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MASTER THESIS IN
EUROPEAN STUDIES

A new era for transportation in Europe?

Prerequisites for the electric vehicle introduction in Germany, France, Sweden and at EU-level

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ABSTRACT

Today European transportation is 96% dependent on oil, and the vast majority of the oil is imported. Consequently, the European Union (EU) has urged to drastically reduce greenhouse gas (GHG) emissions. Cars are responsible for 12% of Europe´s GHG emissions and the number is increasing. One solution to the current transportation challenges is the electric vehicle (EV), powered only on electricity batteries. The thesis studies the introduction of the EV in Germany, France and Sweden and at EU-level. The thesis examines the EV from three perspectives of importance: the institutional, geographical and industrial by using assumptions for each perspective and country. Using the notion of large technical systems that sees the EV in a system with components that can be added, withdrawn or transformed a comprehensive understanding of the prerequisites for the EV introduction can be made.

With the design of a comparative case study and help from documentation and interviews a picture of the introduction of the EV in three European countries is created. The main finding of the study is that each country has its own prerequisites for the introduction of the EV. France is the country that has been most committed to the EV where the industry and government have taken firm actions to introduce the EV. In Germany, a council has been created to work with the EV, whereas Sweden has many challenges left to introduce the EV in a large scale.

Keywords: The electric vehicle, transportation, infrastructure, Germany, France, Sweden, European Union (EU), institutional, geographical, industrial.

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1. INTRODUCTION

1.1 Background and purpose

Mobility is a major driver of economic growth and societal development and the passenger car has played a crucial role since the first vehicles were developed in early 20th century. Until recently, most passenger cars have been powered on liquid carbon fuels deriving from crude oil, such as diesel or petrol.[1] Europe is striving to be less dependent on oil imports and environmentally friendly cars is one step toward less oil dependency. Today European transportation is 96% dependent on oil, and the vast majority of the oil is imported. Consequently, the European Union (EU) has urged to drastically reduce greenhouse gas (GHG) emissions.[2] Cars are responsible for 12% of Europe´s GHG emissions and the number is increasing.[3] However, during recent years a shift towards more environmentally friendly cars that are not powered by liquid carbon fuels has been visible. According to a report *"Europe needs to diversify the energy sources used for transport, in order to meet climate goals and reduce its dependency on oil."*[4]

There have been numerous debates how the progress of encouraging environmentally friendly cars shall be reached. One of the solutions has been to promote the electric vehicle (EV), which is powered by electricity from batteries.[5] However, expansion of this clean fuel alternative lacks of three major obstacles identified by the European Commission (EC): the high prices of EVs, a low level of consumer acceptance and the lack of refuelling stations.[6] This has become like a catch-22. Since EVs is not that common on today´s roads, investors are not that interested in putting their money into constructing the infrastructure needed to recharge EVs. Consequently, manufacturers do not offer EVs at competitive prices since there is not enough consumer demand and the consumers will not buy them since the infrastructure is not there yet.

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[1] Hacker, et al. (2009) "Environmental impacts and impacts on electricity market of a
[2] COM (2011) 144
[3] EurActiv (2013a)
[4] CARS 21 (2012)
[5] In the thesis I use the term "EV" when referring to the electric vehicle. The EV is powered only by batteries and emits CO_2. CO_2 is carbon dioxide, which is a green house gas. When referring to "vehicle" I mean a passenger car.
[6] European Commission Press release (2013a)

In January 2013, the EC launched its clean fuel strategy, which was a package of methods to certify the build-up of green fuel stations across Europe with mutual standards for their design and use. Regarding EVs and its charging points, the EC intended to increase the numbers significantly in each member-state. The EC urged their member-states to increase amounts, both in terms of EVs in their country as well as building out infrastructure for the EVs.[7] There had to be a significant amount of work conducted by each member-state to be able to achieve the numbers that the EC set up. The EC proposal was later discussed in the European Parliament (EP), which backed the EC proposal to a large extent.[8] Later in 2013 it was adopted by the member-states, but with certain amendments. In the EC proposal, it was suggested that the goals were to be reached by each member state by 2020, however some member-states did not comply with the time limit. 2030 is the new date for each member state to achieve the goals set out by the EC. Each member-state will return to the EC with its own national targets to be reached by 2030.[9]

Since the introduction of EVs is a question both at national level and EU level, the thesis seeks to examine the introduction of the EV in Europe by looking closer at the situation in Germany, France and Sweden. These countries have rather different prerequisites for the introduction and development of the EV. The thesis also studies the EV at EU-level. The thesis studies the prerequisites for the EV introduction from three perspectives that are the institutional framework, national geographical situation, and the national car industry. The thesis seeks to make a contribution to the electric mobility field in general and prerequisites for the introduction and development of the EV in particular by studying it from three perspectives. Since this is a very current matter, research is needed in this area to better understand the prerequisites for the EV introduction. There are constantly things occurring in this area, both at the political and the industrial side.

The aim of the study is to throw light on the prerequisites for the introduction of the EV in the EU. This is accomplished by studying the situation of the EV from an institutional, geographical and industrial perspective. Another purpose of the study is

[7] European Commission Press release (2013a)
[8] COM (2013) 18, final
[9] European Commission Press release (2013b)

to explore to what extent different national prerequisites in Germany, France and Sweden may affect the introduction of the EV. The study is performed by data collection that comprises of interviews with stakeholders in the industry and by studying official documents and news articles concerning the EV.

1.2 Outline of the thesis

In chapter two I will discuss the EV from previous research and where the research stand today. In chapter three, a theoretical approach is constructed to better understand the EV and I present my assumptions that serve as basis for my research. Chapter four contains a methodological discussion how I have chosen to conduct the study and present limitations. In chapter five, six and seven I present my results that are divided into the three perspectives, institutional, geographical and industrial. In the end of chapter five, six and seven there is a summary of the main findings. Chapter eight comprises of the analytical part where I will discuss and evaluate the results from my assumptions. In chapter nine I will draw conclusions from the analytical chapter and present some suggestions for future research of the EV.

2. PREVIOUS RESEARCH OF THE ELECTRIC VEHICLE

In this chapter I discuss the EV from previous research. I find that the EV is not a new invention and that consumer acceptance is important. I see that there are different opinions if the EV is a success or not. This section also brings up the relationship between the state and inventions.

2.1 Not a new invention

Electricity as a technique for powering vehicles is not a new invention. In fact, the first experimental EV emerged together in the US, UK and the Netherlands in the 1830s. The development of batteries is closely linked with the developments of the EVs. In the beginning of the 20th century Thomas Edison, who invented the light bulb, came to interest for the EV. His contribution was when he developed the more efficient nickel-iron battery, which could store 40% more energy than the lead battery. However, production costs were very high and the success failed.[10]

Anderson and Anderson describe the history of the EV and compare it with the internal combustion engine (ICE)[11] car.[12] They state that one third of all vehicles in New York, Chicago and Boston were powered by batteries and competing with the steam engine car and the gasoline car at the beginning of the 20th century. In New York, there were 1,900 charging stations.[13] The EV had the potential to become even more frequently used, but the government halted the development. In the 1920s the weight of a vehicle became an important factor, which did not benefit the EV since the batteries made the EV much heavier than other vehicles, which increased the fees. Governmental incentives, as contrary to today, did not support EVs, instead the fees made it less attractive. The EV is not a new phenomenon, and government incentives made it less appealing in the early 20th century. From the 1920s until the 1970s the EV played a peripheral role of transportation and the ICE car dominated. *"The electric vehicle did not make it back into the general public´s eye again until public*

[10] Höyer, K. (2008): "The history of alternative fuels in transportation: The case of electric and hybrid cars"
[11] The ICE car is powered on conventional powertrains such as diesel or petrol.
[12] Anderson, C. & Anderson, J. (2005): Electric and Hybrid Cars A History" p.3f
[13] Höyer (2008): p.64

concern about air quality grew after mid-century."[14] Politics and legislation have been a part of EVs since the beginning, but it was after 1960s when acts and legislations came that started politicians to support the EV again due to rising oil prices and negative effects of air pollution in the US.[15]

EVs are seen as an attractive choice for transportation because of its significant reduction of CO_2 emissions. Several European governments are trying to reduce its oil dependence and promote green technologies.[16] The EU has tried to position itself as a key actor in global environmental politics during recent decades and several member-states have pushed for stronger environmental regulations. Some member-states also see themselves as innovative countries where research and development (R&D) of green technologies are seen as essential in economy. More and more of the production side is moving to low wage countries whereas European countries focus on bringing new technologies to the market. In this sense, promotion of the EV is one essential part of the development towards a sustainable and innovative future.[17]

2.2 The future of the electric vehicle

In an article written by Dijk et al. (2012) it is stated that *"(...) electric mobility has crossed a critical threshold and is benefitting from various developments: some technological, both within and outside the automotive sector, and some developments in the social context of car mobility.*[18] It is stated that from 2005 and forward, there has been a development in favour for the EV in which we can see climate change concerns and peak oil tendencies, which has motivated governments around the world to try to push their car industry to further reduce CO_2 emissions. This has been evident in Europe where the EU´s 2008 climate change package desired member states to reach 20% energy efficiency enhancements and 20% of the energy provided by renewables by 2020. Further regulations in the EU will require the average CO_2

[14] Anderson C. & Anderson, J. (2005): p.9
[15] Dijk, M. et al. (2012): "The emergence of an electric mobility trajectory" & Gärling, A. et al. (2001): "Marketing electric vehicles" p.136
[16] Van Mierlo, J. et al. (2007) "Fuel cell or Battery: Electric Cars are the Future" & Åhman, M. (2004) "Government policy and the development of electric vehicles in Japan"
[17] Lundvall, B-Å. & Borrás, S. (1997) "The globalising learning economy: Implications for innovation policy"
[18] Dijk M. et al. (2012): p.135

emissions of vehicles to be reduced.[19] Dijk et al. present a figure that suggests electric mobility to benefit from developments such as; higher oil prices, improved recharging systems, urban policies to curb car traffic and promote green and quiet cars and cultural acceptance of electric mobility.[20] They conclude by identifying a number of activities that favour electric mobility corresponding with: climate protection policies and targets that included an electric push as a method for decreasing CO_2 emissions. Further, improvements in battery technology driven by consumer electronic sector helps lowering costs of the EVs. The economic recovery programmes in the US and Europe have promoted green technologies and car manufacturers adopting a diversification strategy, including green technologies.[21]

However, there are those who are not as confident in the EV.[22] Dudenhöffer (2013) states that around 2005 carmakers began to invest into the development and promotion of EVs.[23] Despite numerous benefits of plug-in electric vehicles (PEVs) and massive subsidy amounts by the German government, electric mobility had no impact on the German car market. She concretizes this by showing that out of 3.1 million registered cars in 2012; only 4,606 of them were EVs, which corresponds to 0.15% of the total German car market. She states that; *''There is no demand for PEVs, despite a wide range of subsidies in the US, France, the Netherlands, UK, and Japan.''*[24] Although several incentives from governments, consumers are not willing to invest in an EV. She explains this dilemma by the fact that there are not enough amounts of information and knowledge about this new innovation, which the EV can be referred to. Her contribution to the research field is that she performed an experimental study with 232 participants before and after test-driving an EV. The technology acceptance model (TAM) is used in the study providing two essential constructions that determine the acceptance, which is perceived usefulness and perceived ease of use.[25] Her result proved shifting motivation and acceptance patterns

[19] Dijk, M. et al. (2012): p.138
[20] Ibid, p.144
[21] Ibid, p.145
[22] Hawkins, T. et al. (2013) "Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles"
[23] Dudenhöffer, C. (2013) "Why electric vehicles failed: An experimental study with PLS approach based on the Technology Acceptance Model"
[24] Ibid, p.96f
[25] Ibid, p.99

through increasing familiarity with a new product. She concludes by stating, *"(...) detailed consumer information would be a certain step to success of plug-in electric cars. Possibilities to test the radical innovation are absolutely essential. The results indicate that electric vehicles failed, because promotion programs lacked test possibilities for potential consumers."*[26]

It is not only on the technological side that the EV faces certain challenges. It is also at the consumer side. Consumer information and knowledge are regarded as essential when a new product enters the market. There is a consensus among researchers that private consumers have approached EVs more reluctantly than public companies and authorities.[27] Research has to a large extent been focused toward the consumer perspective and not to the car manufacturers. There is a need for research on how the carmakers regard this development of EV regarding the perception of the challenges for introducing the EV. Therefore, one part of the study will focus on the car industry and how they regard the introduction of the EV. A deeper study will also be conducted of Sweden´s auto-motor industry where Volvo has been the only actor since Saab went bankrupt in 2011. During the spring of 2014 Saab started to produce cars again but now with the focus on EVs.

