial activities (F1) or guidance of the search (F4), which can be harder to find in scientific literature. Knowledge gathered is processed using the FIS theory. Found factors and events from the desk research are allocated to one of the functions if possible. Other factors and events that do not fit in the system functions are documented without a function allocation, but are processed in the history event analysis in chapter 4. These factors are discussed in chapter 6.3 on why they do not fit one of the functions, and what potentially could be done to enhance the Hekkert et al. (2007) theory.

Literature was searched in internet search engines such as Google, Google Scolar and Scopus. Other sources of information are libraries such as the TU Delft Library. The method of searching in search engines uses search parameters such as AND, OR and NOT. The keywords consist for instance out of ‘Electric vehicle’, ‘BEV’, ‘Adoption’, ‘Norway’, ‘Sweden’, etc. One example incorporating the search parameters and search terms is; EV AND Adoption AND Norway NOT Fuel Cell.

3.2 Interviews

The data from the desk research is used to create a format for the interviews. The interviews are semi-structured, and allows for flexibility in the interview when an interviewee has information that was not found in literature. According to Fromhold-Eisebith and Werker (2013) universities, industry and government play an important role in the introduction and adoption of innovations. People experienced in these areas are interviewed face-to-face to extract important relevant information from the field and research. The interviews are fully transcribed to gain as much knowledge as possible, and are positioned in the appendix. The interviews are used as literature sources and presented as ‘personal communication’. For example the interview of Petter Haugneland is presented as P. Haugneland (2017). Furthermore, extra knowledge gained during the research is also included in the appendix.

3.2.1 Interview design

Some questions are asked in every interview, to gain an overall view on how certain BEV subjects are perceived across the interviews. Furthermore, questions are asked about BEV diffusion influencing factors, and about the transferability of Norwegian BEV policies and incentives. Other questions are more detailed which specifically concern papers which the interviewees have written or from which the interviewee has expertise in or knowledge about. These questions are specifically placed in certain interviews. Flexibility is important in the

interviews, as the goal is to gain knowledge not contained in literature and validating findings from scientific literature.

At first, an introduction is given to the interviewee. Here the viewpoint of the research is given, as well as the structure of the interview. An important point is to not bias the interview beforehand. The knowledge gathered in the research is not shared with the interviewee beforehand. This could result in answers that are biased to the nature of the question, and therefore not providing new insights in BEV adoption.

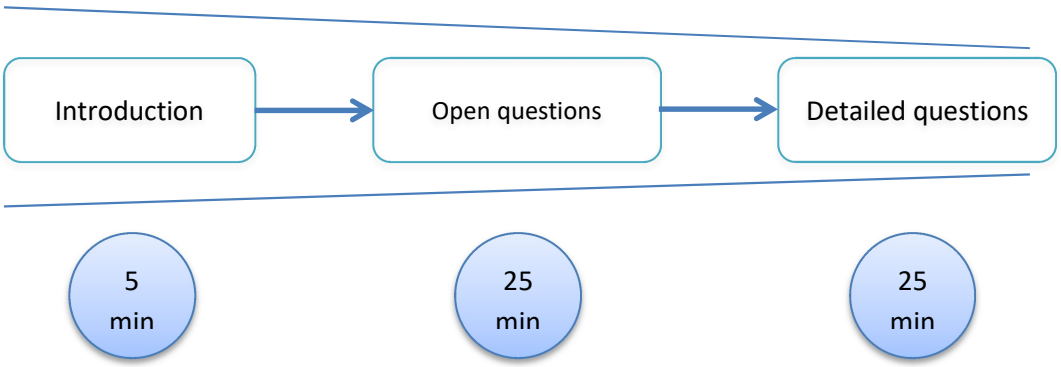

Figure 2: Interview structure

The second part consists out of open questions. The intention is to ask the interviewees about their opinion and knowledge on BEV policies and BEV diffusion. New relevant knowledge that is gained in the interview, and was not found in literature, contributes to a larger knowledge base for analysing the research case. If during the open questions subjects are discussed which have also been found in literature, than this validates the findings in scientific literature. A combination of findings in the interview together with findings from scientific literature provides a more complete set of BEV adoption contributing factors. Contextual factors highlighted by the interviewee are further questioned. The intention of the open questions part is to gain as much information as possible.

In the last part of the interview, more detailed questions are asked. Figure 2 illustrates the interview setup. During the interview, the questions become more specific and are more directed towards validating findings from literature. Framing occurs through asking the interviewee how he or she thinks about how certain factors correspond to BEV diffusion. The interviewees are asked their expert opinion, and their knowledge about the case question. The goal of this interview part is to validate findings, and ask people from the area of BEV technology in Norway and Sweden their expert opinion on the matter. From here, apart from validation, gaining new knowledge could also occur.

3.2.1 Interview schedule

The list of interviews is presented in Table 3: Interview schedule. Face-to-face interviews provide the opportunity to ask further on questions, retrieving more specific information, and allows for greater flexibility than phone or other digital communication (Sekaran & Bougie, 2009). Furthermore, being in Norway and in Sweden allows for a personal impression of the current level of BEV adoption.

Table 3: Interview schedule 2017

Date	Interviewee	Associated government/company	Location	Duration
11 April	Petter Haugeland	Elbil – The Norwegian Electric Vehicle Association (Elbil Forening)	Oslo	1h 20min
	Marika Kolbenstvedt	EFI –Norwegian Centre for Transport Research (TØI)	Oslo	1h 5min
18 April	Eva Sunnerstedt	City of Stockholm – Clean vehicle project	Stockholm	58min
19 April	Björn Nykvist	Stockholm Environment Institute – Stockholm University	Stockholm	55min
21 April	Mikael Askerdal	Swedish Electromobility Centre / Volvo AB	Gothenburg	50min
30 April	James Odeck	NTNU University	Trondheim (Skype)	55min

The reasoning behind why these people were chosen to interview is because they can bring a valuable contribution for the research. Petter Haugneland works for Elbil Forening, a large promoting and legitimizing actor in the Norwegian BEV field, and who also writes papers regarding user experiences with BEVs in Norway. He has valuable knowledge regarding the perception of BEVs in Norway, as to the historic developments of BEVs in Norway. Marika Kolbenstvedt works at TØI and researches BEVs use in Norway. She also co-writhed the COMPETT study (Figenbaum, 2015), an extensive report regarding the development of BEV diffusion in Norway. James Odeck has experience in electromobility and the economic consequences of public market formations in the form of BEV policies and incentives. He has therefore a lot of knowledge regarding the institutional side of promoting BEVs which is valuable for discovering factors influencing BEV diffusion.

Eva Sunnerstedt is one of the promotors of electromobility at the City of Stockholm in Sweden. She has set up multiple BEV procurement projects and also organizes BEV seminars in legitimizing BEVs in Stockholm and Sweden. This becomes very valuable for this thesis research, as it gives an insight into what BEV promoting events have occurred in Sweden. Björn Nykvist has done research into the diffusion of BEVs in Sweden. His research is very valuable in extracting the developments of BEV initiatives over the course of time in Sweden. Furthermore, he has a lot of knowledge regarding BEV diffusion processes, and this contributes strongly to the thesis research. Mikael Askerdal works at the Swedish Electromobility Centre, where research is being done into electromobility in Sweden. Furthermore, Mikael has over 15 years of work experience at Swedish car manufacturer Volvo AB, giving insights into how domestic vehicle manufacturers view the increasing market share of BEVs.

Five interviews were conducted in Norway and Sweden between the 11th and 30th of April 2017. The Interviews took place at the offices of the interviewees. An interview with James Odeck was scheduled after the Norway/Sweden trip, and was conducted via Skype on the 30th of April 2017. The reason for a Skype conversation was that no suitable date within the reserved timeframe to go to Norway/Sweden could be found. The knowledge from the interviews is used in the history event analysis in chapter 4, the FIS theory (Hekkert et al., 2007) in chapter 5 and the discussion in chapter 6.3. The transcribed interviews are located in the appendix.

3.3 History Event Analysis

As already discussed in chapter 2.3, the purpose of using the concept of FIS is to understand processes of technological change and innovation (Hekkert et al., 2007). System functions interact and can lead to virtuous circles, gaining momentum, and force technology change. The FIS consists out of the 7 system functions presented by Hekkert et al. (2007), and in this thesis are presented in Table 2 in chapter 2.3. The data input for these system functions comes forth out of the desk research and the interviews, and structured by the history event analysis.

The research approach in structuring the data is done by applying process or sequence approach. Hekkert and Negro (2009) present this process method as 'Historical Event Analysis'. The process approach conceptualizes development and change processes as sequences of events. This approach includes continuous and discontinuous causation, critical incidents, contextual effects and effects of formative patterns (Poole, Van de Ven, Dooley, & Holmes, 2000). The process approach presents a story line of how a system function influences technology development and also other system functions.

There are two different methods of mapping processes. Van de Ven, Polley, Garud, and Venkataraman (1999) present a process method where events were mapped around one innovation project. Their focus is on the micro level of innovation and therefore very detailed information could be gathered. Hekkert et al. (2007) propose an alternative viewpoint on this theory. Rather than focussing on the micro level, the events that took place within the technology specific innovation system are under investigation. The focus is not on the individual agents or innovation projects in the system, but on events that are reported at the system or national level (Hekkert & Negro, 2009). A detailed focus suggested by Van de Ven et al. (1999) would be very time consuming if done on the system or national level, and therefore too time consuming within the time frame set for the thesis project. Therefore, the broader method of Hekkert et al. (2007) was used in this thesis research.

As already discussed in chapter 3.2, suitable sources to collect information on events that took place are newspaper archives and professional journals. A historical database is constructed in which all BEV related events are mapped, and system functions are allocated to the events as in Table 2 in chapter 2.3. Chapter 4 presents the history event analysis to research and structure the events that have occurred around the diffusion of BEVs in Norway and in Sweden. Chapter 5 uses the outcomes of the history event analysis to analysis system function interactions.

4. SYSTEM FUNCTIONS OF BEVs IN NORWAY AND SWEDEN

In this chapter an analysis is conducted on the information obtained from the desk research and interviews. Chapter 4.1 discusses the differences between Norway and Sweden on BEV adoption. Chapters 4.2 provides an introduction to the history event analysis. Chapters 4.3 and 4.4 present the history event analysis for Norway and for Sweden respectively. In chapter 4.5 a comparison is made between both countries for each system function. In chapter 4.6 the transferability of Norwegian BEV policies and incentives is discussed, and in chapter 4.7 a conclusion is presented.

4.1 BEV statistics comparison Norway and Sweden

Around 2010 an accelerated uptake of BEV market share started (EAFO, 2017). If the Norwegian BEV market share is compared to other countries, than Norway can be seen as the BEV leader in the world (Bjerkan et al., 2016). Figure 3 from Figenbaum (2015) illustates this.

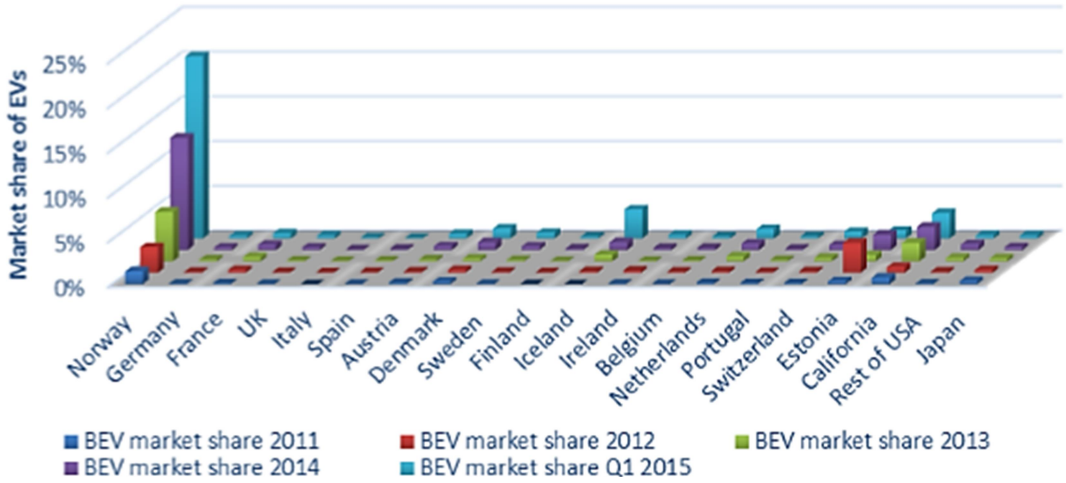

Figure 3: BEV market share 2011-2015(Q1) (Figenbaum, 2015)

BEV market shares in Norway exceed any other country in the world by a relative big margin. It is therefore interesting to see why this difference is so large. One country which has a, relative to Norway, low BEV market share is Sweden. (EAFO, 2017). Figure 3 shows BEV market shares in Norway and Sweden from 2008 to 2017.

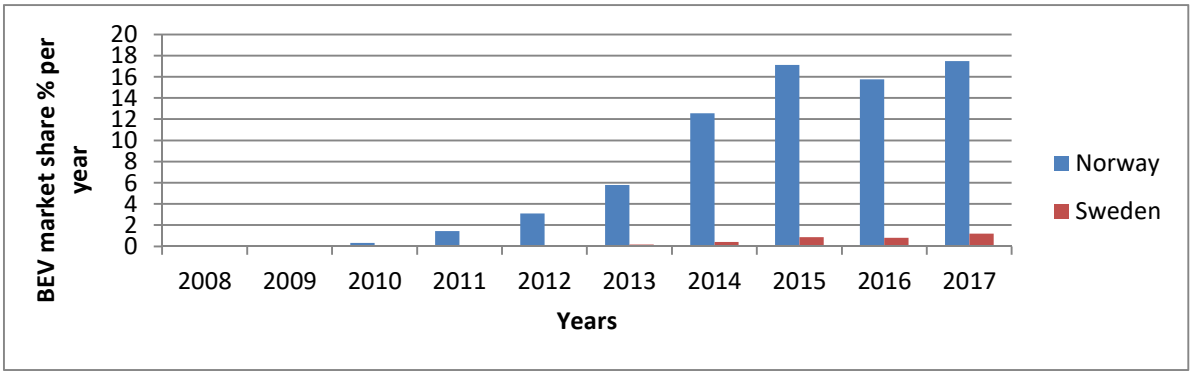

Figure 4: BEV market share percentage per year for Norway and Sweden (EAFO, 2017)

Sweden is often viewed as an environmental pioneer and a top innovative country. Nykvist and Nilsson (2015) state that 'in the European Commission's Innovation Scoreboard, Sweden came out as No. 1 of EU's member states in 2013'. Globally, Sweden was the second most innovative country in 2013 (Nykvist & Nilsson, 2015). The automotive industry in Sweden includes major car (Volvo AB, Saab) and truck (Volvo Trucks and Scania) manufacturers, which have a long history in Sweden. Other examples are that Sweden was the first country to introduce a carbon tax.

Table 4 shows some economic and demographic characteristics of Norway and Sweden. Both countries have a GDP per capita PPP within the global top 15 (The World Bank, 2015), but the current Norwegian GDP per capita PPP is considerably higher than that of Sweden. The difference between Norway and Sweden used to be smaller as can be seen in Figure 5.

Another difference is the length of highways and paved roadways. Sweden has more kilometres of roads, which is a disadvantage to BEVs in Norway. Their range would force them to charge more often, which is one of the major barriers EVs face (Figenbaum, 2015). One final difference from Table 4 between these countries is the use of other transportations. The percentage of cars used as transportation is lower in Sweden than in Norway, although this difference is significant.

Table 4: Norway and Sweden comparison on wealth, population and infrastructure data

	Unit	Norway	Sweden
GDP[1]	10^9 Euro	513,66	572,17
GDP per capita[1]	Euro	98.895	58.290
GDP PPP (2015)[2]	International $	62.084	47.862
Population[1]	-	5.194.000	9.816.000
Total land area[1]	km^2	323.902	449.964
Population density[1]	per km^2	16	22
Passenger vehicles[1]	-	2.500.000	4.495.000
Persons per passenger vehicle[1]	-	2,08	2,16
Highway[1]	km	194	1.740
Paved roadways[3]	km	75.754	135.444
Unpaved roadways[3]	km	18.116	444.412
Average driving per passenger vehicle[4,5]	km	12.289	12.216
Average trip per passenger vehicle[6,7]	km/day	32.9	32.1
Travel means (2015)[8] Car / train / bus	%	90 / 4 / 6	84 / 9 / 7
Sources; 1: EAFO (2017), 2: The World Bank (2015), 3: Index Mundi (n.d.), 4: Statistics Norway (2017b), 5: Transport Analysis (2017), 6: Statistics Norway (2017a), 7: Liu, Susilo, and Karlström (2015), 8: European Commission (2015)			

There are also some expects in which Norway and Sweden perform similar. For example Figure 5 shows that the person/passenger car ratio is comparable to Norway. Another aspect is the average distance travelled per year and per trip. This indicates that the use of passenger cars in Norway and Sweden is the same. Nykvist and Nilsson (2015) confirm for that for Stockholm and Oslo passenger car use is comparable.

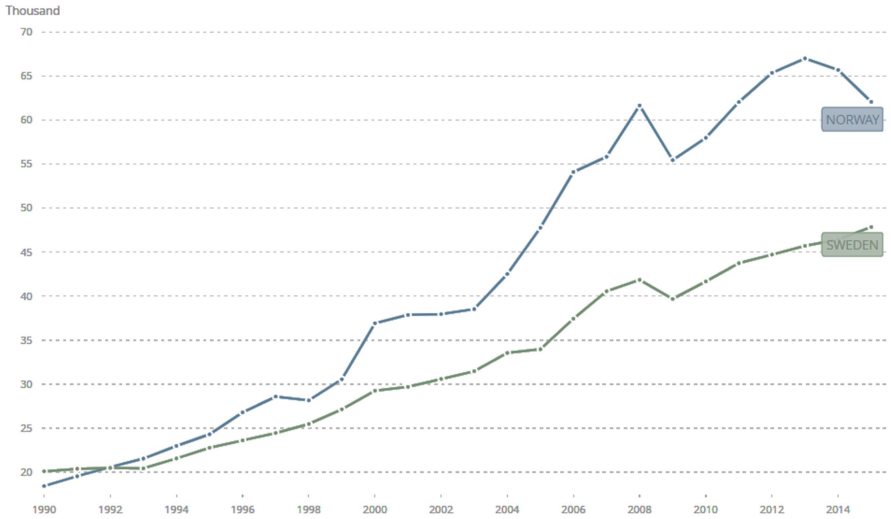

Figure 5: Norway Sweden comparison on GDP per capita, PPP (international $ currency) (The World Bank, 2015)

Despite some comparable data on cars/persons and vehicle use, there is a difference in the market share of BEVs. Sweden has a considerably lower BEV market share in comparison to Norway (Holtsmark & Skonhoft, 2014). This difference is further remarkable as the two Nordic countries experience a similar climate, both have access to renewable energy sources and are trying to adopt renewable transportation energy sources to replace current ICEV transportation (Nykvist & Nilsson, 2015).

Figure 6 from P. Haugneland, Bu, C., Hauge, E. (2016) shows the primary reasons to buy a BEV in Norway. The key reason are costs, which indicate that the provided Norwegian policies and incentives reach their goal to lower overall costs of BEVs, since this is the main reason.

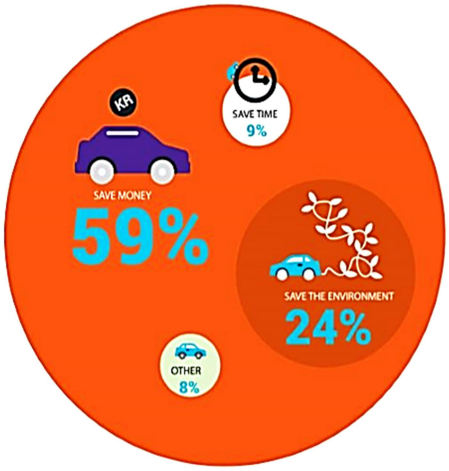

Figure 6: Prime reasons to buy a BEV in Norway

The cost of ownership, over a period of five years, of an EV is lower than of an ICEV in Norway (Hannisdahl et al., 2013). Hannisdahl et al. (2013) have calculated that (Figure 7) in 2012 a Mitshubishi i-MiEV (white) has a lower combination of purchase and running costs as a similar sized Fiat 500 (red) over a period of 5 years and 15.000 km annual driving. This annual number corresponds to the average distance travelled by BEVs from Figenbaum (2015).

Two differences can be seen from Figure 7. First, there is a difference in the overall costs between a BEV and an ICEV in Norway and in Sweden. Due to the provided policies and incentives in Norway the BEV is less expensive than a comparable ICEV. This is not the case in Sweden, where the overall costs of an BEV are higher than those of a ICEV. Secondly, there is a difference between the price of an ICEV in Norway and in Sweden. In Norway the overall costs are higher than in Sweden, for the same vehicle.

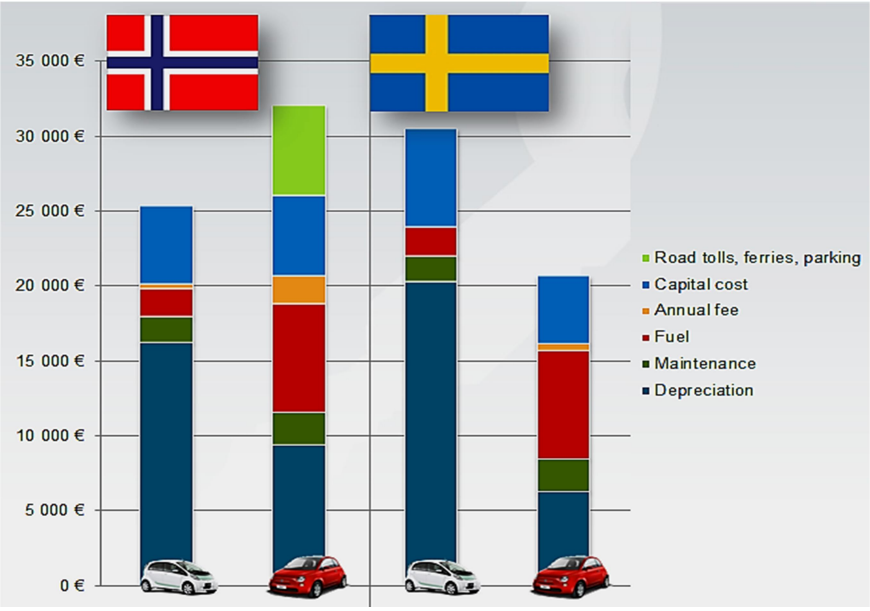

Figure 7: Comparison purchase and running costs BEV and ICEV (Hannisdahl, Malvik, & Guro, 2013)

Historically incentives have been important to introduce alternative fuel vehicles, and are crucial for BEVs as they lower purchasing prices and lower switching costs in situations where there in uncertainty (Bandhold, Carragher Wallner, Lindgren, & Bergman, 2009). Policies, incentives and subsidies are necessary to reach a mass market for EVs (Eppstein, Grover, Marshall, & Rizzo, 2011). According to Aasness and Odeck (2015), Bjerkan et al. (2016) and P. Haugneland, Bu, C., Hauge, E. (2016) the increase in EV use in Norway comes from the many incentives the government provides (Function 5 from Hekkert et al. (2007)). According to Larson, Viáfara, Parsons, and Elias (2014) the relative high purchase price of BEVs is the biggest barrier for wide-spread adoption.

In terms of energy both Norway and Sweden have the capacity over large quantities of renewable energy. Although Norway has a large oil production, this is not used to provide energy. Hydropower is the predominantly used energy source in Norway (Hannisdahl et al., 2013). Due to the vast amounts of hydro power electricity there is a lot of relatively inexpensive electricity (Vergis, 2014). According to Hannisdahl et al. (2013) this creates a higher interest in BEV technology. Sweden on the other hand has the possession of large quantities of forests, and therefore potential biofuel stock (Hannisdahl et al., 2013; Ulmanen, Verbong, & Raven, 2009; Vergis, 2014). The availability of these domestic resources creates predominant technological pathways in where selection of the technologies becomes a reason to become self-sufficient. This also creates path dependency, as other energy sources are more difficult to come by, and selection of other technologies becomes more difficult process.

Chapter 4.2 continues with the historic events surrounding the BEV adoption process in Norway in Sweden.

4.2 History Event Analysis process

In this section the analysis on the events and processes, relevant for BEV adoption, are presented separately. System functions are allocated to each event, and they are chronically ordered to get insights in whether there is a relation between the follow up of events. Some events may not correspond to one of the system functions. In the paper of Hekkert and Negro (2009), such events are categorized as external factors. The events will not receive a function designation, but are discussed in chapter 4.5.8 'External BEV influencing factors'.

As said in chapter 4.1, the FIS theory is used as a lens to obtain insights into the events that caused divergence in adoption of the BEVs. The outcome of the process analysis is a narrative storyline. The focus on the narrative is on extracting interaction patterns between system functions. This exercise is largely intended to strengthen the qualitative argument argued by Hekkert and Negro (2009).

4.3 BEV History Event Analysis Norway

The BEV history event analysis of Norway is divided into several parts. These parts are chronologically ordered, with the first BEV relevant event in Norway being in 1973.

4.3.2 The first BEV related activities 1973-1989

The earliest example of BEV entrepreneurial activity in Norway comes from Lars Ringdal in 1973 (F1). Lars Ringdal was a successful Norwegian industrialist (Ekeland, 2015) who owned the company Bakelittfabriken, which was specialized in all kinds of plastics, starting with bakelite. Two EV prototypes were constructed with codename Personal Independent Vehicle (PIV). The intention was to present the PIV as an answer to the global oil crisis at the time (Røste, 2001) but also to showcase Lars Ringdal's competences with plastics, such as fiberglass from which the prototypes were made (Ekeland, 2015). The PIV project was stopped shortly after as the project ran out of funds. The partners of the project had tried to manufacture every part of the car, which consumed a lot of resources. With no competent industrial EV network at the time, the project was halted (Hoogma, 2002).

The PIV project started again in 1980 under the supervision of Jan-Otto Ringdal (F1), the son of Lars Ringdal. Jan-Otto Ringdal reached out (F7) to the Royal Norwegian Council for Scientific and Industrial Research (NTNF), from where he eventually received financial support (F6) for the early development of the idea (Røste, 2001). Ringdal was the managing director at Bakelittfabriken in Norway, from where the spin-off Personal Independent Vehicle Company (F1) was started (Hoogma, 2002).

Besides the PIVCO project, the NGO Bellona, together with pop group A-ha, started to promote and lobby for BEVs in 1989 in Norway (F7) (Bellona Europa, 2017; Norsk elbilforening, 2012) to bring more environmental technologies to Norway. Bellona would be one of the first to import an EV, see Figure 8, to Norway in 1989 (Ekeland, 2015; Norsk elbilforening, 2011a).

Figure 8: Bellona BEV (Norsk elbilforening, 2011a)

4.3.3 Norwegian support of the PIVCO project in 1990

In 1990 Bellona created legitimacy for a temporary abolishment of import tax for BEVs, as they wanted to promote electromobility in Norway. By creating market formation (F5) the first steps were taken to make BEVs more price competitive.

Also in 1990, funds were allocated to the PIVCO project (F6) by the Norwegian government in order to compete with Swedish car industry in 1990 (Hoogma, 2002; Røste, 2001). Some politicians regarded PIVCO as an opportunity that could compete with Sweden on the car manufacturing industry. In this decision, environmental and energy saving reasons were secondary (Hoogma, 2002). The allocation of funds to the PIVCO project can also be seen as guidance of the search (F4), as the government focusses their agenda on BEV technology.

Table 5: BEV related events Norway 1973-1990

Year	Event	F#
1973	Lars Ringdal produces two EV prototypes as an answer to the 70s oil crisis, and to showcase Bakelitt fabriken expertise in fiberglass. Project discontinued.	F1
1980	Jan Ringdal's son Jan-Otto picks up the PIV EV project.	F1
1989	NGO Bellona starts promoting BEVs in Norway	F7
1990	Jan-Otto Ringdal (Bakelittfabriken managing director) enlists large companies and research foundations in Norway to help develop an EV.	F7
	Bakelittfabriken spin off PIVCO (later Th!nk) is started	F1
	PIVCO company receives governmental financial support (subsidies and loans) to start a vehicle company.	F4/F6
	PIVCO is sponsored by Bakelittfabriken, Stat oil, Norsk Hydro, Oslo Energi, National Postal Service, Statens Näringsdistrikts Kreditbank	F6
	Temporary abolishment of import tax for EVs after Bellona lobby (permanent import tax abolishment for EVs in 1996)	F5

Jan-Otto Ringdal was able to enlist (F7) several companies that could deliver complementary abilities and financial resources (F6) to the PIVCO company. These companies included Bakelittfabriken, Statoil, Norsk Hydro, Oslo Energi, tha national postal service, Statens Näringsdistrikts Kreditbank and the Norwegian Technological Institute which was responsible for testing the vehicles, and in their turn to acquire competence in EVs (F2) (Hoogma, 2002). This gave Ringdal enough resources to start the PIVCO company (F1) in 1990 (Hoogma, 2002).

1990 saw the first governmental incentive being introduced (F5) after lobbying from Bellona. EVs were exempted from Norwegian import tax (Norsk elbilforening, 2012). From 1990 on a number of incentives will be introduced as a stimulation of the introduction of EVs (Hoogma, 2002). The Norwegian government's role in the PIVCO project was for the most part that of a sponsor, but it too got involved in the development of the City Bee through statements from politicians (F4) stressing environmental benefits of using EVs and the job creating effects of an own car manufacturer in Norway (Hoogma, 2002).

4.3.4 Further development of PIVCO 1991-1997

In 1991 the Danish EV company Kewet was created (F1). In 1998 Kewet went bankrupt, and was taken over by Norwegian Kewet dealer Elbil Norge A/S (Kewet.de, 2011), and was later renamed as Pure Mobility. The Kewet model Buddy was one of the most sold EVs in Norway until 2011, with a Norwegian EV market share of 26% and 50% of EV capital in Oslo in 2011 (Norsk elbilforening, 2011b). That same year Pure Mobility would file its final bankruptcy (-F1) (Vergis, 2014).

After the first prototypes (PIV1) of PIVCO were created in 1992, which was now called the City Bee, the prototypes were tested in 1993 (PIV2) (Hoogma, 2002). The research and development of the prototypes created more knowledge (F2) at PIVCO about electromobility. Furthermore the presentation of BEV prototypes received a lot of attention and was closely followed by Norwegian press (Vergis, 2014), raising expectations about BEVs. In 1994 a series of 10 City Bees were presented and tested during the 1994 Winter Olympics raising the companies profile, and making people more aware (F3) of BEVs (Hoogma, 2002; Norsk elbilforening, 2012; Røste, 2001). Another notable commercial event was the Scandinavian Electric Car Rally from Gothenburg to Oslo in 1995, which the City Bee won (F3) (Hoogma, 2002).

The Norsk Elbilforening, or Norwegian Electric Vehicle Association, was formed (F1) in 1995 by Norwegian industry to promote EV interests (Norsk elbilforening, 2012). Their goal is to support BEV technology (F1) and BEV users, and also try to convince (F7) the Norwegian government to introduce further policy and incentives measures (F5). Furthermore they try to spread knowledge to potential BEV buyers (F3), who have limited knowledge (F2) of the benefits of BEVs.

From 1995 on, Norsk Elbilforening started lobbying the Norwegian government for BEV support (F7) (Vergis, 2014). This lead to a package of incentives that were implemented during the following years, with the reduced annual registration tax for EVs in 1996 (F5) and exemption of road tolls for EVs in 1997 (F5) (Norsk elbilforening, 2012). This created a further market formation for BEVs in Norway.

