Urban Policy Implications on the Electric Vehicle Transition in Berlin and Washington, DC

Tina Sänger
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Supervisor: Cecilia Mark- Herbert
Evaluator: Peter Söderbaum
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SÄNGER, TINA


Abstract: This thesis argues for an approach which goes beyond the conventional urban climate governance view. With engagement in social-technical practices, a more sustainable and inclusive way of transforming the city can be accomplished. One way of doing so is with the offering of the urban living lab as a playground for real-life experiments. With a purposive intervention in an urban socio-technical system, the three-dimensional concept of urban environmental governance, socio-technical experiments and strategic experiments with designed policies can create a more sustainable urban transition. The urban electric vehicle transition is just one example of how these three concepts can be applied. In order to demonstrate the interaction of a sustainable urban transition, an empirical case study was conducted.

This thesis makes a conceptual contribution by engaging with current understanding of urban sustainability transition, using the urban electric vehicle transition as a reference point. The insights of this study extend the theories of the socio-technical system and argue that it is not only about social and technological innovation but how multiple innovations are experimented with and combined in an existing urban context. In addition, the research addresses how this transition is governed on a municipality level and is achieved through a multiple case study approach, analysed through the lens of environmental governance and offers an empirical exploration and develops the theoretical and conceptual framework of the socio-technical system further.

Keywords: Electric Vehicle, Environmental Governance, Sociotechnical transition, Sustainable Development, Urban Development, Urban Policy

Tina Sänger, Department of Earth Sciences, Uppsala University, Villavägen 16, SE- 752 36 Uppsala, Sweden
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Summary: The need for a sustainable urban transition is recognised by international, national and regional authorities and included as an aim in the Paris Agreement and the Sustainable Development Goals. Yet, the implementation varies from city to city since every case is unique and offers different challenges, approaches and opportunities. Aspects such as the replacement of the conventional fossil fuel driven car with the electric vehicle are one way of approaching a sustainable urban transition. Although urban areas and case studies are unique, hindering aspects are common and identified as high purchase price, deployment of charging infrastructure and communication to the public. This thesis aims to examine the development of the electric vehicle transition in Berlin and Washington, DC. The analysis of this study applies the methodology of a qualitative case study and uses a conceptual framework focusing on a socio-technical system. Moreover, interviews through semi-structured interviews are collected and analysed through the lens of environmental governance. Finally, from the examination of the developing process of the electric vehicle transition in each city, a comparison will be made that helps to understand how individual actions can form a sustainable transition.

Keywords: Electric Vehicle, Environmental Governance, Sociotechnical transition, Sustainable Development, Urban Development, Urban Policy

Tina Sänger, Department of Earth Sciences, Uppsala University, Villavägen 16, SE- 752 36 Uppsala, Sweden
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<th>Description</th>
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<tbody>
<tr>
<td>CARB</td>
<td>Californian Air Resource Board</td>
</tr>
<tr>
<td>eMO</td>
<td>Berliner Agentur fur Elektromobilität</td>
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<tr>
<td>EPA</td>
<td>US Environmental Protection Agency</td>
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<tr>
<td>EV</td>
<td>Electric Vehicle</td>
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<tr>
<td>EVSE</td>
<td>Electric vehicle supply equipment</td>
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<tr>
<td>GHG</td>
<td>Greenhouse Gas</td>
</tr>
<tr>
<td>HOV</td>
<td>Lane High Occupied Vehicle Lane</td>
</tr>
<tr>
<td>ICEV</td>
<td>Internal Combustion Engine Vehicles</td>
</tr>
<tr>
<td>ICCT</td>
<td>International Council on Clean Transportation</td>
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<tr>
<td>MLP</td>
<td>Multi Level Perspective</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental-Organisation</td>
</tr>
<tr>
<td>PEPCO</td>
<td>Potomac Electric Power Company</td>
</tr>
<tr>
<td>PHEV</td>
<td>Plug-in Hybrid Electric Vehicle</td>
</tr>
<tr>
<td>SD</td>
<td>Sustainable Development</td>
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<td>SDGs</td>
<td>Sustainable Development Goals</td>
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<td>UN</td>
<td>United Nations</td>
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1. Introduction

Transportation is one of the fastest growing sectors in the world, heavily dependent on fossil fuels and creates sustainability issues related to social, economic and environmental concerns. The Internal Combust Engine Vehicle (ICEV) (Çağatay Bayındır, Gökçeküçük and Teke, 2011; Lefevre and Enriquez, 2014). In addition, according to the United Nations (UN) cities account for 60 till 80 per cent of energy consumption and 75 per cent of carbon emissions (www.un.org, 2015) and are a significant contributor to climate change. Furthermore, urban areas are expected to grow by 40 till 50 per cent of the global population until 2030 which results in increasing demand for energy and brings challenges policymakers to create a sustainable urban agenda (www.wcr.unhabitat.org, 2017).

One part of a modern planning agenda will be urban transportation. Especially Western cities were built to occupy the most desired form of transportation, the car. As a result, streets became crowded and highly polluted.

With the Paris Agreement nations committed themselves to reduce emissions and work actively on the decarbonization of urban transport to deliver on climate targets. The commitment on a national level to a more decarbonised transport system varies (www.unfccc.int, 2016). Whereby Germany is highly involved in the Paris Agreement. It has high carbon emission reduction targets and tries to reduce its CO₂ emissions by 40 per cent compared to the emissions caused in 1994 by 2020. However, recent calculation estimates, Germany it will only achieve 32.5 per cent. The German federal government includes several stakeholders such as the Association of Cities and Communities as well as institutions with a focus on zero emission mobility management (www.bmub.bund.de, 2017).

Currently, most cars are ICEV and are powered by diesel or petrol which causes different emissions. Some of them are CO₂ which contributes directly to climate change and NOx which cause significant harm to public health. Other health issues in urban areas related to transport, is the noise pollution also caused by ICEV (www.mdr.de, 2018).

In order to address global issues such as climate change, the UN adopted 17 Sustainable Development Goals (SDGs) in 2015. Goal 11 is dedicated to the creation of sustainable cities; in particular, the target 11.2 aims to achieve sustainable transport systems and the related environmental impact in urban areas by 2030. It also promotes the accessibility and affordability aspects of transportation (www.undp.org, 2017).

The correlation between urban development and decarbonised transport was also highlighted at COP23 in Bonn 2017 (www.unfccc.int, 2017). Political leaders think tanks and Non-Governmental Organisations (NGOs) worked on recommendations on how to make cities more resilient, clean and accessible for the future. The main massages and agreements related to transportation are (www.ppmc-transport.org, 2017):

- Decarbonization of all modes of transport by 2050 is possible
- Action on low carbon transport supports eight of the SDGs
- Investments in sustainable low carbon transport offer great value for money
- Innovative solutions have the potential to transform current transport systems into efficient, low carbon people-orientated solutions
- The global transport community stands ready to support countries, cities and companies’ action on climate change and development

Next, to international governmental commitments, the national governments receive pressure from citizens. The diesel scandal started in September 2015 when the US Environmental Protection Agency (EPA) issued a violation notice to Volkswagen. The violation notice based on the discoveries by the California Air Resource Board (CARB). Manipulation software was programmed to present low NOx emissions during laboratory testing. However, real-life testing showed up to 40 times higher NOx emissions. Moreover, in 2016 the CARB discovered the unlawful changing of CO₂ emissions which contribute to global warming and climate change.
The car manufacturing industry experienced a severe image loss and governments are looking for alternatives and solutions to offer to their citizens.

One solution and a way of achieving an environmentally friendly urban transition is the expansion of electric vehicles (EV). This technology has the benefit of having zero emission while driving and is therefore environmentally friendly transport method. With electricity produced from the renewable energy the transition to an EV dominated market can also lead to the independence from fossil fuels. Moreover, the EV transition creates new employment opportunities and opens new research fields (Le Petit, 2017). Another positive side effect is the minimal noise which resolves another urban issue, noise pollution (Anonymous, 2009).

From an industry perspective, the EV transition became important when a niche car manufacturer called Tesla announced a car battery capacity of 240 miles in 2011. In the beginning, the new hype was mostly for wealthier people and considered as an image product. However, leading automakers recognise the future potential, the competitiveness, and started issuing the market with their models (Thompson, 2017). Yet, the market share is still less than 2 per cent in Germany and the US (Kwan et al., 2016; Field, 2017). The slow uptake is due to the high purchase costs, limited charging infrastructure deployment and restrained consumer awareness (Hildermeier, 2017).

Other countries have been more active in integrating the EVs in their policy framework, with high incentive policies and signals to ban ICEV. These political commitments send strong signals to their citizens and car manufacturers. Table 1 shows which countries announced an ICEV ban, gives an overview of EV market share in the country and highlight some national policies. Figure 1 shows how the EV sales developed during the year 2010 and 2017 globally and in selected countries.

![Figure 1. Global electric vehicle sales between 2010 and 2017 by country (Lutsey, 2017a).](image-url)
Table 1. List of policy commitments, financial incentives and electric vehicle market share in selected countries

|----------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| China          | “in the near future” (Agence France-Presse, 2017) | • Purchase incentive of $4765 since 2016, but gradually declining until 2020 incentive is phased out  
• Up to 30% subsidy for installation of charging infrastructure (Lu, 2018) | 1.31                                                        |
| France         | 2040 (Chrisafis and Vaughan, 2017) | • exemption from the registration tax (total or 50%)  
• Under a bonus-malus system, n up to 30% premium is granted for the purchase of a new electric vehicle  
• €10,000 to electric vehicle buyers when they scrap an ICEV (www.ACEA.be, 2017) | 1.5                                                         |
| Germany        | 2030 (Böll, 2016)                | • exempt from the annual circulation tax for a period of ten years from the date of their first registration  
• Environmental bonus of €4,000 when EV purchased (www.ACEA.be, 2017) | 0.7                                                         |
| Netherlands    | 2030 (Lambert, 2017)             | • exempt from the registration tax  
• As of 1 January 2017, passenger cars with zero CO2 emissions are exempt from motor vehicle tax up to 2020  
• discounted income tax (4%) is levied on fuel-efficient cars (www.ACEA.be, 2017) | 6.4                                                         |
| Norway         | 2025 (Staufenberg, 2016)         | • No purchase taxes (extremely high for ordinary cars)  
• Exemption from 25% VAT on purchase  
• No charges on toll roads  
• Free municipal parking  
• Free access to bus lanes (Valoen, 2012) | 29                                                          |
| United Kingdom | 2040 (Agence France-Presse, 2017) | • exempt from the annual circulation tax and company car tax  
• up to 35% of purchase price subsidy (Gordon-Bloomfield, 2015) | 1.4                                                         |
| USA            | No target                        | • Tax credit up to $7500 (www.fueleconomy.gov, 2018) | 0.9                                                         |
Both illustrations (Figure 1 and Table 1) demonstrate a constant trend to an EV adoption. The outlined policies are all on a national level and mostly focusing on making the first-time purchase for the EV as affordable as possible. In addition, those countries expanded the needed charging infrastructure and consumer awareness education programs (Lutsey, 2017a).

Despite the historical, technological and first political developments, there is still an insufficient transition to an EV penetrated market. The analysis of EV adoption on an urban level finds very limited focus on the academic literature. Although the topic of EV is relatively new, the academic research in that field emerged quickly. There is already evidence on the impact of EVs, technical analysis and future outlook. It lacks, however, specific urban case studies (Geels, 2002). National policy frameworks are analysed, general consumer awareness and response, and industry opinions addressed but the difficulty urban leaders are facing to transform their city into EV leading streets has not given much attention in the academic field.

It is necessary to assess cities, specifically with small economic resources because they are often overlooked in their efforts, but their results can be even more important. The response and adaption observing of an EV transition in a less financial benefited area make conclusions valuable because it has the potential to be duplicated in rich cities or cities with the similar economic situation.

1.1. Aim and research questions
This thesis aims to explain factors that determine a transition to electric vehicles in Berlin and Washington, DC. The project includes the context of stakeholder participation within a socio-technical system. In particular, it is going to examine the role of policy approaches and its value on the urban electric vehicle transition. The study also focuses on challenges to get a brief overview of how and in what policy field the transition can be improved.

Given the political commitments towards an environmentally friendly city, Berlin and Washington, DC are good case studies for analysing the challenging process of assessing policies that are aiming to foster the transition towards an EV market penetration.

To achieve the aim, the following research questions are framed:

- What challenges and opportunities for the chosen cities EV transition are identified in the literature?
- What are the challenges for the cities to achieve a transition to an EV dominated market?
- What milestone and obstacles can be identified in the transition to EV market in Berlin and Washington, DC?
2. Method

This thesis aims to analyse the transition to an urban EV dominated market and concerning stakeholder participation and the provisioning of policies. It is also responding to challenges and existing developments in that field. To achieve the aim a combination of a case study and literature review is conducted for an empirical study. In addition, semi-structured interviews via phone and in person will be conducted to develop a case study related outcome. Choices melted to these parts of the project are planned below.

2.1. Research design

This study is analysing a complex transition in an unexplored phenomenon of the electric vehicle transition in an urban context. The transition is influenced by multiple stakeholders including policymakers, the industry and citizens.

The research focuses on real-life data and sees the urban case study as an urban lab experiment which offers results on an individual sphere but provides insights and best or worse practise examples. Real life research can be a challenge for a researcher and defining a particular fixed research framework and tools beforehand can be a complicated process (Robson, 2011). Maintaining certain design flexibility can allow reconsidering applied framework and tools, which then can lead to novel findings.

Good quality research depends on the researcher’s interpretation and is confronted with the threat of missing out some interpretation of data. The abductive approach is a technique to avoid this risk by moving back and forth between, empirics, analysis and theory (Dubois and Gadde, 2002; Yin, 2013). That way, multiple sources of open data and the trustworthiness of the research increases. Moreover, this strategy helps to identify new variables and relationships. To close the gap between the identified problem and the socio-technical system, this project will build on an abductive approach consisting of a comprehensive case study and a literature review.

2.2. Literature review

Research should be based on previous scientific knowledge (Thiel, Sage and Conroy, 2015). To gain insights and overviews on the existing research on EV transition in urban areas, policy approaches and stakeholder participation and a literature review was conducted.

A literature review involves the identification, location and analysis of documents containing information related to the research aim. Those articles are to be found in academic journals, journalistic publications, social media and municipality homepages. The literature review will expose gaps in the knowledge on the topic and helps to identify patterns to findings, conflicting findings and helps to define the topic in more depth (Robson and McCartan, 2015).

A relevant construct for this research was a set of interdisciplinary literature in the field of public policy analysis related to EV transition. In addition, publications and communication material from Berlin and Washington, DC council will be used to have the most recent local developments in the field of the EV transition. Databases used are Uppsala University online library, google scholar and generic google search. Although the research is focusing on two specific cities, the research will look at similar developments on an US and EU context.
Search results were limited to the timeframe 2008 till today; there were no particular journals considered to keep the research field as brought as possible, and search words were presented in table 2:

Table 2. List of empirical and theoretical search terms.

<table>
<thead>
<tr>
<th>Empirical search terms</th>
<th>Theoretical search terms</th>
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<tbody>
<tr>
<td>Urban mobility transition</td>
<td>Stakeholder engagement</td>
</tr>
<tr>
<td>Charging infrastructure deployment</td>
<td>Innovation transition</td>
</tr>
<tr>
<td>Berlin/ Washington, DC policy, electric vehicle</td>
<td>Environmental governance</td>
</tr>
<tr>
<td>Electric vehicle development</td>
<td>Socio-technical transition</td>
</tr>
<tr>
<td>Electric vehicle policy</td>
<td>Urban policy development</td>
</tr>
<tr>
<td>Electric vehicle incentives</td>
<td>Multi-Level Perspective</td>
</tr>
<tr>
<td>National electric vehicle policy</td>
<td>Case Studies in Urban Planning</td>
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</tbody>
</table>

In sum, the literature review ensures the quality of this research and will be analysed through the lens of the theoretical framework of Environmental Governance.

2.3. Case study

Case study research is a methodology applied to real-world issues and outcomes in relevant structures. According to Patton and Appelbaum (2003) and Yin (2003) case study research can be used for developing a new theory through observations, for testing, evaluating or improving existing theories through their implementation in practice.