2.3 Government strategies to support the electric vehicle

Research concerning how national government incentives have or have not influenced EVs has been subject for several researchers.[28] As has been previously discussed, government incentives have been related to EVs from early years. There has been a shift from government incentives that have decreased the popularity of EVs up until to today where government incentives try to increase usage of EVs. The reasons for the government incentives today corresponds with environmental concerns and ambitions to be less dependent on oil, but also for car manufacturers to diversify and be able to offer environmentally friendly cars.[29] In a recent published article by Schamp (2014), the EV is discussed in a national trajectory perspective. France is

[26] Dudenhöffer, C. (2013): p.116
[27] Dudenhöffer, C. (2013) & Gärling, A. et al. (2001)
[28] Anderson, C. et al. (2005)
[29] Hildemeier, J. et al. (2011) "Shaping an emerging market for electric cars: How politics in France and Germany transform the European automotive industry"

used as case since the country is the current leader in the electrification of their fleet, both in terms of consumption and production.[30]

After the economic crisis 2008-2009 that struck the world, the auto-motor industry where among several industries that decreased significantly in terms of sales. Hildemeier and Villareal (2011) contribute to the research-field of EVs by examining government incentives in Germany and France, two of the largest car-industry markets in Europe. They use a sociological approach that presents the significance of politics in firms´ behaviour and market creation and performing.[31] They see that due to the differences in the institutional structures in Germany and France, the government in each country have chosen to manage the development of EVs in rather different ways. In Germany, the government *"(...) pursued a more supply-oriented, innovation-centred approach by setting framework regulations and relying on purely market dynamics (...)"* whereas the French ditto *"(...) intervened with the purpose of creating a national and European market for electric cars (...) and to promote French firms as leaders in this type of technology."*[32] Since the study was conducted in 2011, much has happened during these years, and they state that this is a work in progress. My intention with the thesis is to study the French and German government policies concerning how they will increase the usage of EVs. I will also add Sweden´s institutional structure in my thesis. Therefore studying the EV in an institutional perspective gives me an understanding how each country´s government regard the EV introduction.

2.4 Reflection of previous research

We can see that the EV as a technique for transportation has existed since the beginning of 20th century. However, it is not until recent years that the development of the EV is actually present in terms of technical solutions and policy developments. The EV may be one solution to decrease oil usage, air pollution and promoting new innovations in the important European car industry. I want to emphasise that research concerning the EV is still in progress. With this I mean that even though the EV as an

[30] Schamp, E. (2014) "The Formation of a New Technology Trajectory of Electric Propulsion in the French Automobile industry"
[31] Hildemeier, J. (2011)
[32] Ibid, p.9

idea has existed for a long time, it is not until recently that politicians and car-industry have begun to regard the EV as an attractive choice. Currently, lot of things are happening, both at the political side and the car-industrial side, such as technological developments and incentives to promote the EV. We can draw some conclusions where the research community stand today.

2.5 Where research stands today

Many of the researchers agree that the EV is one solution to reduce the oil dependency and CO_2 emissions. They agree that the EV faces certain challenges to accomplish as an attractive choice in the car market. Incentives are crucial for customers to choose a car that often is more expensive than an ICE car, the question of range-anxiety and charging point have been highlighted by studies.[33] Consequently, as researchers agree on some aspects, the question of how to promote the EV to consumers is disagreed. Some say that political and economical incentives are the most important whereas others raise consumer information and acceptance as important. My intention with the thesis is to contribute to the field of EV by studying it from three perspectives. I see that there is a lot of research concerning the consumer side of the EV but not as much about how the carmakers regard the EV. Geographical preconditions are also important when studying the EV since the electricity supply is central and where people live in the country. A further reason that I want to contribute to the research field of EVs is that there is a lot occurring in this area. Studies conducted only a few years ago may be deemed as irrelevant and there is a need to better understand the situation of the EV as an attractive choice and to see how political incentives impact the development.

[33] Dudenhöffer, C. (2013): p.96

3 THEORETICAL APPROACH AND ASSUMPTIONS

The EV can be studied from several approaches and it is not evident from which one it should be studied. I depart from the notion of large technical systems when studying the EV. I argue that it is best suited for my thesis since my intention is to study the EV from three perspectives. A presentation of my assumptions is also made in this chapter.

The EV can be described and analysed from a number of theoretical approaches. The perspectives in this study are three, the institutional, geographical and industrial, and are connected to the introduction and the development of the EV in Europe. The EV can be referred to as an innovation.[34] The distribution of innovations where indicators go through, after the introduction and up until it has reached saturation can be seen in several perceptions, such as room and time. The distribution of indicators, such as the EV, follows the same pattern with introduction in a few places and thence distribution consequently as strengthening around the original places. The innovation process goes through several phases. In the primary phase, most objects near the innovation-centre is accepted, while in the distribution phase, there are larger extents of acceptance outside than near the centre. Thereafter, the densification phase follows and in the saturation phase the innovation process decreases or is interrupted. The distribution of innovations tends to occur from larger cities to smaller.[35]

In the central place theory, developed in early 1930s by the German geographer Walter Christaller, cities and regions with high availability have good preconditions to compete in information-demanding activities.[36] This increases the possibility to appeal successful companies. Competitive advantages are associated with infrastructure, transports and communications.

However, these theories cannot fulfil my entire purpose with the study. I see them as too static because I see the EV as a system in the society, from which components can

[34] Innovation refers to "an object or phenomenon of the individual or other entity is regarded as a novelty. A new product introduced into a market as well as new technologies, new customs, a new fashion can also be termed as an innovation." Törnqvist (1967): p.3

[35] Hägerstrand, T. (1953) "Innovationsförloppet ur koronologiskt perspektiv"

[36] Christaller, W. (1966) "Central Places in Southern Germany"

be added or developed over time. The notion of large technical systems (LTS) was launched during the 1980s and developed by the American historian Thomas P. Hughes.[37] LTS studies are not best presented as a coherent theory in a strict social science sense. Instead, it can be defined as a number of narratives, concepts and research approaches that can stimulate analysis.[38] The definition of technical system contains several complex and problem solving components. The systems are socially constructed and at the same time also shaping the society. Among many components in technical system there are also physical ones such as generators, batteries and power systems. Technical aspects are also parts from the society and nature since they are socially constructed and adopted to our society. On the basis of the theory, several conclusions can be made with the EV and its technique, that the EV is an innovation with parts from society, humans and nature.

Objects that may be studied with help from theories of large technical systems often address complex organizations that both are of societal and technical concerns. The organizations have been historically developed to handle the necessities in well develop industrialized societies, and to better understand them in a system. LTS studies have been used to study telecommunications, transportation, and energy supply system.[39] Geels (2007) uses the LTS approach when he studies the Dutch highway system between 1950-2000. In the article, he describes the development of Dutch highway systems from post war situation in the 1950s via raise of environmental concerns in the 1970s up to the 1990s where stakeholders embraced new ideas about participating in decision-making processes.[40]

Bolton et al. (2014) use the LTS approach when they examine socio-technical challenges of large-scale investments in low carbon energy infrastructure in the UK. They found that in the UK, as in other countries, new policy frameworks are needed to direct the shift from an energy governance model focused on reaching short-term efficiencies through market operation to a long-term style that is robust and adjustable

[37] Hughes, T. (1983) "Networks of Power: Electrification in Western society 1880-1930"
[38] Van der Vleuten, E. (2009): "Large Technical Systems" p.218
[39] Coutard (1999) "The Governance of Large Technical Systems"
[40] Geels (2007) "Transformations of Large Technical Systems: A Multilevel Analysis of the Dutch Highway System (1950-2000)"

to meet new uncertainties.[41] Magnusson (2012) discuss the district heating in Sweden and see the technique as stagnated and in the later phase of the system development. He argues that most studies have been carried out to look at a system in the earlier phases whereas the district heating in Sweden is heading to a stagnation phase and his aim is to identify and analyse the internal and external elements that influence this future stagnation.[42] As we can see there are several areas in which the LTS approach is useful. Commonly for all these studies are that they examine systems with many actors involved and at different levels in the decision making process that may affect, or be affected. Systems are also at different stages as identified by Hughes. As the Swedish district heating is in the latter phases, one can see the EV in both earlier stages in a system since the technique for powering vehicles recently begun to gain interest, but also in the later phase since the technique has been available since 1830s.[43]

According to Hughes, these systems contain components as organizations, humans as inventors, engineers, administrators, financiers and politicians.[44] Both physical and non-physical objects work as components in a system where they interact with other objects to reach the final goal. If a component would be removed from the system, or if the capacity of the component changes, the resisting objects in accordance with other components in the system will then change its capacity. The way to success is not always without any problems or disturbance. The problem can be seen as technical, economical, administrative or political. Allowing the problems to progress, the involved actors must cope with the problem to make them solvable.[45]

The development of the sociotechnical systems progress can be divided in four main phases. These are invention, development, growth and momentum.[46] The first idea is developed and spread (invention). Nevertheless, different components of the system are developed faster than other, which mean that the less developed components are

[41] Bolton et al. (2014) "A socio-technical perspective on low carbon investment challenges – Instights for UK energy policy"
[42] Magnusson (2012) "Swedish district heating – A system in stagnation: Current and future trends in the distric heating sector"
[43] Höyer (2007)
[44] Hughes, T. (1987): "The Evolution of Large Technical Systems" p.287
[45] Hughes (1983): p.22
[46] Hughes (1987): p.57ff

halting the well-developed ones. The phenomenon is referred to as "reversed salient", according to Hughes. Systems with many actors and components involved will always have reverse salient since the interaction between society and nature is complicated. The problems that arise are obvious and are easy to find. The components in the sociotechnical system that do not have the same development, as the well-developed components are the reasons that systems still evolve as new techniques for solving problems are used.

In the last phase, which is the momentum, the system has reached to a level where it affects other systems, groups and humans in the society. The momentum is because our choices are linked to a context and that the various technical systems have a very complex relationship to each other and its surroundings.[47] In this thesis the EV is referred to as a system, which can be affected through components added, changed or withdrawn. The EV has several actors involved at several levels, which make the LTS approach suitable for understanding the EV from different perspectives. They are both technical and societal.

The thesis examines three perspectives of importance for the market-introduction of the EV at national level in Sweden, Germany and France and at EU-level. I discuss the situation for the EV from three perspectives that I have identified as indicators for the introduction of the EV. Firstly, the institutional perspective, the three countries have rather different setup and therefore government incentives regarding EVs have had a different character. Secondly, the geographical preconditions are different in the three countries. The EV is powered by electricity and therefore electricity, as a power source is an important necessity. How densely populated a country is, is also a concern for the EV since the range of it is limited before it need to be charged. Thirdly, Sweden, Germany and France are countries with a large domestic car industry and the national carmakers have taken rather different position of the EV.

Since the EV introduction of a larger scale is a recent event, sufficient theoretical frameworks have not yet been developed. To better understand and analyse my data I will make one assumption for each country´s perspective and one for the EU-level.

[47] Hughes, T. (1983): p.23

Therefore, with three countries and at the EU-level, times three perspectives making it a total of twelve assumptions that are analysed with help from my data collection. This is because I want to understand the EV from several perspectives to make my analysing as thorough and sufficient as possible.

The first perspective that analyses the EV is the institutional perspective. Government incentives for a new innovation are important in this context. Consumers that consider buying an EV need incentives, since EVs are expensive to buy and the infrastructure for recharging it is not yet well developed. Incentives that have been established to spur the introduction of the EV have been: tax reduction, rebates on the purchase of the car, access to bus lanes and free parking in cities among others. My assumption for the institutional perspective is that there are differences in the institutional framework in each of these countries. Ahnström (1973) discusses this question when he analyses to what extent leading banks and insurance-companies have their headquarters in the capital or in other cities. He concludes that France and Sweden in this perspective are unicentral countries, whereas Germany is a multicentral country.[48] From this perspective, the incentives will be of different character and the state´s view of incentives will be different since the institutional constructions are different in each of the three countries. The reason for using this perspective is that I assume that there are differences to what extent government incentives have been developed to introduce the EV.