The first PIVCO manufacturing factory was built in 1995 (F1) from where the new City Bees (PIV3) were constructed. 1996 saw the beginning of test programs by PIVCO. Around 100 prototypes in total were delivered in car-rental tests in Oslo and other Norwegian fleets, and in San Francisco in the United States (USA). The City Bee's (still prototypes) were available for rent. By doing so the tests provided valuable user test data (F2) and the PIVCO's were used and seen by the general public, raising expectations (F4) and awareness (F3) about BEVs. In San Francisco the Norwegian king and queen attended the ceremony of Calstart (Røste, 2001), as a symbolic gesture (F7) to the then only Norwegian 'car' manufacturer, where 40 PIVCO's were delivered in the Calstart station car rental demonstration project (Hoogma, 2002).

Table 6: BEV related events Norway 1991-1997

Year	Event	F#
1991	Danish EV company Kewet (Buddy) EV company is founded, sells EVs in Norway	F1
1992	PIVCO company presents City Bee EV prototype (PIV1)	F3
1993	First working City Bee prototype on the road (PIV2)	F2
1994	Introduction of 12 City Bee's at Lillyhamer Norway Winter Olympics	F3
1995	First PIVCO production factory build. First City Bee's are built here (PIV3)	F1
	Norwegian EV association 'Norsk Elbilforening' founded by Norwegian industry	F1
	Scandinavian Electric Car Rally won by PIVCO	F3
	2 demonstration test periods start in Norway and in the United States.	F2/F3
1996	Reduced annual registration tax for EVs	F5
	Abolishment of import tax for EVs	F5
1997	Exemption of road tolls for EVs	F5

The test program in Norway was set up by Oslo Energi and Statoil's car rental department (F1). Several municipalities and companies joined the test program in which the PIVCO's were demonstrated. These municipalities and companies projected themselves as environmentally conscious, as they place logos of the company on the EVs and mentioned them in brochures and information materials (F3) (Hoogma, 2002).

4.3.5 Further market formation for BEVs in Norway 1998-2001

The Oslo and San Francisco test programs saw the vehicles being used and tested, at the same time, by rental companies. Potential customers experienced the new EV technology, and this created expectations (F4) for EV technology and the company PIVCO. Though the project was well designed and managed, the test program received some negative attention (-F3). Unlike incumbent car manufacturers, who do not release vehicles until the testing phase is complete, PIVCO leased cars that were still prototypes. They had several design defects such as water leaks when it rained, weak demystifying fans, bad suspension, rattling windows, stuck doors, and battery charging and motor starting problems. All these problems became apparent when the EVs were used by potential customers, which also gave bad expectations (-F4). These problems were addressed by PIVCO and installed in the new model named Th!nk (PIV4) in 1998 (Hoogma, 2002).

Until this point PIVCOs development work was financed by the Norwegian government and by stock offerings. The company ran into financial problems in 1998 and tried to find external financers to stay afloat. The new Th!nk was had its international launch (F1) at the 15th Electric Vehicle Symposium in Brussels in 1998 (F3) (Hoogma, 2002; Norsk elbilforening, 2012), but shortly after PIVCO declared bankruptcy (-F1). PIVCO was bought by Ford in 1999 (Norsk elbilforening, 2012) and renamed as Th!nk Nordic A/S (F1) (Hoogma, 2002) (F1). 1998 also saw Kewet declare bankruptcy (-F1). Thereafter Kewet was bought renamed by Elbil Norge A/S, becoming a Norwegian EV brand (F1) in 1999.

Table 7: BEV related events Norway 1998-2001

Year	Event	F#
1998	Demonstration test period PIVCO City Bee ends.	F2
	Negative user experiences from the demonstration program lower City Bee expectations.	-F3
	Launch Th!nk car (PIV4, continuation of PIVCO City Bee)	F1/F3
	Bankruptcy Th!nk	-F1
	Bankruptcy Kewet (Buddy)	-F1
1999	Th!nk bought by Ford	F1
	Kewet (Buddy) is bought by Elbil Norge AS (A Norwegian Kewet dealer) and becomes Norwegian	F1
	'EL' special number plates are introduced for EVs	F4
	Free parking for EVs in public places	F5
2000	Reduced company car tax for EVs	F5
2001	0% VAT for EVs	F5

Multiple incentives (F5) were introduced such as special designated number plates (1999), free public parking (1999), reduced EV company car tax (2000), 0% VAT (2001), access to Oslo bus lanes (2003) and bus lanes nationwide (2005). These market formation measures were implemented to make BEVs more cost/competitive towards ICEVs, and consequently to promote domestic BEV manufacturing and environmental measures. The designated EV number plates in 1999 made EVs and the benefits for EVs visible for other people (F3), showing governmental selection for EVs (F4).

4.3.5 The end of domestic BEV manufacturers in Norway 2002-2011

Ford sold Th!nk Nordic A/S in 2002 (-F1) as Zero Emmission Vehicle credit program in California, USA, was cancelled (Norsk elbilforening, 2012). Thereafter, Th!nk is bought by a new investor and renamed as Th!nk Global. In 2006 Th!nk Global went bankrupt for the second time (Wells, 2009) (-F1). In 2007 Th!nk is re-erected with help of suppliers and environmental organisations (F1) (Wells, 2009). The Th!nk City is launched at the Geneva Motorshow in 2008, again guiding the search of BEVs (F4). In December 2008, Th!nk again experiences financial troubles and asks for a bailout from the Norwegian government, but this is denied. After a third bankruptcy in 2009 (-F1), Th!nk is re-erected as Th!nk City (F1) financed by EnerDel and Valmet (Wells, 2009).

In 2008 at 21st Electric Vehicle Symposium in Monaco the new Kewet model (Kewet Buddy Citi-Jet 6), now known as Buddy, is launched (F1) (Norsk elbilforening, 2012). The Buddy was financed by private investors. Th!nk and Buddy both account for more than 50% of market share of BEVs in 2011 in Norway, but during that same year, Th!nk and Buddy go both bankrupt. This is the end of the Norwegian domestic BEVs. During 2011 the Mitsubishi i-MiEV is launched in Norway. Sales in first year account for 1050 units (F1) (Norsk elbilforening, 2012). This marks a new era for BEVs in Norway. Suddenly a new BEV model is presented, which does not form a compromise between relatively inexpensive and basic transport and electromobility. Until 2011 BEVs in Norway were mostly viewed as alternative vehicles, or city vehicles, which did not compete with regular ICEVs. The Mitsubishi was one of the first to be viewed as a BEV and as a real alternative next to small-size incumbent ICEVs.

Table 8: BEV related events Norway 2002-2011

Year	Event	F#
2002	California (USA) abolishes Zero Emission Vehicle Credit program.	-
	Ford sells Th!nk. Th!nk becomes Th!nk Global.	-F1
2003	EV access to bus lanes in Oslo Region	F5
2005	EV access to bus lanes nationwide	F5
	New Kewet model launched, the Kewet Buddy Citi-Jet 6. Now known as Buddy.	F1
2006	Second bankruptcy Th!nk	-F1
	Statoil installs first E85 biofuel station in Oslo	-F1
2007	Th!nk is re-erected with the help of suppliers and environmental organisations.	F1
2008	New Th!nk vehicle (Th!nk City) launched at Geneva Motorshow	F4
	Oslo launches municipal EV charging infrastructure program	F4
2009	Free access to road ferries	F5
	Government launches Transnova, an policy program that gives financial benefit to good environmental projects in order for faster implementation.	F6
	More EV infrastructure introductions. 1900 planned charging stations by the end of 2011.	F4
	Th!nk goes bankrupt for the third time	-F1
2011	First (CHAdeMO) fast charger installed and opened	F1
	Th!nk goes bankrupt for fourth and final time	-F1
	Kewet (Buddy) goes bankrupt	-F1
	Mitsubishi i-MiEV launched in Norway. Sells 1050 units during first year	F3/F4
	Nissan Leaf introduced to Norwegian market.	F1

Between 2002 and 2011 the Norwegian domestic BEV manufacturers had a difficult time to stay out of bankruptcy. The Norwegian government created more market formations (F5), such as access to bus lanes was (2003/2005) and free road ferry access (2009) for BEVs (Norsk elbilforening, 2011b). Following the large adoption of Flex Fuel Vehicles (FFVs) in Sweden, the first Statoil E85 fuel station is installed in Oslo (Statoil, 2006) (-F1). This is a negative development around BEVs, as a rival technique besides the ICEV enters Norway.

Besides the BEV incentives (F5), the Norwegian government has introduced several research programs to create more knowledge in electromobility. In 2008 the Norwegian Ministry of Transport and Communication established a research group (F2), led by Energi Norge, to create an action plan for the electrification of road transport (Hannisdahl et al., 2013). In 2008 Oslo also launches municipal EV charging infrastructure program, in order to create more charging points for BEV users. The increased amount of charging points give a direction of the search (F4) from the government, and this also creates more familiarity (F2) of BEVs. Also the funding program Transnova is started in 2009, which is a policy program that gives financial resources to environmental projects and research in order to attain faster implementation (F6) (Figenbaum, 2015; Norsk elbilforening, 2012). A 7 Million euro EV infrastructure program is started in 2009, resulting in 1900 EV charging points by the end of 2011 (F6). In the same year the 24th Electric Vehicle Symposium is held in Stavanger, Norway, raising awareness in BEVs in Norway (F3) (Norsk elbilforening, 2012). The first fast charger is opened (F1) in Norway in 2011 (Norsk elbilforening, 2012), raising expectations about the prospects of BEVs (F4).

4.3.6 The accelerated increase of BEV market share in Norway 2012-2016

2012 marks an important moment where a cross-party political consensus (F4) is reached. In 2012 the Norwegian government introduced a new policy in which zero emission vehicle incentives will be kept until 2018, or until there are 50.000 zero emission vehicles on the road (Norsk elbilforening, 2012). At that time, there are 10.000 EVs on the road in Norway. This equates to 3% of market share that year (Norsk elbilforening, 2012). The incentive package (F5) will be revised and adjusted parallel with the market development in coming years. From 2017 local governments will reconsider the incentives such as access to bus lanes and free municipal parking. Free toll roads will be replaced with a new system with differentiated prices depending on emissions such as CO_2 and NO_x (P. Haugneland, Bu, C., Hauge, E., 2016).

Halfway 2013 sees the Nissan Leaf EV being introduced to Norway. The Nissan becomes the most sold EV for the next coming years. 10.000 Nissan EVs are sold in the first 6 months. The Nissan Leaf even becomes one of the most sold of all cars in Norway. Furthermore in 2013 the the luxury EV Tesla Model S is introduced. In 2014 the Model S becomes even the highest selling car model in Norway with 4039 units (F3). That same year a more affordable mid-size model is announced by Tesla, the Model 3 (F4). The Tesla Model S sells again 4039 units in 2015 (Lambert, 2016c). At that point 50.000 EVs (Frydenlund, 2015) are registered in Norway, increasing to 100.000 (Frydenlund, 2016; Lambert, 2016b) in the year 2016 (F3).

Table 9: BEV related events Norway 2012-2016

Year	Event	F#
2012	Cross-party political consensus to uphold Zero Emission Vehicles financial incentives until 2018, or until there are 50.000 Zero Emission Vehicles on the road	F7
	10.000 EVs in Norway. EVs account for over 3% of new car sales	F3
	Nissan Leaf sells 2,298 units in 2012	F3
2013	Nissan Leaf sells 10.000 cars in first 6 months of 2013	F3/F4
	Luxury sedan Tesla Model S is introduced to Norwegian car market.	F3/F4
2014	Tesla Model S becomes the most sold passenger vehicle in Norway in 2014 with 4039 units.	F3
2015	Tesla Model S sells again 4039 units in 2015 in Norway.	F3
	Over 50.000 EVs now on the roads in Norway	F3
2016	Over 100.000 EVs now on the roads in Norway.	F3
	Norwegian 4 biggest political parties (left and right) agree on new plan to only allow EVs to be sold by 2025.	F4
	Norwegian government extends BEV VAT exemption to 2020.	F4/F5
	Tesla Model 3 pre-orders start	F3
	On 1 May, Volvo announces that it will release its first EV, and that it commits to selling one million EVs worldwide by 2025. (EAFO, 2017)	F4

In the years after 2011, more and more car manufacturers introduce their EVs to the Norwegian market. These vehicles are being bought massively. With 10.000 EVs in 2012 to more than 100.000 EVs (Frydenlund, 2016; Lambert, 2016b) in 2016, the diffusion of the EV goes fast (EAFO, 2017). More EVs on the road means increasing levels of learning by doing (F2) and learning by interacting (F3). More people become familiar (F2) with EVs, which lowers switching costs in the form of less bounded rationality (F2). In 2016 the 4 biggest political

parties (left and right) of Norway agree on a new plan to only sell EVs in Norway by 2025 (F4) (Bellona Europa, 2017; Bilal, 2017). Furthermore, the Norwegian government extends the VAT exemption (F5) for BEVs to 2020 (Lambert, 2016a). The selection (F4) of the government guides the search to zero emitting vehicles.

On 1 May, Volvo announces that it will release its first EV in 2019, and that it commits to selling one million EVs worldwide by 2025 (Chattaway, 2017), which further guides the search (F4) to BEVs in Norway.

4.4 BEV history event analysis Sweden

This chapter focusses on the events surrounding BEV adoption in Sweden. Just as in chapter 4.3 the events are chronologically ordered and system functions are assigned, if possible, to the events. BEV related negative events, such as a shift of guidance to the search to another technology (-F4), will be labelled as negative.

4.4.1 Swedish domestic car manufacturers and alternative fuels 1927-1984

Unlike Norway, Sweden has a large car manufacturing history. The Swedish two largest car manufacturers Volvo (1927) and Saab (1949) are companies with long histories and are embedded into Swedish society. Right after the '70s oil crisis Norway concentrates the guidance of the search BEV technology. This is different in Sweden, as in 1973 Volvo lobbies for methanol (-F7) to use as an alternative fuel to fossil fuels (Ulmanen et al., 2009). This idea is eventually supported by the government (-F4) and large governmental investments (-F6) are done into methanol research. The Swedish Methanol Development Company (SMAB) was formed in 1975 (-F1). SMAB was a joint venture of Swedish government (60%) and Volvo AB (40%) further highlighting the commitment of Volvo AB and the Swedish government (-F4). The main goal of SMAB was to gain knowledge (-F2) in the use of M15 methanol as an alternative fuel for transportation. Following the second oil crisis in 1979, Swedish government intensified the guidance of the search (-F4) even more on bio-fuels to become a fossil fuel independent country (Ulmanen et al., 2009).

Following into 1981, a bill that focussed on pure M100 methanol (-F4) further highlighting the commitment to alternative (bio)fuels. M100 methanol has a larger environmental and oil substitutional potential than M15 methanol. Also included in the government bull were tax exemptions to alcohol fuels (-F5). This bill was pushed by a lobby of the methanol industry in Sweden (-F7) (Ulmanen et al., 2009). In 1983 governmental resources (-F6) were used for large scale M100 methanol trials in fleets, gaining more knowledge about methanol as an alternative fuel to fossil fuels (-F2), including 200-300 cars and 100 busses. These vehicles were mainly Flex Fuel Vehicles (FFVs) provided by Swedish domestic manufacturers Volvo and Saab-Scania (Ulmanen et al., 2009)who also gained knowledge of the tests (-F2).

During the 1980s the Swedish agricultural sector lobbies (-F7) for ethanol production, after Swedish sugar industry was unable to compete with international sugar markets. The excess wheat production had the potential to be used as an alternative fuel to fossil fuels, and also generate jobs in Sweden. After the agricultural sector lobbied for ethanol research (-F2), funding was received from the Swedish government (-F6). In 1984 in Sweden The Federation of Swedish Farmers and industrial company Alfa Laval built the first ethanol plant (-F1) using these government funds (Ulmanen et al., 2009). This also showcased the guidance of the

search of the Swedish government to alcohol fuels as a way to become fossil fuel independent (-F4).

Table 10: BEV related events Sweden 1927-1984

Year	Event	F#
1927	Volvo, with backing of SKF, started production of automobiles and light trucks in Gothenburg	-
1949	After the second world war, military aircraft builder Saab searched for a civilian product to fill their workshops. Production of automobiles started that year.	-
1973	Volvo AB lobbies for methanol as an alternative fuel to fossil fuels	-F7
	Swedish government supports the methanol idea of Volvo, and provides resources for methanol research.	-F4 / -F6
1975	Volvo AB (40%) and the Swedish government (60%) start research company SMAB, for research after methanol as an alternative fuel.	-F1 / -F2
1977	Oil crisis meant small car manufacturers were at risk on going bankrupt. Merge between Volvo and Saab-Scania fails due to Volvo shareholders resistance.	-
1979	Following the oil crisis, Swedish government increases the focus on the use of bio-fuels in order to lower dependence on fossil fuels.	-F4
1981	Methanol industry lobbies for a governmental tax exemptions	-F7
	Swedish government presents a bill that increases guidance of the search to M100 methanol. This bill also includes tax exemptions of alcohol fuels.	-F4 / -F5
1983	Governmental resources used to start methanol test fleet (FFV) to gain more knowledge about methanol fuel use. Volvo AB and Saab-Scania provide vehicles	-F6 / -F2
1984	Swedish agricultural sector lobbies government for ethanol fuel use	-F7
	Government funds allocated to ethanol research	-F6 / -F2
	The Federation of Swedish Farmers and Alfa Laval built first ethanol production plant using governmental resources. Guidance of the search to alcohol fuels	-F1 / -F4

4.4.2 'Clean' vehicles in Sweden 1985-2002

1989 marked as the first year where BEV activity took place in Sweden, as the City of Stockholm procured 10 Volkswagen Golf BEVs (F1). In 1992 the Swedish Development Agency (Nutek) started to import a couple of BEVs to Sweden as part of a national technology procurement program (Nykvist & Nilsson, 2015) to increase familiarity with BEVs (F2). In 1993 the Swedish government commissioned (F4) the Swedish Transport and Communications Research Board to run a development program on BEVs, increasing knowledge (F2) on BEV technology (Birath & Pädam, 2010). 1991 saw the introduction of carbon tax, where passenger vehicles are now taxed on the amount of grams of CO_2 per kilometre. Zero emission vehicles such as BEVs are not taxed of course (F5), but also bio-fuels are exempted from this tax (Sprei, 2013).

In 1994 the Clean Vehicles in Stockholm program was started by the City of Stockholm (F1). The overall aim was to reduce negative environmental impact from road traffic in Stockholm. This was done through promoting clean vehicle technologies through BEVs (Birath & Pädam, 2010). As such vehicle models were not as much around, the focus was broadened (-F4) to include biofuels and electromobility (Birath & Pädam, 2010). Also in 1994, the first FFVs are introduced and showcased (-F4) in Sweden. Three Ford Taurus' are presented by Ford USA.

FFVs expectations rise (-F3), and this was followed up by 50 FFV Ford Taurus' divided over several municipalities in Sweden. For the FFVs an infrastructure of 40 ethanol stations were built (Sprei, 2013), the first being built in 1995 (Kroh, 2008).

Sweden joined the EU in 1995, and the Swedish government lobbied (-F7) for possibilities to give general tax exemptions (-F5) to biofuels in EU legislations (Ulmanen et al., 2009). This supports the reasoning behind the selection of biofuels by the Swedish government. In 1999 the reduction of company car tax for 'clean' vehicles was initiated (F5). This included clean vehicles such as FFVs and BEVs.

With the financial support of the Swedish Delegation for Sustainable Technology (-F6), a technology procurement of mid-size FFVs (-F4) was initiated by the Clean Vehicles program in Stockholm. 300 FFVs were imported during 1997-1998. The City of Stockholm set an world record being the first city to have 300 'clean' vehicles, consisting mostly out of bio-fuel vehicles and some EVs (Birath & Pädam, 2010). In 1998 the City of Stockholm put out an order of 2000 FFVs for any car manufacturer to respond. Volvo and Saab refused, saying that the needed fuel station infrastructure was not sufficient at that moment in Sweden (Kroh, 2008). Ford eventually took the order and the procurement process took place between 1998-2000, and led to the world premiere of Ford Focus ethanol in Sweden in 2001 (Birath & Pädam, 2010). The selection of FFVs (-F4) showcased the commitment to the biofuel technology. The world premiere of Fords FFVs in Sweden raised expectations (F4) of biofuels in Sweden, instead of BEVs (-F3). In 2002 in Sweden the first Ford Focus FFVs arrived (Birath & Pädam, 2010).

Table 11: BEV related events Sweden 1985-2002

Year	Event	F#
1989	City of Stockholm procures 10 BEVs	F1
1991	Introduction of Carbon Tax. Vehicles are taxed on the CO_2 emissions. Bio-fuels are exempted from this tax.	F5 / -F5
1992	Nutek procures several BEVs	F3
1993	Governmental commissions research to development program on BEVs, to attain more knowledge on BEV technology	F4 / F2
1994	Clean City of Stockholm project is started.	F1
	3 Ford Taurus imported to Sweden to showcase Flexible-fuel vehicle (FFV) technology	-F4 / -F2
	Project started with 50 Ford Taurus FFVs in 7 Swedish cities.	-F4
1995	First E85 fuel station installed in Sweden.	-F1
	Sweden lobbies for tax exemptions for biofuels in EU legislations.	-F7
1997	Financial support of the Swedish government for the procurement of mid-size FFVs. 300 FFVs imported to Sweden between 1997-1998	-F6
1998	City of Stockholm places an order for 2000 FFVs to any car manufacturer. Volvo and Saab refuse because lacking biofuel infrastructure, Ford takes the offer.	-F4
1999	Reduction of company car tax for 'clean' vehicles	F5
	Volvo Cars devision is bought by Ford	-
2001	General Motors take full control over Saab Automobile, buying Investor AB's 50% share.	-
	World premiere of Ford Focus FFV in Sweden. In 2001 there are 717 FFVs on the road in Sweden.	-F3
2002	First Ford Focus FFV for Clean Vehicles in Stockholm procurement program	-F1

4.4.2 The rise and fall of FFVs and the emergence of BEV policy programs 2003-2010

Between 2001 and 2005 the most sold FFVs are Fords, accounting to 80% market share (Sprei, 2013). Ford got a head start from the procurement program in 1998 (Birath & Pädam, 2010), but in 2005 the domestic car manufacturers Volvo and Saab both introduced their first commercially available FFVs. These were for the Swedish market only (Sprei, 2013). The increase of FFVs in Sweden raised familiarity (F2) and expectations (F4) about biofuel technologies. During the same period in Sweden BEVs did not acquire such an uptake as FFVs.

General tax reductions (-F5) on biofuels are introduced in 2003 (Birath & Pädam, 2010). Following in 2005, larger tax exemptions (-F5) for biofuels were granted by the Swedish government. This support for biofuels and a biofuel market brought the hesitant Swedish automobile industry (Volvo and Saab) back in the biofuel network (-F1) (Ulmanen et al., 2009). The pump law was installed in 2006 by the Swedish government, ordering large (>3000 m^3 per year) fuel stations to offer one alternative fuel. Biofuel facilities were the cheapest to offer, so most of these alternative fuels became biofuels (Birath & Pädam, 2010; Sprei, 2013).

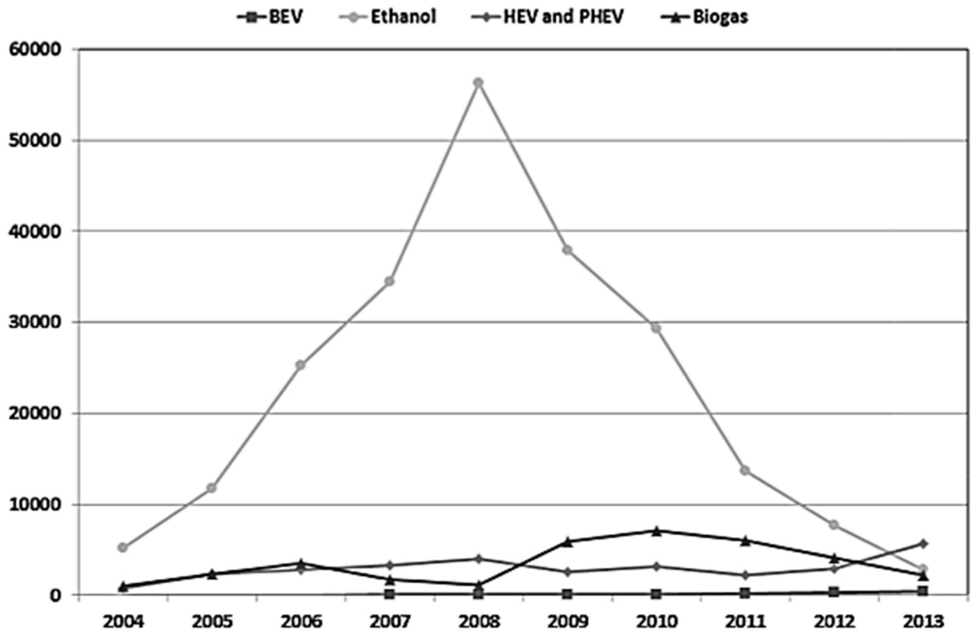

Figure 9: Net change of new passenger vehicles sold per year in Swedish (Nykvist & Nilsson, 2015)

In Sweden, biofuel car sales peaked in 2008, as seen in Figure 9 from Nykvist and Nilsson (2015). This corresponds to a 25% market share (Sprei, 2013)) of FFVs in Sweden. Biofuels received negative image and expectations due to more and more statements that biofuels raises food prices and is not that environmental friendly. The share of negative articles has varied between 18% in 2003, to 50% in 2010. In 2005 the share is 40%, with a specific focus to the fuel station mandate or pump law (Sprei, 2013).

Table 12: BEV related events Sweden 2001-2010

Year	Event	F#
2003	Further tax reductions on biofuels in Sweden	-F5
2005	Ford sells 15.000 FFVs between 2001 and 2005. Ford has 80% market share in FFVs.	-F3
	E85 fuel receives tax breaks, FFV buy bonus, FFV company car tax reductions, lower insurances for FFVs, exemption from congestion charging in Stockholm.	-F5
	Volvo and Saab both introduce FFVs, exclusive to Swedish market. In the years after, these models would become available outside the Swedish market.	-F1 / -F3
2006	'Pump law' mandating large fuel station to offer the option of an alternative fuel to fossil fuels. These were most of the times biofuels	-F5
2008	Height of FFV sales. 100.000 FFVs on the road in Sweden. 25% of new sold cars are FFVs.	-F3
2009	Smaller fuel stations (>1000 m^3 sales of fuel per year) have to offer an alternative fuel (2009)	-F4
	Ford sells Volvo to Zhejiang Geely Holding Group, a Chinese company	-
	Debate on negative environmental and societal impacts of first-generation bio-fuels receives significant attention and political support for bio-fuels fades out.	F4
	Sharp increase of diesel cars at the costs of FFV sales, as they comply with 'green' car rules, emitting less than 120 g CO_2 per kilometre.	-
	Swedish government present 2030 goal, 80% emission reduction in transport	F4
2010	General Motors sells Saab to Dutch company Spyker	-
	Volvo starts BEV lease test fleet, project is eventually discontinued	F1
	City of Stockholm and Vattenfall start The Swedish EV Procurement program.	F4

After 2008 FFV sales declined due to bio-fuel debates, and the eventual fading out of political support for bio-fuels. As bio-fuels received bad expectations, other techniques such as BEV come higher on the political agenda. This can be seen in the paper of Geels (2012), where the disappointment of biofuels started, and the 'hype' among BEVs picked up again (Figure 10).

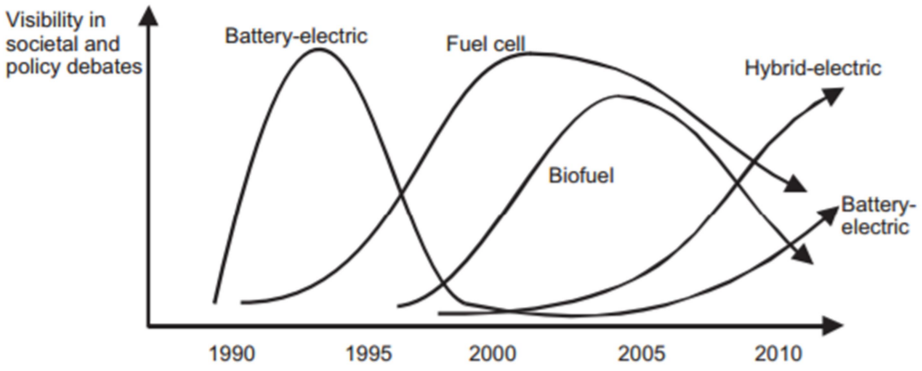

Figure 10: Hype and disappointment in certain renewable transport technologies (Geels, 2012)

The sharp decline of FFVs in Sweden was also caused by diesel cars around 2009 that fell into the category of 'green' vehicles (Sprei, 2013). Between 2007 and 2009 in Sweden the term 'green' vehicles was used to indicate low emitting vehicles, which received a SEK10.000 (roughly 1000 Euro) on purchase (Sprei, 2013). Around 2008, new diesel cars fitted the 120 g

CO_2 rule and were also labelled as a 'green' car. These diesel car sales substituted partly the sales of FFVs in Sweden (Sprei, 2013).

The global economic crisis also had some effect on the Swedish domestic vehicle manufacturing industry. During this crisis, GM filed for bankruptcy, as did Chrysler. These big car manufacturers house multiple other car brands. Volvo and Saab are two examples that were being sold by their parent companies in the recent economic crisis (Sturgeon & Van Biesebroeck, 2010). This had an influence on domestic BEV development, as around this time *"Volvo and Saab both did start to develop EVs. They stated, but then however, Saab unfortunately went bankrupt. Saab had an electric vehicle on its way. Volvo had an EV which was a test with 250 units that they leased out to specific customers. Then they instead started pushing for the diesel HEV (a car they developed in co-operation with Vattenfall)"* (Sunnerstedt, 2017). This Volvo test fleet of 250 electric Volvo C30 that were available for lease. This project was later discontinued (Nykvist & Nilsson, 2015)

One of the first initiatives that had a positive influence on BEV adoption was the 2030 goal announcement (F4), which includes BEVs, and an EV procurement program is started to focus (F4) more on BEV technology. In 2009 the Swedish government established the goal is that the Swedish transport system has to be fossil fuel free by 2030. No precise target has been set on the amount of BEVs or PHEVs (Albrecht, Nilsson, & Åkerman, 2012).

Before 2010 there were, relative to Norway, only minor BEV supportive activities in Sweden. Only the City of Stockholm actively promoted (F7) the use of BEVs in Sweden (Nykvist & Nilsson, 2015) and the amount of BEVs in the City of Stockholm fleet were relatively low compared to the FFVs. A change can be seen from 2010 where the City of Stockholm starts a procurement program (F1), in where companies can rent EVs. Here people learn about EVs by doing (F2) and interacting (F3)(Sunnerstedt, 2011). 2011 sees the introduction of the first Swedish incentives specifically towards EVs (F5) (EAFO, 2017).

4.4.3 Increased focus on electromobility in Sweden 2011-2016

Continuing to 2011, the City of Stockholm carried out a procurement for BEVs for companies in Stockholm (Nykvist & Nilsson, 2015; Sunnerstedt, 2011). Around that time more incentives were introduced, but rebate pay-out difficulties between 2014 to 2016 lowered expectations (-F4) about BEV market formation in Sweden (Tietge, 2017). People received their rebates too late, as the funds dried up every year, following wrongly estimated rebate projections of the Swedish government.

The introduction of new BEV models from Mitsubishi, Nissan, Tesla, etc., further developed the process of BEV adoption. FFVs and biofuels received less attention than before (Geels, 2012), but were still being sold. The goal of Stockholm becoming a fossil fuel-free city by 2050 (European Commission, 2014; Nykvist & Nilsson, 2015) is on bringing down emission in the transport sector, and the focus is on several low carbon emitting options. This differs from Norway where the guidance of the search is primarily on electromobility.