According to Yin (2013) "case study method is an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used".

More specifically, a multiple case study is suitable when an established conceptual framework already exists, but a closer look at an empirical phenomenon can contribute to deepening it further. Moreover, a case study method allows to look at different actors and simultaneously avoids a single analysis by considering individual and group level constructs (Bhattacherjee et al., 2012). This can be useful when looking at an urban mobility transition involving different levels of actors.

Moreover, Bakogiannis et al. (2014) state that urban and mobility research is usually conducted by analysing existing environments, secondary data, and surveys (2014, p. 42). This analysis can be a supporting case and could enhance, in a similar environment, the understanding of a needed transformation or can inform about potential shortages in implementation (ibid, p.42). In addition, observation in urban planning and mobility transitions allow insights on applied policies and approaches.

To execute and write a case study three steps are to be followed (Creswell, 2009):

- Research phase with academic research and searching for relevant interview partners
- The analysis phase includes the collection and analysis of all applicable data
- A solid analysis of the case

In addition, it is recommended to use visual materials such as pictures and photographs in order to make the research more communicative to the reader (Bakogiannis et al., 2014, p. 45). Moreover, reporting on case studies exposes the researcher to a broad spectrum of urban studies and sustainable mobility projects (Bakogiannis et al., 2014, p. 46).

At the same time a case study can become a premature conclusion (Eisenhardt, 1989), may have a poor choice of a suitable framework (Dubois and Gadde, 2002) and can include subjective bias (Yin, 2013). Those flaws can be avoided with a flexible and abductive research design and constant coming back to the research questions and theoretical framework and by modifying the interaction between empirical and theoretical results (Dubois and Gadde, 2002). Lastly, to minimise potential biases, the researcher needs to keep assessment trail with for example a case study protocol (Robson, 2011; Yin, 2013).
2.3.1. Choice of case study

In this project, two cities are studied, so that the challenges, policy approaches, developments and results can be compared and analysed. A multi-case study will give a more scientific knowledge to fill the gap of urban transition to EVs. It also will make it possible for scholars and urban policymakers to identify their own capacities and challenges as well as learning and get ideas from these case studies. The chosen cities Berlin and Washington, DC are good examples due to their political importance as being the capital city. At the same time, both cities have a weak economy and limited resources regarding limited political influence on the EV manufacturing industry. They are dependent on the products the market is providing and need to adapt accordingly with no possibility to be influential on upcoming developments in the EV market. However, cities are highly interested in enhancing the adaptation of the EV transition since the environmental and public health harm in the city needs to be tackled with urgency.

The thesis aims to investigate how the EV transition in the chosen cities are conducted with policy approaches and stakeholder participation. Case studies are well suited to open questions of how and why when the focus of the study is on a contemporary phenomenon within a real-life context (Sporrong and Kadefors, 2014). It is generally used to probe deeply and intensively to gain insights and understanding of new phenomena and an appropriate choice to identify why decisions are made and with which result (Travers, 2001). Moreover, case studies do not require any particular methods for data collection or analysis (Merriam, 1991). Due to the open-ended and exploratory nature of the research questions in the thesis, a case study is ideal.

A qualitative case study is a research approach which enables the “exploration of a phenomenon within its context using a variety of data sources.” ensuring that problems are investigated of only through one lens “but rather a variety of lenses which allows for multiple facets of the phenomenon to be relevant and understood” (Baxter and Jack, 2008, p. 544). In addition, a case study approach is selected, if the study aims to answer how and why questions (Yin, 2013). The case study method used to analyse the case studies Berlin and Washington, DC uses a literature review to gather its secondary data which will be reviewed in the English and German language.

Choosing the conceptual framework socio-technical system as a foundation of analysis, it bears consequences for the research method and brings practices in focus (Reckwitz, 2002). To put it in other words, the practical research becomes a new unit of analysis, and the focus lies on what different actors do and how they engage with a changing landscape of urban development and new policy implications. Nevertheless, perspectives from all levels of actors (e.g. businesses, political leaders, research institutions and others) can still be collected to develop a deeper understanding of how practices change and form (Shove and Pantzar, 2005).

For this research, an extensive analysis of simultaneous and complementary developments to the urban EV transition was considered. This includes, for example, technical developments in charging infrastructure and policy approaches in Berlin and Washington, DC.

2.3.2. Case study research in the urban living lab

Case studies are a practise-based discipline and are looking at ongoing or finished projects which foster either private or public decision-making process. During that research process, the urban environment becomes an urban living lab and is the arena of many techniques which helps to analyse comparative projects and draw lines between different developments in cities. As a result, case study research yields significant outcome and influences practice and ongoing research.

The application of case study research in urban planning resolves in the uncovering of phenomena and is often used to formulate urban public policy, outlines a decision-making process or provides examples on what is considered as best practice (Bulkeley, 2006). Furthermore, case studies are employed by urban planning scholars as a tool to translate knowledge into action. It also allows taking the role of an observer, participant or dispassionate analyst. In addition, case studies are valued in urban planning research since they are “telling stories—innovative efforts at moving cities and urban neighbourhoods in the direction of sustainability, at
finding ways to build economy, reconnect to place and environment, and at once to enhance the quality of life and reduce ecological footprints.” (Beatley, 2000).

However, it is to consider that case study research in urban planning often becomes evident after time. This evidence is displayed in either the transition of new knowledge into practice or stimulated new research and continues to observe, analyse and recommends as cities are in constant change. The importance of the continuous research in urban planning was early identified by Hall. With changes and variations in urban management (economically or political) and geographical location (Europe or America) he found that “in every city [...] growth brings problems, but those problems may vary in intensity according especially to the internal disposition of functions and land uses within metropolitan regions” (Hall, 1966, p. 234).

The urban living lab can help cities to achieve sustainability goals and are a forum “for innovation, applied to the development of new products, systems, services and processes, employing working methods to integrate people into the entire development process as users and co-creators, to explore, examine, experiment, test and evaluate new ideas, scenarios, processes, systems, concepts and creative solutions in complex and real contexts.” (Menny, Palgan and McCormick, 2018, p. 68) For urban policymakers and researchers, this means the urban living lab is to trial simple or more complex social, economic or technical developments with the broader goal of sustainability. It aims to bring together multiple actors who all seek the intervention for a contemporary urban challenge and fostering learning through forms of open engagement.

If the urban lab research has a focus on knowledge and learning, changes can be successfully achieved even if the process has fallbacks, delays or is not reaching the anticipated aim. In particular, the empowerment of multiple stakeholders on an experimental approach can go beyond the traditional dialogue and creates a mode of a participatory communication between politics, business, science and society (Bulkeley et al., 2017).

The urban lab has its placed based focus which can be a transformative improvement across the urban society or transport to energy systems. The learning in real time at a specific place allows responding to a particular economic, environmental or societal issue in an urban area. The urban lab is a wider experiment of politics through the governance of urban environmental governance, and urban sustainability is increasingly implemented.

Development of niches and experiments can foster empowerment which leads to stretch and reform existing regimes such as the transition from ICEV to EVs (Smith and Raven, 2012). This means urban areas with their transformative potentials can gain momentum and contribute to an understanding of new processes.

This thesis project focuses on Berlin and Washington, DC. A comprehensive case study analysis tries to explore and understand the slow EV transition, describe the differences and similarities in the phenomena of new technology the EV and investigates the relationships between policy approaches and niche developments.

2.3.3. Interviews

Preliminary data has been collected through interviews in the field of academic, businesses, non-profit sector and employees in the political sector to obtain the data for qualitative analysis. A detailed list can be found in Table 3.
Table 3. Overview of interviews and conferences attended.

<table>
<thead>
<tr>
<th>Name</th>
<th>Company/Organisation &amp; Position</th>
<th>Date</th>
<th>Type of Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington, DC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nick Nigro</td>
<td>CEO &amp; Founder Atlas Public Policy</td>
<td>23.10.2017</td>
<td>in person</td>
</tr>
<tr>
<td>Matthew Goetz</td>
<td>Georgetown Climate Center</td>
<td>25.10.2017</td>
<td>in person</td>
</tr>
<tr>
<td>Andrew Matthews</td>
<td>Managing Director Sustainability Sector at NSI</td>
<td>23.01.2018</td>
<td>in person</td>
</tr>
<tr>
<td>Sarah Oleksak</td>
<td>Energy Efficient Mobility Systems Deployment Manager</td>
<td>24.01.2018</td>
<td>Telephone Interview</td>
</tr>
<tr>
<td></td>
<td><em>(no direct quotes requested)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genevieve Cullen</td>
<td>President at Electric Drive Transportation Association (EDTA)</td>
<td>26.01.2018</td>
<td>Telephone Interview</td>
</tr>
<tr>
<td></td>
<td><em>(no direct quotes requested)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eric Campbell</td>
<td>Energy Program Specialist, Department of Energy &amp; Environment</td>
<td>26.01.2018</td>
<td>in person</td>
</tr>
<tr>
<td></td>
<td>Government of the District of Columbia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berlin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johanna Reinhardt</td>
<td>Projektmanagerin Innovation, Berliner Agentur für Elektromobilität (eMO)</td>
<td>08.03.2018</td>
<td>in person</td>
</tr>
<tr>
<td></td>
<td><em>(Project Manager for Innovation at the Agency for Electro Mobility Berlin)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christian Lang</td>
<td>Founder Chargery</td>
<td>07.03.2018</td>
<td>Telephone</td>
</tr>
<tr>
<td>Dr Peter Mock</td>
<td>Managing Director ICCT Europe</td>
<td>16.07.2018</td>
<td>Telephone</td>
</tr>
<tr>
<td>Conferences attended</td>
<td>BBSR und IKM: Metropolregionen gestalten die Mobilität von morgen</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>(Creating mobility in metropolitan regions of tomorrow)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Panel discussion with Berlin's Senator for Environment, Traffic and Climate Change</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regine Günther on “Berlin's mobility transition.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The interviewees were chosen by their professional background in the field of EV. To cover as many areas of expertise as possible, various sectors were considered including research institutions, governmental bodies, NGOs and business representatives. Due to the lacking response in Berlin, the research path needed to be altered and urban mobility themed conferences became a part of the primary data collection.

*Interviews* are one of the most important sources when it comes to case study research (Yin, 2013). Collecting details, information, and an explanation of a problem is enhanced through interviews. Especially, semi-structured interviews use open-ended questions to obtain the views and opinions of the answering participant (Creswell, 2009). Structured interviews would “*only allow for limited responses and are, therefore, of little use if ‘depth’ is required*”, and unstructured interviews “*are
usually very time-consuming and can be difficult to manage and to participate in, as the lack of predetermined interview questions provides little guidance on what to talk about” (Gill et al., 2008, p. 291). Semi-structured interviews are the best choice for this project, since they have a certain flexibility and allow for “the discovery or elaboration of information that is important to participants but may not have previously been thought of as pertinent by the research team” (Gill et al., 2008, p. 292). The focus of the interviews lies in the views and experiences towards the EV transition in the country the interviewee is based, with a particular focus on experiences on stakeholder participation and challenges or opportunities with related policies. Furthermore, views and opinions of involved and affected parties are collected to find out which attitudes on the EV transition exist in the local context.

The interviews were conducted in the local language in person or via phone calls. Limitations with telephone interviews are that they might take away some inhibitions in the interviewee since it is not a face-to-face situation, where some people might feel additional pressure. The phone calls were not recorded. To avoid misunderstandings around the wording of the questions, questions were formulated shortly and concisely and avoided negative or leading language by recommendations from Robson and McCartan (2015).

In sum, case study research is a prevalent and valued methodology to analyse urban behaviour in a political arena. Case study research has been done for more than 50 years and ranges from a single case to multiple case analysis. The multiple case study brings the possibility to show repeated patterns, variations or exceptional examples. With developing a hypothesis about the chosen subject, a combination of observation, research, interviews and experience can be conducted and enhance the results.

2.3.4. Quality assurance
In order to achieve a credible outcome of the research, a determination of quality is needed. A combination of an extensive literature review of the problem was conducted with aims to offer a comprehensive set of tools which can ensure validity and reliability in case study research (Riege, 2003). In addition, this can be achieved by fulfilling the following criteria (Yin, 2003, p. 36; Zaborek, 2009, p. 14,15):

1. Construct validation – Establishment of correct operational measures in order to reduce the risk of bias
2. Internal Validation – consistency with the establishment of clear relationships
3. External Validation – establishing a domain to generalise findings
4. Reliability – demonstrates the operations of the study, predominantly the data collection process

Relating those recommendations to the thesis the following measures and techniques were applied. Table 4 summarises the techniques for establishment validation and reliability on case study research.
Table 4. Techniques for establishing validation and reliability in case study research (based on Riege, 2003, pp. 78–79; Yin, 2003, p. 36)

<table>
<thead>
<tr>
<th>Case study design test</th>
<th>Examples of relevant techniques</th>
<th>Applied in this research project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>Use of multiple sources of evidence during data collection</td>
<td>Triangulation via interview methods, data sources and perspectives</td>
</tr>
<tr>
<td></td>
<td>Establish chain of evidence</td>
<td>Transcribed interviews and secondary data documented</td>
</tr>
<tr>
<td></td>
<td>Third-party review of draft case study report</td>
<td>Follow-ups and transcripts sent to interviewees with direct oral validation</td>
</tr>
<tr>
<td>Internal Validity</td>
<td>Use diagrams, maps or statistics in data analysis to support explanation</td>
<td>Graphics from literature review and theoretical framework used for analysis</td>
</tr>
<tr>
<td></td>
<td>Ensure concepts and findings are systematically related</td>
<td>Frameworks are used consistently to all sources of data</td>
</tr>
<tr>
<td>External Validity</td>
<td>Define boundaries and scope in research design</td>
<td>To be found in chapters 2.3.1, 2.3.2 and 2.4 for analytical generalisation</td>
</tr>
<tr>
<td></td>
<td>Compare evidence with existing literature in data analysis</td>
<td>Abductive approach is applied, analysis is built on conceptual framework</td>
</tr>
<tr>
<td>Reliability</td>
<td>Give full attention of theories and ideas</td>
<td>Done and demonstrated throughout the thesis</td>
</tr>
<tr>
<td></td>
<td>Assure congruence between research problem and features on study design</td>
<td>Done throughout chapter 2</td>
</tr>
<tr>
<td></td>
<td>Record and photograph observations and actions as concrete as possible</td>
<td>Interviews were taped, pictures were taken, and notes made during observations</td>
</tr>
<tr>
<td></td>
<td>Develop case study database</td>
<td>Done through organised collected data</td>
</tr>
<tr>
<td></td>
<td>Assure meaningful parallelism of findings across multiple data sources</td>
<td>Same logic/ framework used in all interviews and documents</td>
</tr>
</tbody>
</table>

In order to obtain a high construct validity, the technique called triangulation was used. The term is defined as “a combination of methods used to study the interrelated phenomena from multiple and different angles of perspectives” (Given, 2008, p. 892).

Triangulation can be further categorised into four categories (Stake, 1995; Zaborek, 2009, p. 16):

- Triangulation of methods of data collection – the use of different research methods (e.g. interviews, document analysis, observations)
- Investigator triangulation – investigators collect and analyse data independently and try to solve an identical research problem
- Theory triangulation – data examination through different theoretical perspectives (e.g. sociology, economics) to see if they can provide a coherent explanation
- Triangulation of data sources – drawing evidence from a diversity of data sets and trying to verify the same findings. The sources can include different individuals who are firmly involved in the phenomena
In this research, multiple sources of evidence were used such as personal and phone interviews, secondary data and perspectives from various actors. Personal interviews were transcribed, and phone interviews summarised. The transcripts were sent to the interviewees, and a follow-up phone call gave direct oral validation. Finally, reliability was ensured through various techniques, for example assuring congruence between case study design and the problem, using a case study protocol and database, using the same framework across all data sources, and resorting to peer review (see appendix 1). These actions provide a solid scientific quality in case study research (Riege, 2003).