The second perspective is the geographical. The EV is powered by electricity and one of the advantages the EV has is that it emits no CO_2. We can assume that a country needs electricity to charge the EV. I am aware that today the electricity market in Europe is highly integrated, but I argue that a country still need domestic production of electricity to be able to supply power to the EV. Electricity can be generated from several sources. Another geographical aspect when discussing the EV is how densely populated the country is. The range of an EV is somewhere between 100-300 km depending on several external conditions such as, weather, speed, electric devises.

[48] Ahnström, L. (1973): "Styrande och ledande verksamhet I Västeuropa" p.26

The third perspective will cover the industrial perspective, which consist of the domestic car industry´s perception to the EV. Due to global financial crisis and higher prices of oil, the car industry has experienced great sales losses during recent years. The introduction of the EV is seen by some carmakers as a strategic alternative while other have not made the same conclusion. Some carmakers have invested heavily in the EV, while other regard the EV as a niche market.

Based on above the following assumptions are made. The assumptions are divided into three perspectives with one assumption for each country but first the assumptions concern the EU-level.

Institutional perspective

Assumption 1: Since the EU is governed by several actors, a coherent strategy for the EV is hard to achieve.

Assumption 2: Since Germany is a multicentral country, the government should not be as involved in the development of the EV.

Assumption 3: Since France is a unicentral country, the government should be involved in the development of the EV.

Assumption 4: Since Sweden is a unicentral country, the government should be involved in the development of the EV.

Geographical perspective

Assumption 5: Since the EU is divided into several countries, there are contradicting geographical factors for the development and introduction of the EV.

Assumption 6: Since Germany has a diverse energy mix and is a densely populated country, the country should strive for the development and introduction of the EV.

Assumption 7: Since France has a large supply of electricity by nuclear power and is a densely populated country, France should strive for the development and introduction of the EV.

Assumption 8: Since Sweden has a large supply of electricity but in many areas is a sparsely populated country, there are contradicting factors for the development and introduction of the EV.

Industrial perspective

Assumption 9: Since the EU cannot offer any incentives, the car industry in the EU will not invest in the development and introduction of the EV.

Assumption 10: Since the German government does not offer incentives, the domestic car industry will not invest in the development and introduction of the EV.

Assumption 11: Since the French government offer incentives, the domestic car industry will also invest in the development and introduction of the EV.

Assumption 12: Since the Swedish government does not support the EV to that large extent, the domestic car industry will not invest in the development and introduction of the EV.

4 METHODOLOGY

In this section I discuss why studying the EV in Sweden, Germany and France are interesting examples. I also argue why the EV and not other alternative fuel solutions should be studied and I have a discussion of my methodological choices that are best suited to answer my assumptions.

4.1 Delimitations and case selection

My area of interest can be defined as to study the introduction of EVs in three European countries and at EU level from three perspectives. There are delimitations I have to make, because limits of time and scope for the thesis. The reason why the thesis should be conducted in this specific area is that for many years governments have had an outspoken endeavour for reducing CO_2 emission and reducing their oil dependence. The EV will not revolutionize the way of transportation and not reducing CO_2 emissions in short term to that large extent, but it is one step in the pursuit of a more sustainable society. Therefore, to better understand and conducting research on the EV is important. My level of analysis is both at national level in three European countries, and at EU level. Emphasis of the study is at national level. Studying only at EU level in this sense would not fulfil my purpose. It is instead very much a question for national governments and how they set their domestic policies that they want to achieve.

To better understand the distinction between countries and to be able to compare them I have chosen three countries where the car industry is of national interest. With this I mean that the car industry accounts for a significant part of their economy and that the governments regard it as of national importance. The government control incentives to further support their domestic car industry. I could have included more countries within the EU to study. However, because of time and scope limits I argue that the countries I have chosen fulfil my purpose. Based on numbers from 2013, which will be presented in the result part, the car industry is of national importance since it is not just car manufacturers such as BMW in Germany or Renault in France that solely employ people. There are a number of subcontractors, working together with the car companies providing them with components to the construction of the cars on a daily

basis.[49] The subcontractor industry is also a major employer of people. Sweden, France and Germany are considered as well developed economies in Europe. They perform well in indexes that measure the innovation climate. According to the Global Innovation Index ranking, Sweden is on the second place, Germany on 15th and France on 20th place in the ranking. The index brings several measures that are indicators for how well the country is performing economically. Indicators that are measured are institutions, infrastructure, market sophistication and creative outputs.[50] For establishing a well-performing innovation climate in today's society the government play an active role. Governments can spur the innovation by introducing tax-incentives both to start-ups and existing companies. A report indicates *"Each country has distinctive assets, deficit, and industries at various stages of maturity. All of these shape the environment in which government policies will play out."*[51]

Considering the delimitation, a discussion for only focusing on the EV and not other types of environmentally friendly cars is necessary. Today there are a number of alternatives for consumers that consider buying an environmentally friendly car. The alternatives have increased significantly during the latest years. The plug-in hybrid (PHEV), powered by a petrol or diesel engine together with an electric motor, is one option. The hybrid electric vehicle (HEV), which also is powered by a petrol or diesel engine another. On the HEV, the electric engine works as a complement to the regular engine. The HEV uses only the battery at low speeds and the battery is charged by the regular engine and the energy when the car breaks, which then are stored into the batteries. The Toyota Prius, which has been a worldwide success story, uses the plug-in hybrid technique.[52] The amount of natural gas vehicle (CNG) has also increased lately. As the name indicates, it is powered by gas and the gas can derive from different sources. If the gas derives from the soil of the earth it is labelled as natural gas whereas if it derive from food waste or fertiliser it is biogas.[53]

Nonetheless, the alternatives mentioned above do not reduce the CO_2 emission to that large extent and the techniques still rely to some extent on an ICE engine, which

[49] EU SMEs and subcontracting (2009)
[50] Dutta, S. et al. (2014) "The global innovation index 2014"
[51] PricewaterhouseCoopers (2010)
[52] Green Car Congress (2013)
[53] SVT (2012)

emits CO_2. The EV emits no such at all. Hence, I argue the fact that the EV does not emit any CO_2, it is a sustainable option in the transportation and should be studied. However, there are often two sides of the same coin, so even with the EV. Analysis of the EV´s life cycle shows that nearly half the lifetime CO_2-emissions come from the energy used to produce the car and especially the battery, which is lithium based. The EV has been responsible for 30,000 pounds of CO_2 when leaving the production line. Comparing it with making a car with conventional powertrain only accounts for 14,000 pounds, illustrates disadvantage for the EV. The question of where the electricity, which is the main power source for the EV, derives from is another disadvantage for the EV. Electricity has several sources such as and oil, which may be hard to argue as zero emission power sources. These facts do not put the EV in such a good place in the endeavour of reducing CO_2 emissions. I am well aware of these weaknesses, but the EV needs to be seen in a long-term perspective where it is one important brick. As one director puts it "*The electric car might be great in a couple of decades but as a way to tackle global warming now it does virtually nothing. The real challenge is to get green energy that is cheaper than fossil fuels. That requires heavy investment in green research and development."*[54]

Since this is a thesis in the political science sphere and not a thesis that has any engineering science ambitions it is obvious that I will not evaluate any technical aspects in depth of the EV. Instead, I only mention the challenges with the technical aspects, but from a political science perspective. I can determine that there need to be a battery for powering the EV and existing infrastructure to recharge the EVs, but not how they are developed etc. It would be hard for me to evaluate how a battery would increase its range by adding certain components since my knowledge of this is highly restricted.

4.2 Material

Since I study government incentives for EVs my main source for understanding Sweden, France and Germany´s governmental opinion will thus be to study official documentation. The official documentation will provide me with adequate information of their stand toward electric mobility in general and EVs in particular.

[54] The Wall Street Journal (2013)

Sweden however, lacks a national electric mobility plan at the moment and therefore, Swedish governmental official report is used to study its stand on the electric mobility, which was presented in December 2013. Both France and Germany have a national plan for electric mobility and they will serve as point of departure. Since this is a current matter and development, news articles are also a source for studying the EV. Information from national agencies and authorities also serve as material.

I have also made an in depth study of how Swedish automakers see the situation of the EV. To gain full perspective, the best way to study this is to make interviews with representatives of Volvo and NEVS. This is because I want to study their stand toward the EV and how they regard the current situation. If I had studied other materials, such as documentation, they would not provide me with as extended knowledge about my area of interest as the interviews would. The character of the interviews will be discussed in the next part.

4.3 Method and design

The thesis has a qualitative approach and the design of a comparative case study. I compare the three perspectives in three EU member-states and try to see what the differences and similarities there are. A single case study would not fulfil my purpose since I want to compare and understand the EV in three countries and at EU-level. Mair (2008) states, *"Most political and social science research, whether explicitly or implicitly, is comparative research. That is, most research is concerned with findings which are directly compared across countries or cases, or which can be tested against theories and inferences derived from such a comparison of countries of cases."* [55] I could have conducted a quantitative approach and included more countries. But, I want to understand the three perspectives in depth and compare them, and then, a quantitative approach would not fulfil my intentions.

The interviews with representatives from Volvo and NEVS had a semi-structured character. The semi-structured interview follow an interview-guide but it also allow me to pick up on thing said by interviewees, providing me with further data and information. I argue that this is the best approach since this is a very current matter

[55] Mair, P. (2008): "Concept and concept formation" p.177

and there might be aspects that I have not thought of but may be pointed out by the respondents. The interviewees have been selected via their position and knowledge about EVs in the company. This has several advantages since valuable knowledge can be received from them because of their position and insight they might provide to the study. Both interviews lasted for one hour and were conducted in early April 2014. At NEVS I interviewed the head of communication Mikael Östlund and at Volvo I interviewed the vice-president of Volvo car Electric Propulsion Systems Lennart Stegland. Even though, they have different positions at each company, they have an extensive knowledge of the company´s understanding of the EV and are able to respond to my questions. After the interviews were conducted I complied them and returned with the citations that I intended to use.[56]

4.4 Ethics and discussion of sources

Since I have conducted interviews there are some ethical aspects that I need to take into consideration. Studying EVs in itself do not include any harmful aspect. However, I had to be aware as I conducted the interviews with the respondents that they might have had an own agenda. I also need to take precaution since they might have strategies that they do not want to share with competitors or me as a researcher. Therefore, I need to go beyond what is actually said and try to draw conclusions for further analysis. The EV debate is a very current matter and extensive reports and evaluations are hard to find and thus news articles about my area of interest also serve as material. The news articles derive mostly from well-known media sources. I need to take precaution when studying these secondary sources since they are not official documentation deriving from a neutral source. I need to be careful and thoroughly understand what is actually written in the article. The producer of the material might have an own agenda and opinion regarding the material, which need to be considered.[57]

[56] See appendix for interview guide with Volvo and NEVS
[57] Bryman, A. (2008): ”Social research methods” p.525

5. INSTITUTIONAL PERSPECTIVE

In this section I will discuss the EV from an institutional perspective and to what extent there have been incentives and strategies implemented. We see that there are differences between a unicentral state and a multicentral state in regard of incentives for the EV. I start at EU-level and thereafter at national level.