Table 13: BEV related events Sweden 2010-2016

Year	Event	F#
2011	The City of Stockholm, Vattenfall and SKL Kommentus Inköpscental AB carried out a national procurement of 50 EVs for 30 organisations.	F1/F2/ F3
	Swedish municipalities can now reserve parking spots for in public spaces for EVs.	F5
	Nissan Leaf introduced to Swedish market	F1
2012	Saab goes bankrupt and is bought by Chinese-Japanese National Electric Vehicle Sweden (NEVS)	-
	Super Green Car Rebate (supermiljöbilspremie), where EV buyers receive a 40.000 SEK (4.200 Euro) rebate if the vehicle emits 50 g/km CO_2. This accounts for BEVs and PHEVs.	F5
	Nissan Leaf sells 129 units in 2012 in Sweden	F1
	Tesla Model S introduced to the Swedish market	F1
	Swedish government 2030 report is presented.	F4
2013	Nissan Leaf sells 145 units in first half year of 2013	F3
2014	Tesla Model S sells 268 units in 2014	F3
	The City of Stockholm announces that it will become fossil-fuel free in 2050	F4
	Rebate troubles lower expectations about EV sales incentives and government commitment	-F3
2015	Tesla Model S sells 996 units in 2015	-
	Currently over 15.000 EV's in Sweden	F3
2016	Super Green Car Rebate (supermiljöbilspremie) is halved to 20.000 SEK for PHEV buyers. BEV buyers still receive full 40.000 SEK.	F5
	On 1 May, Volvo announces that it will release its first EV, and that it commits to selling one million EVs worldwide by 2025.	F3/F4
	Governmental plan for public fast chargers along every 50km of highway	F4
	Tesla Model 3 pre-orders start	F3

As more and more BEV models become available, the amount of BEVs in Sweden started to increase. In 2016, Swedish domestic car manufacturer Volvo plans to make 1 million EVs by 2025 (Chattaway, 2017; Volvo, n.d.), and could become a future BEV competitor for Tesla (Galeon, 2017). From this point on, the regime player Volvo who lobbied for biofuels in the past, commits to shift its focus on electromobility in the years following 2016.

4.5 System Functions BEV comparison Norway and Sweden

Following from the history event analysis in 4.3 and 4.4, the system functions are presented in this chapter, and a comparison is made between the system function activities between Norway and Sweden. The goal is to show what differences have occurred relative to the BEV adoption development. By using the theory of Hekkert et al. (2007) the activities can be categorized and compared clearly between Norway and Sweden. Chapter 5 will go in deeper into the interactions the system functions, further using the theory of Hekkert et al. (2007)

4.5.1 F1: Entrepreneurial activities

Entrepreneurs are essential for a well-functioning innovation system. Entrepreneurs can be new entrants that grasp business opportunities through their vision, or incumbent companies who diversify their strategies to take advantages of new developments (Hekkert et al., 2007).

After the oil crisis in 1973, both Norway and Sweden shift their focus on alternative transport technologies, away from the fossil fuel regime. Where Norway slowly focussed on electromobility (Table 5), Sweden started doing more research into alternative alcohol fuels (Table 10).

Table 14 shows a representation of BEV entrepreneurial activities in Norway and Sweden. What stands out is the larger amount of entrepreneurial activities in Norway against Sweden, although the majority of BEV entrepreneurial activities start at around the 1990s for both countries. Another difference is the sort of activities between Norway and Sweden. In Norway the BEV manufacturers and EV association are started as do governmental charging programs. In Sweden BEV entrepreneurial activities mostly contain procurement and lease programs. There seems to be a difference in how the BEVs are targeted, as BEVs in Norway are more orientated towards private use by setting up an BEV market, and BEVs in Sweden through procurement programs which are more orientated towards public ownership.

Table 14: BEV entrepreneurial activities (F1) Norway and Sweden

Norway	Sweden
• Early entrepreneurial BEV activity around BEVs, start of PIVCO (1973, 1980-1990) • Kewet founded (1991), sells vehicles to Norway, goes bankrupt (1998) and becomes Norwegian after re-erection (1999) • PIVCO manufacturing plant (1995) • Norsk Elbilforening founded (1995) • Official launch Th!nk (1998) • Th!nk goes bankrupt (1998, 2006, 2008, 2011) • Governmental charging programs (2008, 2009), and first fast charger (2011) • New foreign BEV models introduced to Norway (2011), diffusion goes relatively fast.	• BEV procurement programs (1989, 1992, 1994, 2010). • Volvo BEV test lease fleet (2010). • New foreign BEV models introduced to Sweden (2011), diffusion goes relatively slow.

4.5.2 F2: Knowledge creation

Mechanisms of learning are at the core of an innovation system process (Hekkert et al., 2007). Learning by doing can have positive effects on how the technology is perceived. Furthermore, an increase in knowledge can positively contribute to the attractiveness of BEVs. Knowledge boundaries or bounded rationality can negatively influence the attractiveness of BEVs and can form a barrier to BEV diffusion.

The PIVCO project created BEV knowledge with researchers, policy makers and society, as the PIVCO and later Th!nk was the Norwegian domestic 'car' manufacturer. Norsk Elbilforening (Elbil) conducts research into BEV use (P. Haugneland, Bu, C., Hauge, E., 2016), and acts as an consultant for (potential) BEV users and foreign governments (P. Haugneland, 2017). Further research in Norway is done using governmental subsidies such as the program Transnova. Knowledge about BEVs in Sweden was gained through procurements of, predominantly, the City of Stockholm. Early Swedish governmental research programs in 1993 created BEV knowledge by searching.

BEV knowledge creation has started around the 1990s in Norway and in Sweden. The difference is that from the 1990s BEV knowledge creation would continue to increase in Norway, while BEV knowledge creation in Sweden would slow down between 1994 and 2010. Due to relatively low BEV knowledge creation over the years, the knowledge boundaries and uncertainties about BEVs in Sweden remain relatively high (Nykvist, 2017; Sunnerstedt, 2017).

Table 15: BEV knowledge creation (F2) Norway and Sweden

Norway	Sweden
• Knowledge is gathered through learning by searching during PIVCO creation (1980-1990). • Learning by searching through PIVCO prototype testing (1992, 1993). • Learning by doing through PIVCO rental test programs (1995-1998). • BEV knowledge gathered by Norsk Elbilforening (1995-present) and transferred (F3) to (potential) BEV users. • Government funded (F6) Norwegian institutes, such as TØI, research BEV user experiences. • Knowledge transfers (F3) between industry, government and society raises BEV knowledge in general. • Increasing amount of BEVs and charging stations increases overall BEV knowledge.	• Procurement programs (1989, 1992, 1994, 2010) raise knowledge by using. • Governmental research committees investigate BEVs (1993), knowledge by searching. • Volvo starts BEV lease test fleet (2010). • Increasing amount of BEVs and charging stations increases overall BEV knowledge.

4.5.3 F3: Knowledge diffusion through networks

The exchange of information is essential in networks. Network activity can be regarded as a precondition to learning by using and by interacting. Policy decisions should be consistent with the latest technological knowledge (F2) and societal norms and values (F2) (Hekkert et al., 2007). In the theory framework of Hekkert et al. (2007) knowledge through networking is stimulated by knowledge by doing and searching (F2). This effect is also vice versa, as knowledge interaction raises overall BEV (F2) and also expectations (F4) about the technology potential.

Table 16: BEV knowledge diffusion through networks (F3) Norway and Sweden

Norway	Sweden
• NGO's such as Bellona and Norsk Elbilforening lobby (F7) for resources (F6) and market incentives (F5) and spread knowledge by interaction. • BEV knowledge transfer occurs at promotional events such as Lillyhammer Olympics (1994), Swedish EV rally (1995), PIVCO launch in San Francisco, attended by Norwegian King and Queen (1995). • Norsk Elbilforening communicates and spreads knowledge with (potential) BEV users through meetings, seminars, commercial events, and BEV user research. • Interaction between PIVCO, government and society creates knowledge transfer of BEVs. • PIVCO rental tests (1995-1998) in Norway create knowledge by using of BEVs in Norway. • BEV user incentives such as free ferry, toll fee exemptions, bus lane use, free parking stations and EL number plates raise knowledge by interacting, as the BEV benefits are visible. • More people use BEVs, and interact with other people, embedding user experiences in society.	• City of Stockholm procures BEVs for municipality use (1989, 1994), transferring user BEV knowledge at governmental level. • City of Stockholm interacts with 30 organisations for procurement of BEVs (2010). BEV knowledge transfer occurs. • City of Stockholm gives presentations and organizes seminars for potential BEV consumers (2017). • More people use BEVs, and interact with other people, embedding user experiences in society.

In Norway and in Sweden BEV promoting actors have distributed BEV knowledge through government, industry and society. Norsk Elbilforening (Norway) and the City of Stockholm (Sweden) have organized BEV promoting events and seminars for (potential) BEV owners. The difference here is that Norsk Elbilforening has been actively promoting BEVs since 1995 (P. Haugneland, 2017), and the City of Stockholm briefly in 1994 (Birath & Pädam, 2010) and since 2011 (Sunnerstedt, 2011) through procurement events, while large open seminars are organized since 2017 (Sunnerstedt, 2017). Also, procurement programs in Sweden focus more on industry and government, and not as much as society. This together with the time spend distributing BEV knowledge creates an important difference in the BEV knowledge embedded in society.

Especially Norsk Elbilforening has been an important influencing factor in knowledge by interacting. By support BEV seminars, organising BEV events and generally promoting BEVs, knowledge by interacting and using increased in Norway. Special events celebrating the 50.000 and 100.000 landmarks for BEVs in Norway received national and international news coverage (Frydenlund, 2015, 2016; Lambert, 2016b). Also foreign governments visit Norsk Elbilforening for consulting advice on BEV technology and implementation in society (P. Haugneland, Bu, C., Hauge, E., 2016). The level of embedded BEV knowledge in society has been greater in Norway than in Sweden.

One other implicit factor in knowledge transfer is the amount of BEV market share and public charging stations (EAFO, 2017). For instance Nissan Leaf and Tesla Model S sales between Norway (Table 9) and Sweden (Table 13) show that BEVs are sold considerably more often in Norway than in Sweden. Knowledge barriers occur due to a limited amount of people using BEVs in Sweden (Nykvist, 2017). According to P. Haugneland (2017) a great factor in BEV awareness is the knowledge transfer of BEV owners to non BEV owners. According to Kolbenstvedt (2017) people gain a totally different picture of BEV use after they have used a BEV. The limited amount of BEVs itself does not raise awareness in the BEV technology in Sweden as much as it does in Norway.

4.5.4 F4: Guidance of the search

The guidance of the search can be seen as the selection by governments or companies (Hekkert et al., 2007). Resources are limited, and selecting a technology means that the learning process is directed to a particular technology. Guidance of the search can also be seen as governmental or company visions or goal setting statements.

Since 1973 in both Norway and in Sweden initiatives have come up in searching for alternative renewable fuels. Sweden has concentrated on biofuel development and Norway on electromobility. The reasons why this selection has occurred can be found in the discussion in chapter 6.3. Eventually biofuels became a troublesome case from 2008 onwards. The Swedish selection has always included multiple propulsion technologies to become fossil fuel free. After the demise of biofuel interest, BEVs in Sweden have received a greater policy attention and therefore guidance of the search towards BEVs in Sweden.

From 1990 on BEV technology has been supported in Norway, and seen as an feasible environmental friendly transport solution. In Sweden this has been the case since 2008 after the demise of biofuel interest, and has been one of the supported technologies. This wider focus has meant that more technologies are supported, but BEV specifically the support has been lower than that in Norway. According to Nykvist and Nilsson (2015) and Nykvist (2017), the Swedish guidance of the search (F4) is directed to several different technologies. This comes forth out of the failed support of biofuels and FFVs. Therefore, the Swedish government does not want to 'pick winners' (Nykvist & Nilsson, 2015). The result is that technologies such as HEVs, PHEVs, and full EVs are supported, and '*The net outcome is a plurality of multiple options on the table*' (Nykvist, 2017).

Guidance of the search (F4) towards BEVs has a positive influence on BEV investments (F6), research (F2) and market formations (F5). This has over time been more the case in Norway

than in Sweden, where BEVs received political cross-party consensus and governmental support earlier and to a larger extent than in Sweden.

Table 17: BEV guidance of the search (F4) Norway and Sweden

Norway	Sweden
• Governmental selection of BEV technology, as PIVCO (1990) receives government funds and loans (F6). • Several Norwegian companies act as sponsor (F6) for PIVCO (1990). This commitment raises BEV expectations. • Multiple incentives introduced (1990, 1996, 1997, 1999, 2000, 2001, 2003, 2005, 2009, 2016) promoting BEV technology in Norway. • Promotional events such as presentation of PIVCO in San Francisco (1995) shows governmental selection for BEV technology. • Norsk Elbilforening promotes BEVs and guides search towards BEV use. • Charging programs launched (2008, 2009), instalment of BEV infrastructure and BEV selection. • Governmental consensus on BEVs (2012, 2016) creates a strong policy base for BEV. • Norwegian government announces 2025 goal, in which EVs have an 100% market share.	• Governmental research into BEV technology (1993), selects BEV as a possible solution to become fossil fuel free. • Clean City of Stockholm (1994) project is started, with focus on electromobility. Later focusses also on biofuel. • Debate on biofuels (2008) guides the focus to other fossil fuel free technologies, such as BEVs. • 2030 goal by Swedish Government announced (2008) and presented (2012), 80% emission reduction in transport. Raises expectations for BEVs in Sweden. • City of Stockholm, Vattenfall and SKL Kommentus carry out a national BEV procurement (2011), guiding search towards BEVs. • Multiple incentives introduced (1991, 1999, 2011, 2012, 2016) promoting BEV technology in Sweden. • Domestic car manufacturer Volvo announces (2016) BEV for 2019. Raising BEV expectations in Sweden.

4.5.5 F5: Market formation

New technologies may experience difficulties to compete with embedded technologies in society (Hekkert et al., 2007). Market formation in the form of policies and incentives can create protected spaces in where new technologies can progress and evolve. Here they can grow and become more efficient to compete with already existing technologies.

The BEV incentives and policies have both been installed in Norway and Sweden, although there is a difference in how specific to which technologies the incentives are. Since the 1990s market formation has occurred towards BEVs in Norway and Sweden. Import tax exemptions (1990 in Norway) and carbon tax exemptions (1991 in Sweden) are directed to low emitting vehicles, although there is a difference in focus. Zero emission vehicles are supported in Norway, and low emitting vehicles in Sweden. Only after the demise of biofuels in 2008 saw the introduction of EV specific incentives in Sweden. The guidance of the search (F4) on several alternative technologies in Sweden has resulted in not 'picking winners' (Nykvist & Nilsson, 2015), which was also discussed in chapter 4.5.4. One other difference is the amount of BEV policies and incentives, which is higher in Norway than in Sweden.

Table 18: BEV policies and incentives (F5) used in Norway and Sweden (ACEA, 2017; EAFO, 2017)

Year	Norway (BEV)	Sweden (BEV)	Sweden (FFV)
1981			Tax exemptions biofuel
1990	Temporary abolishment of import tax		
1991		Carbon tax	Carbon tax
1996	Abolishment of import tax		
	Reduced annual registration tax		
1997	Exemption of road tolls		
1999	'EL' special number plates are introduced	Reduction company car tax	Reduction company car tax
	Free parking in public places		
2000	Reduced company car tax		
2001	VAT exemption (until 2018)		
2003	Access bus lanes Oslo		Further tax reductions
2005	Access bus lanes Norway		E85 tax breaks
			Insurance reduction
			Congestion charging exemption
2006			Pump law
2009	Free access road ferries		
2011		Municipalities can reserve EV parking space	
2012		Super Green Car rebate	
2016	VAT exemption (until 2020)		

4.5.6 F6: Resource mobilization

Financial and human resources are necessary as a basic input to all activities within an innovation system (Hekkert et al., 2007). The allocation of resources to a specific technology can improve knowledge creation (F2), and eventually influence entrepreneurial activities (F1). Resources can be allocated as a result of lobbying or creation of legitimacy (F7). According to Hekkert et al. (2007) interviews are the best way to see if the access to sufficient resources have been sufficient or problematic.

Table 19: BEV resource mobilization in Norway and Sweden

Norway	Sweden
• Governmental resources are transferred towards BEV projects such as PIVCO (1990). • Research institutes such as TØI are government funded by Transnova (2008) to perform BEV user research, such as Figenbaum (2015). • Norwegian industry provide financial sources to set up PIVCO (1990) and Norsk Elbilforening. (1995).	• Clean City of Stockholm procurement programs use municipality finances (1989, 1994) • Vattenfall and SKL Kommentus work together with City of Stockholm on national EV procurement.

The PIVCO BEV project was financed through Norwegian domestic organisations, research institutes and government. The same level of financing has not been reached in Sweden, where government funds were not allocated towards electromobility but to biofuels until 2008. Already in 1973 investments were made in Sweden for biofuel production. Some funds are eventually used in the national procurement of BEVs in Sweden, but not on the scale of Norway.

4.5.7 F7: Creation of legitimacy / counteract resistance to change

A new technology has to become part of an existing socio-technical regime, or has to overthrow it. Advocacy coalitions can stimulate creative destruction, by putting the technology on the political agenda (F4), lobby for resources (F6) and ask for favourable tax regimes (F5), and by doing so create legitimacy for new technological paths (Hekkert et al., 2007).

Table 20: Creation of legitimacy for BEVs

Norway	Sweden
• NGO Bellona tries to create legitimacy for BEVs (1989) and lobbies import tax exemption (F5) for BEVs (1990) • Jan-Otto Ringdal lobbies for financial resources (F6) from government and from industry to set up PIVCO company (1990). • Promoting events such as Lillyhamer Olympics (1994) and others create legitimacy for BEVs. • Norsk Elbilforening (1995-present) put BEVs on the political agenda (F4) and lobby for market formations (F5).	• Electromobility projects (1994) and procurement programs (1989, 1992, 2010).

Creation of legitimacy has been very different between Norway and Sweden on terms of BEVs. Already in the 1980s attempts of BEV legitimacy have occurred in Norway, and these have continued until today. Some creation of legitimacy has been in place with procurement programs of the City of Stockholm.

If the creation of legitimacy of Norway and Sweden on alternative vehicle technologies is compared, than an more similar development can be seen. BEVs in Norway and FFVs in Sweden have been promoted for since the 1980s. There was an increase in these technologies in their respective countries through the 1990s, supported by lobbying activities. The difference is that biofuel technology has experienced a demise because of negative perception of the technology since 2008, and electromobility has gained momentum through that period.

4.5.8 F#: External BEV influencing factors

The conceptualisation of technological changes relies on factors endogenous of the innovation system. However, as stated by Hekkert and Negro (2009) state that external factors can be included in the eventual narrative of the system function analysis, but are not conceptualized in a formal way. The related externalities play a role in BEV diffusion and BEV policy and incentive implementation in Norway and Sweden. These factors are presented in this chapter and are further discussed in chapter 6.3.

Table 21: BEV related externalities

Norway	Sweden
Threshold and network effects	
Battery and charging developments	
Institutional differences between Norway and Sweden	
Difference in GDP per capita	
Domestic energy commodities	
Foreign BEV model introductions	
Fall of biofuel interests	

Threshold and network effects are difficult to map in the innovation system. Hekkert and Negro (2009) state that in technology change processes certain thresholds need to be reached in order for a function to be fulfilled and another function to be activated. The height or number of this threshold is difficult to estimate, as further network effects may influence these thresholds. An example is the amount of BEVs on the road. At a certain point knowledge by interaction is faster fulfilled as more BEVs are present, and the perceived feasibility of the technology is increased. Consequently this influences BEV knowledge diffusion (F3) and BEV knowledge in general (F2).

Another external factor are battery costs, which is a major deciding factor on BEV costs. If battery costs go down than the overall costs of BEVs will go down. Battery cost developments (P. Haugneland, 2017; Nykvist, 2017) together with charging duration (Askerdal, 2017; Odeck, 2017) are important factors that make BEVs have a higher price/performance towards comparable ICEVs. The development of these factors is exogenous to the innovation system because most BEV models are not from Norway or Sweden.

There are more BEV incentives in place in Norway than in Sweden, but there is also an institutional difference between these countries (Odeck, 2017). Taxation on vehicles in Norway is higher (Bjerkan et al., 2016) as import tax, toll roads, tunnel and ferry fees are not in place in Sweden. There is no other country in the world where it is so expensive to buy a car (Kolbenstvedt, 2017). Import tax, toll roads, tunnel and ferry fees are used in Norway, but not in Sweden. With the exemption of Norway, EVs are still more expensive than ICEVs (Bjerkan et al., 2016; Kley, Wietschel, & Dallinger, 2012). According to Odeck (2017), Norwegians are used to pay a lot of tax for using their infrastructure. It is therefore easier to give BEV tax exemptions in Norway than in Sweden. This shows a deeper meaning of BEV policies and incentives possibilities, and is an important contextual factor in the BEV diffusion difference between Norway and Sweden.

Odeck (2017) also mentions the richness of Norway, following from the national fund which contains domestic Norwegian oil revenue, and the high GDP per capita. Due to this wealth subsidies for BEVs are more easily given. Furthermore, the higher GDP per capita provides relatively lower switching costs to a new radical innovations such as BEVs (Odeck, 2017).

Both Norway and Sweden have the possession of renewable energy sources, although there is a difference in what energy sources used. Norway has the possession of large hydro power electricity resources (P. Haugneland, Bu, C., Hauge, E., 2016), and this lowers electricity prices

(Odeck, 2017). Sweden has the possession of large quantities of forestry and other biofuel resources (Nykvist & Nilsson, 2015; Sunnerstedt, 2017).

The Norwegian BEV market share saw a high increase around 2011, at the time of the introduction of foreign BEV models. The availability of attractive BEV models has influenced the perception of BEVs. BEVs were no longer alternative vehicles, but real competition towards incumbent ICEV manufacturers (P. Haugneland, 2017; Nykvist, 2017).

One last externality is the fall of interest in biofuel technologies around 2008. This can be seen as an external influence on the guidance of the search (F4) in the BEV system of Sweden.

4.6 Transferability of BEV policies and incentives

During an exploratory literature study before the start of the research, a non-consensus was discovered between several sources on the matter if other countries should and could copy the BEV policies and incentives of Norway. The purpose of this section is to identify what determines the transferability of the Norwegian BEV incentives to other countries.

Aasness and Odeck (2015) mention that the BEV incentives used in Norway have some severe side-effects and should not be copied to other countries without care. There are financial losses in revenue due to tax and toll exemptions for BEVs in Norway. Furthermore, the matter of electricity generation is important, as only hydropower produced electricity as in Norway, offers a positive impact on greenhouse gas emission. Countries with other energy sources will not attain such a positive environmental impact.

Holtsmark and Skonhoft (2014) argue that the Norwegian EV subsidy should be ended as soon as possible, and that this policy should definitely not be implemented by other countries. The reasons given are the financial costs of tax exemptions, and also the small to non-existent reductions of CO_2 emissions. Energy generation is important here, as the majority of electricity generated in the world is through fossil fuels (Holtsmark & Skonhoft, 2014).

A different opinion is provided by Bjerkan et al. (2016). The authors argue that some policies can be adopted fairly straightforward, while others should be adjusted to other circumstances. Bus lane entrance is a free incentive, and road tolling, free parking and ferry fees could be cost neutral, as ICEV access prices could be increased to fund these reductions for BEVs. Import tax is an example which relies on the high vehicle taxation in Norway. Countries with lower taxation would experience difficulties to attain competitive price/performance levels against ICEVs.

Vergis (2014) has a similar explanation as Bjerkan et al. (2016). Countries with high taxation that are interested in BEVs, may consider sponsoring policies that apply similar purchase incentive structures as Norway. This can be done by removing sales taxes and fees for BEVs. Countries that do not have high vehicle taxes may consider purchase vouchers or income tax credits.

The question that rises from these different views is what factors determine the transferability? This question was asked in the interviews.

P. Haugneland (2017); *"I hear that the reason why is that Norway is rich, but this is not a direct reason. We do not have a car industry, so we do not have any lobbying against the policies. But still the politicians decide on themselves, they do not have to give in to the lobbying. Other countries, such as Spain, could introduce small taxes on polluting cars without any loss of revenue. Some people will protest, but that is how politics work. If you want to do something about the pollution and global warming, you will have to do something that not everybody is happy about".*

Kolbenstvedt (2017) mentioned; *"Not one to one. The incentive giving free tax when you buy the car, cannot be used in other countries without such a system. And for the local ones, they have their challenges as well. And then is the case about the clean electricity source. But, in Europe you have the quota system. When cars are getting electric, they become a part of the quota system. I think it is a very important point to get the transport sector into the quota system. Because why should transport, being responsibly for so much pollution globally and regionally, not be included into the system that one have developed. Probably not perfect, but it would work better if one would got transport in"* (Kolbenstvedt, 2017).

Nykvist (2017) replied; *"The whole discussion on transferability is quite challenging. It is highly contextually dependant. There is some transferability. When you would adapt the Norwegian case to another country, the core barrier to that happening would be politics rather than contextual differences. You can design a way that it is transferable but politicians need to be there to actually support that."*

According to Odeck (2017); *"Many of them can be adopted. But there are others which would mean a lot of transfers, from the government to the people. It would mean a lot of financing. Like for example for a country like Spain it could be a disaster. Whereby exempting EVs for tolls would be a real problem. They can be implemented in other countries, but there will be a loss in revenue. There must be sufficient budgets. This has to do with the cultures. What I have seen is that when there are tolls being implemented, there is always resistance and public outcry. In Norway nobody resisted against EVs driving in the bus lanes. But if you could do this in France, this could result in such resistance. People would ask you why."*

What can be concluded is that a couple of contextual factors determine the level of transferability of Norwegian incentives. Institutional systems determine the availability of tax-exemption possibilities. Sufficient financial budgets are required to provide funding for potential lost revenues associated with BEV incentives. Available energy resources influence the effectiveness of the BEV technology on emission reductions. Political interests and guidance of the search determine the eventual technology selection. These contextual factors determine to what degree the transferability of Norwegian BEV policies and incentives.

4.7 Conclusion History Event Analysis

The history event analysis has revealed the events leading up to the adoption of BEVs in Norway and Sweden. From 1973 onwards, both in Norway and in Sweden a search has been started to find alternative technologies towards ICEVs. Creation of legitimacy (F7) has proved to be a factor in what technology path eventually would be taken. Where in Sweden biofuels were selected (F4) for becoming fossil fuel independent, electromobility was selected (F4) in Norway to set up a vehicle manufacturing industry, as a reaction to Swedish car manufacturing industry.

This has led to multiple entrepreneurial activities (F1) surrounding alternative technologies. Looking specifically at BEV technology, there is a difference in the amount of these activities between Norway and Sweden. In Norway efforts have been made to create a domestic BEV company, and to embed BEVs in society. Swedish governmental and organisational BEV introductions have been made (procurements), but not as much into Swedish society itself.

Also comprehensive BEV specific resource allocations (F6) and market formations (F5) have been in place in Norway, and not so much in Sweden. Until recently biofuels were primarily supported in Sweden. This has effected the knowledge base (F2) and knowledge diffusion (F3) of BEVs in Sweden. Resulting in BEV knowledge boundaries which remained high over the years in Sweden. Norway in comparison predominantly gathered and embedded the BEV knowledge into government, industry and society.

System functions are bound to context within the innovation system. Externalities to the innovation system influence historic events and also give a deeper context to the diffusion influencing factors. The external factors are not identified within the FIS theory, but have to be taken into account as they influence the BEV diffusion pathway.

Contextual factors determine the level of transferability of Norwegian policies and incentives. Import tax and toll road exemptions for BEVs are in place in Norway and other countries may experience difficulties to implement these. Institutional differences, financial budgets, available energy resources and political interests influence this implementation and therefore determine the transferability.

Chapter 4 has identified what has happened around BEV diffusion, policies and incentives in Norway and Sweden. Chapter 5 will continue with the system function approach, and create insights in why there has been a difference in BEV adoption between Norway and Sweden, and what motors of change drives have driven the innovation system process.

5. MOTORS OF CHANGE

Chapter 4 is used to create an insight into what activities around BEV diffusion and policy implementations have taken place in Norway and Sweden. In this chapter the findings from the history event analysis are further researched on system function interactions, to answer why certain events of system functions have occurred, and why such an innovation process path was taken. The outcome of the process analysis is a narrative story line on how and why the system functions have influenced BEV development in Norway and Sweden.

The system function analysis is conducted using the theory of Hekkert et al. (2007) and Hekkert and Negro (2009), in which the latter presents a validation test of the system functions use in five empirical case studies. From the empirical FIS results in Hekkert and Negro (2009) some important system dynamics are presented, and will be investigated for the BEV research. The interactions between system functions are started by the Motors of Change (Hekkert & Negro, 2009; Hekkert et al., 2007). In the research case these are identified to see what has driven the innovation system in the first place, but also after possible stalling of the innovations process. Furthermore, the content of the events and the chronological order can show reoccurring system function sequences, which can take the form of virtuous or vicious circles (Hekkert & Negro, 2009). These may strengthen or weaken the innovation system progress, and will be presented from the analysis in this chapter.

5.1 System Function interactions and Motors of Change

System functions interact with each other, and the fulfilment of one system function will likely have an influence on other system functions. This effect is vice versa, and a non-linear model with multiple interaction between system functions can be expected (Hekkert et al., 2007). Virtuous cycles of such process changes can build up momentum for creative destruction within the incumbent regime. Another possibility is a vicious circle between system functions, leading to potentially influencing the overall process of the entire innovation system. Another possibility from Hekkert and Negro (2009) is that there is no sequence of system function events, leading to a chaotic and erratic innovation process. The interactions between the seven system factors are important to identify, as these interactions can explain changes within the diffusion of the BEVs in Norway and Sweden.

The seven system functions have many possible interaction possibilities. From the case studies in Hekkert and Negro (2009) a number of system functions play an especially important role. Entrepreneurial activities (F1) are a prime indication whether an innovation system progresses or not (Hekkert et al., 2007). If entrepreneurial activity is relatively low, then cause can be found in the other system functions. In most cases technology diffusion co-evolves with these activities. Entrepreneurial activities (F1) follow from well fulfilled guidance of the search (F4) and market formation (F5). Well fulfilled F4 and F5 guarantee a long term stable perspective where uncertainties are relatively low. Knowledge creation (F2) follows from, among also resource mobilization (F6), guidance of the search (F4). This creates an environment in which entrepreneurs dare to take action, as entrepreneurs only dare to invest in new technological trajectories when there is a minimal knowledge base present.

In turn entrepreneurial activities (F1) trigger other functions (Hekkert & Negro, 2009). In this process lobbying (F7) is crucial to build up expectations (F4) about a new technology, and to successfully influence governments to introduce policies and incentives (F5) and resources (F6). Figure 11 shows a representation of the system functions from Hekkert et al. (2007).

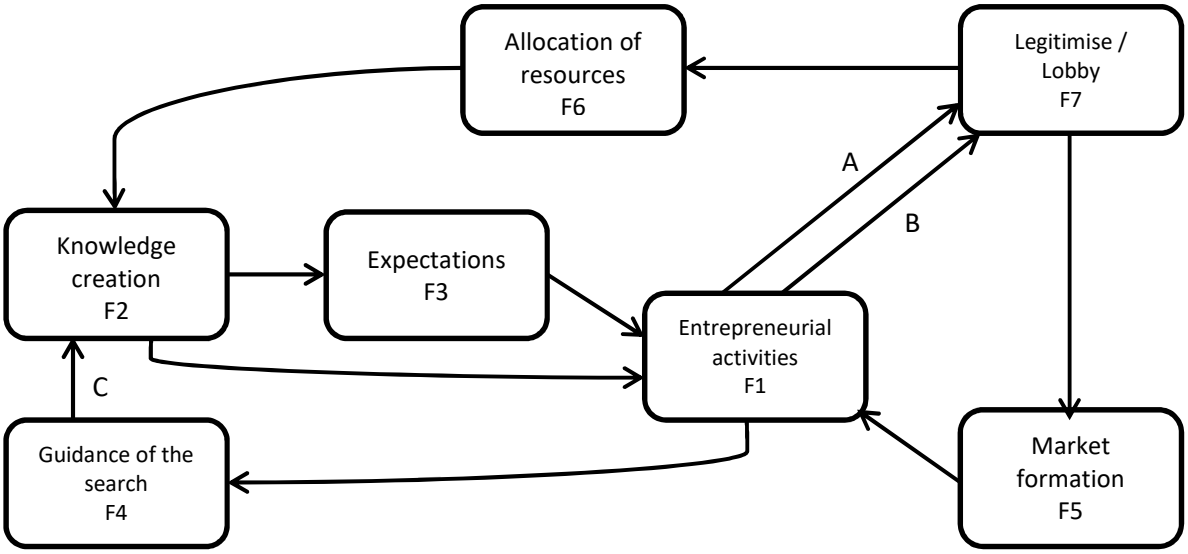

Figure 11: Three typical motors of change (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007)

According to Hekkert et al. (2007), empirical work from their researches has shown that there are three motors of change that build up momentum. These three possible motors of change each trigger a virtuous circle and can be seen as starting points of innovation processes. The motors of change are pictured as A, B and C in Figure 11 and explained in Table 22. Which starting point is taken in the Norway and in the Sweden case will be investigated by analysing the gathered data from the history event analysis in chapter 4.