2.3.5. Ethical consideration
Another critical element in research is the ethical consideration (Guillemin and Gillam, 2004). There are four key factors to reflect on which are (Kvale and Brinkmann, 2008):
- Informed consent
- Confidentiality
- Consequences
- Role of the researcher

All interviewees were informed about the study before their participation. They also received an interview guide (see Appendix 2) before the interview as Robson (2011) suggests. Since some of the interviewees were in a sensitive political position, direct quotes were avoided. However, key messages were paraphrased in their interest, but anonymity was not offered. This was one measure to minimise the risk for the interviewee and avoided negative consequences from superiors. The participation was on a voluntary basis, and no compensation was offered. Moreover, the research was conducted indecently in searching for answers.

2.3.6. Data analysis
According to Yin (2003, p. 109) “the analysis of case study evidence is one of the least developed and most difficult aspects of doing case studies”. The analytical process is further described as a process containing three steps: (1) description, (2) systematisation and categorisation, and (3) combination (e.g. interpreting data) (Hamad et al., 2016). Interview questions were based on the conceptual framework, and the results were categorised accordingly. This categorisation leads, according to Harrison et al., 2017), to an examination of relationships, condense and display data for further analysis. However, during the research process, it is possible that the interviews drift away from the interview guide. If new categories or topics arise during this departed interview process, it can be used as new categories in the analysis. Furthermore, by analysing the collected data, the answers of interviewees can be transferred in different categories which correspond to the themes of the conceptual framework. A way to put case study evidence in order is with organising data into matrices structures (Yin, 2003).

2.4. Delimitations
The scope of this research is within an urban context and excludes the rural or suburban arena. This specification will help to create a narrowed analysis and limits the research agenda to a geographical area. There was a disproportionate number of interviews conducted. Although 20 interview requests were sent out to relevant actors in Berlin, only three agreed to participate. To compensate for the lack of primary data, I attended two EV related conferences (more information in chapter 2.3.5) were included. Participants from Washington, DC asked not to be directly quoted due to their sensitive political position. In addition, it was not possible to conduct an interview with a representative of an environmental NGO or a civil society group representing consumer interests. The consumer's voice is reflected by using existing academic research, and the environmental perspective is seen as addressed since the aim of the EV transition results positively on the reduction of emissions. Since this research is focusing on the individual consumer, initiatives related to fleet and business EV transition will be excluded. Other issues such as traffic jams, long distance travels, sharing programs and public transport alternatives are also excluded from this research. Moreover, aspects of material source and availability, life cycle of the EV or carbon footprint during production were also excluded from the research scope.
3. A Theoretical framework: Urban environmental governance

The theoretical framework will be the theoretical foundation of the thesis and provides a rationale for predictions about the relationships among variables of this research project. Moreover, it is used as a guide to identify the relationship between variables systematically. The chapter will first briefly explain the term governance, moves on to deepen into environmental governance and simultaneously identifies stakeholder participation, narrows it then down to urban environmental governance with the aspect of the urban laboratory. Finally, the relation between urban environmental governance and transition in transport will be addressed.

3.1. Governance

The term governance has no uniform definition but can be identified as “the coexistence of collective regulations via cooperation’s, between the public and private actors on the level of sovereign government decision making.” (Mayntz, 2004). Appendix 3 is offering a table with an overview of interpretations of governance, environmental governance, multi-stakeholder engagement in context of sustainability transition and urban development. In order to establish successful governance on climate change issues, a variety of stakeholders need to be involved, including NGOs, industry representatives, civil society and different levels of government (international, national, subnational, regional). Furthermore, the role of governance is to address existing regulation and learning gaps between private, public and non-profit stakeholders (Bäckstrand, 2006a). Whereas the government is formally ruling, governance is highlighting the vital role of arrangements in the political economy and policy making. Moreover, governance is understood as a mode of social coordination which is for example to guide, control or manage society (Kooiman, 1993).

Good Governance in action can happen through the following key factors (figure 2):

![Factors of good governance](source)

**Figure 2.** Factors of good governance based on (www.gdrc.org, 1997) modified by author

Governing through provisioning, for example, infrastructure services, can shape behavioural choices and restructure markets. This could be the provision of renewable energy (solar roofs) which creates green energy and can be used to provide private or public charging infrastructure for EVs. A way to enable the transition, the provision of information, rewards and public recognition through municipality governments can create actions by the private sector. The engagement with the private sector can create partnerships which bring another layer of climate change mitigation.

Self-governance of a municipality can be observed in the transportation sector. For example, the replacement of their vehicle fleets to EVs. One of the most prominent and most used tools to reduce carbon emission in the transport sector are regulations (Sperling et al., 2009). The provisioning plays a crucial role in efficient policy implementation. With incentive programs the enablement of governing a transport transition is possible. The adaptation of public campaigns creates public awareness and knowledge of cleaner transportation. Furthermore, it is the interaction or self-regulation of deliberation which can add a stakeholder as a participating actor and leads to a collective decision-making process.
Therefore, effective execution of power happens with stakeholder participation and can bridge global sustainability issues with local actions in fields such as sustainable transitions (Bäckstrand, 2006b).

The actual definition of stakeholders varies in the literature. For the purpose of this research, stakeholders are defined as: stakeholders are those who are affected by the outcome of those who can affect the outcome of a proposed development [...] (www.worldbank.org, 1996). In addition, it is important to include the interdisciplinary skill and knowledge set of stakeholders because it creates a sustainable decision-making process (Kaatz et al., 2006). Moreover, the inclusion of interdisciplinary knowledge groups is important to cover a larger interest which can be related to climate change or urban development. Further, the importance of stakeholder participation in SD has been defined by Van Huijstee, Francken and Leroy (2007, p. 77) as a “collaborative arrangement in which actors from two or more spheres of society (state, market and civil society) are involved in a non-hierarchical process, and through which these actors strive for a sustainability goal”. This definition is a good example how the transition to the urban EV market can be governed, through the provisioning of collective good and the link to a public policy objective (Waddock and Bannister, 1991; Schäferhoff, Campe and Kaan, 2009).

3.2. Environmental governance

Narrowing the concept of governance down to environmental governance the definition can be specified to: Environmental Governance is the continuing process of interactive decision-making in environmental matters. It includes institutions and organisations as well as binding agreements, policy instruments and procedures that regulate environmental protection at the international, national or local level. (United Nations Environment Programme, 2017).

Environmental governance on local, national, and global level scale is associated with the rise of less hierarchical and more collaborative governance arrangements with the aim of sustainability and environmental protection (Koenig-Archibugi and Zürn, 2006; Smismans, 2006). Stakeholder dialogue, citizen juries, network governance, public-private partnerships and voluntary standards are some examples of the deliberative, participatory and market-oriented strategies that have gained ground in policy areas such as climate change mitigation (Bäckstrand, 2012). Since the environment has no voice to be heard, governmental bodies are under pressure of providing environmental protection policy. As long as the environment is depending on state actions, the state must remain as a strong advocate for environmental policy.

3.3. Urban environmental governance

Urban policymakers act within their own boundaries and have limited capacities to govern a sustainable transition. This is due to the limited accessibility to funding, geographical circumstances or lack of national political commitment. To act on both challenges national governments are emphasizing on local level policy approaches. It is the empowerment of local administrations and a bottom-up perspective to respond to a higher-level policy initiative (Ward, 1996). Moreover, a real-life challenge for municipalities is to achieve their own sustainability targets, and often large-scale transitions are beyond their core competencies. Nevertheless, urban policymakers take up on their responsibility and are now searching for creative or alternative ways of governing a sustainable transition based on a case-by-case approach and own initiatives (Sanchez-Rodriguez et al., 2005).

In addition, it is important to observe and learn from interactions in a city and rethink how the involvement of stakeholders can help to create effective urban climate policy (Lindley et al., 2006). Moreover, the adaptation of a specific challenged makes urban environmental governance and planning a complex process. In particular with the new urban transition to an EV dominated streets and the required infrastructure development and the lack of experience or professional expertise can hinder the transition or lead to a bad decision-making process. According to Bulkeley (2011), there is a lack in scientific assessment to what extent social, economic and scientific research can measure different actions of urban environmental governance (Qi et al., 2008; Satterthwaite, 2008).

Initiatives enhanced by urban policies can facilitate, enable, and empower non-governmental actors to take responsibility and participate in tackling climate or environmental related issues (van Welie and...
A practical implementation of governance are policy instruments such as tax or incentives regulations. However, western governance decision making processes is still dominated by market-based factors. The challenge remains to what extent the tax or incentive program reflects an accurate price which includes the social and ecological costs (www.sustainabledevelopment.un.org, 2012).

Kemp and Parto (Kemp, Parto and Gibson, 2005, p. 22) argue that sustainability can be obtained with the immediate use of modern technologies. They argue further that a system innovation is needed to achieve long-term sustainability. That argument leads to the conclusion that governance for sustainability needs frameworks in policymaking which actively coordinate the transition to sustainable technological changes. However, technological innovation can only be provided to the society. Therefore, related initiatives need to be accompanied by societal processes. Policymakers should communicate visions to the public and the importance of sustainability with learning and information programs. With the improvement of knowledge and practices system innovation can offer environmental benefits such as renewable energy and emission-free mobility including EVs.

The Rotmans- Kemp model conceptualizes the challenge for a successful policy change in a transition process (Rotmans, Kemp and van Asselt, 2001). Three of the basic rules are:
- Embedded transition policy into existing decision-making frameworks and legitimise transition management: means the transition management is a politically accepted and joined effort for policy makers and society. Policy should focus on long-term goals with respect to short-term concerns.
- Take the long view of a dynamic mechanism of change: If negative results occur during the transition, the process should not stop but rather reflected and adopted to the unforeseen circumstances. The learning experience is important for future policy creation.
- Engage in multi-level coordination: Top-down policies with a bottom-up initiative (with a combination of vertical and horizontal coordination) and local experiments should be informative for national policies. It is important to coordinate top-level policy with local policy.

Cities with self-governance and enabling modes are dominating the urban response to climate change. Partnerships, provisions and, regulations play a key role to manage transitions. This applies in particular to the urban transportation sector. Leadership though political campaigns have been identified as important for driving initiatives forward. That way, municipalities can become global leaders on the issue of climate change and environmental protection (Bulkeley, 2011). Instead of a centralised state-imposed regulation, the local government is the new empowered deliverer for environmental initiatives. This includes the involvement of stakeholders such as environmental groups, community organisations or local businesses. With the rising engagement of local actors, the policy-making process becomes more socially and politically inclusive (Gibbs and Jonas, 2000).

3.4. A conceptual framework

The conceptual framework for the socio-technical transition with a multi-level perspective.
The following sub chapters will (1) describe the meaning and role of a conceptual framework, moves on to (2) identify the term transition and (3) explain the socio-technical transition framework.

Next to the theoretical framework of environmental governance, there is the need to apply a conceptual framework. It will serve as a map and will guide the research to answer the research questions. It is used to make conceptual distinctions and organize ideas. The conceptual frameworks capture something real, in a way that is easy to recollect and apply. By organising empirical research with deductive, empirical and individual case study research, conceptual frameworks are particularly helpful (Shields and Rangarajan, 2013).

In addition, it represents the researcher’s path on how to explain a phenomenon. This includes the literature review, which is supposed to highlight the existing knowledge in the field, and the own observations conducted during the research process. That way it is possible to highlight how different variables interact with each other. “Setting the stage” for the presentation of the chosen
research question and what drives the study which is reported as a problem statement (McGaghie, Bordage and Shea, 2001).

This research attempts to operationalise the conceptual framework and show its helpfulness by applying to an urban case study. Especially, the aim of this thesis is to examine the EV transition and discuss the experiences made with local polices to analyse how EVs can foster in an urban environment.

3.4.1. Transition

There are different ways of defining the term "transition," such as "[...] transition is a gradual process of societal change in which society or an important subsystem of society structurally changes" (Rotmans, Kemp and van Asselt, 2001, p. 19). Furthermore "it is a result of the interplay of developments that sustain and reinforce each other" (Kemp and Loorbach, 2003, p. 7).

Narrowing it further down to a context with the socio-technical concept, transition is defined as "change from one sociotechnical regime to another" (Geels and Schot, 2007, p. 399) whereby the traditional ICEV is identified as the existing regime and is going to be replaced with the new niche the EV.

Transition is processed and goes through stages which typically takes between 25-50 years until its full adaption (Kemp and Loorbach, 2003, p. 8). The transition stages are:

- **Pre-development**: has very little visible change but goes through experimentation
- **Take off**: the change is ongoing, and system shift begins
- **Acceleration**: structural change becomes visible through accumulation of socio-cultural, ecological, institutional and economic changes which react with each other. Simultaneously, there is a learning and embedding process (also known as acceleration phase)
- **Stabilisation**: speed of societal change decreases and new dynamic equilibrium is reached (Rotmans, Kemp and van Asselt, 2001)

The described phases are visualised in figure 3. The state of the EV transition in the case study environment is identified in-between take-off and breakthrough (highlighted with a star).

Figure 3. Four phases of the socio-technical transition (Binder, Mühlemeier and Wyss, 2017, p. 2).

Kemp and Loorbach (2003, p. 9) argue further that a transition is a result of exogenous and endogenous developments. The interaction between technical change and social or cultural changes are a cause for transition but remain an abstract model and are difficult to adopt for policymakers.
To overcome this barrier a multi-level perspective (MLP) is needed. The MLP is a key component of the socio-technical transition and will be further addressed in the following sub chapter.

3.4.2. The socio-technical system

After understating what environmental governance and transition means and how it develops over time, the conceptual framework will now relate to the research. This subchapter will first introduce the concept of socio-technical system and highlights the importance to the research field, moves on to explain how the concept is going to be applied and finally explains the link to an urban case study research.

There is an increasing interest in how policy initiatives are supporting transitions. The academic world has a consensus understanding that governments play a key role in bringing transition forward. However, the challenge for policymakers is to transform a socio-technical system into a more sustainable arrangement (Smith, Stirling and Berkhout, 2005). What has less developed is how policymakers can support these initiatives and which policy tools are most promising. Especially, how to govern transitions is a less developed research field (Smith, Voß and Grin, 2010).

The socio-technical system is based on the technological trajectories and argues that policymakers, users and other interest groups are contributing to the modelling of technological development (Bijker, 1997). The socio-technical system takes it further and argues that existing trajectories are stabilised in many ways which include but is not limited to sunk investment in infrastructure or lifestyle and technical systems (Anderson and Tushman, 1990; Christensen, 1997).

A socio-technical transition, with the aim to achieve sustainability, is a difficult process because existing structures in the field of infrastructure or transport are established systems and have mechanism related to sunk investment, behaviour patterns or favourable subsidies and regulations (Unruh, 2000). In order to understand a sustainability transition, the framework of MLP provides an overall idea of the multidimensional complexity of changes within a socio-technical system (Rip and Kemp, 1998; Geels, 2002, 2010; Geels and Schot, 2007).

The MLP differentiates between three analytical levels:

- Landscape
- Regimes – locked in and stabilized on several dimensions
- Niches – harbour for radical innovations (Geels, 2010, p. 495)

The first level is the landscape reflects the constant factor of a system over a long period of time. The landscape concept has three distinctions: (1) factors which do not change or slowly such as climate, (2) long-term changes (e.g. the German industrialisation in the late 19th century) and (3) external shocks (e.g. wars or price fluctuations in oil) (H. Driel and Schot, 2005, p. 54). All of those factors can be summarised as a landscape because they come from an external context that actors cannot influence on a short run (Geels and Schot, 2007, p. 403).

The following level is the regime. Regimes are institutional factors which change over time and are often affected by landscape developments. These factors are dominated by certain technologies, institutions, user practices, regulatory framework or scientific knowledge. Regimes are relatively stable configurations (Rip and Kemp, 1998). The stability has a downside though, it is seen as “locked- in “ (Unruh, 2000) or “entrapments” (Walker, 2000).

The last level is the niche. It often refers to technological or innovative change within a system and has a single or some actors, which influence the landscape and regime layer. However, niche innovations need to be fully developed in order to take advantage of a disruptive landscape development. Niche innovations have a competitive nature and try to replace the regime. But they also can develop a symbiotic relationship to regimes, if they can resolve a problem and improve existing performance (Geels and Schot, 2007, p. 406). This project focused on niche level development whereby the regime and landscape levels provided context to the analysis.
Table 5 provides a summary on how shocks to the landscape layer react with each other. Those shocks can occur on an economic, socioeconomic, political or cultural level and affect the regime and niche layer accordingly.