5.1 The electric vehicle at European union level

In Europe, cars are responsible for approximately 12% of the total EU emissions of CO_2.[58] The EU has the ambition to reduce CO_2 emissions in several areas and transportation is one of them. The EU has adopted regulation that obliges carmakers to reduce cars´ average emissions in several steps.[59] In November 2013, the EU member-states agreed that in 2021, all manufacturers are obliged to ensure that their new car-fleet will not emit more than 95 grams of CO_2 per kilometre (g/km). Today, the EU has a 2015 CO_2 limit of 130 g/km, which almost every car manufacturer will reach.[60] The 2011 White Paper for transport puts its focus to a more sustainable transportation in the future by establishing several goals and setting a target of 60% reduction of GHG emissions from transport by 2050 as of 1990 level.[61] According to the White Paper, oil as an energy source will become scarcer in the future and the EU imported oil for approximately 210 billion euros in 2010. It further states; *"Transport has become more energy efficient, but EU transport still depends on oil and oil products for 96% of its energy needs. Transport has become cleaner, but increased volumes mean it remains a major source of noise and local air pollution."*[62]

Regarding the EV, the EC in January 2013 announced a package that would spur the usage of EVs in Europe. The EC set out targets, both for publicly accessible infrastructure and numbers of EVs for each member-state to be reached by 2020.[63] The Commission proposal was discussed in the Transport Council and certain amendments were added. Some member-states voiced their concern over the time

[58] European Commission (2014)
[59] COM (2007) 19
[60] EurActiv (2013b)
[61] COM (2011) 144 final
[62] COM (2011) 144 final: note 7
[63] European Commission Press release (2013a)

limit and the numbers they had to achieve by 2020. Only five member states preferred to maintain the numbers set out by the EC. Thus, in December 2013 the member-states agreed on a general approach that each member state would adopt a national policy framework for the market development of alternative fuels infrastructure.[64] It included national targets for establishing new infrastructure and measures including budget to infrastructure construction and to support manufacturing for alternative fuels.

Standardization of components for the EV has been a concern for the European car industry. They have not been able to agree, which type of charging plug that should be standard. The appropriate standard has not been the same in the EU member states. Disputes over which plug to choose have been noticeable as carmakers have not been able to agree which plug to use in the future. In January 2013, the EC gave its official backing of the "type 2" plug, which is developed by "Mennekes", a German company.[65]

5.2 Germany

The 16 federal states (in German "Länder") enjoy a high level of autonomy. They can implement legislations by themself in many areas.[66] Berlin has been capital since 1999 as the parliament and government moved from Bonn to Berlin. In the field of transportation, the German federal government has adopted several policies promoting sustainable transportation and to support the car industry. The federal ministry for economic affairs and energy concludes that EVs help to protect the climate and the environment. Electric mobility is a crucial future-oriented industry that can secure up to one million jobs, particularly in small- and medium- sized companies and the use of EVs reduce dependence on oil-based fuels.[67] Since 2009, the German Federal government has distributed 500 million euros to fund the expansion and commercialization of the EV. This number has been increased by one billion euros and projects across Germany are being implemented. Currently, there are

[64] Council of the European Union (2013)
[65] Plugincars (2013)
[66] Landguiden (a)
[67] National Electric Mobility Platform (2013) "Vision and Roadmap of the National Electric Mobility Platform"

eight[68] model regions testing the application of EVs with different approaches and focuses.[69]

The German federal government in 2009 released the national electromobility plan, which was developed jointly by the Ministries for the Environment (NEPE), Economics (BMU), Transport (BMVBS) and Research (BMBF). This was the first coordinated policy paper to encourage electric mobility in Germany. The plan set the goal of having one million EVs on the roads by 2020 and turn Germany into a lead market for electric transportation.[70] In the plan it is stated *"Even tough the internal combustion engine will remain important for transport (...) we must begin today to make the necessary gradual transition to new efficient technologies. To keep up with international competition, Germany must become the lead market in electromobility."*[71]

In May 2010, the German federal government created "The National Platform for Electric Mobility" (NPE), which is a cooperative council for introducing EVs in Germany. The initiative was established with its purpose to shape the roadmap for realization of the objectives presented in the electromobility plan from 2009. The council consist of stakeholders from politics, industry, science, local authorities and consumers working in seven working groups, each with around 20 members.[72] The two central goals within the council is that Germany aims to become a leading market in electric mobility sector with at least one million EVs and PHEVs on the roads by 2020 and at becoming a leading provider in the electric mobility sector.[73] The council has published three interim reports since it was first established: the first in November 2010, the second in May 2011 and the third in May 2012.[74] To achieve the goal of having one million EVs and PHEVs on German roads by 2020 three phases will follow. The first is a market preparation phase to 2014, where much focus is on R&D. The second phase, the market start-up to 2017, where focus will be on vehicle and

[68] The regions are: Hamburg, Bremen/Oldenburg, Rhine-Ruhr (Aachen and Münster), Rhine-Main, Saxony (Dresden and Leipzig), Stuttgart, Munich and Berlin-Potsdam.
[69] National Organization Hydrogen and Fuel Cell Technology
[70] German Federal Development plan (2009)
[71] Ibid, p.2
[72] Germany Trade and Invest "National Electric Mobility Platform (NPE)"
[73] German National Platform (2010) *(*First report*):* p.15
[74] German National Platform (2012) (Third report)*:* p.79

infrastructure market development. The third is the mass-market phase to 2020, where sustainable business models are in focus.[75]

In May 2011, the German federal government adopted a government programme for electric mobility shortly after the second interim report was released. The programme builds to a large extent on many recommendations presented in the second interim report by NPE. Some of the programme´s incentives and measures are: A 10-year vehicle tax exemption for cars with CO_2 emissions of less than 50g/km and bought before 31 December 2015. An adjustment of the taxation on company vehicles in order to remove current taxation disadvantages of EVs, as compared to conventional vehicles as company cars, and a gradual change of the German federal government vehicle fleet to EVs. There is a target-value of 2013 and onwards for CO_2 emission of 10% for all new government cars to use less than 50 g/km, and the use of bus lanes and special parking areas for EVs.[76] In June 2013, a new policy paper regarding "The Mobility and Fuels Strategy of the German Government" (MFS) was published. This strategy urges step-by-step developments of energy sources in transportation and increases in energy efficiency for all transport modes.[77] Regarding EVs, the strategy suggests that the on-going NPE work with collaboration between industry and government should be continued and developed.

The incentive in Germany for buying an EV is dominated by tax exceptions. The government does not offer rebates for purchasing an EV. According to the government, market and competition are the best drivers of innovation and development in the area of electric mobility.[78] The government is currently evaluating incentives for the EV in the model regions, such as bus lane use and special traffic lanes for EVs. Presently, only EVs are exempt from motor vehicle tax, but as previously stated; vehicles that emit below 50 g/km will be exempt from motor vehicle tax for a period of ten years from 2015.[79]

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[75] German National Platform (2011) (Second report): p.5
[76] Ibid
[77] Federal Ministry of Transport, Building and Urban Development (2013)
[78] Federal Ministry for Economic Affairs and Energy
[79] Germany Trade and Invest "Government Program Electromobility"

5.3 France

The French state is unicentral with power concentrated to the capital Paris, whereas local authorities have been seen as part of the administration in Paris. The 22 regions that France consists of were established in the 1980s in order for the central government to more effectively coordinate social and economical issues. The regions´ autonomy is however restricted to only consist of minor aspects.[80]

In January 2008, a bonus/malus system was implemented in France. The system builds on a bonus, which is a subsidy received when purchasing a low emitting car and a malus, which is a charge for the consumer buying a high emitting car. The system depends on how much the car emits, and the level have been reduced several times due to technological development and objectives to be achieved in the mid-long term. The system is only affected on newly registered vehicles and the purpose is to incite consumers to consider more environmentally friendly cars. However, due to the success of the system, the administrative cost has been high in order to processing all the applications and managing an online webpage. The bonus/malus system has also had to make changes in certain areas, such as reducing the large interval for neutral classes.[81]

In April 2010 the French government established an agreement with 12 territorial collectivities[82] and two car manufacturers; Renault and Peugeot-Citroën (PSA). The aim of the agreement was to develop and install battery-charging point for EVs. The French state had the responsibility for operational recommendations regarding the arrangement of infrastructure and details on potential economic support. The collectivities had the responsibility to determine where to place the charging stations and the car manufacturers had the responsibility to produce 60,000 EVs. Further, a national plan for environmentally friendly cars was adopted in the same time. The plan defines regulations for constructing charging stations in new private building from 2012 and in office building from 2015.[83]

[80] Landguiden (b)
[81] WSP (2013): p.10
[82] The collectivities are: Bordeaux, Grenoble, Rennes, Nice, Angouleme, Pays d´Aix-en-Provence, Orléans, Paris, Rouen, Strasbourg, Le Havre, Grand Nancy
[83] WSP (2013): p.7

The minister of industrial renewal, Arnaud Montebourg, presented in July 2012 the "Automotive Plan" to overcome weak car sales. The government views the French car industry´s strive for cleaner cars as essential and increased subsidies for HEVs and EVs.[84] The main feature of the plan was a 490 million euro package of subsidies for environmentally friendly cars. The government increased the subsidy for consumers purchasing an EV to up 7000 euros from 5000 euros. However, in November 2013 the subsidy was reduced to 6300 euros. Montebourg said that the cost would be paid for extra charges on high-emission cars, where German manufacturers are dominant.[85] The government agreed in 2012, that 25% of the new cars it buys should be hybrid or electric, which represents 1500 vehicles per year and charging point will be installed at the ministries and public administration parking locations.[86]

Infrastructure for charging EVs is important, and the French state has taken an active part in the construction. In the beginning of 2009 the French government appointed a working group to draw up a French national strategy for the development of charging infrastructure. The working group consisted of car industry, energy utilities, local authorities, building and constructing professionals and managers of public space.[87] The working group state in their strategic roadmap: *"One of the keys to success for these vehicles is establishing user confidence in their driving range and safety. To ensure sufficient driving range a charging infrastructure is required."*[88] France is planning to establish this charging system in all part of daily life, especially at enterprises, public domain and residential sector. The working group further concluded that there need to be a strong commitment by the state up to 2020, but after 2020 and until 2050, new economically and industrially models must take over.[89]

5.4 Sweden

The Swedish institutional structure can be viewed as something in between Germany and France. Sweden is divided into 290 municipalities and they have rather high self-

[84] IA-HEV Annual report (2013): p.11
[85] Financial Times (2012-07-25)
[86] IA-HEV (2013): p.112
[87] ADEME (2010): p.3
[88] Ibid, p.4
[89] Ibid, p.10

governing, where each municipality can set its own collection of taxes.[90] Sweden is also unicentral, but not to such large extent as France. In January 2012, the super-green-car-rebate was introduced and the Swedish government allocated SEK 200 million for the rebate to be used from January 1 2012 until December 31 2014, or as long as the money lasts. The policy instrument is a SEK 40,000 rebate on purchased cars that emit less than 50 g CO_2 /km and EVs are included.[91] However, the rebate has been a debacle and in 2013 only 144 vehicles were sold to private persons.[92]

Regarding EVs, the Swedish state lacks a national strategic plan as in France and Germany. Sweden instead, has chosen to evaluate the situation and set a strategic target that by 2030 the Swedish transport-fleet shall be fossil-free.[93] The Swedish government official report (SOU) was published in December 2013. According to the report, EVs are expected remain as niches the next coming years but on a long-term perspective, EVs can play a substantial role in reaching fossil-free transportation. However, the uncertainty regarding how the development of EVs will progress forces the Swedish government to further evaluate the incitements and needs for investment in different types of infrastructure.[94] It is more likely, according to the report, that different types of hybrids that use both an electric engine together with an ICE engine will be a more attractive choice for consumers. Early niches for EVs can be service vehicles for commercial or public use, mainly in bigger cities.[95] The report suggests an increase of the rebate from todays SEK 40,000 to SEK 70,000 to increase the market introduction of EVs and hybrids.[96]

Since Sweden lacks a plan and strategy for EVs at national level, municipalities in Sweden have developed their own strategy for introducing the EV. Stockholm´s strategy, which was adopted in 2011 and then renewed in 2013, states that transportation in Sweden´s capital shall be fossil-free by 2050.[97] The city should work

[90] Landguiden (c)
[91] Sveriges Riksdag "Förordning (2011:1590) om supermiljöbilspremie"
[92] Dagens Nyheter (2014)
[93] Swedish Proposition 2008/09:162
[94] SOU (2013): 84, "Fossilfrihet på väg", p. 501
[95] Ibid, p. 511
[96] Ibid, p. 674f
[97] Stockholm stad (2013): p.5

to make it easier to purchase and charge EVs, but there remain challenges for the EV to become a success.[98] The experiences from companies and organizations regarding the EV show that the reluctances remain mostly at the high purchasing price, insecurity of the vehicle´s performance and possibilities to access charging points.[99] The Swedish energy agency has collaborated together with the car manufacturer Volvo to conduct research on developing the EV.[100]

5.6 Summary

The institutional perspective shows that the EU has adopted regulations that oblige the European car industry to decrease cars´ average CO_2 emissions in several steps. The EU has tried to promote the EV by establishing targets for each member-state, but they have been neglected to a large extent by several member-states. The German government has established a council for the introduction of the EV. They have also adopted a program for electric mobility. The French government has worked firmly to introduce the EV by establishing targets and systems that benefit the EV. Heavy investments have also been implemented as the French government intended to overcome weak car sales. The Swedish government approach to the EV has been to evaluate the situation and the only incentive that exists is the purchase rebate. There is no strategy for the EV but a vision of a fossil-free transportation fleet in Sweden by 2030.