Table 22: Motors of change in theoretical model (Hekkert et al., 2007)

Start	Motors of change
A	Entrepreneurs who lobby for better economic conditions to make further technology development possible. Lobby for more resources to perform R&D which may lead to higher expectations.
B	Entrepreneurs who lobby for better economic conditions to make further technology development possible. Lobby for market formation since very often level playing field is not present.
C	Societal problems are identified and government goals are set to limit environmental damage. These goals lead to new resources which, in turn, lead to knowledge development and increasing expectations about technological change.

For the research case it is important to investigate how the BEV policies and incentives have evolved in Norway and in Sweden. Entrepreneurial activities (F1) are a reflection of the state of the innovation system process. Guidance of the search (F4) indicates policy statements and policy goal setting in which BEV selection occurs. Market formation (F5) are policy incentives and tax exemptions aimed to positively influence better market conditions for BEVs. Creation of legitimacy (F7) can influence governmental guidance of the search (F4), market formation

(F5) and resource mobilization (F6). These system functions have of relative large influence on innovation process, and will be analysed for the research of BEV policies and incentives in Norway and Sweden.

5.2 BEV system functions interactions Norway analysis

In Norway the first BEV system functions are triggered in 1989 (Bellona) and 1990 (PIVCO), excluding the PIV presentation in 1973. Lobby activities (F7) from entrepreneurs (F1) activate resource mobilization (F6) and market formation (F5). In this case motor A and B are activated at the same time (Figure 12).

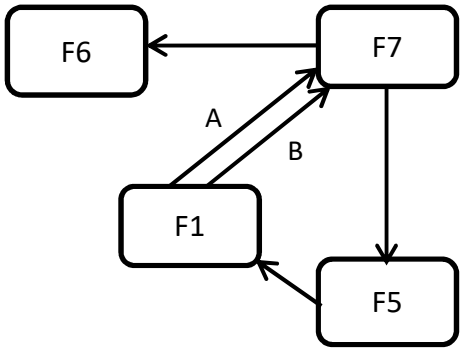

Figure 12: Motor of change A/B

Two virtuous circles are started in the innovations system, since motor A and motor B are triggered. Motor A creates resource mobilization (F6), allowing for funds to create learning by searching (F2) through experiments and prototype use. This eventual leads back to entrepreneurial activities (F1).

Motor B forms another virtuous circle as lobby activities (F7) stimulate market formations in the form of BEV tax exemptions and incentives (F5). These create a more attractive market, in which entrepreneurial activities (F1) are stimulated.

The guidance of the search (F4) at this point follows from the activities in the innovation system, as BEV technology is selected. Governmental investment (F6) and market formations (F5) for BEVs is seen as is an opportunity to compete with Swedish car manufacturing industry, and environmental reasons were secondary (Hoogma, 2002).

During 1994 and 1995 in Norway momentum is built through knowledge gathering by learning by searching (F2) in prototype testing, and learning by interacting (F3) by Norwegian press following the Norwegian domestic 'car' project. The Nordic EV rally (F7), Lillyhammer Olympics (F7), and San Francisco presentation (F7) further legitimize the selection of BEVs in Norway.

Norsk Elbilforening was started (F1) in 1995, a legitimacy creator (F5) was introduced. The introduction of Norsk Elbilforening can be seen as a second motor of change, namely motor B. The BEV innovation system is accelerated, as market formation (F5) is increased through further creation of legitimacy (F7).

Well fulfilled guidance of the search (F4) and market formation (F5) create an attractive environment where entrepreneurs (F1) dare to take action. This may also show that around 1998, where these functions are well fulfilled, the innovation process of BEVs in Norway is accelerating and in good condition. Although the entrepreneurial environment improves over the years, as more knowledge is gathered (F2), market formations (F5) are being implemented and the guidance of the search (F4) is focussed towards BEVs, the entrepreneurial activities fluctuate (F1/-F1) as both domestic BEV manufacturers Th!nk and Buddy go bankrupt multiple time, and for the final time in 2011.

Norway has been unable to support a sustained domestic BEV manufacturing industry (Vergis, 2014), even though there was a supportive BEV climate where other system functions are well fulfilled. This did not mean that the BEV momentum was stopped. The supportive BEV environment, in which guidance of the search (F4) and market formation (F5) were well fulfilled, hosted a fast diffusion of BEVs once foreign BEV models were introduced (F1) in 2011 in Norway. The BEV system function momentum was present in Norway, and was triggered when these new BEV models were introduced to the market (P. Haugneland, 2017; Kolbenstvedt, 2017; Nykvist, 2017).

5.3 BEV system functions interactions Sweden analysis

Since the oil crisis in 1973 Sweden has focussed on becoming fossil fuel independent (F4). Early lobby (F7) activities into biofuels created legitimacy to allocate funds (F6) towards biofuel research (F2) and also market formations (F5), which further created better circumstances for biofuel entrepreneurial activities. This virtuous circle created biofuel momentum in the Swedish alternative technology innovation process throughout the 1980s and 1990s.

Around the same time as in Norway (1989) the first BEV functions are activated. The vision (F4) of the Swedish government is to become fossil fuel free. Electromobility is being researched (F2) in 1993 and some entrepreneurial activities (F1) in the form of procurements start to come up. This can be seen as motor C (Figure 13), as societal problems are identified and government goals are set to limit environmental damage (Hekkert et al., 2007). This virtuous circle does not gain momentum as not enough suitable BEV models are available, and because through biofuel selection (F4) the biofuel technology had already gained higher momentum in Sweden.

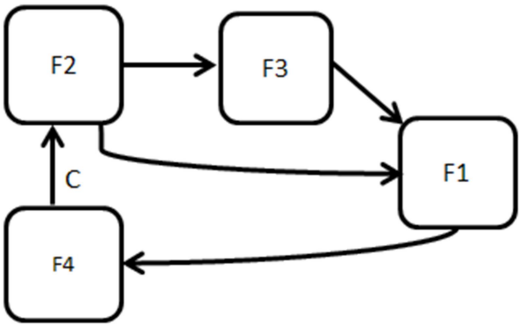

Figure 13: Motor of change C

Virtuous circles in biofuel technology gain more and more momentum. Meanwhile BEV technology slips into a vicious circle. With low guidance of the search (F4), few market formations (F5), and a lack of knowledge creation (F2) the momentum is lost. Legitimacy actions (F7) are important to fuel system function interactions, but are not apparent until 2009 and 2010. The vicious circle is broken by the deselection of biofuels (F4). Following this event BEV procurement programs start (F1), knowledge is gathered (F2) and BEV specific incentives (F5) are introduced. Motor C is started for a second time for BEV technology, as fossil fuel reduction goals (F4) are set by the Swedish government, for instance in 2012. Swedish BEV momentum is growing, as more foreign BEV models are introduced to Swedish market. In 2016, Volvo announces to build BEVs by 2016, gaining more momentum towards BEVs.

5.4 BEV motors of change comparison

Motors of change create momentum in innovation systems. From a BEV perspective there have been different motors of change in place between Norway and Sweden. For a start, BEV system functions for Norway and Sweden were roughly both first activated around 1989. Around that time Motor A and Motor B are activated in Norway and Motor C in Sweden. Both

motors provide momentum in the respective BEV innovation systems. Eventually BEV momentum is lost in Sweden, as biofuels have a higher system function interaction.

Table 23: BEV motors of change Norway and Sweden comparison

Norway	Sweden
• First BEV system function appearance 1989 (1973) • Motor A & B start BEV system function interaction (1990) with market formation • Motor B starts in 1995, and continues building up momentum until present day	• First BEV system function appearance in 1989 • Motor C starts BEV system function interaction (1991) with market formation • BEV momentum lost (1994) • Second motor C starts BEV system function interaction again (2008)

The difference in the motors of change lies in the system functions. In Norway BEV function interactions are started by entrepreneurial (F1) and creation of legitimacy actions (F7). BEV interaction in Sweden follows from governmental goals (F4) set to limit societal problems, in this case fossil fuel dependence. This triggers knowledge creation (F2) and eventually entrepreneurial activities (F1). The difference in motor of change for BEVs in Norway and Sweden shows two different mind-sets in BEV innovation process initiation.

The difference in momentum build-up is dependent on the fulfilment of the system functions at that time. There were no other mentionable lobbies for alternative technologies towards ICEVs in Norway. In Sweden BEV technology not only had to compete against the incumbent ICEV regime, but also the rise of biofuel technology. Since in Sweden biofuel technology as an alternative to ICEVs had already gained momentum, BEV technology had difficulties to find build-up of system function interactions. After the deselection (F4) of biofuels in Sweden, government goals were still set on becoming fossil fuel free. Motor C was started up again in Sweden, this time with less resistance from other alternative technologies.

5.6 Motors of change conclusion

From the theory of Hekkert et al. (2007) a distinction can be made into what has driven the BEV innovation system in Norway and Sweden. In Norway, system functions F4 to F7 are well fulfilled, and have led to a BEV supportive innovation system. In this Norwegian system the function interactions are fuelled by BEV legitimacy efforts (F7) and a clear selection (F4) of electromobility. The BEV innovation system in Sweden is powered by governmental goal setting (F4), where the emphasis is on becoming fossil fuel free. BEV system functions in general are less fulfilled in Sweden than in Norway, and BEV system interactions are less abundant. Deselection of biofuels has increased BEV selection, but not on the same level as in Norway.

Chapter 6 presents a concluding argument to the main research question and the discussion of the research findings.

6. CONCLUSION & DISCUSSION

In the past 45 years 80% of CO_2 emissions have come from road transport. Battery electric vehicles (BEVs) have the potential to lower greenhouse gas emissions, fossil fuel depletions and urban air pollution. Therefore, wide-spread implementation of durable transport technologies, such as BEVs, is an important factor of high priority in solving these problems. Over the years BEVs have diffused to a relatively large extent in Norway, where-as in Sweden this diffusion has been relatively low. There are multiple factors that influence the BEV diffusion rate difference. Until now only partial analyses have been made, and knowledge is scattered and incomplete. Therefore, the research objective is to explain the BEV diffusion rate difference.

This chapter presents the findings in the research. Chapter 6.1 presents the conclusion to the research question. Chapter 6.2 further discusses the factors presented in the conclusion. Chapter 6.3 presents the contribution of the study, while chapter 6.4 discusses the limitations of the study. Recommendations for further research are presented in chapter 6.5.

6.1 Conclusion

The main research question is:

Which factors explain the difference in BEV adoption rates in Norway and Sweden?

From the research four main factors are identified which have influenced the BEV adoption rate difference. First, the institutional difference between Norway and Sweden results in different vehicle taxations. Norway's larger number and higher vehicle taxations have led to the possibility to introduce more effective tax exemptions for BEVs than in Sweden. Second, the early introduction and selection of BEVs in Norway has contributed to a higher level of BEV knowledge in society, industry and government than in Sweden. This translates into lower switching costs in Norway than in Sweden. Third, available energy supplies direct the technology selection. Norway's hydro power supplies provide inexpensive electricity and channel towards electromobility as the only alternative option to fossil fuels. Swedish biofuel reserves have guided the search for fossil fuel independency towards biofuel technologies. Four, the incumbent vehicle industry in Sweden legitimizes incremental innovations, and therefore the selection for biofuel and hybrid technologies, instead of radical innovations such as BEVs. In Norway such manufacturers are not present, and BEVs can be selected more easily.

6.2 Discussion

The factors presented in the conclusion are further elaborated upon in this chapter.

6.2.1 Institutional difference and implemented market formations

Market formations increase the cost competitiveness of BEVs against ICEVs. A BEV supportive climate is created when many market formations are implemented. The costs of owning and using a vehicle in Norway are one of the highest in the world. In Norway there are some particular taxes devoted to vehicles. Import tax, road and tunnel toll fees are not present in Sweden. Consequently, this provides a situation which provide more possibilities to make financial exemptions, resulting in relatively lower vehicle costs for BEVs in comparison to the incumbent ICEVs present respectively. In Sweden this is not the case, as vehicle taxations are

fewer and lower. Thus there are more possibilities to introduce policies and incentives to lower BEV costs in Norway than in Sweden.

The contextual nature of the import tax and toll roads makes it difficult to implement these in other countries. For instance, implementing tolls roads in Sweden would be problematic, as this would be a new form of (extra) taxation. Sweden is therefore not able to introduce incentives such as toll road fee and import tax exemptions. Thus, the institutional difference between Norway and Sweden is a factor in the diffusion of BEVs.

6.2.2 BEV introduction and selection

In 1990 in Norway the PIVCO project was financially supported by the government and several Norwegian companies. The funding came through the creation of legitimacy of the PIVCO company. The PIVCO company was intended to start a Norwegian BEV manufacturer as an answer to Swedish vehicle manufacturing industry. This early introduction of BEVs forms an important factor in the eventual diffusion of BEVs. BEV knowledge became entrenched into society and in the political and industrial sector. Promoting events, such as the PIVCO promotional ceremony 1995 in San Francisco joined by Norwegian king and queen, spread knowledge about BEVs in Norway. The creation and diffusion of knowledge into the innovation system has increased the perception of BEVs. Further creation of legitimacy, by among others Norsk Elbilforening, further aims the selection for BEVs.

The early introduction of BEVs in Norway results in well-fulfilled system functions (pictured as F..). Creation of legitimacy (F7) and entrepreneurial activities (F1) guide the search towards BEVs, and this results in BEV selection (F4) and market formations (F5). Financial resources (F6) are provided to the PIVCO project. Knowledge creation (F2) and diffusion (F3) are stimulated. What can be concluded that in the early 1990s all system functions are apparent in Norway. System function momentum is gained, and the BEV innovation system develops. The only aspect that is missing is the lack of capable BEV models. Further market formations (F5) are introduced to support the fragile Norwegian BEV manufacturers. The provided incentives create an very supportive BEV environment, however the BEV manufacturers go bankrupt several times. After 2010 in Norway, the arrival of capable foreign BEV models within the BEV supportive environment, including abundant BEV incentives, results in the large BEV diffusion acceleration.

BEVs made their introduction in Sweden around the same time as in Norway. However, the technology selection (-F4) was focussed on biofuel technologies and Flex Fuel Vehicles (FFV). Until 2008, BEV system functions were little to not activated and no system function momentum is created. The deselection of biofuels results in the selection of a plurality of technology options, where no single technology is selected. In Sweden, uncertainties arise about the technology (F4) selection. BEV knowledge creation (F2) and diffusion (F3) remain low and switching costs remain high. This is also caused by the lack of abundant BEV market formations (F5). Only small scale BEV entrepreneurial activities (F1) and creation of legitimacy (F7) are created by the City of Stockholm. The eventual arrival of capable BEV models in 2010 does not see a large adoption as in Norway. This is because the BEV supportive environment in Sweden is not as predominant present as in Norway. Late BEV selection occurred after 2008 and introduction of BEVs through procurement programs in 2010. This has influenced the BEV

diffusion rate in Sweden. Therefore, the time of BEV introduction and selection forms an important factor in the BEV diffusion rate difference.

6.2.3 Available energy resources

1973 forms the first significant event in the history event analysis. That year includes the presentation of the first PIV concept (F1) in Norway and the creation of legitimacy for biofuels by Volvo AB in Sweden. These events show the direction taken from the 1970s. In Norway, large amounts of hydro power guide the search towards BEVs. In Sweden, biofuel reserves direct the search towards FFVs. These technologies are eventually selected (F4) by legitimacy creation (F7) by domestic stakeholders. Lobbying occurs in Sweden by the agricultural sector and Volvo AB, and Jan-Otto Ringdal from Bakelittfabriken in Sweden. The initial selection for alternative technologies follows from the available energy resources. Until the deselection of biofuels in Sweden little to no BEV system function fulfilment occurred in Sweden until the deselection of biofuels.

Path dependency occurs by the available energy resources. Market formations (F5) were introduced in Norway to support the fragile Norwegian BEV manufacturers. The eventual introduction of foreign BEV models into the supportive environment caused a large adoption uptake. This introduction is a externality to the innovation system. Without this externality, the selection of BEVs in Norway could have followed the same route as biofuel selection in Sweden. The available energy resources dictate the initial technology selection, stimulated by legitimacy creation. Therefore, the available energy sources are an important factor in the diffusion rate difference between Norway and Sweden.

6.2.4 Swedish incumbent vehicle industry in Sweden

In 1973 in Sweden Volvo AB created legitimacy (F7) for biofuels. Biofuel system function momentum is created, as the vehicle industry and the government supports the biofuel development. In Sweden, little to no BEV system functions are fulfilled. Market formations (F5) are implemented, but include tax exemptions for low emission vehicles and FFVs. The governmental selection (F4) of biofuels supports goal of becoming fossil fuel free, while not selecting radical innovations such as BEVs. Radical technology selection would become troublesome for the vehicle industry, as these companies have invested in current ICEV drivelines.

The deselection of biofuels creates a situation where no clear technology selection occurs. Incremental innovations such as Hybrid Electric Vehicles (HEV) and Plug-In Hybrid Electric Vehicles (PHEV) are developed by Volvo, and policies and incentives are targeted to these low emission vehicles. The lack of clear BEV support results in higher switching costs, as hybrids are also supported and form a less radical step from ICEVs. Norway does not have an incumbent vehicle manufacturer, and this factor does not have to be taken into account. Policies and incentives are directed towards zero-emission vehicles in Norway. BEV system functions are more fulfilled than in Sweden where multiple technologies are selected. More BEV momentum is gained through BEV specific selection in Norway. This clear selection results in more BEV diffusion in Norway than in Sweden. Hence, the presence of an incumbent vehicle industry influences the BEV diffusion rate difference between Norway and Sweden.

6.3 Contribution of the study

The added value of the thesis was introduced in chapter 1.5. This chapter further elaborates on the contribution of the study to scientific and managerial knowledge concerning the adoption of BEVs in Norway and Sweden. The scientific contribution consists out of the research results and potential enhancements to the FIS theory concerning the research case. Lessons for policy and industry are presented in the managerial contribution.

6.3.1 Scientific contribution

Since there is a lack of comprehensive research into the thesis topic, the research results provide new knowledge to the scientific knowledge base of BEV diffusion in Norway and Sweden. Through the history event analysis a clear picture was drawn from the events that have influenced the diffusion process. The identification of system functions, following the FIS theory, has revealed the time and frequency of the types of events. The FIS theory was used to find system function interactions and the motors of change. This has revealed the time frames into which system function momentum was gained, and also what has driven this momentum. The combination of the desk research, interviews and the FIS theory have indicated what factors explain the BEV diffusion difference. The factors were unknown before the research, and thus are the first scientific contribution of the thesis.

The history event analysis and the FIS theory proved to be very supportive to the research. However, there are a three aspects in which the FIS theory could potentially be further enhanced for this particular research case. The potential enhancements are the second scientific contribution to the thesis.

First, externalities to the system are difficult to map within the FIS framework, as they do not follow the interaction process and momentum build-up between system function. These externalities, together with coincidental actions or events, do not follow predetermined paths of system interactions. One system function may appear without the influence of other system functions. These externalities are important factors in the diffusion process pathway. The deselection of biofuels is one example which affects the technology pathway in Sweden. The externalities have to added to the narrative story line outcome of FIS. Including externalities in the FIS framework could benefit system function interaction insight, and pose a potential enhancement.

Second, the contextual nature of the influencing factors creates challenges in comparing BEV diffusion. For instance, the institutional differences between Norway and Sweden are difficult to quantify within the FIS theory of system functions. The FIS theory is suitable to find system function interactions, however comparing two innovation systems surrounding the same technology becomes difficult. Incorporating contextual factors, such as the institutional difference, could enhance the FIS theory's innovation system comparing power.

Third, threshold effects cause system functions to be fulfilled or to interact. The level of these thresholds is difficult to map. One example are the number of BEVs on the road, as these can cause changes in knowledge creation and knowledge through interaction. Incorporating clear guidelines into when certain system functions are fulfilled and interact could potentially contribute to the FIS theory, concerning this research case.

6.3.2 Managerial contribution

The research has shown that the transferability of market formations depends on a number of contextual factors. One of these factors is the institutional system, which determines the possibility to give tax exemptions and incentives. The high vehicle taxation system in Norway provides an environment where a lot of BEV incentives are possible to introduce. Countries that have relatively low vehicle taxations may experience difficulties to provide tax exemptions, and therefore may be unable to lower switching costs for BEVs. Policy makers trying to implement the Norwegian style incentives have to take care, as some of these incentives are only optional in Norway.

Another important factor is the availability of energy resources. As can be seen from the research case, both Norway and Sweden have initially pursued the predominantly available energy sources. What can be seen is that the technology selection in Norway and Sweden follows these resources, but the eventual outcome is different. The biofuel selection eventually became unsuccessful, and lessons can be drawn for policy decisions. Other technology options have to be evaluated, as externalities such as the fall of biofuel interests can cause problems. Policy makers could therefore consider not putting all the eggs in one basket, and decide to consider the selection of multiple technologies.

The availability of domestic energy resources influences the likelihood of technology selection. Lessons for vehicle industries can be made out of this point. Countries where electricity is the predominant form of energy may encounter path dependency towards BEVs as an alternative towards ICEVs. The same accounts for the biofuel selection in Sweden. Vehicle industries could capitalize on this point, as it yields a high chance of the respective technology selection. Early investments into these areas could provide competitive market positions. An example is the capitalization in 1998 on the flex fuel vehicles (FFV) by the City of Stockholm, which was taken by Ford. By doing so, Ford became the FFV market leader in Sweden. Another lesson for strategic introductions relies on shifting trends in technologies. Nissan and Tesla have achieved large BEV market shares in Norway and Sweden. Volvo AB have announced to build BEV models in 2019, which reveals a cautious strategy in vehicle introduction. This has also been present in the introduction of FFVs, where Volvo AB and Saab introduced FFVs in 2005. During the same year, Ford has 80% FFV market share in Sweden. Concerning the research case, a more adaptive approach on shifting trends could yield higher BEV market shares in the future.

6.4 Limitations of the study & recommendations for further research

This section presents the limitations of this exploratory study and suggestions for further research. Four constrains are presented on how they have affected the research and how they may have influenced the results. Further research recommendations are made which could use these improvement points.

Interviews were held to gain new knowledge and to validate findings from the desk research. six people were interviewed for this research, which can be seen as a relative small amount. A total of 15 people were contacted, however only six were able or willing to have an interview and contribute to the research. Although knowledge saturation appeared on several cases, new knowledge could potentially be found if more people were interviewed.

The common attribute of the interviewees is knowledge in electromobility. Also, the interviewees were connected to universities / research institutes and public organisations. A limitation is the lack of multiple interviewees within the vehicle industry. Most interviewees have some experience or knowledge about the workings within vehicle industries, but only one interviewee had previously worked for a vehicle manufacturer. During the scheduling of interviewees several vehicle manufacturers were contacted for an interview. These all denied any cooperation. It therefore became very difficult to extract exact insights from the vehicle industry on BEV diffusion. Creation of legitimacy is a strong driver for technology selection. And the influence of domestic vehicle manufacturers has been identified to some degree in the research. However, to precisely what extent the influence of vehicle manufacturers was on BEV market formations remains partly unknown. Future research could focus on the influence of legitimacy creation by vehicle manufacturers on market formations, as it could provide new insight and knowledge in the diffusion of BEVs.

Another limitation is that only one single research case is studied. Except Norway and Sweden, no other countries are researched in this thesis. This has a consequence for the presented potential enhancements for the FIS theory. These enhancements are considered following only this single research case. Another research case could confirm or dismiss the recommendations. The proposed enhancements in this thesis follow from the single research case, and therefore have to be taken with care. Future research could focus on confirming or dismissing the proposed enhancements to make FIS more capable in comparing innovation diffusion networks surrounding the same technology.

The type of history event analysis is presented in Chapter 3.3. One limitation is the level of detail in which events are searched. National innovation systems encompass large amounts of events. In this research a more general history event analysis is undertaken in order to make the research manageable within the proposed time frame. The consequence of this is that the general focus misses potential small scale events, which could provide extra knowledge about diffusion factors. For this research case, the eventual BEV diffusion outcome will not change due to a more detailed focus. However, in answering the research question, other diffusion factors could come up in small scale events. Entrepreneurial activities and knowledge diffusion are two cases which may appear on such small scale. A high frequency of such small events could have an effect in FIS theory, and potentially reveal an unknown factor in the diffusion process. Future research could focus collecting these events which could reveal new factors in the BEV diffusion case.

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APPENDIX

The appendix contains extra knowledge gained during the thesis research and the transcribed interviews.

Not all knowledge gained during the research ended up in the thesis. These include some further in-depth knowledge in the BEV diffusion factors from the desk research and the interviews. The reason not to incorporate these subjects in the main thesis report is that they did not contribute significantly in the particular research case. However, the choice was made to include these extra findings, as they provide some more in depth knowledge into the BEV diffusion rate difference between Norway and Sweden. This can be seen then as extra knowledge gained outside the thesis research.

The interviews were recorded with a Olympus WS-811 Voice Recorder. 6 interviews appointments were planned through phone and email contacts. Flight tickets were bookend and from the 10th until the 21st of April 2017 I was in Oslo, Stockholm and Gothenburg. Interviews took place at the respective interviewees offices. One interviews was eventually recorded using Skype on the 30th of April 2017, since no appropriate date between the 10th and 21st of April could be found. The interviews start with a small introduction of the interviewee, after which the interview starts. The email address of all the interviewees is presented on the first page of every interview.

I: Further in-depth BEV diffusion knowledge gained during the research

From 1990 onwards there have been more BEV incentives introduced in Norway than in Sweden. There are some further differences between the used BEV policies and incentives, besides a higher amount. There is a difference in the focus of the used policies. In Norway the policies are directed to zero emission vehicles only. This is a strong difference towards Sweden, where low emitting vehicles are targeted. Within some policies biofuel FFVs are exempted from taxes as well, showing a wider focus of technology selection (F4).

One case which is already discussed in chapter 5 is the nature of the policy goal. In Sweden this is on reducing fossil fuel independence, while Norway wanted to create a domestic vehicle manufacturing industry. According to Hannisdahl et al. (2013) this is actually part of the explanation why EVs have received tax exemptions and market incentives in Norway, as promoting a home grown car industry is a strong driver for such policies.

From the interviews opinions differ about the appropriate level of the Norwegian BEV tax exemptions and policy incentives. According to some these Norwegian incentives dedicated to BEVs have been *'adequate'* (Kolbenstvedt, 2017) or that *'the government could do more to speed up the process'* (P. Haugneland, 2017) to ensure a higher diffusion in Norway. Others mention the Norwegian incentives financial resources as being *'overcompensating'* (Sunnerstedt, 2017) or *'economically not profitable'* (Odeck, 2017), though distributional effects need to be taken into consideration (Odeck, 2017).

The example from the interview of Odeck (2017) indicates the institutional difference between Norway and Sweden. In Norway there are some particular taxes devoted to vehicles. Import tax, road and tunnel tolls and ferry fees are some examples of vehicle taxing that are not present in Sweden. This provides a situation in which there are more possibilities to make financial exemptions for BEVs, for instance for road tolling. A combination of extensive road tolling and exemptions for BEVs has proved to be quite effective in promoting BEV adoption (Bjerkan et al., 2016). One particular example was highlighted of a infrastructural project between Norway and Sweden during the interview:

"… a toll service on the Swedish – Norwegian border. There is a huge bridge. It would be financed with tolls. It worked well until it had to be implemented. The Swedish shared some very serious problems. By definition collecting tolls will be equivalent to taxing. According to them, road users are already taxed through the gasoline tax and the vehicle purchase tax. So tolling will be an additional tax. It could not be implemented. So they actually had to change the law, in order to implement that toll" (Odeck, 2017).

In Sweden vehicle taxes are only used to build new roads and other infrastructures. It becomes therefore very difficult to implement tolls (Odeck, 2017), since this would be a new form of (extra) taxation. It is easier to give the consumer exemptions than install new fees (Kolbenstvedt, 2017). The institutional difference is an important factor between Norway and Sweden on the aspect of the number of policies provided, as there is a deeper context to the amount of policies and incentives offered.

The Norwegian BEV incentives seem to have a broad support across the spectrum of the Norwegian government, though the issue is high on the agenda and much debated (Bjerkan et al., 2016). In Norway the majority of political parties agrees on that zero emission cars should be economical beneficial compared to high emission cars (P. Haugneland, Bu, C., Hauge, E., 2016). According to Nykvist and Nilsson (2015) there is significant ambivalence and lack of political signals given by policy makers in Sweden. Many misconceptions of the process of BEV among planners, policy makers and consumers exist resulting in limited awareness, experience and knowledge of BEVs. Politicians are also clearly reluctant to act proactively in advance of demand for charging infrastructure (Nykvist & Nilsson, 2015).The ambivalence of Swedish national policy makers results in weak guidance of the search. The lack of policy signal can be pictured against the aversion to technology specific support. The support of ethanol as a transport fuel has backfired on politicians when public (Nykvist & Nilsson, 2015) and expert opinions on biofuels changed (Sprei, 2013). Politicians are therefore more hesitant because they do not want to make the same mistake again. This has changed the guidance of the search in Sweden towards less radical developments such as full EVs, to also include PHEVs, which can be seen as a less radical step from ICEVs.

From the Norwegian BEV incentives the exemption from import tax can be identified as being the most important (Bjerkan et al., 2016; Diamond, 2009; Kley et al., 2012). According to Odeck (2017) if you would remove all the incentives, but keep the import tax exemption, than this would be enough for people to buy the EVs in Norway. Furthermore, government incentives in the form of purchase or tax waivers have stronger effect than rebates or tax credits (Diamond, 2009). Tax and purchase incentives are also found to be more attractive if received at the time of the purchase (Kley et al., 2012). The “super green car rebate” was introduced in 2012 in Sweden. The intention of the rebate was to cover the first 5000 low-carbon vehicles. But this number was already reached halfway 2014. The program was extended in 2014, in 2015 and in 2016. The amount of rebates set in these years was too low to cover all the demand of rebates for low-carbon vehicles (Tietge, 2017). According to Tietge (2017) more vehicles were bought than that were anticipated, and people did not receive the rebates at the time of the purchase. The combination of insufficient funding and the wait-time of new BEV owners receiving their rebate, interrupted the rebate program during these years. This created uncertainty for BEVs in Sweden, and also about the commitment of Swedish government about BEVs.

More BEV incentives have been introduced because of more tax-exemption possibilities in Norway than in Sweden due to the institutional difference. Also the technology selection has played a role, as Norway tried to stimulate and support an own domestic vehicle manufacturer. In Sweden the selection of biofuels caused a lack of interests in electromobility. BEVs were more supported after the deselection of biofuels. An ambivalence of BEV selection by the Swedish government causes uncertainties in policy support. Policies and incentives are directed to a number of technologies, such as BEVs but also hybrids. Therefore, BEVs in Sweden become less attractive as an ICEV alternative as HEV and PHEVs form a less radical step away from the dominant design. These factors surrounding the provided policies and incentives contribute to the existing BEV diffusion difference.