**Table 5. Summary of Sociotechnical system (based on Geels and Schot, 2007; Shackley and Green, 2007; Verbong and Geels, 2007; Kern, 2012)**

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Macroeconomic trends</th>
<th>Socioeconomic trends</th>
<th>Macro- political developments</th>
<th>Cultural patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E.g. climate change, oil crisis</td>
<td>e.g. financial crisis</td>
<td>e.g. “philosophy” behind policy making</td>
<td>e.g. trend towards more individualization</td>
</tr>
<tr>
<td>Regime</td>
<td>Changes in rules e.g. belief systems, problem agenda behavioural standards, regulations, laws</td>
<td>Changes in technology e.g. in case of EV: resources, knowledge, battery and charging technology</td>
<td>Changes in social networks e.g. new market entrants gain in importance compared to incumbents</td>
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<tr>
<td>Niche</td>
<td>Learning processes e.g. learning process has stabilised in a dominant design</td>
<td>Price performance e.g. price-performance improved to a stage where it is believed to continue to improve</td>
<td>Support from powerful groups e.g. powerful actors have joined support network</td>
<td>Established market niches e.g. innovation is used in market niches</td>
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The interaction between these three levels in a transition is also called regime shift (Geels, 2010, p. 495). A radical regime shift occurs in niches, here dominating actors encourage “configuration that works” on multiple dimensions (Rip and Kemp, 1998, p. 330). Those niche innovations have the potential to change external landscapes and can take place on multiple levels such as infrastructure, regulation or markets (see figure 4).
The foundation of the socio-technical transition within sustainability is related to the rational choice of the causal agent. The causal agent acts in self-interest and given that the agent has full access to information and access to an alternative, the decision can be based on a cost-benefit calculation and therefore, rational the best alternative (ibid. p. 496). In particular, customers defining their decisions based on budget, whereas producers are focusing on profit maximisation and efficient resource allocation (ibid. p. 497). A transition with a sustainable route can be addressed by governments with policy tools and such as environmental taxes or subsidises (ibid. p. 497). These governmental initiatives have the potential to facilitate and initiate a transition because the industry is shifting its capital investment, and R&D catches momentum focusing on new technological developments. Rugman and Verbeke (1998) observed that companies’ investments are often postponed because of uncertain regulations and the degree of willingness of the consumer to pay more for green products. Moreover, a transition caused by innovations can come through niches and entrepreneurship (Cattani, 2006). It might be a small change at the beginning but can put pressure on the established system (Levinthal, 1998; Geels and Schot, 2007). The dynamics of a transition is often a shift in a system which influences consumer preference and create pressure on policymakers and demand stricter regulations (Geels and Schot, 2007, p. 499). Furthermore, a hindering aspect of a sustainability transition in a socio-technical system is the lack of a shared vision. This is due to the different interpretations of sustainability. Although SD aims to balance environmental, social, and economic aspects, actors see priorities of those three factors differently and prioritise developments one over the other (ibid. p. 500). In order to achieve a sustainable transition, policymakers should set environmental goals such as the SDGs and the Paris Agreement (ibid. p. 501). The mismatch of sustainable factors prioritisation makes it difficult for niche actors to lobby for their ideas because politics is dependent on larger companies to provide employment and economic stability. However, niche developers can increase their possibility to enable change through the outlook for an economical alternative with the benefit of addressing the other two sustainability aspects, social and
environment. In addition, the public opinion may demand a change, and voting power creates a pressure point for politicians (*ibid.* p. 502).

The conceptualisation of a regime change has similar attributes of the MLP which demonstrates the interaction between both theories. Both see two dimension of adoption which is (1) the availability of resources (knowledge, resources) and (2) the degree of management of resource deployment (Geels and Schot, 2007, p. 401). Another challenge for a niche- innovation is the uncertainty of legislation and financial support, whereas regimes act in a stable and well- framed environment (*ibid.* p. 402).

Since the car became the dominant source of transport and an important economic source, the technology and relevant sub- systems (e.g. roads, petrol stations and others) developed an interdependency on the social, technological and institutional level. This can be called a socio-technical regime. The interactions are demonstrated in figure 5, whereby the socio-technical system is conceptualised with a cluster of aligned elements (Kern, 2012, p. 299).

![Socio-technical system for land-based road transportation](image)

**Figure 5.** The socio-technical system for land-based transportation (Geels, 2005, p. 682).

The ICEV is dominating the regime, and other technologies will find it difficult to compete since habits of users, policies and the built environment changes slowly. Society is now locked into that trajectory, and it requires a radical event, a so-called shock to the system or regime, to change it. Those shocks occur from either the internal or external factors, and a response comes from regime actors with the use of internal resources (Smith, Stirling and Berkhout, 2005). This transition, however, becomes coordinated at some point. The alignment of visions by different actors and groups helps to converge achievements that emerge during the transition process (Geels and Schot, 2007, p. 402).

The landscape started to shift with increasing concerns from society on topics like climate change, oil price peaks and dependency on other countries resources. As a result, a window for innovative technology is now opened and offers alternative solutions room to develop. Policymakers react to their citizen's demand and look out for technological alternatives and are willing to adjust policies in order to manage landscape disruptions. Additionally, the opened windows for so-called technological niches create a destabilisation of the regime. Technological niches have often a protected space within the regime. If the niche develops fast and in a mature way, it has the potential to replace the current regime. So, if the EV and its complementary systems (e.g. battery technology and charging infrastructure) reach a point of affordability, accessibility and mass production, the regime can be replaced, and the EV becomes the new regime.

Within the EV transition, sub- regime tries to compete with the provisioning of an alternative power source for cars and develops complementary technology such as battery production. With the provisioning of electricity, produced through renewable energy, and the provisioning of charging infrastructure, the transition creates a complementary and competing regime.

The niche level is the specific development of a technology or innovation. The advanced EV
technology as such started the transition. At the same time, innovations like new business models with developing charging infrastructure, mobile applications to allocate the charging station but also the possibility to use a car share vehicle arise. These niche level developments are not limited to an urban environment. As outlined in the introduction chapter, international and national governments became interested in the EV transition as one solution to climate change mitigation.

Although the socio-technical system is mostly applied to national research, the EV transition is observed on an urban scale, and through the lens of environmental governance, the living urban lab will make the socio-technical system adaptable for urban case study research.

Cities are a place where different groups come together such as citizens, businesses, politics and others. Therefore, it is viewed and observed from different perspectives. Economists see the economic potential in a city, citizens as a social system (Hodson, Geels and McMeekin, 2017). However, it can also be seen as a complex socio-technical system. The interaction of different groups, also known as stakeholders, make urban development a complex phenomenon. In particular, urban infrastructure development enables collective living and working. The expansion of infrastructure has significant effects on people’s life. It can enhance or hinder the access to services or the workplace. At the same time, the political and social life determines where development occurs and expands. This often leads to a targeted investment and economic activities in specific areas. In addition, depending on the political decision-making processes the specific development of selective urban areas can be enhanced and other areas left out of a transition process. These implications can influence the management and governance of a city. Since all groups to some extent interact with each other, the social dimension interacts with the technical dimension, and the technical dimension interacts with the economic dimension and so forth. Decisions made on one dimension can have a significant impact on another dimension. This means a well-informed decision process is needed in an emerging topic such as the urban EV transition.

Smith (2007) argues, in order to manage and govern a transition in a socio-technical system three main components need to be considered:
1. Holistic approach
2. Long-term perspective
3. Flexibility

Having the complexity of an urban transition in mind and considering the recommended governance approaches by Smith (2007) will now discuss how the socio-technical system can be conceptualized.

3.4.3. Social innovation within the socio-technical system

The socio-technical system is mostly focused on how a niche innovation, mostly an advanced or new technical invention, is implemented in the market with policy approaches and industry reactions. However, another aspect which comes to the transition process is the social innovation component. The term social innovation is defined as “innovative activities and services that are motivated by the goal of meeting a social need” (Mulgan, 2006). This includes lifestyle and behaviour change, energy savings through new forms of governance and business and users utilizing new technical solutions (Bergman et al., 2010). A social innovation, also known as bottom-up innovation, emerges through the interaction of less powerful actors and need to overcome regulatory and resource barriers. Consequently, bottom-up social innovations are often overlooked and their potential to contribute to climate change mitigation not well enough addressed in the academic literature as well as governance initiatives. In fact, an innovation process always entails a social component. Therefore, any technical innovation involves a social process and needs to be included and considered in the transition phase (Bergman et al., 2010).

Another reason why social innovation is often overlooked in the socio-technical system is the definition of innovation. The term is mostly associated with new technologies but should be seen as a new practice, new service or changing social structures. After all, innovation raises from a social, creative process (MacKenzie and Wajcman, 1999). Moreover, through social innovations, the
sustainability aspects are more respected since new technologies can help the city to transform into a less polluted and carbon reduced space. However, the innovation needs to spread beyond its origin in order to have a significant impact on climate change issues. Yet policies are often designed to support technical innovations with a commercial aim and leave out the social goal. A downside of bottom-up innovations is the missing measurable component. Quantifying the outcome of social innovation or a related policy is difficult because the transition process is still developing to a standardised outcome. The social innovation also leaves room for a creative mind to lead the way towards a new regime and show established industries how much a vision can create sustainable change.

The phases of social innovation are identified by (Mulgan, 2006) as:
1. Coupling of ideas with a need that is not met
2. Developing a promising idea and test in practice
3. Scaling up, replication, adapting and if necessary diffusing of an idea that has been proven in practice
4. Learning and adapting ideas into forms which may be different from the original

The conventional scholars in the socio-technical system can link their theories to the small subcategory of social innovation. Henderson (1996) sees the social innovation as a critique of established technology and highlights the social and environmental benefit of bottom up innovations. This approach matches broadly with the first two identified phases by Mulgan (2006).

Further, Phillips et al. (2008) see three critical instruments of social innovation:
1. Exchange of ideas and values between actors and engaging with different motivations and values to the innovation (E.g. government, businesses or community groups)
2. Shifts in roles and relationships between different actors
3. Integration of private capital and public support

These stages are in line with Mulgan’s (2006) the four stages.

In sum, bottom-up social innovation has the potential to play a significant role in combating climate change. Experiments on technologies and forms of social organisations together can support the stakeholder collaboration (Hegger et al., 2007). With appropriate policy instruments, the social innovation process can become influential on a national but also regional level. Moreover, a joined approach of the social, cultural, environmental and economic benefit, the social innovation can become a guiding tool for future governance framework.

3.4.4. Conceptualizing the socio-technical transition

After addressing the theory of socio-technical regime and first applications to the EV transition, it is needed to explain how the framework can be applied and conceptualised in this thesis.

Since transport systems are applied nationally and subdivided into the urban area with public transport, bike lanes and parking spaces, the analyst needs to divide the empirical level of the research and then operationalise the MLP (Geels and Schot, 2007, p. 402). The identification of different levels is not always clear but for the purpose of this research are defined as actors who are: industry, society, policy makers, independent organisations such as NGOs or research institutions. These actors are assumed to act self-interested and strategically (Geels and Schot, 2007, p. 403). This multidimensional model of actors is also identified as a rule influencer and user (Giddens, 2014). Those groups also have different problem definitions, which can lead to a hindering solution finding process or can enhance a creative solution finding path. With building a shared cognitive frame, it is possible to work towards an outcome all groups can be satisfied with. However, beforehand it is necessary to identify common “goals, key problems, problem-solving strategies, requirements, testing procedures, design methods and criteria” (Bijker, 1997, p. 123).

The adoption of a fully developed niche innovation will be accepted when the following conditions
outlined by Geels and Schot (2007, p.405) are met:
1. The learning process has stabilised in a dominant design
2. Powerful actors have joined the support network
3. Price/ performance improvements have improved and are strong expectations of further improvements (e.g. learning curves)
4. Innovation is used in market niches, which have a market share of at least five per cent (Rogers, 2010)

3.4.5. Urban socio-technical transition

Within the theories of the MLP and socio-technical system, there is a lack of a special identification. The leading scholar Geels identified the lack of research which applied the theories on an urban case study (Hodson and Marvin, 2010, p. 480; Hodson, Geels and McMeekin, 2017).

Cities in their capacity of being shaped by a national transition have a role which needs to be understood in the socio-technical system, especially in an MLP perspective (Bache and Flinders, 2004). It is not possible to reduce the examination to solely local authorities or local economic actors. All urban actions are somehow influenced by actors at national and supranational levels who affect the action and outcome of a transition (Brenner, 2004). The different levels and power relations of governance can leave urban areas within a critical phase of transition initiatives. With a contemporary landscape pressure of responding to climate change and local pollution issues, cities consider for strategies and as outlined in the introduction chapter alternative infrastructure solutions.

The urban socio-technical infrastructure system is organised through local authorities and involves local actors and attracts external stakeholders. This is also due to the nature of territorial governance influence and control over local infrastructure or energy systems. In order to manage the urban transition a vision is a key communicator and participation tool to engage, inspire, and mobilise social actors (Rotmans, Kemp and van Asselt, 2001; Kemp and Loorbach, 2003). The vision is a signal to actors and groups such as utility supplier, citizens and business which also lead to a network building process beyond transitional industry boarders (Russell and Williams, 2002). A vision can be altered during the transition and finds a clearer definition through the learning process. However, the message is key to ensure the socio-technical regime change is a continuous transition. One could even argue the vision is the reason why a niche innovation reaches momentum and can progress in a relatively stable and firm environment as urban governance is experiencing the same attributes (Hodson and Marvin, 2010, p. 482).

This research is aiming to partially fill the gap in the literature (Hodson, Geels and McMeekin, 2017, pp. 1, 3). Consequently, is it difficult to identify where the transition takes place. To overcome this missing knowledge the national scale transition can be considered as a starting point. Hereby, the national context in terms of policies, historical developments and social discourse will be taken into account. The role of an individual city is still unclear but using two specific case study examples the research will be conducted in a closed analytical approach. The conclusion might be limited to the closed urban system; however, lessons can be taken further and be an inspiration for other cities with a similar aspiration of transforming to an EV market penetration and become and mediator for national transition. The socio-technical system is used as a tool which can be adopted within the environmental governance framework and helps to underline the transition characteristics in the urban EV transition.
All outlined aspects will guide the research and The Rotmans- Kemp model will be used to frame interview questions. The Rotmans- Kemp model conceptualizes the challenge for a successful policy change in a transition process (Kemp, Parto and Gibson, 2005, p. 24). Three of the basic rules are:

- Embedded transition policy into existing decision- making frameworks and legitimise transition management: means the transition management is a politically accepted and joined effort for policymakers and society.

- Policy should focus on long-term goals with respect to short-term concerns. Take the long view of a dynamic mechanism of change: If negative results occur during the transition the process should not stop but rather be reflected and adapted to the unforeseen circumstances. The learning experience is important for future policy creation.

- Engage in multi-level coordination: Top- down policies with a bottom-up initiatives and local experiments should be informative for national policies. It is important to coordinate top-level policy with local policy.

Finally, the research tries to expand the socio-technical system and adds a new perspective, the urban/ small-scale development, to the discourse.
4. Empirical Background

This chapter sets the stage for the case study research. First, it will give a brief overview of the history of EVs, what technologies are already in place with an overview of how this creates challenges and opportunities for cities. It then will delve deeper into the policy approaches the cities are providing and will address how successful or hindering they are.

4.1. Background on electric vehicle history

The oil crisis made industry and government leaders aware how high the dependency from imported oil is and started looking into alternatives. Other important motivators were the awareness of climate change and air pollution caused by car emissions. The California Air Resources Board (CARB) was the first authority in the world releasing a public policy on focusing to steadily implement the emission-free car as the only available car. This pressure on automakers leads to the intensive research in the field of a car battery, charging equipment and model variation. After various developments mostly from German and US automakers and different research projects, the first long-distance EV was introduced by Tesla. The Tesla Roadster had a range of 200 mile/ 350 km and became available as the first mass-manufactured EV in 2008. International automakers were now facing a new and advanced competitor. The interest in EV is now a global phenomenon. International competing automakers are heavily investing in its EV technology and somewhat forced to do so as a result of pressure from policymakers. Leaders try to react quickly with policy initiatives. For example, the German federal government issued a 1 billion Euro fund to finance even more research and the deployment of charging infrastructure. The US has also issued more policies such as the American Recovery and Reinvestment Act of 2009. By purchasing an EV tax credit between $2,500 and $7,500 per vehicle (depending on the battery capacity) is applicable. The enhanced public discourse on eco-innovation, economic potentials and environmental protection is now focusing on alternative transportation, including EVs.