6. GEOGRAPHICAL PERSPECTIVE

In this section I discuss the EV from a geographical perspective. It includes a discussion how the electricity is produced in each country. When the consumption of EVs increase, the demand for electricity increases and therefore production of electricity is essential. Further, the question of population density and settlement structure is essential when discussing the introduction of the EV.

[98] Stockholm stad (2013): p.13
[99] Ibid, p.18
[100] Energimyndigheten (2013)

6.1 The European union

The EU, divided into 28 member-states covers a total area of 4, 381, 000 km^2. The total amount of people residing in the EU´s member-state is approximately 508 million. The total population density is estimated to 116 persons per km^2 where the highest population density is on Malta with 1,261 persons per km^2 while the lowest is in Finland with 16 persons per km^2.[101] Around 80% of the EU inhabitants live in urban areas.[102]

As the name indicates, the EV is powered by electricity. Electricity can derive from several sources such as geothermal, solar, wind, oil, coal/peat, natural gas, nuclear, and hydropower. Depending on a country´s geographical structure and preconditions, the source that electricity is generated from diverges. In the EU28, the production of energy has increased since 1990 when the total electricity production was 2,500 TWh compared to 2011 production level, which was around 3,400 TWh.[103] Between 1990 and 2009, gas and renewables are more and more contributing to the EU electricity production, just after the dominating nuclear and coal.[104]

It is hard to predict to what extent the introduction of EVs has on the demand for electricity. Some estimate that when the EV hits the market to a larger extent, so will the demands for electricity increase. Nonetheless, according to information requested by the Committee on industry, research and energy in the EP, analysis for further demand generated by the introduction of EVs will only have minor effect on the total electricity supply in the short- and medium-term. Even large introduction of EVs would not meet limitations in terms of electricity challenges. Calculating energy utilization of an EV to be around 100-120 Wh/km and an average travel of 10,000 km per year follows that 1 million EVs will need around 1 TWh of energy. This is only a minor part of the total electricity production in the EU.[105]

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[101] Eurostat (2014)
[102] Eissel, D et al. (2013): ”The future of sustainable transportation system for Europe”, p.10
[103] IEA (2013), ”Electricity generation by fuel: European Union-27”
[104] European Commission (2011), ”Key figures”
[105] DG for Internal Policies (2010): p.14

6.2 Germany

Germany is situated in the centre of Europe with 82 million inhabitants, making it the most populated country in Europe. The country covers an area of 357.000 km^2 making it around 229 inhabitants per km^2. There is no dominating city in Germany, which is referred to a multicentral geographical structure. Instead there are a number of competing cities where the most populated are Berlin, Hamburg, Munich and Cologne. The population in the largest German cities are quite same. It ranges from Berlin, which has 3.3 million inhabitants, to Cologne´s one million inhabitants.[106] One explanation to the fact that there are a number of competing cities in Germany is by the late unification of the country. The German empire was up until 1918 a divided country with 27 constituent territories. Before the 19th century, Germany had not existed as a unified state and consisted of hundreds of self-governing states.[107]

Germany has a diverged energy production. In 2013, the electricity production accounted for a total 478 TWh. Production of electricity is generated from several sources where the largest are brown coal (145 TWh), followed by hard coal (110 TWh).[108] In September 2010, the federal government in Germany adopted a broad strategy, the Energy Concept, which founded principles of a long-term energy route by establishing renewable energy as the basis of future energy source and prolong the existence of German nuclear power plants. Germany is one of the global leaders in renewable energy production and in 2010, around 102 TWh came from renewable energy sources.[109] After the Fukushima nuclear accident in Japan in March 2011, a political decision was taken to accelerate the phase-out of the country´s nuclear power plants by 2022. This decision had a major impact on Germany´s energy situation and a second Energy Package was adopted, generally recognized as the "Energiewende". It contained seven legislative measures to support renewable energy, grid extension and change the prior decision to extend the existence of nuclear plants.[110]

The federal government in Germany has established a GHG-reduction of 40% below 1990 levels by 2020 and additional reductions up to 2050 when reduction of GHGs

[106] World Population Review (2014) "German population 2014"
[107] Landguiden (a)
[108] Fraunhofer (2014)
[109] German government (2010)
[110] IEA (2013) "Germany": p.9

will be 95% below 1990 levels.[111] A central aspect of the Energiewende is electricity. According to an IEA report from 2013, *"Electricity is at the core of the Energiewende and Germany has a large diversified electricity system which benefits from strong interconnections with neighbouring countries."*[112] Further, the federal government in Germany states: *"Electricity used to power vehicles will be drawn from renewable energy sources. According to recent studies, only 0.3% more electricity per year will have to be generated in order to put one million electric vehicles on Germany's roads. At the same time, the batteries of electric vehicles create new opportunities for storing renewable energy, and this will contribute to the long-term stability of power grids."*[113]

6.3 France

France is situated in the centre of Europe sharing borders with several countries. France has a landmass of 552.000 km^2 making it to the largest country in the EU. There are 64 million inhabitants in the country denoting a population density of 112 inhabitants per km^2. Power in France is concentrated both politically and economically to Paris.[114] The largest cities in France are Paris, Lyon, Marseille and Toulouse. Paris is by far the largest city with 12 million inhabitants in the urban area of the capital, while the other major French cities have around one million inhabitants.[115] The settlement structure in France indicates that a large amount of the population residing in the capital and its surroundings. Historically, this is explained by the fact that France is characterized as a kingdom and a monarchy. Power and influence has historically to a large extent been concentrated to Paris.[116] This has also affected the settlement structure, where large amounts of the French population reside in the Paris region.

Electricity production in France derives to a large extent from the 57 nuclear power plants. France is the country that exported most electricity in Europe in 2013, with 47.2 TWh exported to its neighbouring countries. The total production of electricity

111 IEA (2013): p.10
112 IEA (2013): p.11
113 Federal Ministry for Economic Affairs and Energy
114 IEA (2009): p:15
115 World Population Review (2014) "France population 2014"
116 Landguiden (b)

amounts to 550.9 TWh in 2013 and nuclear production represented 73,3% of the total production, which is the highest share in the world. The total electricity consumption reached 495 TWh. In 2013, production from renewable energy sources represented 25 TWh.[117]

The country is among the least CO_2 emitting economies among industrialised countries, since nuclear accounts for such large role in production. France has set the target to reduce its CO_2 emissions with 75% below 1990 level by 2050 through the Energy Law adopted in July 2005.[118] The French government has established a multi-stakeholder programme in 2009, "Grenelle de l´Environnement, which focuses on a framework of policies and measures, setting targets for specific areas among them the transport sector. In 2010, the parliament adopted "Grenelle 2", which further strengthens the reduction of CO_2 and essential changes in the transport sphere. "Grenelle 2" outlines a development and encourages electric and hybrid vehicles by building and maintaining necessary constructions of charging infrastructure.[119] In a review by the International Energy Agency (IEA) in 2009, it states *"Thanks to its low-cost and low-carbon electricity supply, France has the opportunity to reduce transport sector emissions by focusing on electricity-based technologies, such as (...) electric vehicles."*[120]

6.4 Sweden

Sweden is situated in northern periphery of Europe and has large sources for producing electricity thanks to its large supply of water and nuclear power. The country is the third-largest country in the EU with an area of 450 000 km^2 and a population of 9.7 million. This denotes a rather low population density with 22 inhabitants per km^2 and most of the inhabitants reside in southern parts. The largest cities are the capital Stockholm, followed by Gothenburg and Malmö. The country is covered by 65% forest and meagrely populated.[121] Stockholm is the largest urban area

[117] RTE (2013)
[118] IEA (2009): p.8
[119] France government (2010) "Grenelle 2 Law"
[120] IEA (2009): p.8
[121] IEA (2013) "Sweden review": p.3

with around 1.3 million inhabitants.[122] Sweden is similarly to France a kingdom, and from the 16th century there appeared a state with more centralized government structure and a monarchy. This explain the unicentral structure, however Sweden is not as unicentral as France.

Swedish electricity production is depending on nuclear power and hydropower.[123] In 2012, electricity production derived from 48% hydropower, 38% nuclear power and 4% from wind-power. Total electricity production in 2012 was 161 TWh.[124] Swedish energy policy is directed by both short-term and long-term targets through two government bills adopted in 2009.[125] Sweden´s target for 2020 is a 40% reduction of GHGs compared to 1990 level and at least 10% share of renewable energy in transport sector.[126]

6.5 Summary

The geographical perspective shows historical explanations of where the power and population is concentrated. Sweden and France are both kingdoms with power and population concentrated to the capital region, whereas Germany with its late unification, power and population are not concentrated to the capital. The energy production, both in the EU and in Germany, France and Sweden indicate large differences. This is explained by the country´s geographical preconditions, but also from events that have occurred in other parts of the world affect how to produce electricity.

7. INDUSTRIAL PERSPECTIVE

In this section I discuss the introduction of the EV from an industrial perspective. How have the national carmakers responded to the EV and how do they regard the EV. The Swedish part will consist of interviews conducted with representatives from Volvo and NEVS. The German and French companies will consist of data from

[122] World Population Review (2014) "Sweden Population 2014"
[123] Swedish Energy Agency (2013): p.5
[124] Swedish Energy Agency (2013): p.42
[125] The bills are 2008/09:162 and 163
[126] IEA (2013): p.7

documents. The EU will in this perspective work as a coherent actor for the total European car industry.

7.1 The car industry in the European union

The car industry in Europe has experienced a turbulent time during the latest years. There have been great sales losses and they have seen themselves outdone by new actors on the global car market. The European car industry is a strategic sector for the European economy occupying more than 12 million people.[127] The European market is considered as mature, comparing to third countries´ markets. According to CARS21, a high-level group launched in 2005 by the EC to make policy recommendations: *"The intense competitive pressure is growing further and EU companies are increasingly being challenged on their home market and developing opportunities in third markets. To meet long-term greenhouse gas targets as well as air quality objectives, the internal combustion engine will be further improved and the development of breakthrough technologies, such as electrified propulsion, will happen."*[128]

The European car industry is diverged in its stand toward electrification of vehicles. Some carmakers, such as Renault and Volkswagen have already introduced the EV into their fleet, whereas other companies have been more reluctant to the introduction of the EV. European car industry has traditionally been a technological world leader in many segments. However, in the EV development and introduction, European carmakers have seen themselves beaten by mostly Asian manufacturers that have offered competitive products and have well-established know-how for the EV. Nonetheless, there is a consensus among European carmakers that they need to develop the technology in order to reduce the oil consumption.