Since the oil crisis in 1973, both Norway and Sweden have pursued alternative technologies towards oil based ICEV technology. Governmental selection of a certain technology is dependent on the availability of particular resources, and on creation of legitimacy of these technologies. Looking at the available resources in Norway and in Sweden, the choices can be traced back to the domestic commodities these countries have (Odeck, 2017). Inexpensive electricity in Norway stimulates electromobility, and biofuel reserves in Sweden stimulate the selection of biofuel technologies. These energy sources also create path dependency, as other options become less attractive. The available resources therefore influence the technology selection.

Selection of technologies can also be influenced by creation of legitimacy actions. Kolbenstvedt (2017) has mentioned that; *"The policy and the incentives were build up brick by brick, stone to stone, to get to this enormous heap of incentives."* Early creation of legitimacy in by Bellona and PIVCO has influenced the BEV selection in Norway. Further BEV selection was influenced by actors such as Norsk Elbilforening. This has promoted the guidance of the search towards BEVs and the implementation of new BEV policies and incentives.

Volvo AB and the Swedish agricultural sector pushed for the selection of biofuels, as this was in their own interest. FFVs are relatively similar to conventional vehicles (Sprei, 2013) and form an incremental change from ICEV technology. There is a reluctance towards BEVs in the car industry, as invested infrastructures towards ICEV technology creates large switching costs for incumbent ICEV manufacturers (Nykvist & Nilsson, 2015). This also creates path dependencies within the domestic car manufacturer industry, and potentially also governments.

According to Sunnerstedt (2017), this could be why BEV selection is not fully achieved in Sweden; *"Well if you look back, that is usually how it has been. Considering Volvo and Saab, politicians want to keep jobs and job opportunities. A lot of employees are employed by them and also by their local suppliers and so on. This has been a very important core business of Sweden and for other countries too, that is not anything different. When this core industry does not really go for EVs, that is not where they make their money, then it is problematic"* (Sunnerstedt, 2017)

Sweden's strong push for ethanol and FFV is unique for European standards (Sprei, 2013). From 2002 to 2008 the national and local incentives, prospects of environmental and economic gains, and the lack of a 'green' alternative helped to foster the growth of market share of FFVs in Sweden. Together with falling gasoline prices the difference with biofuels became less, making FFVs less attractive. Together with the turn of the image of biofuels around the year 2009, sales dropped and the technology became less attractive (Sprei, 2013).

"And this back-fired quite substantially when the debate started nationally, and internationally, on bio-fuels picked up. So what happened was that towards the end of the decline, as a post-mortem analysis, the environmental party said that they did wrong. You could hear some public statements from some politicians that maybe it was not a good idea. But it was done with good intensions. You have to view this high decline of ethanol cars as a high ambition level of trying to reduce emissions. So it not that was a failure, it was a experimentation to decrease emissions" (Nykvist, 2017).

From this point onwards, guidance of the search in Sweden is geared towards several technologies, as fossil fuel independence is still the goal. Nykvist and Nilsson (2015) discuss from their research that the lack of lasting political support resulted in uncertainty and low expectations in BEV technology. The governmental parties do not want to leave the "technology neutrality" in solving fossil fuel dependence. There a multiple technologies considered and used to reach fossil fuel independence goals in 2050 (Sunnerstedt, 2017). These parties do not want to be accused for picking winners, in particular ones that have limited support for the car manufacturers.

"They did not really consider EVs until quite recently. Now they are considering it due to these shifting trends. Now that we have EVs on the table, with HEVs, PHEVs and full EVs, all of those come on top of this historical development of bio-fuels. These are also supported, and the support has varied, with support for individual bio-fuel technologies that has varied over time. The net outcome is a plurality of multiple options on the table" (Nykvist, 2017).

At the beginning of the 21st century, Volvo and Saab created FFVs much more progressively than EVs. After the bust of biofuels, the Swedish domestic car industry is more geared towards hybridization and PHEVs instead of pure BEV. Changing towards a more radical change towards BEV could came at a heavy price, and an evolution towards HEV and PHEV seems to be a more preferred route for established car manufacturers. Volvo, which has strong market shares in Sweden, has favoured a slow progression of hybrids over pure BEV (Nykvist & Nilsson, 2015). This is comparable with the earlier mentioned development of FFVs, as these are incremental innovations compared to BEV technology. During the slow uptake of BEVs in Sweden the car manufacturers and policy makers both waited for the other to take the lead. This has influenced the selection (F4) of BEVs in Sweden, which is not as fulfilled as in Norway, where BEVs experience great financial benefits directed to only zero emission cars.

From Hekkert et al. (2007) knowledge creation (F2) and knowledge diffusion (F3) are important aspects in the innovations system. A technology is perceived on the basis on available knowledge. Innovations that are further away from the reigning dominant design are associated with higher levels of uncertainty (Anderson & Tushman, 1990), and the more an innovation differs from the conventional technology, the less consumers are willing to pay for it (Sierzchula et al., 2014).

When BEV knowledge is distributed among more actors switching costs become lower, as the technology is perceived differently. According to research done by Figenbaum (2015) and P. Haugneland, Bu, C., Hauge, E. (2016), opinions and perceptions of BEVs after using is completely different from before. Learning by using lowers knowledge constrains such as range anxiety. The diffusion of knowledge is influenced by network effects. Increasing returns to BEV adoption create more familiarity with BEVs itself. The more a technology is adopted, the more knowledge and understanding is embedded into society (Anderson & Tushman, 1990).

"If there are a couple of EVs in a group, people will get familiar with them very fast. So in Sweden this is not really happening right now. You need to have a base, or else the process of adoption will be slow. All Norwegians probably know someone with an EV, and then it becomes easier" (P. Haugneland, 2017).

Such network effects, in the form of bounded rationality following from a lack of learning by interacting and threshold effects, where consumers do not see enough EVs in the fleet around them, may influence the perception of BEVs (Eppstein et al., 2011). Learning by doing is critical here to overcome bounded rationality. Individuals may act and choose on imperfect information, as they are aware of possible benefits of other technologies (Winter & Nelson, 1982). This is also pointed out by P. Haugneland (2017). *"You will need strong incentives to convince people to try something new. The incentives in Norway are so convincing that they convince people to step over this knowledge barrier, since EVs are so economically beneficial. Giving information is also very important. But to really convince people, you will need a combination of information and economic incentives"*. (P. Haugneland, 2017)

According to Nykvist and Nilsson (2015) one major barrier in Sweden is the lack of personal experiences with BEVs. This leads to a false image and a cognitive barrier on what BEVs are capable of and how they can be used. The very few BEV initiatives in Sweden have led to very limited knowledge of BEVs. This bounded rationality spreads to Swedish policy makers, entrepreneurs and consumers. In Norway there seems to be a better alignment between knowledge and capabilities of BEVs.

Another factor in the diffusion difference has been the introduction of new foreign BEV models. Their entrance has stimulated the wide-spread diffusion of BEVs. Before the introduction of these models after 2010, the BEV market share consisted out of Norwegian BEV models. The Norwegian domestic vehicle manufacturer PIVCO, later Th!nk, went bankrupt several times. According to Wells (2009), the Th!nk's main problem was its price. At NOK200,000 (around US$32,596) the Th!nk was a very expensive vehicle. Although market formation in the form of policies and incentives were introduced, the Th!nk remained unattractive as a ICEV competitor.

The Norwegian domestic BEV innovation system was unable to support the domestic BEV manufacturing industry with Th!nk and Buddy. The 'overcompensating' (Sunnerstedt, 2017) Norwegian BEV policies and incentives had not worked for the domestic BEV manufacturers, although they did provide an attractive and competitive environment where foreign BEV models could be price/performance competitive with incumbent ICEVs. The rapid increase in BEV market share in Norway happened when these new models were introduced. According to P. Haugneland (2017) *"…the effect did not turn up, until new models such as the Nissan Leaf. After that, people started to buy them. The models before that were not good enough for most people. In the beginning, people commuted with only a 2-seater, or a small 4-seater, with limited range. It was only when the major car manufacturers brought car models when the market boomed. We see that for every new model the market grows. For the (Tesla) Model 3, there is a waiting list. The limiting factor is the supply of EVs, and not the demand"* (P. Haugneland, 2017).

This corresponds with the argument made in the interview with Kolbenstvedt (2017); *"At first, the diffusion started really slowly, but in 2012 when for instance many brands had BEVs to sell, it accelerated quickly. We can discuss the incentives and their effectiveness, but without car models to buy there will be no diffusion"* (Kolbenstvedt, 2017).

The entrance of new actors such as Tesla have changed the nature of BEV adoption. Here a new manufacturer has no relation to ICEVs, and can push BEV development as they do not have invested in manufacturing infrastructures as incumbent firms such as Volvo has done.

"We would not have seen, for instance, the Opel Ampera E if there was no Tesla. And also I think Norway has done to show the rest of the world that EVs can work" (P. Haugneland, 2017)

After the biofuel bust, Volvo started focussing more on electromobility, where PHEV is the preferred option towards BEVs. Although car manufacturers are open to tackle climate change problems, they are careful not to carry the costs of spearheading the technology and market development. This results in reluctance to engage with development and promotion of pure electric vehicles (Nykvist & Nilsson, 2015).

But Volvo has changed their strategy, and from 2019 onwards, Volvo will offer BEV models. And when a domestic vehicle manufacturer is going to produce BEVs, than this is a strong driver for BEV diffusion (Sierzchula et al., 2014). *"If Volvo creates a EV and some PHEVs, then you are really at the take-off phase where we are initiating change, such as in Norway now"* (Nykvist, 2017). This change of strategy can lead to independence from the oil industry, corresponding to the Swedish goals set after the oil crisis in 1973.

II: Interviews

Interview Petter Haugneland

Email adress: petter@elbil.no

Mr. Petter Haugneland is the communication manager at Norwegian Electric Vehicle Association and board member in AVERE. The Norwegian EV Association represents the Norwegian EV owners and cooperates with policy makers, the electric car industry and other organizations for the successful introduction of electric vehicles. Petter has a master's degree in political science from the University of Oslo and ten years of experience as a communication advisor at the Center for International Climate and Environmental Research in Oslo (CICERO) (P. Haugneland, Bu, C., Hauge, E., 2016). The interview took place on the 11th of April 2017 at the Elbil office in Oslo.

[PH] = Peter Haugneland

[ET] = Eric Tol

[ET]: Good day mister Haugneland, my name is Eric Tol and I am a Dutch master student from the Delft University of Technology in the Netherlands. In this interview, I want to discuss the reasons behind, why Norway is able to implement its BEV policies, and Sweden is not. The interview is divided into two parts. At first, I would like to have an open conversation regarding BEV adoption. Secondly, I would like to discuss some findings I have done in scientific literature.

[PH]: That is good. One suggestion, I have a presentation that I can show you where I can elaborate on what we do as Elbil. As a starting point, from here, maybe you will get already some answers.

PowerPoint presentation is started.

[PH]: We can start our conversation after this introduction of Elbil. We get a lot of attention from abroad, in the form of research and policy makers. Also the car making industry have a lot of interest what we as Elbil do. Evs are sold and used throughout the country, even in the North.

[PH]: My organisation is a NGO, and our goal is to promote renewable electric transport. Mainly passenger cars, but we also deal with some related issues, like road transport in the form of small vans and trucks. Our employees are the EV owners themselves. So we are a member organisation, with around 40.000 members driving an EV. Our organisation helps our members with charging, and we also do EV policy work to have more infrastructure to keep the EV incentives as long as possible or necessary. We have 13 to 14 employees. What unique is about Norway is the high market share of EVs in a small country. We are more or less a test laboratory for other countries and the car industry. We give a lot of presentations to show other countries what we have done right, and what mistakes we have done.

[PH]: Over 95% of Norwegian energy comes from hydropower. And that makes a better case for the EV on the basis of emissions. Topographically, Norway is not a EV friendly country. It is

cold, there are a lot of hills, distances are long, a lot of topography. Denmark in this sense would be a more suitable country for EVs. Therefore, it is not for the climate that the EV is successful.

[PH]: We are early adopters, and my organisation (Elbil) focusses on the customer side, the experiences, how to build a market, with the customers experience. Recently the government suggested that there will be a new law where the EV market should have a 100% market share. This proposition of the government will be voted for in the parliament this summer (2017). The party suggesting this law has a majority in parliament, so it is highly likely that the law will pass. In international media it is suggested as a ban for ICEV cars. This is not the case, it is an adjustment on the tax system. Eventually, the government wants people to choose for the EV as being the most economical choice.

[ET]: That is something that I have seen in literature. From articles, and also from your paper, is that the BEV policies and incentives are financed by taxes, that have been put on to high polluting vehicles.

[PH]: I will get back to that subject about policies. In Norway, there are a lot of different incentives. The two first, and important ones, are the import/purchase tax on all cars in Norway. This is calculated on the weight of the car, and CO2 and NOx. There used to be the motor-effect tax, but this has been removed. So now it is only weight and emissions. A big SUV, with a lot of emissions will have a lot of tax, maybe three times the cost of the car. All zero emission cars do not have that taxes. In addition, we have exemption from VAT, which is 25%. Most EVs have not purchase tax, because they are zero emissions. The tax will then be zero. Heavier cars such as Tesla might have so small percentage of tax. But the exemption of VAT is one very important aspect, because it makes the car 20% cheaper than a normal car. That makes EVs compatible, as they more or less cost the same. And because we have so much hydropower, the running costs of an EV are really low, if you compare it to diesel and petrol cars. These fuels are also highly taxed in Norway, even when we produce them ourselves. In addition to that, we have a couple of user incentives, as the EV is a new technology. Even when they (comparable EV and ICEV) the same price, people will not by them (EV). There are uncertainties on range, how to charge, how long will the battery last. People are conservative, and stay with the car brand which they are used to.

[ET}: This means than that, although there economically the costs are the same, there are still switching costs to the new EV technology?

[PH]: Of course some will switch to EV even when it is more expensive. If they value the environment very high, than they will choose it. But most people won't. In that case, you will need strong incentives to convince people to try something new.

[PH]: Since the 1990s, the Norwegian government introduced incentives to promote EVs, so it is nothing new. But the effect did not turn up, until new models such as the Nissan Leaf. After that, people started to buy them (EVs). The models before that were not good enough for most people. In the beginning, people commuted with only a 2-seater, or a small 4-seater, with limited range.

[ET]: This was than the Th!ink car?

[PH]: Yes, and that was a good start. But it was only when the major car manufacturers brought car models when the market boomed. We see that for every new model the market grows. For the (Tesla) Model 3, there is a waiting list. The limiting factor is the supply of EVs, and not the demand.

[PH]: Historically, the market share of EVs in Norway are growing. This also holds for plug-in hybrids, because they have removed the motor effect component in the tax system. Therefore, the plug-in hybrids receive also tax reductions, because they have very low emissions on paper, but not in reality. We (Elbil) think that this is not good development but that is how it is today.

[ET]: Did the motor-effect tax had to do with the emissions?

[PH]: The motor-effect was a part of one of the components on how you calculated the purchase tax. Since January this year, the government has removed the motor-effect, so it does not count anymore what kind of motor-effect you have. PHEV have a high motor-effect, as they have two engines. It is not for the environment that they have an electric motor, it is just to lower the motor effect. By removing the motor-effect aspect, the PHEVs got cheaper overnight.

[ET]: This than can be seen in the steep rise of the market share of PHEVs.

[PH]: It is a combination of new models. There were almost no PHEV models before 2014. After 2015, they steadily increased in market share.

[PH]: The most popular EVs are they: E-Golf, Nissan Leaf, BMW, and Tesla which receives the most attention, but this is more of a premium car. For many families, they pay more for the car in the beginning, but the total ownership costs are reasonable. A lot of families they calculate the pro's and con's, and over a period of 5 years, the total costs are lower. Range is also very important. We see a correlation with the model's range and the amount of sales. When the range of a EV is relatively high, this model is then relatively more often sold.

[PH]: From a survey of the Institute of Transport Economics on EV owners and regular car owners. Regular car owners think that EVs have big disadvantages with range. EV owners themselves do not experience this, as they charge at home. Again, it takes a lot to convince people to try an EV. Once you experience this, it is not a problem at all. This also holds for the access to charging stations. On longer trips, this can become a little bit more complicated. Charging times can be long, 9 hours for a Nissan Leaf. But in real life, you charge during night, and sometimes when you are at work. Eventually, charging times in real life are shorter than for petrol cars.

[ET]: In that case, there seems to be a knowledge barrier, hindering the insight with EVs.

[PH]: The incentives in Norway are so convincing that they convince people to step over this knowledge barrier, since EVs are so economically beneficial. Giving information is also very

important. But to really convince people, you will need a combination of information and economic incentives.

[PH]: We also see that more and more people have the EV as there only vehicle in the households in Norway. A lot of households have two cars in Norway, because women are also working fulltime normally, and they drive their car to their work. What we see is that these households have a diesel car for long trips, but the majority of trips will be done by the EV. The EV is being bought as the second car, but used as the first car. What we further see is that user experience is very important. Our members are very happy with their EV, and on average they convince three others to buy an EV.

[PH]: Further things we see are the reasons why people by EVs. On the first place are economic reasons. Environmental reasons and time saving by driving in the bus lanes are second and third in what are the most important reasons for our EV users. 3 years ago, when we did this survey with our members, the EV was not often used as a vehicle to make long trips. New insights have shown us that this is increasing. This has to do with three things. The range of EVs has increased, there are more fast-charging stations on the way, and people get more experienced with EVs.

[PH]: Most people charge at home, around 83%. 15% in apartments, where it is difficult to reach an agreement with the building owners and legislation. This is a barrier in the city areas that we try to solve. Also, fast charging stations are important to solve range anxiety. Public charging stations are being installed, but the rate of EV increase is larger than the increase of these public charging points. More EV owners have to share the charging points. The Norwegian government have an organisation called Annova (Annova Energi AB), that handle all kind of issues that EV owners have in charging. The support building of fast-charging stations, every 50km on high-ways. We now have close to 8000 public charging points.

[ET]: This than excludes the Tesla charging stations?

[PH]: Yes, they have their own charging stations, which are paid by Tesla themselves. This is an offer of Tesla for their users. Other car manufacturers do not use this, they use the public charging points, or the ones of the owners themselves. One other barrier is the access to charging and payment systems. There are a lot of different systems, and different operators. At a gas station you would just use your credit card, but for charging it is more complicated. Charging systems differ, as there are different apps, mobile systems, tags, etc. So what we have done is create this charging tag, which you can register at different charging operators. So you will only use one key.

[ET]: By doing so, you are standardizing the charging process?

[PH]: Yes, We are trying to, but it is not easy. This could be the first step.

[ET]: Is the charging infrastructure owned by private companies?

[PH]: Yes. In the beginning it was only regional companies, that are private but publically owned. They are owned by the municipality or county, but they operate private. The two biggest ones are Fortum, which is a Finnish energy company which just started up in Norway,

and Grønn kontact, which is owned by a lot of different regional companies (see also Figure 14).

[Picture below was taken one day after this interview during a walk through Oslo. These charging tags can be used at the respective charging poles of Fortum and GrØnn kontakt. The universal tag is an initiative from elbil.]

Figure 14: Two charging tags (Fortum and Gronn Kontakt), and a Elbil universal tag.

[PH]: Just a summary (of the presentation). The EAFO, you can also compare Sweden and Norway on all kind of statistics, and other European countries as well. So you see the market share, which includes PHEV. The market share is over 30% for this year. It consists out of 18% BEV, and 17% PHEV. This can be seen on Elbil Statistiek on the website.

[ET]: What are the reasons why the Norwegian government did not continue with the motor-effect policy. Was it because of a loss of revenue for the government?

[PH]: Not really, they started to introduce CO_2 tax in 2007 I think. They will gradually adjust this tax system. In the end it will only be CO_2 emission taxes. It does not make sense to have a tax on motor-effect, as long as we have laws for the pollution and the weight. A heavier car will have more wear on the roads. The overall income will remain the same, even though they have changed the tax system. What we are unhappy about is that the government has removed the motor-effect and replaced it by higher CO_2 emission tax, but this increase is not enough. This makes polluting cars cheaper, and the difference between zero emissions and emissions becomes less.

[ET]: Do you think this could pose as a danger to electric cars?

[PH]: On the long term, no. This (EVs) is going to happen, because we see that all car manufacturers are saying that EVs are the future. The question is not if it is going to happen, but when. If you are going to do something about the climate, global warming and local pollution, we have to make this happen as fast as possible. The government should speed up

this process. Only 4% today of all cars in Norway is electric. We think that the government could do more to speed up the process.

[ET]: I would like to discuss this further on in the interview. For now I would like to discuss some of the open questions that I have. We already discussed how you see the BEV adoption itself. What are then potential factors that could influence the adoption of BEVs. You already mentioned the incentives and network effects, but are there any other potential factors?

[PH]: Well there are three factors. First it is the market. The car producers have to produce good products, that the customers want, in all segments from small cars to big SUVs. Now it is only the middle range cars. The technology development, the batteries. We have seen a lot of development there. Not in the batteries itself, they are the same as mobile phone batteries and computers. But they increased the density of the batteries, so will get more range out of the same batteries. Also the price of batteries has gone down. Cheaper batteries mean that an EV can become cheaper. Also scale-effects, where there occurs a price reduction.

[PH]: But the car producers are not in a hurry, only maybe Tesla. Because they still have invested a lot of money in production facilities for diesel and petrol cars, and they want returns from those investments. They only do what the politicians say, and even then they try to avoid, sometimes by cheating. They want to go slow, start with some HEV and maybe PHEV, and BEV in maybe 10 or 15 years.

[ET]: Are these companies hesitant to take the risk on EVs?

[PH]: Yes.

[ET]: And then the current diesel and petrol cars can be seen as the cash-cow of the car manufacturers, where the technology will be continued until it has become obsolete.

[PH]: Yes, it is the same as the Iphone. They have the technology to have much longer range, but they do not want to do that just now. They want to increase the range slowly. But one problem for them is Tesla. They do not have petrol or diesel cars to sell. So they can push the limits. They have pushed the other car manufacturers to develop. We would not have seen, for instance, the Opel Ampera E if there was no Tesla. And also I think Norway has done to show the rest of the world that EVs can work.

[ET]: And are these car companies actively influencing policies? I can imagine that if they do not create electric models, their company will maybe look less attractive? And also, maybe delaying any policies on electric vehicles?

[PH]: This is hard to prove. But using logic, it makes sense not to speed up this transition. But they see the danger as in a Kodak moment. If they do not follow the developments, they will disappear, as the EV technology is superior to ICEV technology. I have seen some that they sometimes have compliance cars, like in the US market. One model which they do not want to sell it, but they just offer it. It is a sort of greenwash. They offer a green technology, such as an EV, but they see that nobody wants to buy it. They do not actively try to sell it. When the Nissan Leaf came, the Norwegian Nissan importer were sceptical. They put the Leaf (BEV) in the back of the shop. Because of the incentives, people came to the Nissan dealer for the Leaf.

Then the Nissan Leaf was put more and more to the front of the shop. Nissan and Volkswagen are now really interested into selling BEVs. Toyota does not have an EV, and they really regret it as they are losing market share in Norway.

[ET]: Toyota focusses more on HEV then I guess?

[PH]: Toyota say that they will come with an EV. But now they have a FCV. But BEV technology is moving faster, so they should at least start thinking about that as well.

[ET]: On the factors you mentioned, what kind of influence would exert on each other? For instance, the battery tech growth fosters demand in EVs. Are there also other inter-factorial relationships between the factors.

[PH]: Between which factors?

[ET]: For instance between income and switching costs between vehicles? Or when BEV become less expensive, do they get more attractive for governments to subsidize?

[PH]: Yes, because then they do not have to subsidize as much. If you take the production price of an EV and of a petrol car, if they would be the same, than there was no need for the government to subsidize. But this will take a very long time, especially in the beginning. That is why Norway uses incentives to make for the costly production price of the car. Norway started with the incentives, but now the EV is becoming cheaper, subsidies could become less. Other countries can start to use incentives without being so costly anymore as EV technology becomes cheaper. Actually, it is not a subsidy, but tax exemption. Norway has also increased taxes for competing polluting cars. If you raise taxes on diesel and petrol cars, you can lower taxes for EVs. As there are more ICEVs, you will get a lot of taxes that you can use for the smaller amount of EVs. When you have a 50/50 market share, you will not receive as much taxes, but you will not need to use incentives anymore. I think you can adopt this kind of policy relatively easy, without losing revenue. We also here that Norway has a lot of money, but we do not use it for the incentives and policies.

[ET]: What I have read and heard, is that the reason for Norway being able to follow their BEV policy is because Norway is rich from their oil. But this is not the case here?

[PH]: Well, it is not a direct effect. There is no direct connection between the tax and the incentives. The taxes go into the country's budget which is used for hospitals and roads, and in the end EV incentives. If you explain that extra taxes on diesel and petrol cars are used for EV incentives, than it is more excepted, then when it is taken from the big state budget.

[ET]: Do you think that the visibility of these arrangements have a positive influence on the adoption of electric cars? If people know that the government is trying support sustainability, and high emitting cars are being taxed more heavily, and this income is going to the electric cars.

[PH]: Well there is a lot of process on, even in Norway, on the car taxes. One of the right governmental parties is sceptical on car taxes, which is one thing where they get their votes from. So there is a lot of protests on car taxes. And Norway is a very car loving country, since

we have to travel long distances. Outside Oslo public transport may be an issue. But I think people can relate to local pollution, noise pollution and even climate emissions. We have the polluter pays system in the car taxing systems. Same with the toll roads, which are free for EVs, but polluting vehicles have to pay more. The tax on diesel cars will be increased, again a polluter pays system. But if you do not believe in global warming, you can still buy an EV, since they are economically cheaper.

[ET]: I also read that the EVs have special number plates in Norway.

[PH]: That is true, all electric vehicles have EL, but we ran out of EL so now also EK is used. For hydrogen it is HY. That also makes it easy to check if a car can use the bus lane or park for free. This makes it very easy to spot them, since an E-Golf looks a lot like a normal Golf.

[ET]: Do you think that distinguishing the electric vehicles from regular vehicles makes them more attractive?

[PH]: I think this is a very good system and it is cheap. People can see what cars are EV. They are like driving commercials.

[ET]: When indeed they see the cars driving with EL driving on the bus lanes they can see the benefits.

[PH]: Also, people have some thoughts on how an EV looks like, like the Th!nk or Buddy. When they see an attractive car like a Tesla with the number plate, than this can promote EVs.

[ET]: I have some points that I have found in literature, that I would like to discuss. These are more the matters on where Norway and Sweden differ from each other. We have already discussed some of the factors that could influence BEV adoption, such as switching costs and network effects. Also the co-evolution of the infrastructure such as charging stations and parking places. But are there also further cultural differences between Norway and Sweden. Such as Norway being powered by hydro power, are Norwegians than more susceptible to using BEVs?

[PH]: No, I do not think so. Again it is the price. The price of electricity is lower in Norway than in Sweden. The price economy is the most important. Environmental effects are then a nice bonus. But it is not the most important reason why they would choose it. The main points would be the difference in policies. In Sweden they do not have this import tax, at all. I think they are going to implement the bonus/malus system. And also the 'super environmental car' subsidy. But they have included all cars, which does not restrict the incentives to only electric cars. Also bio-fuel and PHEV benefit. And of course Norway had all these policies in place when the new models came, such as Nissan Leaf. We could start selling at once. Other countries first had to implement certain policies, and this takes time. In Norway we had this advantage, because we had these policies. We did not have to discuss this, because they were already in place when the new cars came.

[ET]: So the framework was already there. The interest of car manufacturers then started of whole EV adoption?

[PH]: Yes, and we also see this neighbour-effect. When you have a street, or a town, or a work place where some people have an EV, than the effect spreads rather fast. The hard point is to start with the first EV. But if there are a couple of EVs in a group, people will get familiar with them very fast. So in Sweden this is not really happening right now. You need to have a base, or else the process of adoption will be slow. All Norwegians probably know someone with an EV, and then it becomes easier.

[ET]: This relates to what was in your presentation. The differences between EV users and not EV users is quite big.

[PH]: What also important in the beginning were the bus lanes. In the beginning, when there are not a lot of EVs, so you have a more than enough capacity to use the bus lanes to give access to EVs. Of course you need to stop this when there are too many EVs, because this can delay the bus. In Oslo, there is a new rule out that in the rush hour, you need to have more than one passenger in the vehicle to be allowed in the bus lanes in Oslo. In the beginning, it was crucial to convince people. It is also cheap for the governments. Also the license plates have a positive impact, and the ferry and toll road exemption.

[ET]: Do these incentives differ per state in Norway?

[PH]: It has been a state law or national law. Put free parking can now be determined by each municipality. And toll roads and ferry's regional. In the beginning it was nationally determined, which we think is the better option.

[ET]: What are the reasons that Norway has focussed solely on electricity? If you look at the incentives provided in Sweden, you can see that they can be more interpreted on other low emitting technique. So why does Norway concentrate more on EV?

[PH]: I think it is because of the lack of a car industry, we do not produce cars. So we can do that without anyone complaining. But Sweden will probably receive complains by for instance Volvo and Saab. Norway started with these incentives early in the '90s, to build and own car industry with the Th!nk. They went bankrupt, but this was the main reason in the beginning to build an industry. After that it became more of an environmental policy, out of the industrial policy before. We do not have lobbying against us.

[ET]: So then you are free to move within the rules you want to set. On that note, as Sweden has a wider view on what environmental friendly cars are. When talking about lobbying, are there also other fuel sources in Sweden which are supported or have influence on the policies?

[PH]: In Sweden there is an emphasis on bio-fuels, I do not know why. Probably again because of the car industry. We in Norway do not focus on bio-fuels.

[ET]: Or could it be of the interest of the agricultural sector?

[PH]: Well we have an big agricultural sector as well. They are also lobbying for bio-fuels, the second generation, as we have a lot of trees here in Norway. We also have a lot of hydropower, more than we can use. This extra amount is exported.

[ET]: Between Norway and Sweden, there is a difference between GDP per capita and GDP purchasing power parity. Do you think this has an effect on the switching costs from ICEV to BEV?

[PH]: Well, if you earn more, then you are more likely to take the chance to try something new. You have the luxury to try new technologies. You can become an early adopter. We in Norway are early adopters, if you look at for instance mobile phones. This has to do with the relative high income.

[ET]: Do you think the incentives provided by the government are adequate to counter switching costs?

[PH]: No (laughs), just 17% of new car sales are electric. If they would be too good, market share would be 100%. But it is a balance between what industry and policy can deliver on incentives. We think that in some areas, we should strengthen the policies. For instance, on small electric vans and company cars, the EV market is almost nothing. The tax system does not work in this area, since most EVs sold are for private use. In Sweden companies buy fleet cars because they can pay more, and use them as a sort of green advertisement of the company. In Norway, charging could receive a bigger focus from the government, if they want to reach the goal of 100% market share in 2025.

[ET]: Do you think this is feasible with the incentives that are now provided?

[PH]: Well what we have seen from the last 5 years, where we had 1% market share and a couple of thousand EVs, to now where we have over 100.000 EVs, the technology in 8 years will be tremendous. The process will happen faster and faster. This has to do with the battery prices. Better batteries mean longer range, and why would you then choose to buy a petrol car then?

[ET]: Are there differences in driving distances? What I have found was that the average driving distances per car per year between Norway and Sweden differs only 1%. With an almost even average, do the variation between the trips differ a lot between Norway and Sweden?

[PH]: Well as you said, the average is the same. Further, I think the trips are quite the same. I think trips to for instance our cabins are roughly the same in Norway and Sweden. I think there is no significance difference. Maybe that Sweden has more highways with a higher speed limit. This can pose a challenge to EVs with respect to the range.

[ET]: I have two last questions. The entire system around BEV technology has to co-evolve with the technology. What parts of this system, if any, are lacking behind, and are holding the process behind?