4.2. Background on electric vehicle technology

With growing cities in terms of population, economic activities, there is a simultaneous need for local and regional transportation. The car has been the prioritised form of transport since the 1920s (Moss, 2015) and causes heavy pollution in urban areas and ultimately contributes to climate change. As a result, the demand for cleaner and low emission transport technology experienced a continuing demand. Where ICEV became more efficient the research in alternative motorisation did not stop. In 2011 the niche car manufacturer Tesla presented a fully on battery driving vehicle with a range of 200 miles/ 320 km (Gene, 2017). Until this point Plug-in Hybrid Electric Vehicle (PHEV) was the most common alternative car because it has two motors, electric and a combust engine motor. But with the development of a long-range Tesla the path for a mobility transition was opened. The high- density level of people living in cities and the proximity of connected infrastructure makes the transformation to an EV penetrated market attractive. Charging infrastructure equipment is a crucial and new development element of the EV. The most common way of recharging the battery is at the charging station.
4.2.1. Charging station, plugs and availability

There are three standard charging levels. All cars can be charged at a Level 1 (8 to 15 hours) and Level 2 station (3 to 8 hours) (Guinn, 2017). However, Level 3 (30 min to 1 hour), also known as fast charger or Direct Current (DC), is only usable by some EVs. Fast chargers are considered the most practical and efficient method to reduce long charging durations. However, they are also the most expensive type of charger in terms of installation (Agenbroad and Holland, 2014).

In Germany and the US are four different plugs for charging, which is depending on the car manufacturer (see figure 5). In case the plug at the car does not match the slot at the charging stations, adapters are available but need to be purchased separately (www.autoscout24.de, 2018). Figure 6 demonstrates which charging plugs are most common in the US and Germany.

Moreover, the deployment of charging infrastructure created a preference of where to charge. As demonstrated in figure 7, the hierarchy of charging is at home, work and public. Charging at home is considered as the most convenient way of charging. The EV is plugged in, in the evening and fully charged through the home electricity system in the morning. Similar is the workplace charging behaviour. Employers offer charging stations, and while the car is standing for most of the time, it can easily recharge. Public charging infrastructure is installed in the street, semi-public charging infrastructure at shopping centres or private car parks. At those charging places, the charging time plays a crucial role. Fast charging can offer a full refill within 30 minutes and Level 2 charger within a couple of hours.

Figure 6. Overview of charging plugs in Europe and USA (Zehle, 2014).

Figure 7. Electric vehicle charging hierarchy (Tuttle and Baldick, 2015, p. 35).
But due to the generally limited availability in cities, the fear of not being able to reach the destination hinders a lot of interested consumers on changing to an EV. Although charging at home and work seems to be the most logical solution to deploy charging infrastructure since this is the place where the car is parked most time of its life, it also creates high dependency on home/ work charging and leaves out availability. This is particularly relevant for urban areas. The different dwelling (single or multi-dwelling residential buildings) and limited access to work and public charging facilities make it important to spread the deployment evenly throughout the city (Neubauer and Wood, 2014). Chapter 5.3 will explain the challenges cities are facing within the EV transition in more detail.

4.2.2. Consumer awareness
In order to create a transition towards a sustainable technology adoption, the consumer needs to be convinced about the benefits. Creating awareness of a new product such as the EV is therefore key (Rezvani, Jansson and Bodin, 2015; Adnan et al., 2017).

The variation of plugs is identified as a hindering factor of the adoption to EVs. Drivers are used to petrol stations with one way of refilling the car and the refilling times takes only a view minute. With differences in plugs and recharge time, the consumer needs to adapt and plan to charge ahead. In addition, to identify a suitable charging station in advance the use of a smartphone/ online application is needed. This creates another dependency on online tools and makes it difficult for people who do not use smartphone apps or do not have access to the internet (Steinhilber, Wells and Thankappan, 2013).

An extensive literature review was conducted by the ICCT (Jin and Slowik, 2017, pp. 19–20) and analysed consumer awareness and outreach activities in different countries including the US and Europe.

Based on their research, the following key recommendations were given:
- Active communication with radio/ television commercials, celebrity ambassadors, test drive experience sharing, social media use, competitions and challenges
- Stakeholder collaboration, especially government in cooperation with the auto industry with campaigns which create more consumer awareness and provide partial funding, form partnerships with other stakeholders
- Sustained programs that utilize outreach with well-designed, comprehensive programs to maximise consumers’ exposure to EVs. It also needs consumer-friendly access to information
- Governments should communicate and deliver key messages to potential consumers and the market to build confidence in the transition

4.3. Issues for cities in the electric vehicle transition
After an introduction of historical, technological and environmental aspects related to EVs, the thesis will now continue to address specific issues cities are facing within the desired transition.

4.3.1. Electricity supply
The accurate and efficient way of energy supply is still an uncertainty. A utility provider need to understand, and the observation of electricity use by EV at home or businesses can fill the gap. Whereby the limited offer on reduced electricity rates has only a small attraction to the potential consumer, the incentive for a residential installation of an EVSE is very attractive. In particular, the reach to larger dwellings and property developer can create a larger incentive and has an additional service to local residence (Nigro and Frades, 2014).

4.3.2. Range
The range of an EV varies between 81 miles/ 130 km (BMW i3) and 237 miles/ 380 km (Chevrolet Bolt), depending on the manufacturer and model (Zach, 2017). Potential consumers are afraid of driving an EV on longer trips and run out of power with no option to recharge. This is known as
range anxiety and was identified in 1997 (www.wordspy.com, 2010). An even earlier identification of range anxiety was identified as a psychological stress phenomenon and described as “a stressful experience of a present or anticipated range situation, whereby the range resource and personal resources available to effectively manage the situation are perceived to be insufficient.” (Rauh, Franke and Krems, 2015).

However, numerous research was able to (statistically) prove the range within an urban area is more than sufficient, even with the currently limited access of charging infrastructure (Pearre et al., 2011; Franke et al., 2012; Rauh, Franke and Krems, 2015).

The number of hours and km/ miles driven per day with a car varies depending on the country and source. On average the car is used two to three times a day for a time range between 60 and 80 minutes and a distance between 38 and 45 km (Kraftfahrt-Bundesamt, 2016, WELT, 2017). For example, in Berlin, the average amount of trips is three, and it takes 70 minutes and 6.9 km per way (Senatsverwaltung fur Umwelt, Verkehr und Klimaschutz, 2013). This leaves the car usage to about 80 per cent of its lifetime. Therefore, the issue of the range and charging availability in an urban environment is less important than it seems to the consumer (Forschungscampus3, 2015). There are several factors why the range anxiety is still existing. For example, the limited knowledge on EVs, the limited accessibility or visibility of charging infrastructure or the missing awareness of alternative ways of accessing charging facilities at work or home (Eisel, Schmidt and Kolbe, 2014; Coffman, Bernstein and Wee, 2017).

### 4.3.3. Charging time

The so-called Charging Time Trauma is related to EV customers who experienced the limited availability of charging stations (Taub, 2017). If the EV needs to be charged elsewhere than at home or work, the search and need for a vacant charging station can be another stressful experience. The nearest station is either occupied, out of service or not compatible. Another factor is the frustration of long charging time (Take Charge and Go, 2014; Rauh, Franke and Krems, 2015; www.chargepoint.com, 2018). Even if a charging station is found, the driver has long waiting times until the battery is recharged. This is often seen as a disadvantage compared to ICEV which are refilled at petrol stations within minutes.

Most cities are witnessing the misuse of car parking places at charging places. Responses are parking tickets or the actual wrecking service. However, this approach has only limited success since police controls are unregulaly and drivers are willing to take that risks (Bonges and Lusk, 2016).

### 4.3.4. Cost

The first- time purchase is a significant factor for car buyers. That is not just limited to individuals but also commercial cars such as taxis or fleets. The high price is mostly due to the expensive battery technology and high production costs. The fixed cost of 30.000 $/ 32.000 € for a Nissan LEAF (200 km range) is for many people still too high for a one- time investment considering the range which is considered as limited (www.adac.de, 2018; www.cars.usnews.com, 2018). Currently, EVs lack in cost competitiveness and lacks in an attractive market of used EVs. The used car market is in particular important for people with smaller incomes. Until the price drops and the issue of affordability not managed, the EV remains a luxury product.

Urban policymakers are dependent on national legislative and budget decisions. The national incentive program can be complemented with a regional/ urban subsidy, but it is a financial burden. However, the variable costs, for example, charging prices, registration fees or local tax are an urban policy tool whereby the dimension can be adjusted (Langbroek, Franklin and Susilo, 2016; Yang et al., 2016).
4.4. Political aspects

After the chapter that introduced information on historical, technological and consumer perspectives it will move on with presenting background information from the academic research field. The following articles are very specific reflections on how the EV transition developed in the US, European and urban context. That way a solid foundation of the understanding of the EV transition is set. In order to answer the first research question, this chapter reviews the challenges and opportunities for the EV adoption in the urban environment in the scholarly literature.

In their research Policy option to support the adoption of electric vehicles in the urban environment by Bakker and Trip (2013) work with urban policymakers during a workshop to reflect and discuss ongoing policies on their effectiveness, efficiency and feasibility (ibid. p. 18). Their research was conducted through interviews with urban policy representatives from the UK, Netherlands, Belgium, Denmark and Norway who were invited to share their experiences. The exchange brought some common challenges and barriers to light. For example, policy leaders fear that an increasing purchase subsidy could risk that car manufacturers are inflating the price accordingly with the subsidy. Moreover, all attendees agreed that the deployment of charging infrastructure is necessary to facilitate the introduction of EVs. Here was highlighted, that the urban authorities have large responsibility and power to make the infrastructure EV ready. Investing in public charging infrastructure equipment creates public-private partnerships with service providers and other businesses. In addition, businesses, shops or individual EV owners could receive a financial incentive to invest in a charging station on private properties with the idea of public usage (ibid p. 19, 20). At the same time, cities could install charging stations close to public places such as train stations or public parking facilities. The participants raised the concern that a business model for public recharging brings a low profit margin. Especially, in the pre-development phase where the EV driver relies on low charging costs to offset the initial investment. Another challenge is the strategic installation of charging infrastructure. Cities only install when a stakeholder asks for it. However, “spatial research should result in a strategic plan of where charging points should be implemented in the future. In practice when it comes to installing them, here are not so many locations where it is practical to do so that it is possible to locate them strategically. Where a partner says they want to install a charge point, we agree- there is no decision about whether this fits with the overall infrastructure location strategy.” (ibid. p. 20).

A benefit on public charging infrastructure is the visibility barrier for people to buy an EV. Other regulatory measures could be the exemption of fees on toll- roads or congestion charge schemes. However, those initiatives are costly and should be only available until the market shifted to a certain EV market share. Another more top-down policy could be the obligation to include charging infrastructure in all new property developments (ibid. p. 20).

There was a broad consensus that the experience of driving an EV is important in convincing people that EVs are a fun and proper way to drive. At the moment most citizens are still unfamiliar with EV and have not had the chance to gain that experience. The general lack of technical knowledge, such as range, charging equipment or cost of ownership also discourages the transition to an EV dominated market. Cities could approach that challenge with providing such information on the city’s website or attend all types of events and present the benefits of an EV. It is also recommended to install a physical or virtual office which can be accessed by the public. The “See, try, feel” concept is an effective way of convincing people to switch to an EV. The study also identified and confirmed a specific urban benefit of EVs. The reduction of local pollution in particular CO2 and NOx emissions are an aim most urban leaders have in order to ensure public health (ibid. p. 21).

The study Assessing the impact of policy interventions on the adoption of plug-in electric vehicles: An agent-based model by (Silvia and Krause, 2016) analyses the implementation of selected public policy and affects the patterns of adoption of EVs by residential urban consumers in the US (ibid. p. 105). The barriers to adopting EVs are very similar in the US compared to EU. The high purchase costs, limited range, limited charging infrastructure and missing knowledge are the main factors (ibid. p. 105). Other studies confirming these results are presented in table 6 below.
Range anxiety as a typical and widely spread US American phenomena, even though an average US driver travels less than 40 miles per day (Bureau of Transportation Statistics, 2017). The “individualistic and open road mentality held in much of the United States” is one explanation for the range anxiety phenomena (ibid. p. 107). Moreover, the amount of time spent for recharging and the currently limited availability of charging infrastructure is in correlation with range anxiety. Policies offering incentives to reduce the purchase price are available for all types of low emission vehicles. Non-financial incentives such as High Occupancy Vehicle (HOV) Lanes and free parking have been identified as an insignificant policy (Potoglou and Kanaroglou, 2007). Another reason for the slow uptake of EVs is the missing visibility of an EV. The car is easy to see, but the EV is difficult to recognize for the average consumer (ibid. p.107, p.116). The paper is referring to a survey with the aim to find out which barrier is the largest for the consumer. It concluded that 71.7 per cent would more inclined to purchase an EV if the charging station were located at either their place of work or their trip destination (Krupa, 2014, p. 20). Plenty of incentives are already available in nation states and cities. Programs such as purchase rebates, free parking, even free charging, and incentives of installing public or private charging stations are seen as efficient policy approaches (Bakker and Trip, 2013). Yet the uptake is still slow, and it is now to identify why. The lack of publicly available charging stations which are compatible with the EV limits the motivation to purchase an EV in particular if the driver is a long-distance traveller (ibid. p.64, Schröder and Traber, 2012). The paper is also addressing a rare topic in the field of recharging. Currently, it is not possible to

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<th>Barriers &amp; Measures</th>
<th>Context for the study</th>
<th>Author/ year</th>
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<td>High purchase cost</td>
<td>Municipalities have limited possibilities to reduce purchase costs and need to find creative solutions such as reducing registration fees, offer temporarily additional tax rebates</td>
<td>(Gibbs and Jonas, 2000; Bakker and Jacob Trip, 2013; Langbroek, Franklin and Susilo, 2016; Li et al., 2017)</td>
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<td>Limited range of battery capacity (range anxiety)</td>
<td>Municipalities need to work with the current available technology and only have limited availability on supporting R&amp;D</td>
<td>(Krutko, Moon and Finkle, 2013; Gass, Schmidt and Schmidt, 2014; Rezvani, Jansson and Bodin, 2015)</td>
</tr>
<tr>
<td>Limited access to charging infrastructure</td>
<td>The communication between municipality and charging station providers is a key issue and needs to be enhanced</td>
<td>(Jin, Tang and Ghosh, 2013; He, Yin and Zhou, 2015; Giménez-Gaydou et al., 2016; Silvia and Krause, 2016)</td>
</tr>
<tr>
<td>Missing knowledge</td>
<td>Understanding costs and environmental benefits of the EV</td>
<td>All interviews confirmed the lack of knowledge as a barrier, (Knowles, Scott and Baglee, 2012; Langbroek, Franklin and Susilo, 2016; Adnan et al., 2017)</td>
</tr>
</tbody>
</table>
connect one EV to the other and charging plugs vary depending on the model and station. This is a significant barrier because it is one of the key differences to an ICEV.

In order to have secured access to charging EV drivers with a house install their own charging station which costs around $1000 (Agenbroad and Holland, 2014). Most public chargers are Level 2 chargers which require a maximum recharge time between three and six hours. For most people, this is too long since ICEV only need a few minutes to be refilled (Robinson et al., 2013). Other issues are that the driver finds an EV charging station but is occupied by another EV or an ICEV blocking the spot. There is also a lack of information if one EV driver could unplug the recharged EV. In fact, there is no known legislation which governs the condition under which an EV can be unplugged (ibid. p.65). The paper has three recommendations on how and where to deploy charging infrastructure:

1. the easiest and fastest way to deploy charging infrastructure is on parking areas. Charging stations often have two or more charging slots so that one installed station can serve several cars at the same time.
2. free parking at work or close to shops. Although it is an appealing idea for EV drivers it also results in overcrowded parking areas and negative customer experience.
3. etiquette and practices demand that “only charging when necessary, and only as much as needed [...]” (ibid. p.67) (Bonges and Lusk, 2016, p. 67)

Their suggestion is charging station should display when an EV is fully charged, and the next EV driver should be allowed to unplug in order to access the charging slot. If the charging station is technically not able to display the charging status, drivers could leave an etiquette card which indicates when the EV was plugged in and for how long the charge is needed.