There are large differences between countries within the EU in terms of numbers of EV registrations. France is by far the country where most EVs are registered with

[127] CARS 21 (2012)
[128] CARS 21 (2012): p.3

14,095 EVs registered in 2013. Germany is second with 6,266 registered EVs and third is the Netherlands with 3,476 registered EVs.[129]

7.2 Germany

The German car industry includes brands such as Audi, BMW, Mercedes Benz and Volkswagen (VW) and they are in many segments world leading. The German car industry accounts for a significant part of German industry in terms of persons working within the industry. In Europe, Germany is by far the largest employer in the car industry with 749,000 people. According to the number of vehicles produced in the EU, Germany is also here the largest with over 5 million cars produced annually.[130]

It is not until recently that German carmakers have begun to produce EVs commercially. In fact, the focus for German carmakers has instead been to refine conventional powertrains such as diesel or petrol in the premium car segment.[131] In 2013 and 2014, major German carmakers such as BMW and VW, begun with EV production through new models. VW pledged at the 2013 Frankfurt Motor Show that the company would have a total of 14 EVs and HEVs on the market by 2014. The company also says it aims at becoming the market leader in electric mobility.[132] The total number of EVs registered in 2013 in Germany was 6,266 vehicles, while PHEV sales were 445 vehicles.[133]

According to the mobility and fuels strategy of the German government: *"German manufacturers have announced the market introduction of 15 vehicle models by 2014. It seems that the plug-in hybrid drive will be the dominant form of propulsion for externally chargeable vehicles in the coming years. Several vehicle manufacturers have announced they will be offering the plug-in hybrid drive as an option in numerous models."*[134]

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[129] EVObsession (2014)
[130] ACEA (2013): p.37
[131] Hildermeier, J. et al. (2011): p.18
[132] Financial Times (2013)
[133] EVObsession (2014)
[134] German government (2013): p.73

7.3 France

France is on the second place with 225,000 people employed in the car industry and the country is also on the second place with 1,6 million cars produced annually.[135] Until recently, French carmakers have been in line with its German equals, that they were expecting a focus on refining conventional powertrains. However, after the financial crisis that struck the world, French carmakers begun to invest in research and development of EVs, especially the 15% state owned Renault.[136] Between 2008-2010 the Renault was alone of having an explicit strategy on EVs among European carmakers and invested more than 4 billion euros in programs to develop EVs and batteries. The CEO of the company expressed its conviction that EVs was not only a solution to counteract the GHG effect and decrease CO_2 emission, but also a clear strategy for the future of the company. After the announcement of the "Automotive Plan" in July 2012, the CEO of Renault responded: *"Renault welcomes the government´s determination to support the French automotive industry. The Group is especially pleased with the strong gesture made in favour of clean vehicles, and electric vehicles in particular."*[137]

Contrary to Renault´s anticipation on EVs, the other major French carmaker Peugeot-Citroën (PSA) has a more sceptical stand on the future expansion of EVs. According to Hildemeier and Villareal, *"For PSA, the BEV (EV, my note) is more a niche market in which investments are very limited."*[138] Instead, they have decided to invest more on the hybrid technology and refining hybrid-diesel vehicle. The company´s strategy is the internationalization of the brand and commercialisation of premium models in China and other developing markets.

7.4 Sweden

Sweden´s auto-motor industry occupies 66,000 people and they produce around 162,000 cars annually.[139] The two major car manufacturer SAAB and Volvo have been synonymous with Swedish engineering industry for a very long time. However,

[135] ACEA (2013)
[136] Hildemeier, J. et al. (2011): p.11
[137] Renault (2012)
[138] Hildemeier, J. et al. (2011): p.13
[139] ACEA (2013)

in December 2011, SAAB that had produced cars since late 1940s filed bankruptcy due to sales losses in the aftermath of the financial crisis 2008-2009.[140] The liquidator of SAAB announced in June 2012 that they had signed an agreement with National Electric Vehicle Sweden AB (NEVS) to buy Saab´s assets. The new owner, backed by a Chinese renewable energy investor aim at producing EVs initially for the Chinese market, which is due to start in late 2014.[141] NEVS has begun to produce ICE cars, but their ambition is to start producing EVs commercially in the near future. According to the communication chief Mikael Östlund, *"Our whole reason to be is basically because of EVs."*[142] Further, he states that: *"It would be very easy if you want to, that the electric vehicle will quickly get a market in Sweden (…) Now, there are products that really correspond to a demand and behaviour and driving patterns that makes it work. So why not invest properly in it? And this applies both to subsidies and charging infrastructure."*[143] The communication chief says that: *"It is favourable if the state can be a factor and push the development (for the EV, my note.)."* Further, he discusses the relationship between the state and the EV market: *"It is not a market that works without the government is there and screw in it (…) A certain amount of force and a certain amount of carrot is needed for it to take off by itself."*[144]

Volvo is a substantial player in the global auto-motor industry, but they have been rather restrained in their ambitions of EV production. The company has had concept cars that have been powered by electricity, but never put them into commercial production. They have instead focused on plug-in hybrid electric vehicles (PHEV).[145] According to Lennart Stegland, *"Everybody that is involved in EV development has a bad business case with a few exceptions."*[146] This is because the time that is takes to develop a car is normally very long. And the EV in particular, since the battery is the component that is the most expensive part something that is illustrated by: *"When a car leaves the factory, we fill it with 15 litres of gasoline and it is not as big money*

[140] CNN (2011)
[141] Bloomberg (2013)
[142] Interview with NEVS
[143] Ibid
[144] Ibid
[145] International Business Times (2013)
[146] Interview with Volvo

compared to what the content of a lithium battery costs. And that means that there is always a charge for this."[147]

He states that the EV is a product for urban transportation and in cities. *"The debate is sometimes focused on when I want to take the electric vehicle to go on holidays. Then, it is clear it does not work. There are proposals on that highways should be built with charging stations. That is not where the electric vehicle is beneficial, there you should have conventional fuels. It is in the urban traffic you should have the electric vehicle and there you have access to charging stations. The customer is sometimes uncertain whether they should reach their destination. This has been described as "range anxiety" and is often connected to the electric vehicle."*[148] As previously discussed, Volvo has only developed EV prototypes, and instead chosen to focus on conventional powertrains and PHEVs. *"If you take a plug in hybrid, then you have a smaller battery that is charging less costing for the customer. The plug-in hybrid offers the customer more flexibility, so when the battery is empty, you can use a conventional powertrain. So it does a very good job in the city, but as soon as you drive out of it, you use a normal combustion engine. So it is a very good combination for the customer."*[149]

The rebate today in Sweden, which is SEK 40,000 Lennart Stegland argues it needs to be increased to SEK 60,000-70,000. The reason for this is that *"Our aim is to increase volumes so that we may reach a better scale of economy and by that you can press costs. We, as a manufacturer have a responsibility to decrease the costs, but it is impossible to drive down costs when you are not reaching relatively large volumes. This means that there is a threshold effect in the market and one way of bridging this could be by using incentives or other stimuli."*[150]

7.5 Summary

For the European car-industry that has experienced great sales losses, the EV is one solution. Regarding the EV, there are differing notions whether to invest in the

147 Interview with Volvo
148 Ibid
149 Ibid
150 Ibid

technology among European carmakers. European car companies are in many segments world leading, but in EV and hybrid technology, Asian manufacturers are world leading. In Europe, French companies, and especially Renault has integrated the EV in its fleet whereas German manufacturers recently have begun to invest in the EV technology. Sweden, with NEVS and Volvo, are also investing in the EV technology, but with different ambitions.

8. EVALUATION OF ASSUMPTIONS AND EMIPRICAL MATERIAL

In this section I analyse and evaluate the assumptions presented in the theory chapter. I analyse each perspective with help from my assumptions and the data I have presented. I will analyse them firstly at EU level and then at country level in each perspective.

8.1 Institutional perspective

Assumption 1: Since the EU is governed by several actors, a coherent strategy for the EV is hard to achieve.

The EU, mainly via the EC put policy incentives to promote and build a strategy to increase the numbers of EVs. This was visible in 2013, when the EC launched a proposal and set goals for each member state. However, the goals regarding numbers of vehicles registered and constructing charging points in each country, the member-states could not agree on it. There are diverse prerequisites for each country and also different countries have different prioritizations. As the LTS approach indicates, there are several actors involved in a system, and here we can see that the actors has not been able to agree to reach a goal.

The EU has tried to position itself both by legislative and policy incentives for the EV. However, specific targets for the EV as one step towards a more sustainable future, was nothing that gained any success when the member-states gave their own opinion in the Council on the proposal. The goals and incentives that a government can initiate, corresponds to a large extent to the national prerequisites in terms of geographical and institutional framework. Some countries offer economical incentives, others with tax rebates and free access to bus lanes. All in all there are efforts made both by the EU and member-states to try to push for the introduction of the EV but not everybody are as confident.

With an LTS approach it is evident that the EU has tried to affect the system with policy incentives in order to increase the EVs. However, since the EU lacks of formal legislative incentives, the only influence it has is to try to push the member-states to

set own goals. The EU has instead focused on reducing ICE vehicle´s consumption through binding agreements for European carmakers to reduce the fuel consumption. As the LTS approach indicates, several are actors involved, and here the actors have not been able to agree to reach the goal. Up until date, the EU has not been able to reach a common agreement with all its member-states for a larger introduction of the EV.

Assumption 2: Since Germany is a multicentral country, the government should not be as involved in the development of the EV.

The German federal government has an outspoken endeavour to become a world leading market for EVs. They have been involved by establishing strategies and incentives, which favour the market introduction for EVs. The German federal government has set up strategies with several ministries involved and also established a council where participators from different branches and levels give their opinion. However, the government does not want to intervene in the market to that large extent. This is visible since they do not offer any economical incentives, instead tax reductions are leading in Germany´s strive for the introduction of the EV. It has been concluded that the market is guiding the development and this supports innovation and competition.

According to the three phases identified by the council that the introduction of the EV will go through, the country is in the second phase. Studying it with a LTS approach it becomes evident that the EV is affecting other systems. Other components affect the EV in a direction that is toward an increase. The nature surrounding the system has affected it through several modes. Regulations and goals have been established to favour the introduction and there is a consensus among German policymakers that Germany should take a broad responsibility for the EV. This is mainly visible, as they have gathered several participators to discuss the EV. Since the EV affects many actors they have chosen to include several participators.

Studying the EV in Germany, the multicentral tendencies are visible in two ways. Firstly, the federal German government has strived in a more consensus-oriented way by inviting actors to give their opinion on the EV. Instead from being the driver

behind the development, the German government has instead chosen to draw up broad goals. But the question of how they will reach the target is a question for several actors and not just the government. Secondly, the German federal government has included model regions where the EV can be evaluated from by allowing EVs to use bus lanes and special traffic lanes.

Assumption 3: Since France is a unicentral country, the government should be involved in the development of the EV.

The French government has taken an active role by establishing targets and economical support for the EV. They have been highly involved in the market for increasing the amount of EVs, mainly via the bonus/malus system and economical incentives. The government acted with the automotive plan to overcome weak car sales in 2012 by subsidising environmentally friendly cars. The government has also tried to persuade consumers in France to choose a smaller environmentally friendly car.

Similarly to Germany, France has also established a working group consisting of members from different branches. The group has focused on drawing up a French national strategy for the development of charging infrastructure for plug-in vehicles. The question concerning the infrastructure that is needed to the EVs is one of the core challenges. It is obvious that this is one of the reversed salient components that Hughes discussed.[151] As one technique is developed faster than the other it holds back the entire system to progress and develop. This is what the French government hopes to overcome by establishing the working group to draw up a strategy. Another similarity to Germany is that France has also involved a number of regions within the country to take part in development of the EV. However, in France it has only concerned battery-charging points and the state has had the operational responsibility.

The unicentral French government has taken a resolute leading role to introduce the EV in France. We can see a stalwart example of this as the government in 2012 agreed that 25% of the new cars they buy should be hybrid or EVs and charging

[151] Hughes (1983)

points to be installed at public administration buildings. The institutional structure in France makes evident to see that the French government is committed to support the EV through economical incentives, but also to develop the infrastructure needed to charge the EV and other plug-in vehicles.

Assumption 4: Since Sweden is a unicentral country, the government should be involved in the development of the EV.

Contrary to France and Germany, the Swedish government has not established a strategy for EVs. Instead, the Swedish government initiated a report and a vision for Sweden to have a fossil free transport fleet by 2030 and the EV can play a role in this ambition. The only incentive that the purchasers of EVs in Sweden receive is the super green car rebate, and there is currently no access to bus-lanes or road toll exemptions for these vehicles. The Swedish government has not affected the system to a larger extent than to offer an economical incentive, which hardly has been used by Swedish consumers.

There has been no council or group established that gathered participators from different branches at different levels in Sweden as in France and Germany. Instead, local authorities and the Swedish energy agency have developed strategies and projects for the EV. The Swedish government is quite vague in its commitment to the EV, which visualizes, as the super green car rebate has been a disappointment. Even though the institutional setting with a unicentral government in Sweden it has not been as committed to support the EV as France. Sweden is unicentral but in the case of the EV, the Swedish government has been to some extent reluctant to support the EV. Nonetheless, economical incentives exist but not so much else. Support and strategies have instead been visible at local level that established strategies for introducing and developing the EV.