[PH]: For the car industry, they have to do something about the models that can fill all the segments, from the big cars to the small cars. Currently, EVs are mostly on the small and middle size sector. 50% of cars in Norway are station wagons or SUVs. Currently, only Tesla can be chosen as a big EV. And we need to do something about the charging stations, so people do not need to stand in line too long to charge on longer trips. For the policy, we need to solve

the barrier on apartment buildings. Only 13% of EV owners live in apartment buildings. They cannot charge since there are no charging points in the apartment buildings.

[ET]: As a final question, in your paper I have read that other countries could adopt the (BEV) policy framework of Norway. I have read also two other papers and they have said the opposite. According to them, the policies are influenced by network and to contextual factors, and they play a too big role in the system why Norway is unique.

[PH]: Well I disagree of course. They do not say why, or show research for their reasons. Norway is not that special. We are a democracy, a western country, in Europe. I hear that the reason why is that Norway is rich, but this is not a direct reason. We do not have a car industry, so we do not have any lobbying against the policies. But still the politicians decide on themselves, they do not have to give in to the lobbying. Other countries, such as Spain, could introduce small taxes on polluting cars without any loss of revenue. Some people will protest, but that is how politics work. If you want to do something about the pollution and global warming, you will have to do something that not everybody is happy about. For instance we have the law on smoking cigarettes before. We banned smoking in public places, and the politician who introduced it became quite unpopular. But now, everybody sees the benefits, and the politician is a hero. In the long term, everyone will win on these policies. If you find arguments in the documents you mentioned, let me know.

[ET]: I will send you the papers with these arguments. On a last note, do you have an electric car yourself?

[PH]: No, I do not have an electric car, because I do not own any car. I have an electric bike since I work and live in the city, so I do not need a car. But for people who need a car, it rather should be an electric one.

[ET]: Thank you for your cooperation and your willingness for this interview.

Interview Marika Kolbenstvedt

Email address: mk@toi.no

Marika Kolbenstvedt is a Senior Research Sociologist at the Institute of Transport Economics – Norwegian Centre for Transport Research. She works at the department of Safety, Security and Environment in the research area of Environment and Climate. She has done numerous researches and surveys into the development and diffusion of electric cars, and the pathways of electro-mobility. The interview took place at the TØI office in Oslo on the 11th of April 2017.

[MK] = Marika Kolbenstvedt

[ET] = Eric Tol

[ET]: Good day Marika Kolbenstvedt, my name is Eric Tol and I am a Dutch master student from the Delft University of Technology in the Netherlands. I have read your paper about the COMPETT study. I find this paper very interesting and helpful for my thesis. My thesis focusses on the success and fail factors of BEVs. I am interested to know the reasons behind why Norway is able to implement their BEV policies. Norway is quite unique in the market share of BEVs. I have some open questions I would like to ask you since you are an expert in the area of EVs. Furthermore, I have some more detailed questions that came up when I read other papers and articles. There I want to discuss the findings that I have made.

[MK]: Have you also read some of our other reports?

[ET]: Yes I have read another from the Transport Institute of Economics. I cannot remember the name of it, but it also was co-written by Erik Figenbaum.

[MK]: Yes, he is the head of the group og Technology and Environment. I am the lucky one who can work as a researcher again after many years working as the research director for other researches. Since three years I have worked with Erik on electro-mobility, which I think is a very good position.

[ET]: Yes I think so, this is really a dynamic subject now. Most sources that I have used for my research are all from 2014, 2015 and 2016. It is a really booming subject.

[MK]: It is changing very fast now, and luckily for us we now have a big project where we can continue the work from COMPETT, and it is called ELAN, which stands for electro-mobility laboratory, since we are in a kind of laboratory in Norway. It would be stupid if the Norwegians did not have resources to follow up the development of e-mobility.

[MK]: There is also one other project called MOSES, which concentrates on other types of electro-mobility such as hydrogen. It is a centre which will continue to 2023.

[ET]: So quite a comprehensive research.

[MK]: Indeed.

[ET]: My first question is how do you see the BEVs. Do you see them as the one and only promise for sustainable transportation? What I have read from my literature study, and according to previous interviews is that Norway has focussed on EVs, but not as much on HEVs and any other sort of hybrids.

[MK]: No, but the PHEVs are coming up now. There are some HEVs, but the PHEVs are really coming up. I think, in the fleet, there is now 110.000 full BEVs and 3 to 4 thousand of the Plug-in hybrids. And to your question. As a realist, it is not really smart to just have one egg in your basket. At the time being, at the time when the goals are to reach zero fossil emission to 2030, the BEV and also the Plug-In are the lowest hanging fruits. That does not mean no hydrogen, but this will not be the main solution for the upcoming decades.

[MK]: The BEV vehicles are getting more and more range. There will be less of these initial problems.

[ET]: You mean for instance the range-anxiety?

[MK]: Yes the range-anxiety. Is a sickness that mostly people who have never tried an EV suffer from.

[ET]: So it is more a knowledge barrier?

[MK]: Yes indeed. What we have discovered in the COMPETT project and our new 2016 report (TØI report 1492/2016), where we have made a survey is that persons who have ICEVs and EVs have a completely different opinion and understanding of EVs. It is like they evaluated a completely different product. That is why Norway as a test laboratory is very important. If you ask people, who have not tried an EV, (shows a paper of university of Aberdeen), they have a completely different opinion. In the Aberdeen paper they present who will adopt electric cars, but they have not asked anyone who has an EV. Thus they come to completely different conclusions of motives than we do in our studies. They stress symbolic motives, identity and specific attitudes to technology as stronger predictors to the likelihood to adopt, than demographic, practical or economic factors.

[MK]: One other answer to your question is that, we need persons (also known as the early adopters) that have a positive attitude towards technology in the initial diffusion phases, cf. Rogers theory. But in the next phases, one will need more than people interested in the technology.

[ET]: What I saw in your paper, and what is also part of my master, is where technology is into its diffusion. I saw that the EVs in Norway have passed the chasm. My question is, how do you see that the vast majority is being reached?

[MK]: I suppose you mean a "vast majority" of the new car market. Even in Norway EVs do not represent more than 4% of the total fleet. According to Rogers theory of diffusion successful innovations follow a S curve where chasm is placed somewhere between 10/20% of the new market sale. Cf. discussion I section II:2.6 and II:2.7 in TØI report 1420/2015. But here it is also stressed that incentives probably must last longer.

Anyway the EV diffusion in Norway is not a result of a long lasting climate policy. It is not a strong policy that Norwegians developed in the 1990s, saying that we were going to be the strongest EVmarket (relative to inhabitants) in the world. In that time, it was an industrial question. Norway, or at least some politicians, wanted to have an automotive industry, because some other industry in the south-western area was closed down. And some people , and received some money to work out the Think concept (a small EV). Also, the first economic incentives came; the exemption of registration tax in 1990 and of VAT in 2001. These economic incentives, have had a lot of importance and given the BEVs the same price as ICEVs in the same segment. instance, iI In Norway you will have to pay a very high price to the state when you buy a car. This fiscal access tax , or a buying tax, is higher than in any country. This is one reason why Norway could give exemption from this tax as an incentive in the 1990s, and further on, and not lose much money and without any political objections. It is easier to give the consumer exemptions than install new fees. All cars that do not pollute, can profit from this exemption.

In 2008 the climate question had become more and more important. The government made an agreement with all the parties except one, the ultra-right party. They decided on more incentives, and to keep the current incentives, even if there was a loss in revenue.

[ET]: And are the incentives being paid by extra taxing the polluting vehicles?

[MK]: No, they are not. [MK]: Of course, you cannot continue with this policy when the fleet changes to many non-fossile vehicles. Later on a bonus malus arrangement will probably be made.

[ET]: Is it because of the richness of Norway that they can pay for the incentives?

[MK]: Well no, it is only 4% of the car fleet. In the short run they cost the society some billions. One can afford that. And in the long run, taking the environmental benefits into account, society will profit.

Many factors influence the diffusion: The prices for a BEV and a ICEV are the same, where BEVs are excluded from the access tax. So they are equal. In addition, we have local incentives giving the consumers relative advantages. The first one is the stable policy which the different governments have stayed with. When the climate agreement came in 2008 we had a socialist government. When it changed three years ago, to a more right government, they stayed with the policy. Seen from an industrial standpoint, it is a very stable climate for diffusion. In Sweden you may have seen, since you are comparing these two countries, that ethanol and bio-fuels market shares and environmental bonus are changing.

[ET]: So there is not a continoes policy?

[MK]: It is not continoes. At first they wanted bio-ethanol, and the sales of bio-ethanol cars went up. 60.000 bio-ethanol cars were sold. But when they changed the rules, the sales of these cars went down again. So for a new technology one will need to have a long period of stable policy.

[MK]: Norway is not an automotive country. The Think and the Buddy eventually faded out. Norway was absolutely depending on Nissan and other car makers to develop EVs and come here to sell them - and they did. They saw this opportunity since car transport is responsible for one fifth of climate gas emission and local pollution. For the vehicle industry, electromobility is a good option for changing the fleet to cars that are environmentally friendly. They can still sell cars, and without the pollution. At first, the diffusion started really slowly, but in 2012 when for instance many brands had BEVs to sell, it accelerated quickly. We can discuss the incentives and their effectiveness, but without car models to buy there will be no diffusion.

[ET]: What I have seen is that there was a suitable environment for EVs, but there were not enough models to satisfy that. From 2012 it sort of triggered the rise?

[MK]: One can at least think that the car producers needed a stable political environment. We do not only have this fiscal access incentive. As you for sure knew, we also have the VAT exemption and various local incentives.

[ET]: This is then the 25% tax on cars.

[MK]: Yes 25% VAT is not on EVs. It can be discussed on how long this will be around. These are the national incentives. We further have some local incentives, such as exemption of toll-road fees and ferries costs for the car (both for BEVs and Hydrogen vehicles). In some municipalities in Norway, there are 20% EVs. Some incentives can be location specific, such as ticket exemption for tunnel tolls. According to people which we ask what incentives are most important, it is the toll roads. This is as a local incentive. For the national incentives, also the access tax exemption is very important.

In Oslo now, they are discussing that all should pay for the toll roads, but the EVs will pay less. This is because the EVs are also using the roads, so they should contribute as well, but not as much as ICEVs because they do not emit emissions. And with the bonus malus, you can make the polluting cars pay more. From other research at TØI , you can see that in the long run, economically, you gain more money. Because the pollution will cost society more eventually.

[ET]: So in the long run, this policy will benefit all?

[MK]: Yes. But it is a very difficult discussion politically.

[MK]: We further also have the driving in the bus-lane during rush hours, and free parking where you can charge.

[ET]: Are the charging stations publically or privately owned?

[MK]: The local charging stations at parking spaces are owned by the municipalities. Charging next to highways is owned by private companies. I do not know if private parking stations have free parking, but public ones do.. You probably have read that the users of EVs differ. Te early adaptor include many technology interested mend, but in the early majority we find the larger families with many children and complicated daily travel patterns. If they can gain 20 minutes

instead of sitting in the queue (bus lane use EV during rush hours), that is a huge benefit and an important relative advantage.

[ET]: I can imagine that the arrangements of the bus lanes will, at some point, be restricted. Or else the bus lanes will become full.

[MK]: Yes, but when it is few cars, it is not a problem. When it becomes crowded on the bus lanes, they close this opportunity. Also, since last June you have to be two or more persons in the car to use this opportunity. One other thing, is using IT and apps to find each other to use car sharing. This is has not been a great success in Norway so far. But beter parking options for EV sharing is discussed.

[MK]: In Norway we have the special licence plates for EVs **EL and EK**. Since there are more than 100.000 BEVs the consumers you see them everywhere. Making the vehicles visible is very important. The Elbil association has all kinds of arrangements where you can try EVs, and giving people information about how to charge etc. When people are being asked where they first got the information regarding EVs friends and family was the most common answer (37%). Among the ICEV consumers information from the dealer was dominanat (36%). In the PHEV group 31% got information from the dealer, 24% for advertising material and 19% form friends.. Social networking is thus a very important factor.

[MK]: And one important point is the organisations surrounding EVs. The environmental and automotive organisations work together to push the politicians into a certain direction. That is unique, generally they will be at different meetings and have different opinions. Here they have the same argumentation for the incentives. That is a very interesting new type of stakeholder relationship. UsingGeels theory with the multilevel perspective, we find that within the niches the organisations can talk to the politicians. 10 years ago you could drive in the bus lane with a bigger car with multiple persons. After a while, they banned it. And the organisations asked the politicians if they could do that arrangement with BEVs. Then there was a test, and eventually they adopted it.

[ET]: It that sense, there were a lot of windows of opportunities?

[MK]: Yes, that is what I said from the start. The policy and the incentives were build up brick by brick, stone to stone, to get to this enormous heap of incentives.

[ET]: More of an evolution?

[MK]: Yes. It was not some politicians alone. There have been a lot of stakeholders that have pressed the politicians.

[MK]: At first, it (EV) was an industrial policy, and then it became a part of the environmental policy. And now we have a market phase.

[ET]: Is there an overall consensus about the direction taken? Do all parties agree that this is the way to go?

[MK]: Well, most parties do. And since three years, the ultra-right party is also in the government. They have seen the advantages, and are also presenting the incentives for electro

mobility as a good idea. But there are adjustments all the time, such as the discussion of bonus malus, the demand for more persons in the car when driving in a bus lane.

[ET]: Thank you. For the next part, I would like to ask you some questions regarding my findings in my literature study. I have a list of things that I have found, and some things we have already discussed, so we can skip some. You already told me about switching costs to EVs, and also networking requirements. Do you think that in the co-evolution of the entire infrastructure surrounding EVs there are parts that are lacking behind?

[MK]: The BEVs diffused faster than one first thought. The politicians said that we will have the incentives until we have 50.000 EVs. But this number was faster reached than expected. I remember one politician saying at a meeting that "We never thought it would be 50.000". The Elbil Forening (Elbil organisation) have numbers for charging stations. They have not grown at the same rate as the vehicles.. We now have a new organisation called ENOVA. They give support to establishing charging stations. I am not an expert on this. But the charging stations are a challenging subject. Especially to develop a market for the daily use. From our research and surveys, we find that 90% of trips or travel chains can be done with the capacity the BEVs have. People are charging at home, which is the main charging place. After that comes the work place, and then public charging stations when people go shopping. In our 2016 report, we have a lot of data on where people charge.

[ET]: What I have seen from literature is that the range-anxiety slowly evolves into a charging-anxiety. The question becomes more like are there enough places to charge, instead of is there a place to charge at all?

[MK]: We have seen that people have developed many charging and adoption strategies, cf TØI report 1492/2016.. But there are two main problems here. One is where people are living in apartments, there is a lack of charging stations in apartment buildings. This has to be incorporated in new buildings, especially outside the city centre. People inside the city centre do not drive as much as others, since many destinations are also located in the city centre. Another challenge is to build fast-charging stations alongside highways, where people can charge when they go to their hut or cottage for holiday, average of 14 times a year for Norwegians. It is nice to know that these stations are there when needed.

[ET]: This will then take a lot of the uncertainty away?

[MK]: Yes. The challenge is:Who want to establish charging stations if people son not use them? They have to receive some support.

[ET]: I have some other questions about the potential differences between Norway and Sweden. The is the presence of automotive companies, such as Volvo and Saab. Do you think they have an influence on the policies in Sweden?

[MK]: I have not studied this, but here in Norway we also have large companies like that, such as the oil companies. They are larger economies than the state. So, of course they have influence. But it is not something we have studied.

[MK]: What we see is a change in attitude of the car companies and importers. They are very positive to this transition. The challenge is to convince the politicians and the older (age) potential EV buyers. They think that the car is a right to have. They are not so keen to change.

[ET]: For this question, I would like to focus on other fuel sources. So the availability of other renewable energy sources. Are there other fuel sources in Sweden such as the bio-fuels presented?

[MK]: Yes, they have increased the percentage of bio-fuel in gasoline. They have some actors that want this. But they have not succeeded to have the stamina to stay on.

[ET]: In that sense there was not a stable policy?

[MK]:Yes, you have to be brave to stay on. In Norway the environment was in place for the car makers. It takes some time for car producers to change. In Norway, there has been a lot of research on FCV. But this development takes a lot more time, it is more complicated. What we also have seen is that the owners of EV and PHEV just love their cars. They think they are nice to drive, and you become an environmental person. Among the people who have a BEV, around 90% will buy an electric car next time. The PHEV owners want to have a larger battery so they can drive more on their electric motor.

[ET]: The ICE in the PHEV vehicles will become an extra to the electric motor. Currently it is the other way round.

[MK]: Yes. We see the same with EVs. People want more range, they love driving their cars. 72% of people buy their BEV as a second car. On average 48% of households have two cars in Norway. The EV is being bought as the second car, but used as the first car. One thing that is presented as a negative point is that there will come more cars, as the BEV is most of the time the second car. But this is not the case. Most BEVs will replace an ICEV on the road. But 22% bought an additional vehicle. We found the mort of them would have bought a second car anyway, if there was no bEV available, due to changes in family/ or work situation. We might have a rebound effect of 10%.

[ET]: Do you think then that the ICEV will be phased out eventually? The EV being the second car but used as the first. They will almost not use the second car.

[MK]: Yes, but they will keep the second car for long journeys on holydays,. *[ET]: One other thing that I would like to ask is about the GDP. The GDP per capita in Norway is higher than in Sweden. Also the GDP purchase power parity is higher.*

[MK] Yes, and there is no external debt (Norway). Many other countries have debt. From the late 70s, Norway started to receive money from the found oil. But with this money, Norway has done extremely good. You have to take your hat of for that. The money has not gone to the oil business, but is was put into a fund. The social-democrats at the time made sure that the money did not disappear to the oil companies.

[ET]: And how do you think the GDP difference has an effect on the BEV policies? What kind of effect could be seen?

[MK]: I think that you should see that together with our high tax system. There is no other country in the world where it is so expensive to buy a car. From a fiscal point, you can say that the environment is also important to invest in, and we can since we have a good economy. When the oil industry slows down, a lot of people will lose their job. Here it is important to avoid a Kodak syndrome and to invest a lot of research money on alternative energy sources.

[ET]: Do you think the relative switching costs become lower, when there is a higher GDP and GDP PPP, and higher purchase price for cars. Do you think that relative switching costs become lower?

[MK]: I would not say that there is a clear relation. It is more of a framing instrument. It makes it easier to say let's have a lower tax for welfare for instance. But of course if you look at health costs, such as asthma due to pollution it is profitable to invest in a better environment.

[MK]: Maybe one can say that if you have a lot of money it is easier to try things. One thing that the very right government says is that the BEVs only solve a very tiny bit of the global pollution. On the left or middle side, they say that it is our duty, since we are very rich, to take the lead. Also, Norway gives a lot of money to save the old forests, countries under development cannot pay for such things.

[ET]: Do you think that the incentives provided by the Norwegian government are adequate? Should they do more, or maybe less?

[MK]: I think they have been adequate. They have made the cars (BEVs) cheaper. When we ask the people why did you buy the BEVs, they say it is the best car for my need. They are practical, economic, save time and they have these relative advantages compared to ICEVs. They have made the benefits visible. They have succeeded to meet the challenges of the innovation.

[ET]: The case for Norway can be seen as unique in the matter of the BEV market share percentage. Are the systems and the environment used in Norway, are they transferable to other countries?

[MK]: Not one to one. The incentive giving free tax when you buy the car, cannot be used in other countries without such a system. And for the local ones, they have their challenges as well. And then is the case about the clean electricity source. But, in Europe you have the quota system. When cars are getting electric, they become a part of the quota system. I think it is a very important point to get the transport sector into the quota system. Because why should transport, being responsibly for so much pollution globally and regionally, not be included into the system that one have developed. Probably not perfect, but it would work better if one would got transport in.

[ET]: The electric cars are not part of the quota system?

[MK]: The electricity the electric cars use is a part of the European quota system. *[ET]: As a final point, I would like to summarize the points that we have discussed. You told me about the stable policy.*

[MK]: Yes a stable policy. One has succeeded to change an industrial policy to a climate policy when needed, and eventually to a market phase. One has also had the ability to change parts of the policy. When the bus lanes are full, then they are not used for BEVs. They have been able to make public arrangements (supporting organisation and charging development) and change parts of the incentives.

[ET]: Do you also think that the alignment in the stakeholders is an important point?

[MK]: Yes. And the with the stakeholders that usually do not work together. Industry, politicians, environment organisations and car associations.

[ET]: Thank you for this interview, I really appreciate it. The paper you showed me was 'TI report 1492-2016'.

[MK]: All our papers are free and available on the website. You can download them if you want.

[ET]: I will take a look. Thank you for your time.

Interview Eva Sunnerstedt

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Eva Sunnerstedt is the head of the Clean Vehicles in Stockholm unit. She is responsible for the City of Stockholm's work on electric vehicles and charging infrastructure. She also develops and manages the administrative and financial duties of the environmental car units and European projects at the City of Stockholm. She is the 'Spider of the network' for financial complications, budgeting, forecasting, project reporting, budget monitoring, etc. She has a lot of experience from working with public procurements in the clean vehicles and fuels field. The interview took place on the 18th of April 2017, at the City of Stockholm office, in Stockholm.

[ES]: Eva Sunnerstedt

[ET] = Eric Tol

[ET]: Good afternoon, my name is Eric Tol and I am a master student at the TU Delft. For my thesis, I am researching the reasons behind why Norway is able to implement their effective and drastic BEV policies. Then in my research, I also want to find the reasons why Sweden is not able to implement such BEV policies. Although Sweden and Norway are quite comparable on paper, there seems to be a difference in that Norway is able to implement their policies. I have already read on the City of Stockholm's website that you do projects for the adoption of EVs here in Stockholm, in trying to stimulate the attractiveness of EVs in Stockholm. Can you maybe elaborate a bit more on what you are doing on these projects?

[ES]: We do various things. We started a while ago, and the recent boom of electric vehicles when they started to come in 2009 and 2010, there was a talk about EVs coming. And then we started a nationwide procurement of EVs. We have experiences before with that procurement is a good tool to introduce new technologies, and we wanted to show that the car industry has a market here in Sweden, or otherwise they would go to Tokyo, Los Angeles, and so on, and nobody would remember Sweden, because we are so small and so on.

[ES]: So we did a nationwide procurement in order to put Sweden on the map, so we would be one of the first nations that were starting to introduce EVs on the Swedish market. So we did the procurement like that and it did put Stockholm on the map and we were able to get EVs to Sweden and Stockholm. Once we had the vehicles here, we got money from the Swedish energy agencies to be able to provide some funding of the vehicles. In exchange of the funding, we would provide them with data. How much they drove, and how much they charged. We had focus groups and meetings with drivers. So we had a lot of knowledge about how the first EVs were used and how customers thought about them.

[ET]: So more of a test experiment? What I have read is that it began in 2011 with some car brands.

[ES]: The framework agreements were valid from October 1st. And we received the first vehicles in December, and they started to come in the years after. We have then collected logbooks and collected questionnaires. It resulted in a report, but it is written in Swedish. You

can download it from the website and there is an English summery. I think the last 10 pages is an extended English summery. So you can get some of the experiences which we have had. Now all Swedish car manufacturers have EVs or HEVs on the market. They are here, and serviced and maintained here. So that is not a problem anymore. Now there is a lack of knowledge about EVs, in the sense that they exist and how they work. People know what an EV is, but they do not really know.

[ET]: They do not know all the ins and outs, and the benefits.

[ES]: When you have never driven an EV you have range anxiety, but once you have driven an EV and you use it for a while you do not have it anymore. There is a lot of range anxiety and false expectations or things like that. I think there is still a lack of experience. There needs to be test driving and try-outs. At the Environment and health administration, where I work, we currently have two electric vehicles that other municipal administrations and city owned companies can borrow and test for a week or two, free of charge. In that way, we try to motivate our own employees in the city, to order to get more EVs for our vehicle fleet of the City of Stockholm. So they can have experience and different drivers driving the EVs. We can see if it works in their day to day operation. This has been a very successful way to introduce this, and to show that it actually works. We get all this feedback from, when you have not driven an EV, that charging times are so long, 6 to 8 hours, but actually once you have it, it shows that it takes less time because it saves a lot of time. Our drivers experience it as less time. You charge at night and in the morning it if fully loaded, and so you spend less time compared to when you have to go to the filling station, like you used to have to do. You are actually saving time. There are all these things that you are not aware of.

[ES]: Then there is also the infrastructure issue. You need to be able to charge, and the best charging place is where you park during the night. The parking place of the car is very important. However, once in a while you might want fast charging. What we have seen in Oslo is lot of public parking spaces on the street where you can charge. So people in Oslo get more aware and see that charging is existing and EVs are on their way – they get more assured and think this is for real. That is important. And also in Stockholm we have a lot of multifamily housing, and they are owned by the people who live there. They have a lot of parking, and these need to be supplied with charging. These multifamily houses need to maintain their houses themselves. The house is run of by a board of members living in the house, and they take care of the house on their spare time and are occupied with other more important things like fixing the roof and so on. When they have to discuss charging at their home, it easy to say no, because it will take them extra time. But more and more, people want charging at home and we can see that it raises the price of the property. They think it is a lot of effort, but now you can receive funding from the Swedish government, but it is quite a tricky way to do. So we received a lot of calls from EV owners asking 'I want EV charging', but the multifamily housing do not want to help me. So they called us to ask for advice. We decided to make a big information campaign about this and how you can fix your charging point. I also think that a lot of the charging point providers, that provide the equipment, say that it is complicated and that you need all this extra equipment. It needs to be smart and have a billing solution, online reading and so on. It needs to have all these things because they want to sell a lot of things. They want to tell you that you have to service it once a year. That scares a lot of the

multifamily housings away. I think it is not more complicated than a washing machine, it is even less complicated.

[ES]: What we have in Sweden is that you have a washing machine that is common for the whole house, which you can book. When something is wrong, you just call for service. This is actually more complicated, so I think they (charging point providers) make it too complicated. We have tried to make it less complicated, and make clear instructions. Both what you should think about when you do this to your home, and/or in your parking lot, and how you can apply for funding. We also arranged seminars in January and February of 2017 in Stockholm and 750 people came to these seminars. At each seminar there was an exhibition area where the suppliers were able to show what they can sell. We also have a film of two minutes, explaining the step-by-step process. The suppliers received a lot of offers from the seminars, and we believe that there will be a large increase because of that.

[ES]:We also are pursuing more public charging station on the street. We have some fast-chargers on public land that private operators have put up on their own expense. We have signed access right agreements so they can access to do this. We have previously provided this for normal charging, but there has not been an interest in normal charging or 3.7 kW charging. Fast-charging is like 50 kW charging. But now there is more of an interest in normal night charging on the street by private operators that want to put it up on their own expense on our land. Now state funding is available to apply for. Also there is European funding. EON, Vattenfall and Fortum. These three energy companies want to put these public charging stations into place in Stockholm. So there are going to be over 100 new on street charging points on street by the end of the year, maybe as much as 150. That is something that is coming.

[ES]: The most work so far in Stockholm, concerning EV charging has been done by Stockholm Parking AB. They are 100% owned by the city and they own a lot of parking. In the centre of the city it is mainly normal charging in garages, and in the outskirts of the city it is mostly outside on ground parking. They have around 800 charging points at the moment. They also have private parking where you can rent your spot for a month. And if you have a spot, they can provide it with electricity if you want to.

[ES]: These are the various things that we have been doing. We have had some seminars in the Stockholm area that target companies with regard to electric vans. We believe that, in the sight of EVs, people should actually walk, use a bicycle or use public transport. And actually, Stockholmers do, 80% use public transport or in rush hours. So they are very good doing that. But when it comes to weekends and weeknights they use the car. So well it is good to have an electric car, lot of the traffic that we see during the day is more delivery vehicles or businesses, often in “little white vans”. They can easily be electric. We are trying to target that group, in order to make sure that they start using EVs more.

[ET]: Is there then a less of a need for electric cars than for instance in Oslo? Are they used to take public transport, walking or riding bicycles?

[ES]: I do not know, I cannot really say. What I know is that in Oslo, there is a lot of private people who have bought EVs. In Stockholm, out of chargeable vehicles, over 90% of them are

being owned by organisations, companies or municipalities. Around 6% of them is being owned by private people. So a lot of them are not operated by private people. But in Oslo, the majority are private users. The incentives are targeted to private people in Oslo, with no congestion charging, possibilities to drive in the bus lane, things like that. It makes it cheap for them. Now the municipality of Oslo has purchased a lot of EVs, so they are coming also on the organisation side and the governmental side. Also oven 50% of vehicles in Sweden sold new are sold to companies. And a lot of people buy cars on the second hand market. And EVs are not really on the second hand market yet. When EVs come more to the second hand market, we will see them come more to the private market. (We do see that a lot of EVs on the second hand market in Sweden right now are exported to customers in Norway).

[ET]: Why is there such a demand for second hand cars?

[ES]: I do not know if it is larger than anyone else's. In Sweden, over half of the cars sold are to companies. I do not know if it is different in other countries. A car purchase is expensive, and you do a better deal buying one on the second hand market. It is not worth driving a new car.

[ET]: The depreciation is really high when you just bought a new car indeed. For my research I want to find the reasons behind why there are more cars sold in Norway than in Sweden. The market share of new EVs in Norway is the highest in the world.

[ES]: Yes, they have very aggressive incentives.

[ET]: Indeed, and I want to find out the reasons behind these incentives. I can image that more EVs are sold in Norway than in Sweden because the incentives are so drastic. But I am trying to find out why the incentive package can be so drastic.

[ES]: You should talk to Norsk Elbil Fereningen. They have a very good view on how the incentives started. Norway also had a car producer for a while, which was electric.

[ES]: When you start from the beginning, Norway does not have a car industry, like Sweden used to have. A very strong car industry, and they did not produce electric vehicles. In Norway they have registration tax, so new vehicles pay very much, in order to get registered on the Norwegian market. While in Sweden we do not have a registration tax. Because we have a car industry we obviously want people to buy new cars, because this generates a lot of work opportunities, etc., so it is a political thing. For environmental reasons, it would be good to have a registration tax, and then we could make it free for EVs, but we do not have one (registration tax). There is nothing we can take away, so the situation is different, because Norway does not have a car industry to protect. They have an oil industry, but there is no problem for them selling the oil. And they have a lot of money, because of the oil industry. They also have a lot of hydropower, some wind-power, and they are self-sufficient. Around 90% is hydropower, and they have a lot of electricity, also to power the cars. And then they started with the start-up companies such as the Th!nk. They started with the incentives to intensify the amount of EVs for environmental reasons, and also to secure supply. They do have oil, but they do have a lot of hydropower and electricity, and it is more energy efficient and they can use it different ways. The situation is different in Sweden. To some extent, I think Norway is overcompensating. I mean it is good to give a push to the EVs.

[ET]: How do you mean overcompensating?

[ES]: Well the problem is, for instance driving in the bus lanes. Everybody knows that this is only temporary, because if everybody would do something like that, the busses are not getting there on time and it will be all crowded. The problem with these incentives is, what is going to happen when you take them away? Is the market stable enough to handle it on its own? That is very hard to decide, when that is. Because right now, it is actually cheaper to buy an EV (in Norway). Since they have a lot of oil income you can compensate on that, maybe that is the reason why they can do it. Or you should go in some other funding scheme. It is going to be the same in Sweden. Oil is highly taxed in Sweden. If a lot of cars would start to run on electricity, the state would lose a lot of revenue. How would they solve it? I do not know. I guess you should start talking about kilometre tax. You would tax the vehicles on how much they are using the streets, or actually running. There are other ways where you could tax them.

[ET]: In Norway they are thinking about taxing EV from 2018. Not with the same fee as regular cars (ICEV), but with a proportion of that because of the high number of EVs is growing so fast.

[ES}: They are coming up with something I am sure. So the situation is different in the different countries.

[ET]: Do you think that the influence of an own car industry like Volvo and Scania here in Sweden, has an effect on the adoption of EVs, and on the policies?

[ES]: When it started, Volvo and Saab both did start to develop EVs. They stated, but then However, Saab unfortunately went bankrupt. Saab had an electric vehicle on its way. Volvo had an EV which was a test with 250 units that they leased out to specific customers. Then they instead started pushing for the diesel HEV (a car they developed in co-operation with Vattenfall). Then that was something they were going for, that would become the next generation. Now society is moving more into pure electric. HEVs are good, but it is pure electric that we want. I do not know if Volvo is changing their mind, it is not really clear.