Another issue is the wrongful parking by ICEV drivers. Often the EV slots have a prime location and others may feel disadvantaged and occupy without considering the need of the EV driver. A way to ensure the parking slot s rightfully occupied and only for the duration needed would be by enforced etiquette. This could be with a parking ticket. The authors offer another solution to the etiquette dilemma which is the redesign of the charging station. Increase the number of slots to eight rather than two. With that new octopus charging station, charging should happen on a first comes first serves basis. The EV plugged in first will receive the load, the second with a delay and so on. This would be in particular beneficial for overnight charging where no rush is a long waiting time no issue (ibid. p. 68) and legislation governing EV charging is not yet established on state or urban level. As a result, EVs “occupy the charging location for any period of time, as long as it is plugged in.” (ibid. p.69). The study suggests that in order to increase EV sales and extend the ownership of EVs, charges in proximity to prime charging locations is needed. It further stresses that the deployment should not just focus on the quantitative and qualitative measure. The installation of charging stations is very expensive and needs, therefore, places for provisioning need to be carefully chosen. The identification of a charging slot is on the urban level but also on the public parking space level very important. The benefit to deploying on prime locations in car parks brings little or no benefit and needs, therefore, be reconsidered (ibid. p.69).

A more specific policy analysis was done by Langbroek, Franklin and Susilo (2016) in their paper The effect of policy incentives on electric vehicle adoption. The article starts by identifying the need for charging infrastructure and that home charging would have a higher value than public charging or charging at work (Lin and Greene, 2011). It moves on explaining the taxonomy of policy instruments which can be either use- based or purchase- based incentives. Use-based policy is for example free parking for EVs or allowing to use the bus lane. Purchased- based incentives are described as initiatives which decrease the fixed costs of EV use. Langbroek et al. (2016) state that local use- based policy is more likely to be adopted by municipalities and “only influence people who can gain from these location-specific incentives” (ibid. p.95). There are more local incentives which are also identified as little use “registration tax exemptions or exemption on annual road taxes are not considered as very effective and efficient” (Gass, Schmidt and Schmidt, 2014). In addition, road tax exemptions are not targeting the disadvantage of the initial high purchase costs EVs (Langbroek, Franklin and Susilo, 2016, p. 96). Although the mentioned incentives might not convince the potential consumer at first glance, it has the possibility to become attractive since the cost of ownership scatter over time and are an affordable option for the municipality (ibid. p. 96).
The article also addresses the socio-psychological dimension of EV adoption and concludes that consumers with an advanced mindset on technological change, environmentalism and behavioural change have a decreased price-sensitivity. Consequently, “subsidization is less effective and therefore less efficient for people in more advanced stages-of-change.” (ibid. p 101). Moreover, if the society is able to shift toward the use of EV with an attitude change, policies should be reallocated to EV promotion policy (ibid. p. 101). Furthermore, the article stresses that policy incentives are not designed for infinite use and should only be available until the EV market is able to function on its own (ibid. p. 102). Moreover, used-based incentives such as free parking should also be stopped since they are no longer viable. The socio-economic aspects of incentive policy is identified as “local policy incentives decrease the marginal cost of EV use rather than their fixed costs; those policy measures are of little help for the group of car buyer that can currently not afford to buy an EV” (ibid. p. 102). Side effects of incentive-based policy is the signal to private investors. Industries often wait and react upon governmental intervention and see business opportunities. But policies need to be communicated in a clear and transparent way this includes the length and financial extend (ibid. p.102). The article concludes that “[... a more cost-effective strategy might be to put efforts on moving people towards a more advanced stage-of-change and focussing on this particular group of people when designing a less extensive package of policy-incentives for the specific group.” (ibid. p.103).
4.5. Urban case study Los Angeles and Oslo

To demonstrate successful EV transitions in urban areas two example case studies are selected, Los Angeles (USA) and Oslo (Norway). Their initiatives and success will be briefly introduced and give an example of how the successful implementation of policy can achieve a transition to an EV penetrated market.

4.5.1. Los Angeles (California, USA)

A case study that is of particular interest for this project was conducted in 40 Californian cities (Lutsey, 2017b). A combination of state and federal financial incentives and a new policy framework called the Zero-Emission Vehicle Program became a leading initiative in the US. This program sent a strong signal to local stakeholders and created the foundation of the EV transition. Specific policy tools were free parking for EVs, workplace charging and fleet subsidies. A particular driver was identified in 30 California cities; the accessibility to public charging infrastructure was five times higher per capita than in any other US major city (Lutsey, Searle and Pavlenko, 2016).

Los Angeles is the largest city in the US state of California with a population of 4 million citizens and the highest level of ozone in the US. The city adopted the California Zero Emission Vehicle program and offered a broad portfolio of consumer incentives. An additional driver was the development of two headquarters of EV manufacturers and a settlement of e-mobility related companies from 2010 onwards. Los Angeles has the highest sales of PHEVs and the highest availability of EV and PHEV models. The EV market share lies approximately 3 per cent which is four times higher than the national average (Lutsey, 2017b). Finally, the city offers very high monetary benefits. A brief summary of all relevant policies are listed in table 7:

Table 7. Overview of promotion for electric vehicles in Los Angeles Metropolitan area (Hall, Moultak and Lutsey, 2017, p. 25)

<table>
<thead>
<tr>
<th>Type of Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial incentives</td>
<td>• Federal tax credit up to $7,500 per electric vehicle</td>
</tr>
<tr>
<td></td>
<td>• State rebate up to $2,500 per electric vehicle</td>
</tr>
<tr>
<td>Nonfinancial incentives</td>
<td>• City parking benefit</td>
</tr>
<tr>
<td></td>
<td>• Preferential access to high-occupancy vehicle lanes</td>
</tr>
<tr>
<td></td>
<td>• Preferential utility electric vehicle charging rate</td>
</tr>
<tr>
<td>Charging infrastructure</td>
<td>• 3,473 charge points and 226 fast charge points</td>
</tr>
<tr>
<td></td>
<td>• Low-carbon fuel regulation</td>
</tr>
<tr>
<td></td>
<td>• State private charging infrastructure incentive</td>
</tr>
<tr>
<td></td>
<td>• Electric vehicle-ready building codes</td>
</tr>
<tr>
<td></td>
<td>• Streamlined local charging permitting process</td>
</tr>
<tr>
<td>Research and campaigns</td>
<td>• State manufacturing incentive</td>
</tr>
<tr>
<td></td>
<td>• “Drive the Dream,” “Best.Ride.Ever,” and “National Drive Electric Week” city outreach and awareness events</td>
</tr>
<tr>
<td></td>
<td>• City information materials and events</td>
</tr>
<tr>
<td></td>
<td>• Utility outreach information and events</td>
</tr>
</tbody>
</table>

The table highlights that California is offering next to national incentives state incentives, too. For example, the additional rebate for the purchase price, preferences for the use of HOV Lanes, charging infrastructure expansion and extensive education programs.
4.5.2. Oslo (Norway)
Another empirical study that is of relevance for the project was conducted in Oslo (Norway) by Hall, Moultak and Lutsey (2017). The capital of Norway claims to be the “Electric Vehicle Capital of the World” (Oslo kommune, 2018). The city of Oslo has 35,000 registered EVs and a market share of 21 per cent of new registered EVs in 2015. In addition, Norway and in particular Oslo has a very expanded charging infrastructure. Moreover, the city has a very generous incentive program which is summarised in table 8. Specific highlights are the 25 per cent VAT exemption and various charging infrastructure programs.

Table 8. Summary of electric vehicle support actions in the Oslo Metropolitan area (Hall, Moultak and Lutsey, 2017, p. 18)

<table>
<thead>
<tr>
<th>Type of Program</th>
<th>Description</th>
</tr>
</thead>
</table>
| Financial incentives       | • No purchase or import taxes  
                           | • Exempt from 25% VAT on purchases and leases  
                           | • 50% reduction on company car taxes  
                           | • No fuel taxes for electricity or hydrogen  
                           | • Low annual road taxes  
                           | • Exempt from road and ferry tolls |
| Nonfinancial incentives   | • Planning low-emission zones  
                           | • Free municipal parking  
                           | • Free electricity for normal charging (3.6 kW)  
                           | • Discounted quick- and semi-quick charging for prioritized vehicles  
                          | (e.g., EL-Taxis and Electric Freight Vehicles (FEV))  
                           | • Bus lane access |
| Charging infrastructure   | • 2,973 total charge points, 161 fast charge points  
                           | • Grants for up to 60% (up to 10,000 kroner) of the cost of the installation of additional charging point  
                           | • 2 million euros for the installation of 400 charging points between 2008-2011, 200 new charging points per year from 2013, 1,200 total by of the end of 2016, and 200 new ones in 2017  
                           | • Free public charging for normal charging (3.6 kW)  
                           | • Cooperation with private quick charging companies to deploy quick charging stations (three deployed in 2016 with many more to come)  
                           | • Building “a center of excellence for professional users of electric vehicles” in cooperation with the private real estate company Aspelin Ramm  
                           | • Building dedicated quick and semi-quick charging stations for EL-Taxis together with the taxi industry  
                           | • Building two large parking garages for electric vehicles |
| Research and campaigns    | • Part of European FREVUE, SEEV4, BuyZET, ELAN, and REMIND Programs |

Since Norway’s national authority offers already generous incentives, Oslo’s municipality mostly benefitting from and is actively expanding on charging infrastructure and engages in education campaigns.
5. Empirical results

The following section will give an overview of the selected case studies Washington, DC and Berlin. It starts with presenting (1) the geographical and demographical description, (2) policy efforts and shows the municipalities commitment, (3) presents the current state of charging infrastructure and related initiatives, (4) moves on to the electricity supply as the sources for the EV, (5) addresses the issue of visibility and signage, (6) reports on the local consumer awareness and finally looks at the (7) R&D development in this. All those empirical results will be underlined with the interviews taken during the field trips and reflect the real-life development.

5.1. Washington, DC (USA)

Washington, DC (District of Columbia) with a population of 690,000 citizens (US Census Bureau, 2017) is the capital of the USA and has exclusive jurisdiction and is therefore not considered as an independent state. The city has limited congressional power and is allowed to elect a major. The majors and councils political power reaches over local taxes and a budget. However, the budget can be retrained by Congress at the same time Washington, DC has no voting representation in Congress but a non-voting delegate who is appointed to the House of Representatives. Washington, DC has two neighbouring states, Maryland and Virginia (see figure 8). As a result, the city is experiencing an increasing population due to the commuting citizens in the neighbouring states. Also, air and noise pollution are increasing and create environmental and public health issues.

![Figure 8. Washington, DC area, surrounded by the states Maryland and Virginia (catolico, 2014).](image)

The US leaves most development interactions to the open market and is not active in restricting or even banning consumer choices. There were ideas in setting targets and market share minimum of EVs in the country, but the legal ban of harmful technology such as ICEV is not considered as an option (www.selectUSA.gov, 2017).
5.1.1. Policy
Washington, DC offers some policies and incentives next to the national and industry initiatives and has a market share of 1.87 per cent (www.evadoption.com, 2017). The following table provides a summary and overview of all related and identified initiatives.

**Table 9** Overview of national and state incentives and industry initiatives

<table>
<thead>
<tr>
<th>Policy Name</th>
<th>Policy Program</th>
<th>Incentive in $</th>
<th>Potential solution</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income Tax Credit</td>
<td>This tax credit applies to vehicles purchased after December 31, 2009. The size of the tax credit depends on the size of the vehicle and its battery capacity</td>
<td>2500-7500 per new purchased EV</td>
<td>This policy is tackling the most hindering factor of the EV transition, the high upfront purchase price</td>
<td>(Office of Energy Efficiency &amp; Renewable Energy, 2018; <a href="http://www.fueleconomy.gov">www.fueleconomy.gov</a>, 2018)</td>
</tr>
</tbody>
</table>

| **National Industry Initiatives** |
| Chargenow DC Fast - Washington, DC | Company offer by BMW in cooperation with Evgo for BMW i3 drivers, 24 months no cost for charging | No cost, unlimited 30 minute, DC Fast Combo charging sessions at EVgo Stations | (Chargenow, 2017) |
| Nissan LEAF “No Charge to Charge” Program - DC | Company offer of 24 months of free public charging with the purchase or lease of a new model year 2013 or later Nissan LEAF | Public charging is complimentary for an unlimited number of 30-minute DC Fast charges and 60-minute Level 2 charges at participating locations for 24 months | (EVgo, 2018) |

| **State Level** |
| Alternative Fuel and Fuel-Efficient Vehicle Title Tax Exemption | $ 36.00/ year (first time registration only) | A small saving compared to the high purchase price | (District of Columbia Department of Motor Vehicles, 2018) |
| Alternative Fuel Vehicle (AFV) and Infrastructure Tax Credit | A tax credit for 50% of the equipment and labour costs for the purchase and installation of alternative fuel infrastructure. The maximum credit is $1,000 per residential EV charging station, and $10,000 per publicly accessible AFV fuelling station. | Enhances deployment of charging infrastructure were consumer needs it | (Office of Energy Efficiency & Renewable Energy, 2018) (DC.gov Office of Tax and Revenue, 2014) |
| PEPCO | Electricity price discounts for -100 residential consumers with existing EVs and installed domestic charging infrastructure -50 Smart Level II EV for residential consumers with no existing domestic charging infrastructure -10 Smart Level II EV for apartment buildings with garage parking, with non-existing domestic charging infrastructure -Installation of max. 4 DC fast charger for public use | | (Public Service Commission of the District of Columbia, 2017) |

The table summarizes national, industry and state level initiatives related to the expansion of EVs. Most of the initiatives are addressing the charging station deployment or use of a specific charging stations by offering discounted rates.
5.1.2. Commitment of the Washington, DC municipality

On a municipality level Washington, DC created the Sustainability DC framework to develop the city sustainably. The goal 4 focuses on the improvement of air quality along major transportation routes. Specifically, the goal 4.3 focuses on expanding public electric vehicle charging infrastructure throughout the city. Also, goal 4.5 aims to track and report the mileage data from clean fuel, low-emission, and electric vehicles (Malinowski, 2017; www.sustainabledc.org, 2017).

To communicate Washington, DC’s commitment to the EV transition, the fleet is in the process of changing to EVs. With leading by example of environmentally friendly behaviour, it can increase the visibility and create more awareness. However, the fleet is only labelled with a small sticker and limits its presentation to the unknown person.

Washington, DC is a member of the Clean Cities Coalition. This coalition has over 100 local coalitions with municipalities around the US. They define their mission as “[…] to promote and assist in measurable improvements in regional reductions in the use of petroleum-based fuels through a strong coalition of effective partnerships; increase the use of alternative fuels, vehicles, and infrastructure; promote economic opportunities in clean energy technologies; and, encourage academically focused research on increased utilization of transportation energy efficiency options.” (www.gwrccc.org, 2018). The coalition brings together stakeholders from business interests, research institutions and environmental organisations. However, it was not possible to find any results, events or other measures which can reflect the success of this coalition.

An initiative between Washington, DC and its neighbouring states is the fast lane for carpooling. The HOV Lanes are fast-track lanes on motorways with the condition that three or more people are joined in a car. The lane is also toll-free for EVs in Maryland. However, Virginia stopped that initiative (http://www.virginiadot.org, 2018; www.roads.maryland.gov, 2018).

5.1.3. Charging infrastructure

As outlined in table 7, since September 2015 Washington, DC Council offers financial incentives for the installation of private charging infrastructure. $ 1000 are available per electric vehicle charging station is available for a private household installation (Government of the District of Columbia Office of Tax and Revenue, 2015).