8.2 Geographical perspective

Assumption 5: Since the EU is divided into several countries, there are contradicting geographical factors for the development and introduction of the EV.

The geographical prerequisites that are focused in the thesis are the energy conditions and population density. These are components in a system that in some countries of the EU are benefitting the introduction of the EV, while for other the opposite. The EV has a limited range before it needs to be charged again and traveling long distances is not where the EV is best suited. Some countries, such as those with high population density, the EV is an attractive option for transportation while in countries with low population density the EV is less appealing as a transport mode. However, according to statistics, 80% of the total EU population live in urban areas. It is in urban areas that the EV is best suited since travelling from one place to another within the city and charging station can be frequently used.

Electricity production in the EU has increased since 1990, which benefit the EV as a system since electricity is as a component of the EV. However, likewise with the population, the electricity production is different in different EU member-states. The hydro electricity production hardly generates any CO_2 emissions at all, to producing electricity from coal, which emits high numbers of CO_2. The EU has taken legal actions as it adopted the climate package in 2009 for reducing CO_2 emissions. Studying it help from an LTS approach, politicians have in this sense affected the system in a favourable manner. This is because they have adopted laws to reduce CO_2 emissions, which the EV does not emit.

Assumption 6: Since Germany has a diverse energy mix and is a densely populated country, the country should strive for the development and introduction of the EV.

Germany has the largest population in Europe with several cities over one million inhabitants. In this sense, the EV is an attractive option because of the range that the EV has with limited travel distances. The country is also densely populated which also favour the EV. This benefit the EV in Germany since the country can establish charging points along the roads, and to be frequently used by EVs from several countries. Studying these factors in a LTS perspective, they are positive components for the introduction of the EV in Germany.

The country´s electricity production is diverged and German federal government has also announced a phase out of its nuclear power plants. Germany is installing wind

and solar power as a response to the nuclear phase out. However, it does not generate as much electricity as the nuclear power plants, and the vast majority of electricity is generated from coal and gas. The country´s ambition to reduce its GHG emissions will be problematic.

Germany should strive to increase the EV in this perspective, but the country has challenges. The decision to phase out a major producer (nuclear power) of electricity may affect the total energy situation in Germany in a negative way. With help form the LTS approach, the EV affect the electricity consumption, but not to that large extent according to some estimations. Regarding its population, there are positive indications for the introduction of the EV since it has a large population and the situation in centre of Europe.

Assumption 7: Since France has a large supply of electricity by nuclear power and is a densely populated country, France should strive for the development and introduction of the EV.

Studying the EV in a geographical perspective in France it is evident that the country has several favourable prerequisites. France is centralized in its population structure. The Paris region is by far the biggest urban area in France. France borders to several countries with high amount of transports that passes through the country. As with Germany, this can also benefit France as they can construct charging points for EVs along the roads, which can be frequently used. The extensive production of electricity in France is favourable for the EV. The fact that France is the biggest exporter of electricity in Europe indicates that the country is well prepared for a development of the EV. The French energy production means very low levels of GHG emissions and they may reach their ambitions of reduced CO_2 emissions by 2050. In combination with the country´s ambition to develop the EV, the transport sector may reduce its CO_2 emission significantly, which also is indicated by the IEA report.

The components in this perspective indicate that France should strive for developing and introducing the EV. It is clear that the components presented are favourable for the system since France is a densely populated country and the supply of electricity is good.

Assumption 8: Since Sweden has a large supply of electricity but in many areas is a sparsely populated country, there are contradicting factors for the development and introduction of the EV.

The geographical prerequisite in Sweden is challenging in this perspective. The fact that the country is situated in the periphery of northern Europe indicates that transportation passing through the country is not that large. This means constructing charging points for EVs is not beneficial to that large extent, both because of low population density and the country´s position. The electricity production in Sweden is characterized by its very low emissions of CO_2. This is because there are hardly any emissions when producing the electricity since most of the electricity derives from hydro- and nuclear power that. The production of electricity is also secure and can be controlled if the demand is high, then the production can be increased and vice versa.

The reverse salient phenomenon is in this perspective obvious for Sweden. For the EV introduction to be prosperity the population density needs to be higher. The range of an EV is not so long before the battery needs to be charged. This affects the system in a negative way because of the low population density do not benefit the introduction of the EV. However, what is beneficial is the electricity production with its CO_2 emission free production. The electricity production in combination with the EV introduction could help Sweden to reach its goals by a 40% reduction of GHGs for 2020 and in the longer run that Sweden to be a fossil free society by 2050. Therefore, there are contradicting factors for the introduction of the EV in Sweden in this perspective.

8.3 Industrial perspective

Assumption 9: Since the EU cannot offer any incentives, the car industry in the EU will not invest in the development and introduction of the EV.

The EU itself cannot offer any incentives. The EU has tried to push the European carmakers to promote new green technologies through laws and policies, which has been adopted differently in each company. Some companies have invested heavily in

the EV, while other invested in other technologies. Common for all European carmakers is that they strive to reduce the oil dependence for their cars. This has several explanations such as: increasing oil prices, laws adopted by both the EU member-state´s government and public opinion for green technologies in Europe. The European car industry has been late in its commitment to the EV development. Asian carmakers have been involved in the hybrid and electrified technology for many years and have had global success with models such as the Toyota Prius. The reason why carmakers in the EU have not been in the forefront in this new technology has several explanations.

Using the LTS approach to see why there are differences between the EU member states, the reverse salient phenomenon is clear. The public opinion and policy decisions are two explanations why there are differences but also technical aspects. The technical aspects, such as battery development and charging points, have been developed differently in the EU member-states. There are car companies that have been committed to develop technologies with governmental support, and others that have not received the same support. Finally, there are also large differences of EV registrations between the member states. This has also societal and political explanations, where the public opinion is in favour to support different types of green technologies, in which the EV is one of them. But also to what extent there are incentives for consumers to purchase an EV.

Assumption 10: Since the German government does not offer incentives, the domestic car industry will not invest in the development and introduction of the EV.

The German government has supported the EV but has not offered any economical incentives. The German industry has up until recently responded with reluctance toward electrification of their vehicles. However, as of spring 2014, BMW and Volkswagen have launched EVs in their fleet and more is to expect. It has taken the German car industry time to develop technologies for the EV.

The reverse salient phenomenon for the German car industry is evident. It has been to develop batteries and EV technologies. But lately, consumers have begun to demand more environmentally friendly cars in Germany, which is visible in terms of an

increase in EV registrations. The German car industry has responded to produce and develop new EVs. However, the dominant part of the German car industry´s fleet is still to develop ICE vehicles and EVs only account for a small part of the total amount of vehicles that are offered.

Even though the federal German government does not offer any economical incentives, the German car industry has recently begun to offer EVs and other types hybrid vehicles. It goes well along with the strategy implemented by the government that indicates a future increase for EVs. As the government previously stated this is a question for the market to decide. Factors that explain this development can derive from the society and politicians that have affected the system in a favourable way for the EV. This is evident as strategies declare that the EV is one important part for the German car industry to be innovative and competitive.

Assumption 11: Since the French government offer incentives, the domestic car industry will also invest in the development and introduction of the EV.

Two actors, Renault and the PSA group, dominate French car industry. The French car industry has dealt with sales losses and to try to overcome these, one of the actors has responded to invest and has a strong believe in the EV. Renault is the company that has integrated the EV into its fleet to the largest extent among European carmakers. The CEO of the company, together with the French government is determined that the EV is here to stay.

The two carmakers in France have adapted to the electrification of their fleet differently. This is visible, as Renault has invested significantly in the EV, whereas PSA has responded to invest in hybrid technology and refining conventional powertrains. The system (the EV) contains several actors such as investors and politicians and in this notion they have interacted to reach the same goal, which is to overcome weak sales after the financial crisis, and to reduce oil dependence. However, the actors have affected the system differently in these two companies where Renault, with political influence, has invested in EV technology but not the PSA group.

The French car industry has invested in the development and introduction of the EV, especially Renault, which has a connection to the French state that also is determined in its commitment to the EV. In combination with the largest amount of EV registrations in Europe and the French government´s commitment to the EV, French carmaker and especially Renault are to a large extent committed to the EV.

Assumption 12: Since the Swedish government does not support the EV to that large extent, the domestic car industry will not invest in the development and introduction of the EV.

Swedish car industry consists of Volvo, which is the largest company with several models in its fleet, NEVS that only focuses on developing EVs. The two companies urge the Swedish government to further increase stimuli and incentives for the EV. Volvo, consider the government should only be involved in increasing the economical incentives, whereas NEVS consider the government to be more active in the development of the EV.

Even though the Swedish government only offer a purchase rebate, NEVS believe in the EV. The company has chosen only to focus on the EV, but as of spring 2014 they have not started to produce EVs commercially yet. The system is in the case of NEVS highly affected by its Chinese financiers that have invested in the company. The reversed salient problem for NEVS is that they are a new actor on the market, with few alternatives for customers to choose from. Volvo has also invested to develop the EV, but have not put it into commercial production. They do not believe in the pure EV to that large extent as NEVS do. They have adapted to the market by introducing PHEVs instead. The company see that the EV has too many limitations to be able to invest in the technology at the moment.

Even though the Swedish government has not delivered any specific strategies for the introduction and development of the EV, the domestic car industry has invested in EV technology. They both want to reach the same goal, but they have chosen different approaches to the electrification of their vehicles. In the case of NEVS there are investors that consider the EV to be profitable and therefore they are committed to invest and develop it.

9. CONCLUSION

9.1 Discussion of results

The aim of the study has been to throw light on the prerequisites for the introduction of the EV in the EU. This has been accomplished by studying the situation of the EV from institutional, geographical and industrial perspectives in Germany, France and Sweden and at EU level. To be able to get a comprehensive picture of the EV introduction, twelve assumptions were constructed. Each assumption was specified for the perspective and country. Studying the assumptions was performed by data collection that comprised of examining official documentation and news articles from each country and at EU level. Two interviews with stakeholders from two Swedish carmakers were also performed. Previous research shows that the government always has been integrated with the EV. Historically, they have put incentives that decreased the use of EVs up until now, when governments in Europe try to promote EVs.

There are limits for the EU, as a supranational institution in the decision making process of the EV. Policies for promoting a certain powertrain, such as electricity for transportation, are at national level and not at EU level. Certain incentives for the EV are hard to establish at EU level, as it still is a question for each national government to decide which incentive to promote and how it should be directed. Concerning the introduction of EVs in Europe it is obvious that different member-states have taken different actions. In France it is evident that the government intends to increase the amount of EVs in the very near future, whereas in Sweden, the government has been quite vague in its commitment to the EV.

Nonetheless, the EU has tried to take an active role with transport and energy policies adopted by the member-states and setting specific targets for a reduction of CO_2 emissions with the EU common energy policy. This is an effective tool for the EU to exert pressure, both on the governments in each member-state, but mostly on the carmakers in the EU. As highlighted in the white paper on transportation in the EU (COM 144 final), the carmakers in the EU are obliged to reduce their average CO_2 emissions by 2015. Further, the 2011 White paper states a vision for the EU to

become less oil dependent in the future. It also sets a target of 60% reduction of GHG emissions from transport by 2050 as of 1990 level. These actions are however not specified for the EV. Instead this is an average reduction of emissions in the total transportation of the EU. Within the EU institutions, the Commission has taken the most active role in the EV introduction, which was visible with the launch of the clean fuel strategy in January 2013. This strategy was voted down when the member-states´ government gave their opinion. This is the core challenge for the EU to take an active role. All member-states must support the proposal for it to be implemented and this has until date not been possible.

The main finding of the study is that there are differences for the EV introduction in Germany, France and Sweden. Studying the EV at EU level, it is clear that the EC has tried to initiate proposals to increase the amount of EVs in the member-states, but was voted down later when the member-states gave their opinion. The thesis has contributed to research in European studies that the EU, in this case, has appeared as a policy actor rather than a formal policy player. This was visualized when the EC presented a proposal for the increased number of EVs and charging infrastructure that was heavily over-sized compared to what member-states have today. It is in this case as the EC tried to launch a debate of EVs in its member-states.