[ET]: Is there may be a governmental influence to protect the car industry in their country, because they provide a lot of jobs?

[ES]: Well if you look back, that is usually how it has been. Considering Volvo and Saab, politicians want to keep jobs and job opportunities. A lot of employees are employed by them (Swedish car manufacturers) and also by their local suppliers and so on. This has been a very important core business of Sweden and for other countries too, that is not anything different. When this core industry does not really go for EVs, that is not where they make their money, then it is problematic. I would say that that is a difference from Norway, sure.

[ET]; That was one of my detailed questions that I had. I actually wanted to ask something about the municipality of Stockholm. You are trying to implement the charging poles and the parking stations. Are these private charging stations operated by private companies?

[ES]: Well, Stockholm Parking company, they operate themselves. They are 100% owned by the city, but it is still a company. So they operate their charging, and that is the majority of the

public charging at the moment. Then there are a lot of private operators that have their own on their own facilities. McDonalds, Ikea, shopping centres, galleries, and so on. And some pro-active parties in real estate. They have it for visitors, and offices, and so on. It is their own land, it is public, but only for people going there, such as an errant for Ikea. Fast charging on street is owned by private entrepreneurs, but it is on city's land. We provide the land where charging stations can be built by private entrepreneurs. That is just the same as with gas stations. The city does not own and run any gas stations, we own the land where the station are built upon. We can provide parking spaces, where charging can be put there, but it is not really for us to run, maintain and operate as private entrepreneurs can do so. We sign an agreement with them, where it has to work 90% of the time, and there are some other regulations/demands too, or else we will break the contract. It is up to them to run and use it. So far, we have three very keen actors that want to put up, and maybe we will have more later on. Everyone is welcome. We want to have competition to get prices down.

[ET]: We already talked about range anxiety, and all kind of perceived things about electro mobility. Do you think there are problems with the perceived feasibility with potential customers? It is not going to work anyway, there are not enough charging poles, the technique will fade away and we will end up with using regular cars?

[ES]: I do not know, I think it is probably both. I do not hear that so much, it is more that I will buy a EV later on, and maybe not now. I think it is getting more and more aware. Tesla has done a lot with their vehicles. Actually, it is just as any other car, but then better. People are very aware of those cars, they have seen Tesla cars. They are visible and they are impressed. We now also get the Renault Zoë, with range of 300 km and other brands too with increased range. It is interesting to see when the Tesla Model 3 comes. If it is what they say it is going to be, not so expensive, a lot of millage, family car. I do not know.

[ET]: It is probably an easier step.

[ES]: Well if you think of it, Tesla is doing something new. If they do not make money, they are out of business. They do EVs, that is their core business. For all the other manufacturers, they have diesel and petrol and that is probably, if you ask them, where they want to make their money and where they are making their money, and where their knowledge is. They are doing this electric thing because they sort of have to. They are a little bit forced to do so.

[ET]: Maybe there is a social pressure on making an EV.

[ES]: They are not really into it in the same way. At least they did not used to be. That makes it interesting as Tesla updates their car on the go with new features. If you buy another petrol or diesel car, then you have to buy a new one to get upgraded that way. With this car you do not have to worry so much.

[ET]: It is more of a platform?

[ES]: Yes, but I am not sure if people are aware of that, that these things are happening. There is less wear and tear. The car manufacturers are a bit reluctant. For instance, they have their dealers, and Tesla has done a totally different approach to all of that. But we can see that the car industry is a little bit worried. Because they are into carpooling a lot now too. You have

Drive Now, Car to Go, Audi Unite. They do all kind of schemes here in Stockholm. In Sweden we also have Sun Fleet, which is owned by Hertz and owned by Volvo. They are a bit worried, will people buy cars in the future, or will the co-own. Are the co-owning and the electric cars united? Drive Now has been very good for BMWs where people have been able to test EVs and now they maybe are more willing to buy one. Like I said getting more knowledge out there. Car-sharing can be a good way for people to get the opportunity to actually test these vehicles.

[ET]: It seems to be a good way to pull people into the market.

[ES]: Well you can get all kinds of different opinions from people. It depends on how many you want to move. There is always 10% of people who have been in a diesel Volvo and never want to leave it. And you have the ones who will take the EVs immediately. You have the whole spectrum.

[ES]: But I get questions on what is going to happen. There are a lot of EVs, and when do they start taxing us. Is this really something that will stay? Of course I do not know, I do not have a crystal ball. I do not know what is going to happen. But you can see when the entire car industry is looking into EVs, and it becomes more difficult and difficult to get lower emissions and are reaching a point where we need to do something about the environment. We may be talking more on EV zones. That is something that has been talked about and could be introduced in Stockholm in the future. There is more awareness of that. Maybe in 15 years, and you want to go into the city, you will have to have an EV. I would think that this is a regulation that is going to come.

[ET]: I know that they have these zones in Rome. Do you think that such a thing is possible in, for instance, the next 15 years here in Stockholm?

[ES]: Yes definitely. We have had a proposal on electro mobility zones similar to that. There is a proposal made from the government, and it has been sent out for comments to different kind of stakeholders in Sweden. The City of Stockholm has send in what we think about these proposals. We have an environmental zone for heavy vehicles at the moment. Heavy vehicles needs to have a high Euro-emissionclassification to be able to enter the city. And now the proposal was to maybe make a smaller zone in the Gamla Stan, old town, and areas around that, for purely EVs. And then maybe a zone that is cars thet meet specific the Euro-standard classifications. Sweden going to be CO_2, or fossil fuel, free by year 2050. Stockholm is by 2040. So we have to have something like that. But it does not have to be electric, it could also be bio-gas, ethanol, hydrogen. There are a lot of other fuels as well.

[ET]: Do hydrogen and biofuels get promoted for as well? In the same way as EVs are?

[ES]: Yes. We work a lot with the biogas system in our own fleet. Biogas is produced here in Stockholm from the waste water plant. We used to have a lot of ethanol here in Sweden. But there are not a lot of new ethanol cars that are sold, but we have a lot of filling stations here for ethanol. They are very easy and accessible. For heavy vehicles we work a lot with these kinds of biofuels. And also with HVO (bio diesel). When it comes to hydrogen, we had some test programs. We had three busses about ten years ago, that ran on hydrogen. There is one filling station at Arlanda (airport), which is far away from the city. They say that there will

come another filling station in the city this year. If this happens, we can start running this in our fleet and others could start as well. There are two brands on the market, Hyundai and Toyota. But there needs to be filling stations that are more close by. We also have procurement services for things that we buy for instance taxi services and goods delivery services. We do not say that it has to be electric. As long as it are alternative fuels or, if there are no alternatives, a high Euro standard. We try to put demands to the vehicles that distribute things to us. That is then copied to other municipalities.

[ES]: We treat them (alternative fuels) equal, but you need to have different kinds of activities with the different fuels. Charging points is special. We used to help find funding opportunities for biogas infrastructure and ethanol infrastructure. It is more or less in place but for heavy vehicles. We need to have more fuelling stations for heavy vehicles for the goods distribution. We are trying to find locations for that. We also do different procuremenactivities. We act a little different because the fuels are different. When it comes to electricity, we work with these multifamily houses, to help tehm with advice ets to set up their own charging. Well multi family houses are not really a stakeholder in the biogas program. So that is why we do it a little different.

[ET]: What fascinates me is that Norway generally focusses on electricity, and then BEV. And Sweden, as you said and what I have found in literature, focusses on several alternative fuels. Why is there a wider focus here? Is there a lot of biogas and biomass production, or is there a large agriculture sector?

[ES]: I think it is not wise to put all the eggs in one basket. There were not a lot of EVs for a while. We need to have more alternative fuels in parallel because there is not enough biogas to supply all the vehicles that we are using. There is not enough ethanol for all the vehicles that we are using, and same for the HVO. So we have to have different fuels in parallel. When it comes to electricity, the cars and vehicles do not exist in all these different fractions and the price is quite high. If you do long driving, this will be hard to do with electricity. Sweden is doing tests with EV roads where you can hook up a hook down andcharge while driving. But we cannot say this is the only way. We need to have other fuels as well in parallell. Today we have diesel and petrol. They work in parallel, and I think we will have parallel things as well in the future. It is also good to treat the waste and turn it into biogas and/or HVO. It is also something that we can use in existing car fleets. If we have HVO we can put it into our existing fleet. With small changes such as a new engine you can drive with ethanol. There are different things that can be beneficial using several alternatives.

[ET]: Does this focus on different fuel techniques create uncertainties with people?

[ES]: No I do not think so. Well, with the ethanol it has been that. Ethanol was very big. At its most we had around 250 to 300 thousand ethanol vehicles in Sweden, which is a lot of vehicles. Because of this big debate on food versus fuel debate, the question 'is this really good', and some journalists saying that you are taking food from starving people. This made it all insecure. I think the problem when it comes to biofuel has to come to European commission and the NGOs in Europe. They think that we should not take crop and make fuel from it. Now there is a set limit , and a nation cannot use more than the limit from crop in the national target. Also now some NGOs want a limitation set up on forests and woods. I can

understand that in The Netherlands that there is a limited area, and you need to eat what you produce and you have very little forests. But in Sweden there is large areas of farmland that we are not using, and we have very large resources in the forests too. There is so much farmland that is not in use any longer. And also the European commission pays us not to farm the land. I think this is ridicules not to farm the land and use it. In Sweden it used to be all forests. It is a lot of work to take the forest away and start farming there. If we are going to replant, what if we want to restart food production again. The landscape that people like is this mix between forest and open spaces and agriculture. This is also where there are a lot of species living i.e. species from the red list that you want to keep.. There is a large biodiversity in these mixed areas that we would like to keep. Let us not forget that

[ES]: If we are going to have that, who cares if we are going to drive on the fuel or eat it? Usually it is a combination. You can eat the weed, and from the straw you can make ethanol. In the agricultural sector, you need to alternate for the soil. So it is usually fuel and food, not either or. On the matter of forestry, that is a big thing going on in Europe. Some NGOs want to put a limit on it as well. For Sweden this is problematic, because we have a lot of forestry. We can produce our own fuel and be self-sufficient. There is already a lot of forestry planted. We have a lot of mono-culture. So it is not the 200 year old forest, we would use for biofuelproduction but we have those as well ans have the roon to keep them. We have a lot of them for instance in our national parks. And there are a lot of forests that we can use without damaging biodiversity. So if there is a limit on using forests as a source of biofuels, for Sweden that would be not very good. We have a lot of forests that we can and would like to use.

[ET]: Is Sweden being held back by the EU on that front?

[ES]: Sure. Yes.

[ET]: So then the EU has a definite influence on the fuel that you are using?

[ES]: Yes, when it comes to bio-fuels, we cannot tax exempt, because EC think Sweden is overcompensating. We have a tax exemption and this has been a special permission that has been given year after year. But the European commission wants to do something about it. Now we are introducing some sort of quota system. Europe decided what percentage of bio-fuels that you can include, which differs per country and region. Only 7% of it can be used from agriculture. And now, the European commission and environmental organisations are targeting forestry. I think in some nations in Europe, this can do good. But in Sweden it is not good. If they need a percentage rate like that, it should differ per country.

[ET]: This would maybe be difficult to back that up.

[ES]: Probably.

[ES]: But our gold or our oil is the forestry. That is what we have, and then we are not able to use it. There has been a lot of research done on extracting ethanol from pine and so on. That would be just perfect for us.

[ET]: Do you think that that would be a better technology than electric?

[ES]: No but I think that it can be used in different applications, where busses can be electric in the city. But if we are talking about trucks and busses for long distances, it would be very good to use ethanol for that. This differs per transportation. We have vessels and airplanes too and it will be hard to make them electric.

[ET]: Thank you. As the last part, I have some detailed questions that I would like to discuss. What potential factors could influence the adoption of BEVs. We already discussed infrastructure.

[ES]: Price is an important one. Knowledge. And society issues. What comes out from the government, and what comes out in general? Are we allowing only EVs to drive on the streets in our city? What are the ambitions of the government and the City? And what is proclaimed by society. Also legislation.

[ET]: Due to time I will go through the last questions that I have. I have a list with potential factors that I have found in literature. But I think we have discussed almost all of it. I will quickly run through them. These are: Cultural differences, price/performance, switching costs, we have discussed that one. How about the visibility of the BEV benefits? I know that in Norway they have the special number plates.

[ES]: Yes I think this is a very good idea.

[ET]: Should the Swedish government do something like that?

[ES]: Well they are not planning on it, but I think they should. But it is not for me to decide. When it was introduced in Norway, by the way hydrogen has a HY number plate and gas vehicles a GA. I think it is a very good idea. When you see vehicle using the bus lanes etc., you can see it is an electric car. Sometimes it is not always shown from the outside. However, I do not think that the Swedish government is planning to do something simular.

[ET]: Do you think that this has a significant influences the attractiveness of EVs?

[ES]: I do not know. I think it is smart. It is easy to see when it is a EV. It is easy to see how many there are. And if you would have a zone where only EVs could go and park, and only EVs can drive, then it is perfect. It is very visible.

[ET]: Do you think that a difference in GDP per capita, and GDP purchasing power parity, has an influence on switching costs to a new technology? Such as switching to electro-mobility?

[ES]: I do not know. I do not know because I know too little about Norway in that sense. I do not know how often they switch cars now. Their registration tax is very high. So all the cars are much more expensive than they are in Sweden. And then EVs get an exemption to VAT and not having to pay the registration tax.

[ET]: Do you think that the price of the car makes it more easier to make incentives? If buying a car is already so expensive, than not letting people pay for these taxes is an easy way to make EVs attractive.

[ES]: In Norway it is definitely the incentives that have made the EVs so attractive. Driving in the bus lanes and so on, and the price thing. I do not have a clear answer to that I am afraid.

[ET]: I have to last questions. What aspect in electro-mobility is holding back the evolution of EVs? Things such as charging stations etc. What aspects in the co-evolution are holding back EVs in Sweden?

[ES]: I think it is all the things that we have discussed. Lack of knowledge, also the price of the vehicles, they are much more expensive. And also the total cost of operation. Buyers think a lot about the price tag. Companies are better in thinking like total cost of ownership. But I think this is problematic, and also the charging issues. And then incentives or society issues, what the government says. We come back to all the things.

[ES]: In the future, if the vehicles have longer driving range, of course they would become more attractive. But also the thought of tomorrow, new vehicles might be very much improved, and this holds you back on buying it today. When you think that something going to be even better in one year from now, maybe you are then too early to buy it. So this dilemma is also tricky.

[ET]: Well thank you a lot for your time, and willingness to help me with my research.

Interview Björn Nykvist

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Björn Nykvist is a Research Fellow at Stockholm Environment Institute (SEI). He has a PhD in Natural Resource Management and has worked from 2005 on sustainability, climate change, and governance of energy, transport and natural resources. Björn main interests are innovations, policy analysis, and governance of socio-technical technological systems and natural resource management. Two sets of research topics are currently handled by Björn: Policy analysis and governance analysis of transitions between different socio-technical regimes, including assessments of the technical potential for battery electric vehicles, and studies of the low-carbon transition of the Swedish heat energy system; and research on social learning, adaptive governance, and multilevel governance in natural resource management. The interview took place on the 19th of April 2017 at the SEI office in Stockholm.

[BN] = Björn Nykvist

[ET] = Eric Tol

[ET]: Good morning, my name is Eric Tol and I am a Master student at the Delft Technical University. I will elaborate a bit more on my thesis research. It consists out of a desk research and interviews. The goal of the interviews is to find information to is not yet contained in current literature, and also to discuss things that I have found in literature. This morning I had a read through your article again, and I have some questions concerning the paper. I also have some open questions after that, and at the end some detailed questions which I have found in literature.

[ET]: From your paper I have read that other fuels are supported here in Stockholm, and therefore I suggest also in the rest of Sweden. What causes this support on different technologies? What I have seen in Norway is that they focus a lot on Electromobility. They see it as the future technology to replace the ICEV. Here there is a wider scope, can you explain that to me?

[BN]: So I think that to my knowledge in both countries, you would have to have to look at recent history to find the explanatory factors. For Norway, the combination of early support for EVs, with not that many other options domestically, so the fact that it lacks a motor industry. That is a factor in Norway. That made it easier to go all in for EVs. Combine that with a favourable economic situation, from which you can get high incentives and so on. All those things are a bit of history and present in terms of the conditions that have favoured EVs in Norway.

[BN]: So back to Sweden, you would similarly have to look at present and longer historic technological developments. For Sweden, I think that we have had a strong bio-fuel development. Over the years our focus has shifted from methanol early on, to ethanol, and to bio-gas, and back and forth between the different options. Most recently HVO (bio-diesel), the more modern version of diesel that you can blend in your diesel car. There are also some fuels on the horizon. I am not a bio-fuel expert, but to sum it up; Going back to the oil crisis, in the 70s and 80s, there was a lot of research being done in order to reduce our dependence on

foreign oil. This has benefitted bio-fuel development. With some incentives and some support for basic research and R&D. Now that we have EVs on the table, with HEVs, PHEVs and full EVs, all of those come on top of this historical development of bio-fuels. These are also supported, and the support has varied, with support for individual bio-fuel technologies that has varied over time. The net outcome is a plurality of multiple options on the table. That explains largely the difference between Norway and Sweden. It is broader here as you framed it.

[ET]: What I have seen from the incentives in Sweden is that they are more interpretable for low-emitting vehicles. In Norway it is strictly zero-emission vehicles. Here it is more that if the technology has low emissions, it is supported.

[BN]: Yes, so general, in terms of climate policy, that mantra to have a technology neutral policy that look at CO_2 per kilometre, that is quite strong. That is the prevailing discourse on how to treat climate change. And there is less interest, or less political feasibility to support one individual technology. You read my paper, and I have some evidence that there is a hesitation to support one technology too early, such as with ethanol.

[ET]: Was it the graph in where there was a peak in 2008?

[BN]: Yes that one. We have some quite a lot of support for ethanol. The political alliance between the environmental party and the social-democrat party made sure that they enabled, through some legislation, this development. And this back-fired quite substantially when the debate started nationally, and internationally, on bio-fuels picked up. So what happened was that towards the end of the decline, as a post-mortem analysis, the environmental party said that they did wrong. You could hear some public statements from some politicians that maybe it was not a good idea. But it was done with good intensions. You have to view this high decline of ethanol cars as a high ambition level of trying to reduce emissions. So it not that was a failure, it was a experimentation to decrease emissions.

[ET]: Well I have seen this figure of ethanol car sales, with the decline from 2008. So it is interesting to hear this in another interview. You also mentioned that car manufacturers being present in Sweden that they have some influence on the shift of the technology. How would you say that this can be seen in the diffusion. Is there a hesitation, or is there a lobby from for instance Volvo saying that the focus should be bio-fuels instead of electromobility?

[BN]: Well in my paper it came up in a few interviews that there ought to be at least a link and a explanatory factor for why we have preferred PHEVs versus EVs. I think it is not only true for Sweden, if you look at the past 5 or 10 years of the development of PHEVs versus EVs, it really quite few manufactures that have put serious effort into pure BEVs. The vast majority of the established players regard PHEV the forth option for the near future. So it is a more incremental innovation, easier to embrace for the car manufacturers. Since until very recently, the costs of batteries were too high to consider pure BEVs. It has just not been on the table to go all the way. Now the landscape is shifting. So it is a different equation today.

[BN]: So that gets us back to your original question. So how does this influence or connection between the industry and the government work out. I think that is quite clear if you look at history of how both have expressed their thoughts on the different technology options. They

did not really consider EVs until quite recently. Now they are considering it due to these shifting trends. It is only natural that they are one of the most important industries in Sweden that the government is receptive to on how they view the world. So I do not have any evidence that they have some special channels or tangible impact on the policy, but of course their understanding on how the industry develops is very important. I think this just have and will continue to come through in our rather open, and to some degree quite participatory decision making policies. That you have inquiries of different kind and knowledge from different stakeholders before you have legislation and so on. And then of course you have your politics on top of it that determines the actual outcome at the end. But you do have a lot of information coming in. The information from the vehicle industry is a very strong component. It may be more elaborate than that, but that is enough for being a different picture between Norway and Sweden. In Norway we do not have this factor, we do not have a domestic car industry in Norway. There is a good study by Sierzula on what factors you can statistically that are driving adoption. In the same way, they find that if you have a car manufacturer established that do EVs locally, you have better pick up or adaption of EVs. In the same way, you can speculate that if there is a strong domestic regime player, than you would have a lower pick up. So I think there are two sides of the same coin.

[ET]: I have read the paper of Sierzula that you mentioned, it is also co-written by my professor.

[BN]: Yes it is a very good paper.

[ET]: These were the points I wanted to discuss with you concerning your paper. Now I would like to move to the open questions. How do you see the process of the adoption of BEVs? How do you think where the process is currently? From my study the classic adoption curve is shape like a S. Where in the curve do you think we would be now in the adoption of BEVs in general, and in Norway and Sweden.

[BN]: If you take a national Swedish perspective, I think it is still early days. We have definitely progressed, from the paper 2 years ago, we can be considered not being a laggard, but not on top of things that you could expect. That was our argument in the paper. It has improved since. Pure EVs are selling better, and PHEV are selling better. If you look at them combined we are quite high up now, it is increasing quite rapidly. So it differs if you have BEVs or PHEVs as a focus. If you have them combined, it is much more positive now. If we talk for Sweden nationally, we are still not on the point of no return. There are definitely a lot of barriers, Volvo has just changed their strategy as we discussed before. They have a more tangible time line for their EV program, which will come out in 2019. Those plans are now becoming more concrete. And when you see this happening, these plans, and vehicles appeal to consumers, then you are in a different situation. You have a domestic manufacturer, Chinese owned, as an important driver. If Volvo creates a EV and some PHEVs, then you are really at the take-off phase where we are initiating change, such as in Norway now.

[BN]: Another answer to your question is that we have already made the transition under certain circumstances. In Norway, with high incentives, with lower resistance in different ways, with a supply of different vehicles which are non-domestic, and these suppliers are willing to bet and scale up production for a market as Norway, you are past the point of no return. The

transition is happening. Globally, it is nowhere certain that it is taking off. I could very well be that if incentives are scaled back, sales will drop.

[ET]: Yes at the end of 2017, the incentives are being evaluated, and some incentives will end in 2018.

[BN]: Yes and here you can get the rise and decline situation as with ethanol, but then from a higher top. Simultaneously there is less attention on the transport sector. Politicians prioritize the electricity grid, as we have so much solar and that is reducing CO_2 emissions in the power sector which is more important for the time being. And then it dies down a bit, and then you have to wait for a fourth EV wave. In the beginning of the motorized vehicle, EV were sold more than ICEVs.

[BN]: BEV could die down or it could become a small gradual growth where BEVs become a niche and continue become a niche. Maybe FCV become the new solution. Until recently all global energy systems pointed to hydrogen as being the next energy source. That may be the final key or technology solution.

[ET]: What potential factors could influence the adoption of BEVs? You mentioned already some barriers, and some factors that foster the adoption of BEVs. Are there any more factors that have come in the recent years?

[BN]: I think that the key uncertainty that can change the trajectory of where we are right now, to something more positive. Or something that could make it not fly, is the size of batteries, and their charge, and charging times. Maybe a large battery that charges slowly, or a medium sized battery that can be charged in two minutes. A breakthrough in charging technology is needed, and currently this remains one of the main uncertainties in EV technology. I you would like to get a 100% penetration rate of BEVs, than then charge equation should be solved. These have to be solved to get higher adoption rates. Or you would need a really strong incentive to counter the charging problem. It is a combination of the utilities you seek. That combination has to work out to get a higher adoption rate.

[ET]: And on the social side, are they influenced by the technical items you told me. Are there social aspects that influence the adoption of BEVs?

[BN]: Well on the social side, quite a few of them are related to the charging equation. Range anxiety, the possibility to take your vehicle where ever you want.

[ET]: Charging anxiety?

[BN]: Yes you could say charging anxiety. Basically these two. But then there are other cognitive areas as well. When you try out an EV, you get a completely new understanding about it than before. This is a cognitive barrier.

[ET]: Are there feasibility problems, where people think this technology is probably not going to work?

[BN]: Maybe, but is more challenging is that you basically do not know. There is no data on how these batteries will hold over time. The lifetime of these batteries is largely unknown. We

know that leading manufacturers guarantee 100.000 to 150.000 kilometres. Some states something about the number of charges. The is no science on there, the verdict is still out there.

[ET]: And the prices of second hand BEVs.

[BN]: Yes, those are real uncertainties, not just perceived uncertainties, because we basically do not know. That is of course a barrier. When that is solved in 5 to 10 years, then we have a lot of EVs coming to their end of lifetime. Then we have a final verdict on how the technology actually worked out.

[ET]: From my interview with Eva Sunnerstedt I heard that a lot of cars that are sold in Sweden are second hand cars. Do you think this also has a difference in the BEV adoption difference?

[BN]: I think she means that the majority of cars sold are lease cars. That type of leasing accounts for about 50% of cars sold.

[ET]: I have one more question for the open question part. How do you think that factors that determine BEV adoption inter-relate? I tried to analyse this myself, for instance having a high GDP per capita creates a point that relative switching costs, high purchase price for cars, are more easily taken.

[BN]: Yes I see what you mean. One other observation that came up in literature that studies Norway is that a lot of EVs sold are bought as second cars (second car next to existing car). Norway having a sizable higher GDP per capita than Sweden, and also more people having two cars, than the market niche for being the second car is higher in Norway. That is another factor that makes it more favourable in the Norwegian case.

[ET]: Are there any other contextual factors or cultural differences between Norway and Sweden that could influence BEV adoption?

[BN]: In general, Norway and Sweden are quite the same. People from Norway and Sweden have roughly the same level of dependency on their cars. Also on the amount of kilometres, how the transport statistics look, it is quite similar. They are rather sparsely populated countries. Sweden is may be a bit longer between city centres. But it is roughly the same, so contextual factors will be mostly the same. The difference, what we already discussed, the historical focus on bio-fuels in Sweden versus the huge oil economy which is somehow married with the BEV development in Norway. But the logic is that they have a lot of money, from which the incentives are being paid for, from an outside view because I have not done any interviews in Norway. You have a strong economy, and on the one side the oil business which releases CO_2, and then the BEV project, but also one of the largest CO_2 capturing projects in the world. Due to their climate taxes, but oil drives the economy. We (Sweden) do not have an oil industry, but we have a car industry, and also a bigger bio recourse economy, which has ties to the bio-fuel debate. How large these ties are and how they play out I do not know for sure, since it is not my expertise. It is not as easy as one to one coupling. Historically it has been more crop than forests. On transport demand, the countries are quite similar. The differences are within the socio-technical returns to the industry, and the economy with regard to the industries, oil and biogas. And also as you painted (industry-environmental-market policies in

Norway), the whole ecosystem following the Th!nk car which developed, the incentives and then the market in charging.

[ET]: Do you think that, on how the BEV process in Norway was made, that this is a correct way to do so?

[BN]: Well you need to have all the building blocks in place, because the barriers are quite large. You have the cognitive barriers, the perception of a new technology that is so important on how you live you daily live. It is a big economic investment when you buy a new car. The second or even the biggest investment one makes. There are many structural things around car ownership and car industry that makes the barriers quite high. That's why you need all the building blocks in place. So you need the charging infrastructure, and the supportive ecosystem in a variety of different ways, like they did in Norway. It is an effective strategy like you say. But there is really no other option if you want to have a big fast uptake. So it is not only an option, it is the option. You need to have the pure economy worked out, you need to have the ecosystem around, the charging and the skillset. Electricians have to be educated to work on the infrastructure.

[ET]: What kind of reverse salients are there that hinder the system? May this a repeating question.

[BN]: It is, but let us put it into a different way. Consider a system where you have no incentives, like the technologies are competing on equal terms. This is not as in real life, but let's pretend. We do not have any special incentives for BEVs, it is only the option on how we tax carbon in Norway and Sweden, which is roughly similar. The I think that what is hindering a fast development, or what would have hindered the development in Norway, if that component of monetary, so the VAT exemption and vehicle registration tax, those two have been missing. As they are in Sweden, we have the initiative of the 40.000 SEK, if all those would be not there, you would have a slower growth rate. I would still be that PHEV and BEV would be developing, only at a slower rate. So there you end up with costs being the main reason that can hinder a more rapid progressing of this transition. If I would have to point out one factor it is still costs. Whether we will have a successful transition or not will dependent on that, and how. But as it currently looks, it will only come down to how fast the transition will happen, because the ball is already rolling. For example, Tesla and other pure BEV manufacturers they do sell these vehicles to some degree in a lot of different markets, but of course they sell more in countries where there are incentives. What happens is that you get learning, and you get the economy of scale, and we now see a quite rapid progression towards affordable models with decent range. And if that pans out, as it now looks like, you will see quite rapid development. If all the subsidies disappear, then the same thing will happen, but then over a longer period of time. That is my impression.

[ET]: Do you think the government could do more to stimulate the adoption? Or should do they?

[BN]: Well should do is rather a political question. Let's start with the first one. You can definitely see that some countries have stronger incentives than others, and for quite a few cases it need not be a very costly tax deduction or VAT tax exemption, such they have in

Norway. We have a very strong bonus malus in certain countries such as France, which you can set the admission level where ever you want to. It could be the equivalent of 15.000 Euro's or 5000 Euro's per car at purchase. Countries have different ambitions levels and that in turn boils down to what is political feasible in each country. So yes, you can always do more. We are now in the process of changing our subsidy system in Sweden from the 40.000 SEK system to the bonus malus system. It is slightly more ambitious.

[ET]: As a last question, from literature and from interviews, there seems to be a non-consensus on the transferability of the Norwegian policies. What is your opinion about the transferability of Norwegian BEV incentive policies?

[BN]: This is a rather interesting topic. In general, from a socio-technical point of view, I think the current research forefront is highlighting that there are so many different aspects that make transferability quite questionable, that is one thing. The other thing is that actual completed transitions, that are fundamental enough to be comparable with the type of transitions that we are talking about now, such as the total shift of the transport sector, there are quite few historically. It is one thing to analyse some historical changes, but it is very difficult to make full analogy with all the changing parameters. The whole discussion on transferability is quite challenging. It is highly contextually dependant. On the other hand, you can say what is hindering, or making it context dependent is more in terms of politics in the end. Because if you had significantly ramped bonus malus system that made the costs difference similar to Norway, it could be tax revenue neutral for the government. And they could easily copy some of the developments on the charging site, just ramping up some of the ambition level. It would not be too costly. Quite a few components of the Norwegian strategy could be copied. If you combine that with some revamped ambitious bonus malus system, then of course you could have a similar development as Norway since the countries are quite similar. So in the end, there is some transferability. When you would adapt the Norwegian case to another country, the core barrier to that happening would be politics rather than contextual differences.

[BN]: There was an opening for political commitment in Norway due to favourable economics, lack of barriers of different kinds, and an earlier phase of support of these local niches of the manufacturers. The ground work had been done for quite some years to scale up the ambition. It that sense it was not that unique, but the core was a political commitment and economic capability of doing the whole thing. You can design a way that it is transferable but politicians need to be there to actually support that.

[ET]: And does the EU pose some sort of influence on the innovation rate? Is there may be a difference between Norway and Sweden, as Sweden is part of the EU and Norway is not.

[BN]: Good question, but sorry, I do not know. I know that there is a new directive on charging infrastructure. I have not looked into that in detail. So as you say, it is a different process. If it is materially different I do not know. You do have some high adoption rates in countries in the EU. So I do not think the EU is a big explanatory factor in this case.

Interview Mikael Askerdal

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Mikael Askerdal is a thematic researcher in System Studies & Methodologies at the Swedish Electromobility Center (SEC). The SEC is situated at the Chalmers University in Gothenburg. Mikael does research in the field of Information Management for future energy efficient vehicles. His is currently hired from his present job working at Volvo, where he has worked for the last 17 years. Mikael's has had several roles within Volvo, which include being a Technology Specialist, a Development Engineer, a Project Manager and Team Leader. The interview took place on the 21st of April 2017 at the SEC department, located at Chalmers University, in Gothenburg.