The second commitment of the Washington, DC council is the new EV Public Infrastructure Expansion Act 2017 which has an effect since March 2018. It aims to provide at least 15 public charging stations within the District of Columbia until January 2019 (Council of the District of Columbia, 2017; Government of the District of Columbia District Department of Transportation, 2017).

Currently, there are 746 registered charging stations available (Solving EV, 2018). Whereby most of them are attached to private car parking facilities, so-called semi-public charging infrastructure. The deployment of these charging station is mostly in the city centre of Washington, DC. This deployment pattern is often due to the profitability of a charging station and only attracts investment where quick profits can be generated. This leaves out economically less developed areas since they are less likely to adopt the expensive EV. The most dominant charging station providers are Tesla, Charge Point and EVgo.

There is only one publicly available fast charger available which is located at 870 9th St NW Washington, DC 20001. The distribution of charging stations is demonstrated in figure 9. Although there was no possibility to receive an official interview with a representative of the car park operator, the manager was willing to answer a few questions. The car park is located next to shopping and residential facilities and offers four EV parking spaces for a duration of maximum 2 hours. The fast charger offers a full recharge within 30 minutes if the car is equipped for that technology. However, most EVs are still designed for the Level 2 charger and needs several hours to be recharged. This led to an abuse of the EV charging stations.
EV drivers parked their car for more than two hours which blocked and even with issuing parking tickets of $250 the abuse continued. Especially EV taxis were the most observed abuser. As a consequence, the car park operator disconnected the charging facilities from the grid and stopped the service. The conversation was taking place in October 2017. However, mobile apps are now showing the station is in service again and have been used frequently.

Make infrastructure available in residential neighbourhoods is a difficult task. A specific parking slot needs to be allocated for the EV and ready for charging at any time. Eric Campbell (pers.com, Campbell, 2018) shares his experience stating “… when it comes to dominating public face for the big reason, we are with people taking it away from us. People can get very upset about that very quickly and generally in the US it has been very difficult to identify ways that we can make charging stations accessible on the curb in public.”. He continued and referred to a case study in California where public charging stations where deployed with the “agreement of the entire neighbourhood felt comfortable about the location. People do not want to have random strangers come and leave the car overnight” (pers.com, Campbell, 2018).

Figure 9. Map of registered charging stations Washington, DC (ChargePoint, 2018).

The development is left to the open market on purpose “finding a hosting space is difficult, and they are expensive, too. From a government perspective, you don’t want to own actively and operate charging much rather see private investment from different charging stations supplier coming in.” (pers.com, Campbell, 2018). He continued explaining partnerships, assistance with a permit, finding a plot of land or connecting groups is the role of the DC government. At the same time companies such as EVgo and ChargePoint are also interested in being involved in this transition and are willing to assist with issues related to education and communication.

At the same time, the municipalities can and should take action to expand on the charging infrastructure and cooperate stronger with home owner associations to enhance the charging facilities at home (pers.com, Olexsak, 2018).

5.1.4. Electricity supply

The electricity supplier in Washington, DC is limited to one company Potomac Electric Power Company (PEPCO) and creates a monopolistic supply. It offers in cooperation with Washington, DC Council a new consumer incentive which is available since April 2017. Its aim is to approve a limited, voluntary, demand management program for EV charging stations in Washington, DC (Public Service Commission of the District of Columbia, 2017) (for details see table 9).

PEPCO will offer reduced rates during off-peak hours and offers smart charging options with an option to choose a 100 per cent renewable energy as electricity source which will come with an additional charge. However, this offer is limited to a reduced number of consumers. The aim of that initiative is to collect data and information about charging behaviour and consumer choice. The collected data supposed to be used for an improved consumer service experience and better analysis of the location of the charging station. After data were collected and analysed, it will be presented to the Commission of the District of Columbia. The anticipated program has a limited timeframe until the third quarter of 2019. Moreover, PEPCO aims to:
- develop an understanding of any potential impacts which may increase the adoption of EVs
- gather information to evaluate and mitigate the impact on the distribution system
- test and validate different incentive programs (e.g. Time-of-use rates)

Washington, DC largest utility supplier is PEPCO and has only one competitor Constellation Energy. However, Constellation Energy is dependent on the existing electricity infrastructure provided by PEPCO which results in a dependency of accessibility to residential customers (Constellation, 2018).

5.1.5. Signage and visibility

The availability but not visibility of charging stations is a key observation. There are a lot of underground parking and valet parking facilities in the city which makes the deployment of installed charging stations invisible to the driver or citizen. In addition, there is no signage at the entrance of the parking facility, information about prices or if the charging station is free, generally usable or out of order. Eric Campbell admits, “Having a sign is extremely important and must be done correctly [...] and is another aspect of consumer education.” (pers.com, Campbell, 2018). The available but missing signage possibilities are shown in figure 10.

Figure 10. Car park entrance which offers charging stations but has no signage installed (picture by author). Car park entrance with the digital display not indicating availability or price for electric charging.

5.1.6. Consumer awareness

There is also a lack of EV availability at car purchasing places and a lack of knowledge. The general audience is not aware of the difference between an EV or PHEV. In fact, during casual conversations with local citizens, the EV was often associated with the brand Tesla as the only provider of EVs. Moreover, since ICEV are quite affordable in the US, the consumer sees no benefit in switching to an alternative fuel vehicle or an EV (Dowling, 2011; Jaffe, 2015). Initiatives rising awareness are for example the annual Autoshow which takes place in Washington, DC and presents new models from national and international automakers with a specific subsection of electric vehicles (www.washingtonautoshow.com, 2018). However, these events are often visited by car enthusiasts. It is a question of how to reach those who are not interested in car technology (pers.com, Nigro, 2017).
5.2. Berlin (Germany)
Germany's Agenda 2030, which is closely linked to the SDG framework from the UN, commits to reducing Greenhouse Gas (GHG) by 40 per cent compared to the emission level in 1990. This target also encourages urban policymakers to move toward a low or zero emission vehicle alternatives such as electric vehicles. To achieve a national EV transition in Germany a target of 1 million EVs by 2020 was set (Deutscher Bundestag, 2017a; Enkhardt, 2018). Due to the lack of action by manufacturers and missing policy the target became unachievable and the federal government withdrew from its idea.

Nevertheless, cities still understand their need for a successful transition in order to reduce air and noise pollution for the health of their citizens and for the sake of the natural environment. Berlin is trying to become a leader in the EV transition with its own regulations, incentive programs and projects.

One approach is Germany's Electromobility Development Plan. It is designed to reach energy and climate goals, reduce the dependence on fossil fuels, establish the German automaker industry as the global market leader for electromobility, develop a competitive research and innovations market, and establish social acceptance of electromobility (Die Bundesregierung, 2009). With great ambitions the national incentives for the consumer are insignificant. A rebate amount of maximum 4000 € is less than ten per cent of the purchase price (Bundesamt für Wirtschaft und Ausfuhrkontrolle, 2018). The tax exemption from the annual circulation tax is a few hundred euros per year and cannot be considered as an impact on a positive purchase decision for an EV (www.ACEA.be, 2016). Research initiatives such as the Schaufenster Mobility (Show Case Mobility) allowed regions to develop their own strategies and become a real-life research arena (www.schaufenster-elektromobilitaet.org, 2018b). The showcase went beyond EVs and includes modern forms of transportation visions. That initiative made Berlin the largest urban lab in Germany and an interesting case study.

5.2.1. Commitment of Berlins municipality

Berlin as an independent federal state is surrounded by Brandenburg and many people commute to Berlin by either car or public transport. Figure 11 presented shows Berlin as the city (dark orange) and the metropolitan area (light orange). Metropolitan Berlin has a population of 4.4 million citizens of which 80 per cent (3.5 million) live within the city boundaries (Senatsverwaltung für Umwelt, Verkehr und Klimaschutz, 2013). Almost 300,000 people commute to and out of Berlin on a daily basis which puts pressure on the infrastructure system and creates significant environmental and public health-harming emissions (Vossen, 2018).

![Figure 11. Map of Berlin and Brandenburg highlighting the metropolitan area of Berlin and major highways (Broadway, 2010).](image)

The Berlin Strategy Urban Development Concept for 2030 is an urban planning framework with the vision to set national and international benchmarks climate-friendly city (Senate Department for Urban Development and Housing, 2013, p. 8). More visions go beyond 2030. For example, Berlin
aims to be climate neutral by 2050 with the creation of more green space. This will be achieved with the existing dense energy supply network and the expansion of urban renewable energy projects such as solar panels on roofs. Another focus is the so-called Urban Transportation Development Plan 2025 (Menge, Horn and Beck, 2014) which is linked to the modern transportation framework called be mobile and is the most relevant framework for this research.

5.2.2. Local policy

A recent legal dispute was decided on the highest administrative court (Court of Claims in US English) in Germany, now allowing cities to ban high pollution vehicles from certain parts of the city. The increasing urban air pollution measures and the lack of political intervention motivated the Deutsche Umwelthilfe (German Environment Aid) sued the region Baden-Württemberg for keeping the NOx emissions to the legal maximum which the EU legally set (Neumann, 2017). Although Berlin’s has now the opportunity to ban ICEV from certain street or if needed from the whole city, Berlins Senator for Climate and Traffic sees this step not as an option at the moment. She states that a lot of people have simply not the economic resources to switch to an EV and punishing those citizens would be an unfair policy. She sees the national government is in charge of offering alternative such as the technical upgrade of ICEV to less emission causing cars. In addition, the strategy of Berlin’s overall sustainable mobility transition is to provide more bike lanes and improve public transport. The EV has currently no role in that transition (pers.com Günther, 2018).

Berlin offers no specific or local policies to enhance the purchase of EVs for individual consumers (Deutscher Bundestag, 2017b, p. 7) but for EVs which are used for business purpose (RBB24, 2018). The EV market share in Berlin in 2017 was around 0.14 per cent (total 1668 registered EVs) (Kraftfahrt-Bundesamt, 2017; www.kba.de, 2017; Neumann and Knoblach, 2018). A list with national policies and other German urban incentive programs are listed in table 10.

Most incentives which are addressing the high purchase price are in cooperation with the local utility supplier which are owned by the government. At the same time, the supplier ensures long-term consumer due to the terms and conditions of the incentive program.

The created Agency for electromobility (eMO) in Berlin is a public-private partnership, whereby 70 per cent funding comes from the central government and 30 per cent from private institutions such as the local public transport company. One of the tasks of eMO is to connect related actors and ease the possibility to start new developments in the field of electric mobility. In addition, it aims to encourage the general innovation culture with trends which are suitable for Berlin (pers.com, Reinhardt, 2018). This is necessary since developments on infrastructure systems are a part of public life and are strictly regulated. In addition, new actors who try to enter the market reach out to eMO and find the possibility to network within eMO’s pool of small and large existing actors. At the same time, eMO reaches out to new settled companies and in particular start-ups and tries to maintain the network within the industry.
### Table 10. Incentive programs by national and local authorities in Germany

<table>
<thead>
<tr>
<th>Policy Name</th>
<th>Policy Program</th>
<th>Incentive in €</th>
<th>Potential solution</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment Bonus</td>
<td>From July 2016 all EVs purchased and cost less than 60,000 €</td>
<td>Max 2000 (until end of 2017)</td>
<td>Reduce first-time purchase price</td>
<td>(<a href="http://www.schaufenster-elektromobilitaet.org">www.schaufenster-elektromobilitaet.org</a>, 2018a) (Bundesamt für Wirtschaft und Ausfuhrkontrolle, 2018)</td>
</tr>
<tr>
<td>vehicle tax</td>
<td>No payment of vehicle tax between 2016 and 2020</td>
<td></td>
<td></td>
<td>(<a href="http://www.schaufenster-elektromobilitaet.org">www.schaufenster-elektromobilitaet.org</a>, 2018a)</td>
</tr>
<tr>
<td>Incentives to expand on charging infrastructure</td>
<td>Since 2017 up to 300 Mio € are available for the expansion of public charging infrastructure. Yet there is no specific framework developed</td>
<td>100 Mio. for AC 200 Mio. for DC</td>
<td></td>
<td>(<a href="http://www.schaufenster-elektromobilitaet.org">www.schaufenster-elektromobilitaet.org</a>, 2018a)</td>
</tr>
</tbody>
</table>

**Examples of local/ urban policies in Germany**

| STAWAG Aachen (local utility supplier)          | Incentive is issued if EV owner is customer by STAWAG and can use domestic plug for recharge | 500                   | Reduces first-time purchase price               | (STAWAG Stadtwerke Aachen AG, 2018)                                     |
| Mainova Frankfurt (Main) (regional utility supplier) | If a new EV is purchased and a sticker from Mainova is viable at the car placed     | 250                   | Reduces first-time purchase price               | (www.mainova.de, 2018)                                                 |
| Stadtwerke Frankfurt (Oder)                     | Incentive is issued if EV owner is customer by Stadtwerke Frankfurt (Oder)          | 500                   | Reduces first-time purchase price               | (www.stadtwerke-ffo.de, 2018)                                          |
| Stadtwerke Neuwied                              | Incentive is issued if EV owner is customer by Stadtwerke Neuwied                    | 500                   | Reduces first-time purchase price               | (SWN E-Mobilitätsangebot - Elektro-Fahrzeuge - Ladestation für E-Autos, no date) |
| Stadtwerke Versmold                            | Incentive is issued if EV owner is customer by Stadtwerke Versmold                   | 300                   | Reduces first-time purchase price               | (www.stadtwerke-versmold.de, no date)                                    |
| Stadtwerke Zweibrucken                         | Incentive is issued if EV owner is customer by Stadtwerke Zweibrucken                | 500                   | Reduces first-time purchase price               | (www.stadtwerke-zw.de, 2018)                                           |

#### 5.2.3. Charging infrastructure

The be emobile framework is Berlin’s approach to reduce pollution and enhance the deployment of uniformed public charging infrastructure, electric bike and car sharing business models (Allego GmbH, 2018). Expanding the charging infrastructure in Berlin started off with an ambitious project and considered many of issues cities are facing. But the deployment of charging infrastructure remains an individual challenge and varies from city to city. In particular the availability of
charging stations, it might be blocked by a car and the demand for reserving a car parking spot needs to become an option to create certainty (pers.com, Reinhardt, 2018).

As a part of the Show Case Mobility project, Berlin City Council has contracted a supplier for charging infrastructure Alliander / Allego / The New Motion (Allego GmbH, 2018). The aim was to ensures unified charging slot become available and the user/ charging experience (including payment method and charging price and charging slot) becomes predictable. This project was called Berlin Standard and was established in April 2015. Until today there are installed around 170 AC Stations (around 340 charging slots) and six DC/ fast charger stations all those stations are supplied with a renewable energy source.

This initiative reflects the recommendation from Sarah. The national government might not be willing to force industry leaders to deploy one and the same charging station, however, pressure on the industry could come from the municipality level. Municipalities could form cooperations with one specific charging station supplier and mainstream the transition (pers.com, Olexsak, 2018).

Germany's Eich- und Messgesetz (Calibration and Measurement Law) is valid since January 2015 and active in the field of electric mobility recharging since July 2017 in Berlin and received already a nickname Berliner Modell. It demands that the charging time is charged per recharge rather than charging time or kWh. There is now a lump sum per charging process rather than a flexible charging price (low and high peak times adjustments) (Schwierz, 2017). An overview of the different charging prices in Berlin is summarised in table 11.

Table 11. Overview of charging prices with the three largest charging stations supplier in Berlin.

<table>
<thead>
<tr>
<th>Type of charging</th>
<th>Charging supplier</th>
<th>Street Lamp charging (max. 3,7 kW)</th>
<th>AC charging (Level 2) (max. 11 kW)</th>
<th>DC charging (Level 3/ Fast charger) (max. 50 kW / AC 43 kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be emobil (350 charging stations in Berlin) (be emobil, 2018)</td>
<td>4,50 € Price per charge</td>
<td>6,00 € Price per charge</td>
<td>9,50 € Price per charge</td>
<td></td>
</tr>
<tr>
<td>Innogy (100 charging stations in Berlin) (Innogy, 2018)</td>
<td>30 Cent/kWh</td>
<td></td>
<td>6,95 € Price per charge</td>
<td></td>
</tr>
<tr>
<td>Vattenfall (50 charging stations in Berlin) (Going Electric, 2018)</td>
<td>30 Cent/kWh</td>
<td></td>
<td>20 Cent/ kWh</td>
<td></td>
</tr>
</tbody>
</table>

Public charging infrastructure comes with free parking for up to four hours between 08:00 and 18:00, and ICEV are not allowed to use that car parking slot at all. The aim is to develop a uniformed price for charging, there should be no price fluctuation, and the consumer should be able to know beforehand what costs to expect. However, the practice shows that it lacks in enforcement. If an EV parking space is used by an ICEV or used longer than four hours, there might be a ticket of maximum 20€ (www.auto.meinestadt.de, 2018) which is not a discouraging amount.