Further, the thesis tried to throw light on the geographical preconditions for the introduction of the EV. Energy production and settlement structures are difficult to clearly connect to the EV introduction. This was visualized when calculations made by the DG for internal polices showed that there is not such a clear correlation between a large increase in the number of EVs, and demand for electricity.[152] It also requires deeper studies of how population structures in a country may affect the EV use. Today, regions seems to be more important, especially in Europe where there is free movement of capital, services, goods and people. National boundaries are less important in this case, and you can live in one country but work in another and commute with the EV over the land border. The same applies to electricity production that is highly integrated in Europe with a grid that is connected between several countries. The thesis has only studied the electricity production and from where it

[152] DG for Internal Policies (2010): p.14

derives and the difference between a unicentral and a multicentral settlement structures. Therefore it lacks to draw any further conclusions in the geographical perspective.

In Germany, the federal government has established a council to develop and introduce the EV. The government initiated the council, which is seen as the leader by guiding the policy discussion with its interim reports. The government has also included the German states to be part of the development. This indicates that the multicentral German federal government is not the leader in the development of the EV. Instead the government has acted as an initiator to increase the amount of EVs in the country. Germany has a diverse energy mix and the decision to phase out their nuclear power plants and replacing them with wind and solar power indicates a problematic aspect for the EV. However, there is still a large amount of electricity production deriving from coal in Germany with high levels of GHG emissions. The settlement structure with competing larger cities in the country is historically explained by the late unification of the country. This is a positive aspect for the EV since the range of it is limited and the travelling distances between and in cities can be made with an EV. The fact that the country is situated in the centre of the EU is also a positive aspect since travellers from other countries crosses Germany and may use the infrastructure required for the EV. German carmakers have been rather restrained in their commitment to the EV. It is recently that they have begun to offer EVs in their fleet to customers. German taxpayers have not had to pay the bill for the EV investments in the country, which took place in France. Instead, this is a question for the market to decide.

France is the country in the EU that has invested most into developing the EV. The French government clearly showed its commitment to the EV as they invested in it with packages financed by the bonus/malus system. The unicentral French government has initiated strategies and goals for the EV mostly for overcoming weak car sales for the French manufacturers after the financial crisis. Unlike Germany, the French government has been the leading actor in the introduction of the EV. They established agreements with carmakers and French regions and they committed themselves to invest in the EV making the French carmakers to be able to invest properly in the EV. French electricity production is generated mostly from nuclear,

making the electricity situation secure and they export electricity to their neighbouring countries. The country is also located in the centre of Europe, which enables transportation to cross the country.

The Swedish government has not been as committed to the introduction of EV as the French and German. The unicentral Swedish government has instead chosen to draw up a vision of a fossil-free transportation fleet by 2030. Goals and specified strategies to introduce the EV do not exist to that large extent. Further, the Swedish government has not integrated stakeholders from different branches to be part of the EV development. There are positive indications for the EV introduction in Sweden. The country has large sources for producing clean electricity with hydro and nuclear. The company NEVS is also committed to invest in EV technology. However, the country is large and the population density is low, indicating challenges for the EV. The country is also situated in the periphery of Europe, making crossing transportation low.

The thesis has contributed to throw light on the EV, which is a current subject. I have found that there are differences in the commitment of the EV among member states. The EV as a system is affected in several ways and also affects other systems. For the EV to become a success in the introduction phase and reducing the oil dependence there need to be a commitment from the entire society in a country. This is what Germany and France have done. They have integrated actors from different branches and levels in the society. This is evident as the EV is increasing in these countries. Especially France with its unicentral state, great supply of electricity, and carmakers that have made heavy investments, adds up to an optimistic potential for the EV in the country. Germany has recently recognized the potential in the EV and is now entering a phase where the EV expands in the whole society. Especially at the industrial side where BMW and Volkswagen recently launched their first commercially produced EVs.

The results that I have found are to a large extent expected. What strikes me is the Swedish stand toward the EV. The Swedish government sees itself as innovative and striving to support green companies, which has not been evident for the EV. Sweden performs well in innovation indexes, but the EV, with all its potential is to some

extent neglected in the policy discussion in Sweden. The only incentive that exists is a rebate, which is clearly too low. Concerning the goal and vision in Sweden to have a fossil free transportation fleet by 2030, the EV has a great potential since it emits no GHG.

There are several indications why car companies in the same country choose to invest in different types of fuels even though the same governmental policies exist. To a large extent, it depends how the management view the situation and what they believe is the greatest demand among consumers. This is closely linked to policy reforms and incentives. The government has several tools they can ensure a certain fuel to be more or less sought after among consumers. This indicates why more EVs are sold in Norway today than conventional cars. The Norwegian government has introduced several incentives that make the EV more attractive than a conventional car. For a car company, it takes time to develop a new car. To overcome this challenge, various car manufacturers adopted different strategies. One has been to develop a brand new EV, as BMW, while Volkswagen has chosen to electrify an already existing car model.

From a firm perspective, to invest in the EV there is challenges since it is a commercially relatively new and untested technology. The infrastructure for the EV, particularly in terms of charging stations is not yet developed which indicates some uncertainty for the consumers. The EV is also expensive to buy, in relation to conventional cars. In order to earn money, car companies have to increase volumes of produced cars and thereafter scale down the costs, which was underlined by the Volvo respondent. For the EV, this may require subsidies and guarantees from the state so that the consumers are willing to invest in an EV, at least in the beginning of the development and to make the innovation spread and accepted.

It is evident that different carmakers have taken different strategies toward the electrification of their fleet. Volvo consider that the hybrid give the customer greater choice outside of town where charging stations are in equally makes it more attractive, whereas Renault and NEVS have focused on pure EV´s. As for the EV´s future it is up to both the state and the market to adapt to how an expanded charging infrastructure can be done. Here are different strategies but the prevailing, particularly in France, is that the state takes overall responsibility to build it out together with

local authorities. In Sweden, strategies at local level have been implemented, however at national level the interest has been modest. The relationship between the state and local authorities is something the thesis has not studied any deeper, rather than concluding that there are different structures in different countries. In the multicentral Germany, the federal states have been engaged in the development of strategies concerning the EV.

Relating to the LTS theory, the notion of dividing the system into four main phases can be applied to the EV. In France, there are indications that the country is entering the momentum phase, which is the last phase for systems to progress. The EV has affected other systems, groups and humans. Consumers have begun to invest and perceive the EV as an attractive choice when purchasing a new car. Components of the system have been added in a favourable way for the EV. The incentives that the French government offer, the settlement structure in the country and French carmakers are committed to the EV means positive components for the system to evolve. In Germany and Sweden, the system is in the earlier stages. It has not affected other components to such large extent, and therefore the EV is in the earlier stages of the development.

9.2 Future research

The EV is gaining attention worldwide. Most recently, many carmakers have begun to offer competitive EVs on the market. The question to what extent it will become a success is interesting and to see how the national governments regard the development. A closer look at electrifying the commercial transportation on public roads is also an interesting future topic. It would also be interesting to study the EU´s role for the EV. The EU has not been able to push the member-states towards electrification of their transport fleet. Climate concern will grow and the oil price will increase. The society needs to take broad actions to meet these concerns, and the EV may be a solution to a fossil-free transportation. The question remains if the EV will become a success, but many aspects points towards it. However, researchers have not been able to agree if the EV is here to stay or not. Only future will tell.

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Appendix

Interview-guide with Lennart Stegland, Volvo:

Background questions:
1 What is your position in the company?
2 How long have you had it?

International
1. If we look at other countries. Which are the countries Volvo thinks Sweden should take after in the electric vehicle issue, and what incentives do you see as successful?
2. In France, the government clearly favoured electric vehicle subsidies, while Germany has allowed the market to a large extent to control. How do you regard this as a car manufacturer? Where would you position Sweden between these opposites?
3. How does the Volvo see on a "bonus/malus" system existing in France?
4. How do you see at the international market´s (mainly the US, Asia and Europe) acceptance for electric vehicle? Similarities and differences to Sweden?
5. What is the future for the electric vehicle in Europe, believes Volvo?

The EU
1. Does Volvo regard electric vehicles as a strategic opportunity for the European automotive industry, given the focus right now is on environmental cars in general and electric vehicles in particular?
2. Participates Volvo in any EU-funded projects?

Sweden
1. What is your general view on the Swedish government's position in the electric vehicle question?
2. How do you think it should be developed?
3. What are the biggest challenges for electric vehicles to become an attractive option for consumers?
4. How do you think the Swedish government should be involved in the development of an electric vehicle fleet?
5. Does Volvo think that the reason for the relatively low quantity of electric vehicles in Sweden can be explained by the Swedish government hesitance not to establish a national plan with incentives etc.?
6. Sweden´s government has established the vision to have a fossil-free vehicle fleet to 2030. What do you think of the vision?
7. With Swedish conditions, in the supply of electricity and relatively large country to the surface. What are the challenges for the electric vehicle?
8. Has your company received any government funding to develop electric vehicles?

Volvo
1. Have you been involved in the work on SOU, 2013:84 (Fossilfrihet på väg)?
2. How come Volvo only invests in hybrid and not pure electric vehicles like NEVS does?
3. How does Volvo regard NEVS electric vehicle plans?
4. Can one explain electric vehicle investments as a result of trying to diversify and gain competitive advantage?
5. How do you as carmaker see on the issue of how consumers will be persuaded to choose an electric vehicle? What is it needed? Should the knowledge come from the state, the car manufacturer or a combination?
6. According to many researchers, an acceptance of a new innovation is required to be more widely accepted by consumers and to obtain information and knowledge about the new product. Can you see the same pattern to the electric vehicle?
7. Which government incentives (tax reduction, purchase rebates, access to bus lane, free parking, etc.) is desirable, consider Volvo?
8. Can one today talk about that there is a market for electric vehicles or will it continue to be regarded as a niche market?
9. What is your cooperation with other automakers in the development of electric vehicles?

Conclusion
Other thoughts and reflections. Something that you want to add?

Interview-guide with Mikael Östlund, NEVS:

Background Questions:
1. What is your position in the company?
2. How long have you had it?

International
1. If we look to other countries. Which countries thinks NEVS Sweden should take after the electric vehicle issue, and what incentives do you see as successful?
2. In France, the government clearly favoured electric vehicle subsidies, while Germany has allowed the market to be in control. How do you regard this as a car manufacturer? Where would you position Sweden between these opposites?
3. How does NEVS see on a “bonus/malus” system found in France?
4. How do you see at the international market´s (mainly the US, Asia and Europe) acceptance for electric vehicle? Similarities and differences to Sweden?
5. What is the future for the electric vehicle in Europe, believes NEVS?

EU

1. Does NEVS regard electric vehicles as a strategic opportunity for the European automotive industry, given the focus right now is on environmental cars in general and electric vehicles in particular?
2. Participates NEVS in any EU-funded projects?

Sweden

1. What is your general view of the Swedish government's position in the electric vehicle question?
2. How do you think it should be developed?
3. What are the biggest challenges for electric vehicles to become an attractive option for consumers?
4. How do you think the Swedish government should be involved in the development of an electric vehicle fleet?
5. Does NEVS think that the reason for the relatively low proportion of electric vehicles in Sweden can be explained by the Swedish government hesitance not to establish a national plan with incentives etc.?
6. Sweden´s government has established the vision to have a fossil-free vehicle fleet by 2030. What do you think of the vision?
7. With Swedish conditions, in the supply of electricity and relatively large country to the surface. What are the challenges for the electric vehicle?
8. Has your company received any government funding to develop electric vehicles?

NEVS

1. Have you been involved in the work on SOU 2013: 84 (Fossilfrihet på väg)?
2. How does NEVS regard Volvo's electric vehicle plans?
3. Can one explain electric vehicle investments as a result of trying to diversify and gain competitive advantage?
4. How do you as carmaker see the issue of how consumers will be persuaded to choose an electric vehicle? What is it needed? Should it come from the state, the car manufacturer or a combination?
5. According to many researchers, an acceptance of a new innovation is required to be more widely accepted by consumers and to obtain information and knowledge about the new product. Can you see the same pattern for the electric vehicle?
6. Which government incentives (tax reduction, purchase rebates, access to bus lane, free parking, etc.) is desirable, consider NEVS?
7. Can one talk about that there is a market for electric vehicles or will it continue to be regarded as a niche market?
8. What is your cooperation with other automakers for in the developing electric vehicles?

Conclusion

Other thoughts and reflections. Something that you want to add?