[MA] = Mikael Askerdal

[ET] = Eric Tol

The interview starts with a presentation of Mikael Askerdal about the Swedish Electromobility Centre (SEC).

[MA]: Hi, my name is Mikael Askerdal. I am the thematic researcher. While there are actually two in my theme. We are employed by the centre, together with two others. The four of us are employed by the centre. This is the centre which focusses on networking, connecting the researcher with the correct persons in industry.

[ET]: Are you sort of a hub inside all the actors?

[MA]: Yes, well we want that to be. We have 5 different themes.

[ET]: System Studies and Methods, Electrical Machines and Drives, Energy Storage, Vehicle Analysis, Fuel-Cells (reading from the presentation sheet).

[MA]: These studies compose out of further components. Vehicle analysis does have a helicopter view on how different technologies compare to each-other. For example we have we have a study on when it is suitable to have fuel-cell vehicles and when it is suitable to have BEVs.

[MA]: In System Studies and Methods, we have methodological challenges. They are looking at things that do not fit in one single subsystem, so at the interaction of these subsystems and you are going to deal with that. It is about the larger problems, not the details, so on the complete vehicle level. Most of us here are control engineers, so we are used to these dynamic models and computational methods, simulations, and so on.

[ET]: I also see the 'System Aspects of the Vehicle Interaction with the Surrounding Environment and Charging Infrastructure' (reading from the presentation sheet).

[MA]: It is quite wide area. And energy management is sort of my specialty. I actually employed by AB Volvo Trucks. So the Chalmer centre is sort of renting me four days a week. So I am working both jobs at the same time.

[ET]: Are you more of a consultant? Or more an employed researcher?

[MA]: I do not know really. I have a two year contract, and I am employed by the research centre to do research. But at AB Volvo I work as a Technology Specialist. So there are synergies.

[MA]: Here (presentation) you can see the organisations and industries such as Scania, AB Volvo and Volvo Trucks. In our thematic group it is Chalmers University and University KTH (Technical University Stockholm) in our group, but there are more in the centre. You also have Lund and Uppsala. But it are the major universities that are involved. Here are some projects we are working on.

[ET]: I see (from the presentation sheet) that you are working on 'Can road resistance be divided into vehicle independent and vehicle dependant variables. Can vehicle dependant variables be estimated in vehicle log data.'

[MA]: Yes, in short. The project focusses on these variables such as wind, road type, rolling resistance, etc. We will collect data from a lot of vehicles in some kind of cloud solution, and then try to find the road resistance. That is in short the thematic group and my project.

[ET]: Thank you. I will now tell you about my research and my thesis. I do my thesis at the Technical University in Delft, which is in the Netherlands. I am researching the adoption of battery electric cars in Norway and in Sweden. My research focusses on the reasons behind why Norway is able to implement such drastic, and on the other hand efficient, BEV policies. That is what I am doing. My methodology consists out of a desk research and interviews, to get to know new information not contained within literature. I already spoke to the municipality of Stockhom, and yesterday I had a meeting with Björn Nykvist who wrote why Stockholm is not a leader in BEVs. Furthermore I had to interviews in Oslo. One at the Transport Institute of Economics, and one at the Elbil organisation.

[ET]: My first question is, how do you see the process of BEVs in Sweden?

[MA]: Sorry what do you mean with that question?

[ET]: I mean that EVs are installed in Sweden. And there is an adoption difference between Sweden and Norway in market share, and on government incentives.

[MA]: Yes, it is (incentives) much stronger in Norway. I have thought about that. I think one of the reasons is the vehicle industry in Sweden. If you talk about passenger cars, Norway does not have a car industry as large as Sweden. I do not know if they have any car brands. If we would adopt the same policies, and everybody starts buying EVs, than I guess Volvo would have a problem. They would lose market share. Volvo now do not have fully EVs to sell at least. They could adopt, but the problem is that Sweden may be too small, it is a too small fraction of

their share. It is very expensive for them (Volvo) to create an entirely new model. It is difficult to be in front.

[ET]: So it is a radical decision looking at the current business structure?

[MA]: It might be negative for the car industry in Sweden right now. It has to be more balanced with the industry.

[ET]: Volvo focusses on ICEVs and also PHEVs, is this because they already invested in company infrastructures, which focus on ICEVs? I can imagine that the PHEV is an incremental change to ICEV.

[MA]: I think most companies focus on areas where they can make a profit as much as possible. It is difficult to predict the future, so if you are not completely sure that it will change, than I think it is reasonable to think tomorrow will be the same as today. At that it will change slowly.

[ET]: Do you mean the future of where the car industry is going?

[MA]: Yes. Because it is still uncertain that the EV will be a large proportion of the car market, you do not know this yet. So it is a difficult time for car industries. Should they invest now, should they wait.

[ET]: Where do you think the uncertainty comes from? They do not know if all the systems are co-evolving?

[MA]: Well there are a lot of uncertainties. They are being manufactured now, but there are still thing that have to be solved. They are still too expensive, except when you get governmental incentives. You can also not have them forever. They have to become cheaper in the future. The batteries are the most expensive component. Prices are going down, but there may be a shortage of materials. These batteries have rare materials in them. So there are uncertainties for EVs. Electrified roads could be a solution. Also for oil there are uncertainties, which is getting more and more expensive. It is a global market, Sweden cannot set the oil price. We can put taxes on it, but that is all we can do. There are also range problems. You cannot sell cars until solutions are there. There are uncertainties yes. If you decide to build electrified roads, than you have to decide what technology you are going to use. If you use one technology here and another somewhere else, things can get messy. For trucks especially, you cannot have one system in Sweden and another in Norway.

[ET]: Do you think that, where Volvo is not focussing on EVs, that this has an effect on governmental policies? Where Volvo is such a large employer.

[MA]: I think they take it into consideration. I would guess that they have a dialog. Otherwise it would be stupid not to have in this case.

[ET]: Here in Sweden, a lot of renewable energy sources are offered. I have seen bio-fuel, E85 bio-ethanol. In 2008 a lot of bio-ethanol cars were being sold, but eventually the European Commission asked some questions about it. How do you see this open vision on these

technologies? In Norway the prior focus is on zero and low-emitting vehicles. Here (Sweden) there seems to be a wider focus.

[MA]: I think that this will be the future with different niches. Electrified vehicles such as HEVs could be a solution. For trucks, HEV could be a good solution. It is very difficult to say.

[ET]: We already discussed some potential factors that could influence the adoption of BEV. We talked about the expensive part about the technology, the battery costs. Also range anxiety and charging infrastructure. Could there also be other factors that could influence the adoption of BEV?

[MA]: Well there are still questions about the lifespan of the batteries. If you ask battery experts, they will say that it is very difficult. For me that is one of the reasons not to buy an EV. If the battery pack in your car breaks, it will be very expensive to fix or replace. That could be sold by leasing the battery packs. One thing which I have heard from EV users that it has to become more user friendly. Now you have to plug them in. Automated charging has to come. Also charging itself is a problem. Charging has to go quick. If you are used to fill up your tank in 1min, than it has to be faster than the one hour now.

[ET]: Do you think that on the social level, there are factors that influence BEV adoption? Such as network effects?

[MA]: Sorry, I do not know.

[ET]: As a last question for the open question part, do you have an EV yourself?

[MA]: No, I do not have an EV myself.

[ET]: Is there a particular reason why not?

[MA]: I have a (ICEV) car now, and it is quite old. But I do not know if I would buy another one (ICEV), or an EV. The main reason is that an EV will be more expensive. For the same monthly costs as a Nissan Leaf, I could have a Volvo V60 diesel. It is still too expensive.

[ET]: In Norway, 2/3rds of people who buy an BEV have cost saving as their most important motivation.

[MA]: One survey that I read revealed that for EVs the purchasing costs are much more than the operating costs. In that sense, investment costs is probably the main problem.

[ET]: If costs stay high, than switching costs stay high, and people will not buy the new technology.

[ET]: I also have some more detailed questions. These are questions I got from literature. Do you think the visibility of the financial benefits contributes to the attractiveness of BEVs? In Norway the use special number plates to highlight the BEVs.

[MA]: Yes, in some segments. The ones that fit the profile. I think in cities that when you cannot get around the congestion than it will be very attractive. My vision of the future is that congestion will be the main problem. And if EVs could solve that, than that would be great.

[ET]: Do you think that there are cultural differences between Norway and Sweden? With the respect of the use of vehicles.

[MA]: Maybe we have some differences with the manufacturer history. We are quite loyal to certain brands. In that case it could be more traditional. In that case you could say more conservative. I was thinking if you do not have any (domestic) manufacturers, that you could have a more open view.

[ET]: Have you seen at Volvo that there is a high brand loyalty?

[MA]: Well at Saab this is even higher, because it is an older brand. Those people are quite conservative. From the truck industry, the Scania drivers are very conservative. Furthermore I would think that Norway has more hills. Recuperation is maybe more convenient there, but this maybe more for trucks. For passenger cars, congestion is probably more important.

[ET]: There is a difference between Norway and Sweden on GDP, and GDP per capita. Do you think this has an influence on the focus of the government to certain techniques.

[MA]: Yes could be. These incentives are costly. There was another thematic researcher from Estonia. He presented what happened in Estonia. They put a lot of money into the charging infrastructure. And then they had these incentives to make the EVs cheaper. In the years after, the sales of the EVs they increased quite a lot. But after a couple of years, the government ran out of money, and the project was stopped. Then you saw the sales of the EVs collapse. The utilisation of the stations went down fast. He showed that only two stations were used, from 150 that were built.

[ET]: So the financial package is very important on the incentives that are provided?

[MA]: I think the less money you have, the more careful you need to be. Timing is very important here, and Estonia was probably too early. Norway probably can afford it, they can continue as long as they need.

[ET]: Interesting. In Norway the incentives are reviewed in the Autumn of 2017.

[MA]: It will be interesting to see what will happen. In Estonia the sales of EVs crashed when incentives were stopped.

[ET]: From my interview on Tuesday at the municipality of Stockholm, I discussed the use of the Swedish forests to make bio-gas and bio-ethanol. As Sweden has so much forest, and therefore renewable energy, do you think Sweden wants to be energy independent, and therefore support other transport techniques rather than EVs?

[MA]: No I do not think so, not for the cars. For trucks is different because they have to drive a lot longer. So they need some kind of fuel, until there are electrified roads. What I have heard, and I do not know if it is true, is that these bio-fuels could go to aircraft and shipping industries, and that electrification would go to cars and eventually trucks. I think they are different niches, and that these fuel sources are not competing in the future.

[ET]: The Swedish government has a package of incentives for BEVs. They consist out of some charging points and reduced vehicle tax and maybe some bonus malus. Do you think the Swedish government should do more?

[MA]: Well less would not be a good idea. But do you mean should or could? That is a difference.

[ET]: With hindsight I mean both. Could and should they do more?

[MA]: They could subsidize the price of EVs. But you have to be in the right time to do that. The probably could put more money into it to make it more efficient. I am not sure they should. They should come to the centre. It is a difficult question.

[ET]: Do you sometimes get questions from the Swedish government?

[MA]: Yes, sometimes they ask us questions from the energy agency. But most of the time they ask us where or what to research, not on their policies.

[ET]: Is there then a bias towards one technique that the government wants to investigate?

[MA]: Well it is shifting all the time. I would say that the last years it has shifted from hybrids to fully EVs.

[ET]: Where do you think the uncertainty comes from?

[MA]: Some people who work with cars think that the hybrids are a middle step between regular cars and EVs. You have both techniques. For my field of work it is really interesting. EVs are relatively easy compared to hybrids. Bio-fuels are sort of outside our scope.

[ET]: On what techniques do you think Volvo has its focus? Do they think that PHEVs have the future?

[MA]: Volvo is a very big company. You have people who believe in EVs, and some that do not. I say that it is slowly shifting to more electrification. Some people believe it shifts way too slow.

[ET]: What do you think about the role of Tesla, an pure BEV only company. Do you think that they are disrupting the market? Do you think that changes the mind-set and focus of the incumbent firms?

[MA]: Absolutely, I am quite sure about that.

[ET]: And are the firms from Sweden and Germany are pushed therefore more to Electromobility?

[MA]: Yes, you have to get 'on the train', or else it is too late. But still, they are not sure yet. Tesla are one thing, their cars are quite expensive. Except in Norway perhaps. But Nissan Leaf is something else, they are doing interesting things. Fuel cells are another thing, but they have even greater uncertainties. There is one hydrogen fuelling station I thought in Sweden. In 1998 or something at Volvo they thought FCV would be the promising technique, but this is still in the promising stage. Uncertainty is still there.

Interview James Odeck

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James Odeck is a professor at the Norwegian University of Science and Technology. He teaches transport economics and planning to post graduates and PhD students, on the Department of Civil and Transport Engineering (Trondheim). He also teaches at the Department of Economics at the University College Molde. Furthermore he is a Senior Research Economist for the Norwegian Public Roads Administration. He specializes in applied transport economics, production economics and performance measurement, and he has several publications on transportation research and EVs. The interview took place on the 3rd of May 2017 using Skype.

[JO] = James Odeck

[ET] = Eric Tol

[ET]: Good afternoon. Thank you for your time and willingness to help me with my research. I have already send you a short description of my research, but I will explain a bit more. In my thesis I want to find the reasons behind why Norway is able to implement such an effective and efficient BEV policy. In doing so, my research consists out of a desk research and also interviews with stakeholders and experts in the field of BEVs. What I have comprised this interview out of is, at first, some open questions, secondly I have some questions that I have found in literature. I have read several papers about BEV technology, and also your paper. My question becomes, can you elaborate on how you perceive EVs in Norway. How are they perceived?

[JO]: Well the perception of EVs is gradually changing. Before, we in Norway used to produce some EV. The company went even bankrupt.

[ET]: Is this the Th!nk company?

[JO]: Yes. During that time, EVs were seen as small vehicles that had very short coverage. This was not a car you see (laughs).

[ET]: I have seen a Buddy (also an early Norwegian EV). It is a really small tinny vehicle.

[JO]: People thought how can I buy a car like this? I does not even cover 30km. But you see the development for lasting batteries that cover many more km's. That has made the EV a very attractive second car.

[ET]: What I have heard is that a lot of people buy the EV as a second car, but eventually they use it as their first.

[JO]: Yes they use it as their first. And with the government implementing a lot of goodies for EVs, the perception has become really good. The EV industry is creating EVs that can cover a lot of miles. Convertible cars like Tesla. At the same time the government is giving out tremendous amount of incentives. To people to buy those vehicles. So long as these incentives are still in place, and so long that the industry that produces EVs, soon produces EVs that can

match the traditional vehicle. Than the perception of the EV in Norway will be like any other vehicle.

[ET]: Do you think that, on that note, that the EVs are severely dependent on those incentives?

[JO]: right now the EV is very dependent on those incentives. By incentives we do not mean only not paying tolls, and that they can use the transit lanes. But it also means exemption from taxation, purchase tax and so on. But, I will say, even if there were no incentives, the fact that electricity is cheaper, could still be a factor that may make people buy EVs.

[ET]: So despite all the incentives the cheap energy specifically in Norway is an important factor in that?

[JO]: Yes.

[ET]: The electricity generated comes mostly from hydro-power, and a small proportion of wind power. Itself provides cheap energy, but does it also acts as being 'really environmentally' friendly for the EVs, if all the electricity comes from renewable energy sources?

[JO]: That, in my opinion, in regard in how people perceive EVs, I do not think that the average person who buys an EV is someone who is especially environmentally friendly. I think it is all down to costs. The total costs of running the vehicle, the generalized costs. Than we are back to the economic theory that says if the generalized costs of operating a vehicle is high, people are tend to buy less of that types of vehicles. Even in the vehicle segment today, you know that you buy a 4-wheel drive which consumes a lot of gasoline, than the operating costs will be too high to afford. The fact that if you take all the incentives away, the costs of electricity per kilometre, is just a small percentage of that of gasoline per kilometre. The operating costs of an EV will always be cheaper than that of a traditional vehicle. That is then why people buy EVs.

[ET]: In the long run the operational costs outweigh the high purchasing costs.

[JO]: Exactly.

[ET]: What I have seen in Norway is that these incentives really pull people into the EV market, because they are so cheap. From literature I also read that 2/3's of people who buy EVs buys them because of the costs. My question then becomes, how are the incentives actually paid for? Are they being paid for by the general large pot of tax revenue, or are they funded by extra taxing polluting vehicles.

[JO]: Neither of those two. If you look at the incentives, assume that the vehicle purchase tax is low for an EV, than one would assume that the government would some revenue for the tax collection. Than the question is how will they cover that loss? To that one can just simply say that Norway is a rich country and they most likely pay the incentives from the gasoline revenues, the oil revenues. Or they are taxing some other commodity or some other people to cover that budget. So obviously, they must do something. A second way to look at it is to look at the toll revenues. All the major cities have toll roads. The fact that EVs are exempted from

these tolls has become a really big problem for them now. It is a really large loss of revenue. Especially around Oslo, Trondheim and Bergen. So who pays for that?

[JO]: The thing that is straight forward in that it is the ordinary motorists, that have to pay for the toll roads, because the toll roads will have to be operated for a long period of time. Here it is the traditional vehicle user who is paying for that.

[ET]: So a percentage of the general pot of income goes to the incentives?

[JO]: Yes. And also you have municipalities spending. Before you had free parking for EVs. They have charging points that EVs could use to charge for free. So the municipalities are using their own revenues to pay for the incentives as well.

[ET]: Some incentives are based per region? I heard that fees for tunnels and toll roads that are not taken into consideration on other parts of the country.

[JO]: Yes. One other thing is that the larger concentrations of EVs are in the big cities, where the tolls and the transit lanes are. But, we have seen a large increase also in smaller cities. There you have for instance the ferry fees. In that case, the government has to compensate the ferry companies for their loss of revenue.

[ET]: The incentives are being arranged by the municipalities, but private companies have to conform to that. The private companies being the ferry companies.

[JO]: Yes. A couple of the ferry companies tried to sue the government to give them transfer's compensation. But that has not worked.

[ET]: Something that we have discussed earlier on the phone was they are considering to start toll payments for EVs again? Are they going to ask a certain percentage?

[JO]: Yes. I do not really know what the rates will be, but they are going to be around 50% of what a regular vehicle pays. We are seeing that trends are changing. In Oslo now in the rush hours the EVs are not using the transit lanes.

[ET]: Does this come from the success of the EVs?

[JO]: What we see in Oslo, especially in the east part where the rich people live, we saw a tremendous increase in EVs that use the transit lanes. Then it became a problem for transit services. The busses suddenly found themselves in queues. Congestion on lanes that are just for them.

[ET]: That is really a reverse salient of the system I would say.

[JO]: Exactly.

[ET]: Another point is the access tax in Norway, which is the highest in the world. I can imagine that this has a large influence on the attractiveness of EVs.

[JO]: Yes, but this a static point. We now have EVs that are increasing tremendously in range capacity, and the EVs are comfortable. If you remove all the incentives such as the toll roads,

etc., but keep the import tax exemption. Than this would be enough for people to buy the EVs.

[ET]: Do you think that this is the most important incentive?

[JO]: In my mind I think so. And also given that we have seen that everything should become equal with the traditional vehicle. The comfort and the (range) coverage, like Tesla is doing. If that kind of development is going to continue, than the most important incentive will become that import tax.

[ET]: So what you are saying is that the EV market is solving many of their own issues. The range and the attractiveness. But the buying price is still something that has to be compensated for.

[JO]: Yes.

[ET]: On the note of success and fail factors, we have already discussed some. The incentives are a strong point in making the cars attractive. What you said is that the battery technology is also important. Are there other factors that play a role in the diffusion of EVs in society?

[JO]: One of the major important factors impacting the diffusion of EVs are charging points. The spread of charging points. The government and the different communities have been very helpful in having country wide charging points. We see for example in Oslo and the Trondheim area that they have quick charging points. Within 40 minutes you get the battery fully charged, or at least 90% charged. That does help a lot because Norwegian people like to spend their time in the mountains.

[ET]: Especially during Eastern people go to their hut.

[JO]: Yes, so you can simply think that if you cannot get charging stations along the route, like petrol stations. Then those who have EVs cannot go to the mountain cabinets. The spread of these charging points has been very important for those who have EVs.

[ET]: In Oslo you have two major charging companies. These are Fortum and Grønn Kontakt. And these are then private or public companies.

[JO]: I think that they are publically sponsored companies.

[ET]: Do you think that a more market phase is coming up, where more people are providing charging stations?

[JO]: This will be very drastic actually. I am trying to look at this. I think when the EV hits a point where most people are going to buy electric vehicles, than we are going to see a sort of petrol station style of competition style.

[ET]: The reason why I am asking this is that, from other interviews, I got the idea that if you look at the timeline of the incentives where the first ones were implemented in the early 1990s. Eventually they evolved in more comprehensive incentives. At first there was an industrial policy, in that Norway wanted to have their own car industry. This later became an

environmental policy. In the end, or what we are seeing now, is that it will evolve more in a market phase. What I wanted to ask is, was there a demand for a Norwegian car industry?

[JO]: Well I cannot remember so much about that. But I was thinking, there was a nature of two things. There were people who were thinking about the environment. But then again, I think it was trying to support a Norwegian car industry, the Th!nk company. Norway does not produce any kind of car as anyone knows. The idea was that Norway was going to become a car industry nation. So much was a support for the car industry.

[ET]: The industry did not really take off. My idea was that the cars were not attractive enough. Is that is something that is true, or other factors that caused the Norwegian EV industry to catch on?

[JO]: The thing is that the EV at that time was not attractive enough. The material used to construct those cars, you know, they looked like carton boxes moving on wheels. And believe me, the income among Norwegians, compared to now are two completely different things. If at that time, you wanted to buy a car, you needed to put your money on such small vehicles with small luggage spaces. They were tiny cars that were not able to compete with todays car.

[ET]: So they were designed for the time being?

[JO]: Yes, for the time being. At that time I just finished school and we used to look at those small cars and laugh. At that time at most they would do 20km's (range).

[ET]: At some point the environmental policy caught on. What was then the deciding factor that made the whole thing work?

[JO]: I do not know for sure. There is only so much that you can remember.

[ET]: What I mean is that, these small cars were not going to work. From around 2008 there was a shift where car makers started to make EVs.

[JO]: Well at first cars that appeared to be able to match the traditional cars where the HEVs. I think that such kind of vehicles caused policy makers to believe that that would be the way to go. The EVs caught on from there. The heavy vehicles where still polluting, and they saw that the EVs were very clean. Something had to be done to motivate people to buy these vehicles.

[ET]: At some point then the diffusion started. Now we see a widespread diffusion. What we then not see in Sweden is such a diffusion of BEVs. My research concentrates on these differences. In Norway a very stable policy can be seen on BEVs. What I further have seen in Sweden is that there is not such a stable policy. Do you know what factors influence this policy stability? Are there fuel sources in Sweden that are being pursued?

[JO]: I think that why the policies are different is more because of institutional differences. I think that that is the main reason. There are two things. The first is the institutional difference class. And the government willingness to use the taxpayers money. We have a situation whereby in Norway, once something is sanctioned, the government is willing to spend money on it. That will be also because Norway is much richer. From the oil reserves, that richness is something that Norway can use, so tax-payer money on EVs.

[ET]: Is the reason that they have a higher GDP, makes that the switching costs relatively low?

[JO]: Yes, yes I think so. Especially things that people tend to favour. That is number one. Number two, Norway has implemented a lot of funny things for road users for decades. You know that you cannot drive 30 km's without passing a toll. You know that there are a lot of ferries because of the difficult terrain near the coastline (in Norway). People use a lot of money to use these. The government has subsidized a lot of these services, and the government is building a lot of tunnels and so on. In Norway, we are used that the government also contributes by charging people as well, to provide infrastructure. So once the government commits to build an infrastructure, then there is no difficulties in finding resources to finance that.

[ET]: So there are no difficulties on finding resources because they have such a high income?

[JO]: They have a high income, and they used to paying a lot for the distribution of infrastructure. The use of government resources per unit of infrastructure is very high in Norway.

[ET]: So then you would suspect that the overall quality of the infrastructure is quite high?

[JO]: You would think so, but it is not yet. Because of the difficult terrain. All in all, it is much easier to give subsidies in Norway. The Norwegian government will easily subsidize something, compared to Sweden. And that is institutional framework. In Sweden on the other hand, charging people an extra fee, is taxation. As compared to Norway, Sweden does not want any taxation. Sweden will be more like the rest of Europe, where people resist against any increase in tax.

[ET]: They are sort of hesitant to paying more taxes?

[JO]: Exactly. The politicians are afraid to implement things that are equivalent to more taxes.

[ET]: So is this then more of a cultural difference?

[JO]: Yes it is. I know this very well. I once worked with a toll service on the Swedish – Norwegian border. There is a huge bridge. It would be financed with tolls. It worked well until it had to be implemented. The Swedish shared some very serious problems. By definition collecting tolls will be equivalent to taxing. According to them, road users are already taxed through the gasoline tax and the vehicle purchase tax. So tolling will be an additional tax. It could not be implemented. So they actually had to change the law, in order to implement that toll.

[ET]: On the Norway side of the bridge, I can image that they had a different situation.

[JO]: Yes, well, their toll is everywhere. The Norwegians say it is a way to finance the road that you drive on. It is a self-provision. All the tolls are used to build the roads, so you actually pay for what you are using.

[ET]: I see. But in Norway they also have tax on vehicle weight right?

[JO]: Yes, but then again, their mind set is, every Norwegian knows, tax on the weight of the vehicle, vehicle registration, there is nowhere written that that tax should go back to the vehicle user. That goes to a common tax base to finance other public services.

[ET]: Then the overall welfare goes up?

[JO]: Yes. It is a question of making people understand how taxes are used.

[ET]: Is then this then more transparent in Norway than in Sweden.

[JO]: If not transparent, the average person has a fairer understanding on how taxes are used. In Norway, you cannot come with an argument that because the government is taking a lot of money over vehicle taxes, then they should use it to build roads. You tell a Norwegian that, and they will say that it is a common tax that goes to a tax base that can also be used to build schools and other things. In Sweden it is more like that a larger proportion of the tax that is taken from vehicles is used again to provide for roads and those kind of things. It then becomes very difficult to argue for implementing tolls.

[ET]: Then this can be seen as extra taxation.

[JO]: Yes. That is one of the things that is very particular. And from planning theory, if I would say, there is one thing that policies in Sweden are more instrumental. But the fact that the Swedish would do a kind of formal evaluation to find whether if it is going to benefit the society at large. They are very instrumental. Like things need to be quantified and need to be find beneficial, before we can implement them, in Sweden.

[JO]: While Norway is more like consultation. Their planning is more communicative, it is more of a dialogue. They can do calculations of things are beneficial, but in the end of the day, it is good to have it discussion based, or communication based.

[JO]: So in Norway you will see that many decisions to implement things are done despite that the economic analysis shows that that implementation will not be profitable to the society, as judged by cost-benefit analysis (CBA). They will use the unquantified effects in these implementations. There is a lot of tradition in that even if something was quantified in economic terms, there will be some unquantifiable effects in the long run, that can make the project worthwhile to implement. So most of the discussions are based on that.

[ET]: So the unquantifiable effects in CBA's are more taken in consideration in Norway than is Sweden?

[JO]: Yes.

[ET]: And is the effect of having a higher GDP and higher GDP purchasing power parity, does that eventually mean that, in CBA's, that unquantifiable effects are taken more into consideration?

[JO]: Yes you can argue that from an economic point of view the higher GDP and income they are maybe more willing to compensate. That is a fair argument. But another argument, which is quite different from that, is that it is not always the case that a decision must always be

based on CBA. Because some decisions have to be politically based, especially if they are supposed to be distributional. An undertaking can have negative net-present value, but distributionally, it can have a lot of impact. The government may wish to implement it anyway. That is very typical for Norway, as it is very long stretched with a very low population density. So you want a large distribution of the effects. You may decide to build a road in a region where very few people are living, but distributionally these people also deserve a road. Such considerations are very common in Norway as compared to Sweden.

[ET]: If we then take this concept back to the EVs, what sort of example could we think of? Is it the pollution?

[JO]: Yes, the thing is that we can think, here we can think in terms of the fact that giving people incentives to buy EVs may not be socially economic profitable. That is what I said in my article. It is just too much, it is economically not profitable. But distributionally, it is a good thing because it leads to a reduction in pollution, noise, etc. So you are kind of redistributing. You are taking from those who are polluting and creating noise, and give them to those who are not polluting.

[ET]: And that is the effect of the tax exemptions.

[JO]: Yes.

[ET]: And is this also with the charging points everywhere in the country? So they work in the whole country.

[JO]: Yes exactly. And that is also why they have exempt all EVs on ferry fares, because they have exempt them from paying tolls in the cities.

[ET]: Ah ok. I have some last matters I want to discuss in the interview. What I suspect is that in Sweden, there are more stakeholders with a different agendas on renewable energy sources. On the other hand also on the availability on EVs. I would think about bio-ethanol and bio-gas that is being produced. On the other hand the existence of an already existing car-industry. How do you think that these would have an effect on the policies?

[JO]: I do not know. This is something outside of my knowledge.

[ET]: What I was thinking about is the car industry in the country. Since there is a large industry in the country, they sort of want to protect their industry itself. I would think that the EV is a too radical technology for them, that could result in that the manufacturers have to create other infrastructures to produce the EVs. Maybe this could upset the economy in the country. Is this something that could be true?

[JO]: From my standpoint that would be like conspiracy theory. Well that maybe happening yes. But if you look, Volvo is now creating an EV isn't it? At the same time we know that is the very same Volvo that is used for experiments for autonomous driving. Now, an autonomous vehicle is probably going to be an electric vehicle. Why they maybe be reluctant as you propose, I think that they know that the EV vehicle is here to stay. Their own reason why they

cannot motivate the process of EVs is, maybe as you postulate, they will know they costs of their traditional industry, most likely.

[ET]: That is something that came up to me after some interviews, and I wanted to ask it to some others whom I am going to interview. I know that it is a far-fetched story, but I think with the different agendas causes uncertainty by customers. In what technology will be the existing technology in maybe 10 or 5 years, and what car should I buy then.

[ET]: On a last note, I wanted to ask something about the incentives. Do you think that the government should do more, or do less with the incentives?

[JO]: So far, the incentives in Norway have been enough. They have worked according to their intentions. They have worked to the point that they are having adverse effects.

[ET]: That is what we have talked about with the bus lanes.

[JO]: Yes, we have suggested to the government that some of these incentives can be phased out. Let the tolls come back. There is no reason why they do not have to pay no tolls. Or at least they should pay some portion of the tolls. There is no need for them to use bus lanes. I think they incentives have worked. They have made the car manufacturers develop their concepts. They have made a large proportion of people buy EV and see how easy they are to use. They have served their purpose.

[ET]: The incentives have worked, and now the process is started where they are being phased out.

[JO]: Yes, in fact when they implemented the incentives they said they would at some point phase them out. That is already happening. The EV policy in Norway is working fine.

[ET]: Do you think that the policies and incentives used by Norway should or can be adopted by other countries?

[JO]: Many of them can be adopted. But there are others which would mean a lot of transfers, from the government to the people. It would mean a lot of financing. Like for example for a country like Spain it could be a disaster. Whereby exempting EVs for tolls would be a real problem. They can be implemented in other countries, but there will be a loss in revenue. There must be sufficient budgets.

[ET]: Are there further other incentives that would maybe struggle in other countries?

[JO]: This has to do with the cultures. What I have seen is that when there are tolls being implemented, there is always resistance and public outcry. In Norway nobody resisted against EVs driving in the bus lanes. But if you could do this in France, this could result in such resistance. People would ask you why.

[ET]: Also the access tax plays a big role. Buying a car in Norway is already very expensive.

[JO]: Yes

[ET]: Thank you for your time and your willingness to help me with my research.