There are more suppliers of charging stations which comes to a total of over 500 publicly available charging stations and over 700 charging slots (www.berlin.de, 2017; Frese, 2018). The number looks, at first sight, sufficient, but it needs to be remembered these are still with different slots and only in specific areas of Berlin. As demonstrated in figure 12, as further out of the city centre as fewer the installed stations. It is not surprising since these are the areas with citizens with lower incomes or unemployment.

Berlin is moving away from the
strategic recommendation of charging stations pattern deployment and leaves the decision-making process to the industry and citizen. With the proof of ownership or right of usage on an EV (e.g. company car), it is possible to apply for a charging station which will be installed in a public space. The application process is simple and available online. However, it is not clear how informed the public is about that opportunity which raises again the critique of the lacking an inclusive planning process (be-emobil, 2018).

Figure 12. Berlin map with charging stations (ChargePoint, 2018).

The creative and startup industry is well established in Berlin. This includes the mobility scene which hosts many startups with innovative business ideas such as alternative charging equipment supplier named Ubtricity (Evert, 2013). Their innovation is the installation of a charging station at a street lamp which has access to a parking slot; figure 12 shows an active charging station at a street light in Berlin.

Figure 13. Charging station at street light (authors image).

Although the idea of using the existing electrical infrastructure to provide charging station seems logical, it is only possible in a very limited manner and needs to be incorporated into the local electrical grid system. The costs to re-engineer the street light is around 1,000 Euros and takes about 30 minutes. Ubtricity concept is expanding beyond Berlin and Germany’s boarder and is reaching to cities such as London and New York (www.ubitricity.com, 2017, 2018).

Another mobility related start-up Chargery sees Berlin as a good starting point to develop the business idea. Chargery offers a mobile charging service of EVs. With cargo bikes and charged batteries the startup brings the charging facility to the EV rather than the car is going to the charging station (3sat.online, 2018; Przybilla, 2018). Moreover, the communication between the local municipality is positive and gaining access to a local political representative is no challenge. However, there is also the need for more subvention for mobility specific business opportunities to encourage the development of alternative and next-generation mobility ideas (pers.com, Lang, 2018).
5.2.4. Electricity supply

The local electricity supplier Stromnetz Berlin (owned by Vattenfall) is very optimistic in being able to accommodate a growing EV market and sees the fear with blackouts and lack of electricity supply as unreasonable. In an interview stated the general manager “The fairytales about blackouts caused by a booming electric mobility has no substance” (translated from German into English) (Klinger, 2018). Various scenarios were simulated, and a growing EV market of 250,000 EVs by 2025 is no problem for the grid (Stromnetz Berlin, 2017).

5.2.5. Signage and visibility

Charging infrastructure, free parking during charging is very visible in Berlin. Parking slots have a highlighted line, and signs are indicating the dedication of the slot. there was one occasion were the instruction sign installed or later changed the wrong way around. The factor of the visibility of the charging stations and electrified mobility is fairly obvious in Berlin. With business models such as shared mobility with e-scooters a growing network of charging stations with designated parking slots makes it obvious for pedestrians and drivers that the transition is an ongoing process in the city. Examples of signage for EV charging and parking slots are demonstrated in figure 14.

![Figure 14. Signage related to electric vehicle parking or charging (Parkaffe, 2018).](image)

Another form of signage is the registration sign at the car. As demonstrated in figure 15 the registration plaque has the letter E at the end which indicates that this vehicle is an EV. EVs are at first sight not different to an ICEV and the additional signage on the registration plaque makes it easier for the police officer to grant the free parking option at a charging station and other designated slots. The registration plate is for free by first registration, if a driver is interested in changing it after registration a fee of 27,50 € applies (Service Berlin, 2018).
Figure 15. Car registration plate with the E indicating this is a registered electric vehicle (Gutschild, 2018).

5.2.6. Consumer awareness
The Dieselgate scandal received great attention by the public and politics. A long-term solution was demanded and EVs quickly identified as a key role in the low carbon/emission transport transition (tagesschau.de, 2017). However, the knowledge of EVs itself is still limited and the difference between an EV and a PHEV is also a confusing concept.

The industry should make larger efforts in reaching out to consumers and educate with commercials and other activities (pers.com, Mock, 2018).

The communication with citizens is important. Technology is only as good when people can actually use it, and the purpose of the idea is fulfilled. Furthermore, the demand to expand the communication to the citizen with educational initiatives from the national and regional government is missing. According to Johanna a budget should be allocated for specifically that purpose and seen as a long-term investment to enhance the urban EV transition (pers.com, Reinhardt, 2018). In addition, the need for information on individual boroughs of Berlin is underdeveloped. Municipalities of a sub-local level need more help to develop the EV transition with knowledge and understanding of the process (pers.com, Reinhardt, 2018).
6. Analysis

In this chapter, the empirical results are analysed with the help of the conceptual socio technical system presented in chapter 3.5. At first (1) the socio-technical aspects are examined for their relevance for the EV transition in cities. Then (2), the analysis shifts towards practices. This chapter separates by the key characteristics of the theoretical and conceptual framework; Vision and Political Will, Networks, Communication & Education and Knowledge building. Finally (3), a closer look is taken to individual actions and their contribution to the urban EV transition.

6.1. Reconfiguration of a system in an urban transition

The theories of urban environmental governance offer ways in which governing is conducted and address forms of interventions (Gibbs and Jonas, 2000; Bulkeley, 2011). Those interventions can be considered as experiments (Hodson, Geels and McMeekin, 2017). These dynamic of an experiment such as the urban EV transition is an overlapping intervention and can be categorised in the outlined theoretical concepts; urban environmental governance, socio-technical system and urban living laboratory. With concepts drawing from those literature, the case study research served as a means through which the EV transition in the chosen cities takes place. At the same time, it opens up the space for analysing related technical and social innovations as well as policies approach which are designed for that particular transition.

Understanding urban environmental governance and institutional arrangements within the urban living lab is important because it is shaping the ongoing reconfiguration of a system. Within this reconfiguration, network building, stakeholder participation and innovation development become key criteria for analysing the process of a socio-technical system transition. During the transition process and the rise of the niche innovation, the reconfiguration of elements such as policy priorities and experimental governance initiatives will become present and visible in the urban built environment. Furthermore, the experiment with innovation in a closed environment such as the city will provide an empirical and theoretical contribution to developing a conceptualised way of achieving sustainability.

Experiments demonstrate the relationship between technical and social aspects and the governance of urban environmental governance experimentation. This process includes actors who are involved in or affected by the emerging niche development and the new political sphere of providing space for this innovation (Bulkeley and Castán Broto, 2013, p. 361).

The urban living lab provides the playground for multiplicity transition at the same time and helps to embrace the niche innovation. Usually, the niche innovation occurs with on a singular transition, the urban lab will embrace the multiplicity transition and helps to understand the wider interaction between technology and society. Moreover, the urban living lab sets parameters for the experimental and learning process in the city and become a strategy of urban governance (Hodson, Geels and McMeekin, 2017, p. 4).

A quote by Wittmayer et al. summarises all those aspects:

“[…] governing sustainability should be about finding creative ways for opening space for participation, change and experimentation, that is, for creating alternative ideas, practices, and social relations” (Wittmayer et al., 2016, p. 49).

Interpreting this quote in relation to the empirical findings, it can be said that an urban transition governed with the integration and participation of networks, creative ideas, real-life experiments and development social niches can be achieved. This conclusion will guide the analysis and helps to capture the MLP.
6.2. The character of an urban electric vehicle transition

The start of the transition came from the development of a sophisticated electric car motor, increasing pollution in terms of CO2, NOx and the fraud coming from the diesel scandal. As a result, the public outrage was increasing, and national policymakers started accommodating alternative policy strategies promoting eco-innovations. This development is a good example of the socio-technical system. The system is experiencing an external shock (climate change, consumer demand, air pollution), creating a window of opportunity for novelties (the niche innovation - the EV) and leads to the reconfiguration the socio-technical regime.

Because this transition is related to the promotion of an eco-innovation and the political sphere is highly involved in the promotion of this novelty, the creation of a common political vision is key to promote the momentum of the innovation (Smith, 2007; Hodson and Marvin, 2010; pers.com, Goetz, 2017; pers.com, Nigro, 2017; pers.com, Mock, 2018; pers.com, Olexsak, 2018). The technical novelty and proposed vision of an EV penetrated market communicated through media to the citizens and industry leaders and reached a greater momentum which enhances the transition. Furthermore, the socio-technical system theories see small networks of actors as those supporting novelties (Geels and Schot, 2007). In addition, during that rising process of niche innovation, the learning process (further referred as knowledge) takes place and is required to compete with the established regime.

The niche innovation brings new actors to the scene, and the window of opportunity creates space for subsystems to emerge. That sub- systems are for example the charging infrastructure and online applications. Urban leaders quickly identified their role in the transition since urban streets are highly polluted and citizens negatively affected. This includes Berlin and Washington, DC and their approach on how to govern this transition is quite different.

Taking the theories from the socio-technical system into account there are four processes distinguished to create a successful development of a technological niche; Vision, Communication, Network, Knowledge (Kemp, Schot and Hoogma, 1998, p. 1998; Hoogma et al., 2005; Geels and Kemp, 2007; Geels and Schot, 2007). For the purpose of this thesis the analysis of the identified aspects are adjusted and help to create an analysis of the multiple case study in context of the EV transition. These four aspects are guiding the analysis, and the empirical findings are adapted accordingly.

6.3. Vision

A clear defined vision is the foundation of a transition governed by local authorities. This should be communicated to all stakeholder including civil society and the business sector (Geels and Kemp, 2007; Loorbach and Rotmans, 2010).

Moreover, urban policy leaders should dare to govern and to manage the desired transition with a bold policy framework (Edmondson, Kern and Rogge, 2018). As seen in other case studies (see chapter 4.5.1 and 4.5.2) with a comprehensive and ambitious policy framework the transition to an EV penetrated market becomes realistic and fast growing. After all regulations and governance is seen as a cornerstone of the socio-technical transition (Kern, 2012; Steinhilber, Wells and Thankappan, 2013)
Table 12 provides a summary of the identified initiatives in Berlin and Washington, DC.

**Table 12. Overview of local policies to enhance the electric vehicle transition in Berlin and Washington, DC (based on chapter 5)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Initiative</th>
<th>Berlin</th>
<th>Washington, DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory Aim</td>
<td>Development of a political vision</td>
<td>• Show Case Mobility</td>
<td>• Sustainable DC Framework: Improve air quality with sustainable transport systems, public charging infrastructure</td>
</tr>
<tr>
<td>Indirect Incentive</td>
<td>Preferential Access</td>
<td>• Free parking at public charging station during charging</td>
<td>• Free use of HOV Lane between Washington, DC and Maryland</td>
</tr>
<tr>
<td>Charging Infrastructure</td>
<td>Funding for charging infrastructure</td>
<td>• Free installation of public charging equipment when application form is submitted</td>
<td>• Infrastructure tax credit</td>
</tr>
<tr>
<td>Complementary policies</td>
<td></td>
<td>• Coherent charging price through the Calibration and Measurement Law</td>
<td>• No registration fee (Tax exemption)</td>
</tr>
</tbody>
</table>

Berlin’s EV vision is outlined in the be emobil framework. The reduction of pollution caused by motorised transport and the deployment of charging infrastructure is the main aim. Moreover, the partnership with Allego aims to create a uniform charging infrastructure plug system which gained already the nickname “Berlin Standard” (Allego GmbH, 2018). Especially, the deployment of charging facilities per demand is an inclusive form of a decision-making process. This approach is so interesting because it is moving away from a purely statistic method of a decision finding and let the citizens and businesses lead the way to form the built environment.

Another policy initiative and conversion of the vision is the free parking slot during charging. However, the high purchase price, which is considered as the main barrier for consumers, is not addressed through subsidies and only a small deduction.

The industry is showing its commitment to offering renewable energy on a voluntary basis as an energy source for charging. This is a good example of how businesses are participating to a sustainable urban EV transition (Menge, Horn and Beck, 2014).

Washington, DC is offering various charging infrastructure incentives. The city is focusing on shaping the built environment rather than addressing the purchase barrier. With its own created infrastructure tax, PEPCO charging station deployment initiative, and reduced residential charging prices, the barrier to access a private charging facility is lowered. The local target to install 15 public charging stations by January 2019 is a small step forward but shows that Washington, DC is not ignoring its responsibility for provisioning and ultimately shows its dedication to the urban EV transition. However, there is the obstacle coming from the empirical results from Washington, DC. The local community has a passive attitude toward the public charging infrastructure installed in their neighbourhood and lobby against the deployment (pers.com, Campbell, 2018). Since the citizens is a key stakeholder in all forms of urban development, their concerns need to be taken into consideration.

6.4. Communication

Just a vision from policy leaders is not enough; it needs to be communicated and instrumentalised. Especially the industry is waiting for signals from the national and regional authorities to see a shifting demand which creates certainty for future investors (Loorbach and Rotmans, 2010; Edmondson, Kern and Rogge, 2018; pers.com, Mock, 2018). In addition, “the articulation of
expectations and visions [...] are considered crucial for niche development because they provide direction to learning processes, attract attention, and legitimate (continuing) protection and nurturing.” (Schot and Geels, 2008, p. 540). Moreover, communication of the vision is key to find shared targets with other stakeholders, further, with incorporating these stakeholders a coordinated transition at a coherent pace becomes possible (pers.com, Olexsak, 2018).

Another form of communication comes from the citizen. The original demand for an EV transition came from the citizen. Whilst being affected by air pollution and climate change results, there are limited possibilities on contributing to the EV transition. The dependence on industry coming forward with alternatives is high, and the government can only act when technological niche emerged to a state where it is appropriate to use. The EV and related technologies are now sophisticated, and it is time to respond to the demands and make the access to alternatives possible. This applies not just to the general access to the EV but also education on different EV types and the education of the second largest barrier, range anxiety. Furthermore, it is important to stress to the citizen that range anxiety is in an urban context a myth and becomes with the increasing charging infrastructure deployment an unrealistic fear (Franke et al., 2012; Steinhilber, Wells and Thankappan, 2013; Rauh, Franke and Krems, 2015).

Table 13 gives an overview of identified communication initiatives within the EV transition in Berlin and Washington, DC.

<table>
<thead>
<tr>
<th>Type</th>
<th>Berlin</th>
<th>Washington, DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility</td>
<td>• Active deployment of public charging infrastructure</td>
<td>• Cooperation with local energy supplier PEPCO in deploying more public charging infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Obvious signage around charging stations</td>
<td></td>
</tr>
<tr>
<td>Consumer education</td>
<td>• Awareness building through the E at the end of the EVs registration plague</td>
<td>• Annual Autoshow</td>
</tr>
</tbody>
</table>

Berlin, with a German tradition of strong regulations, has a lot of signage at the charging station itself and highlighted car parking slots. This is a highly visible tool to show citizens and car drivers the transition has priority in the infrastructure development. The letter E on the registration plaque of an EV is another visibility factor, but the educational value needs to be questioned. If consumers are not aware of EVs in general, the additional letter will not be a communication alternative. Nevertheless, these approaches are visible and can be traced to governance actions and reflect the local policy leaders’ vision (Edmondson, Kern and Rogge, 2018).

Washington, DC annual Autoshow is an example of an educational measure. However, it only attracts people who are already interested in cars. Signage is a form of communication is a significant gap in the EV transition and charging station availability, and accessibility is not visible yet neither at public or private parking spaces. The cooperation between PEPCO and the municipality to expand on infrastructure can be seen as a strong communication to other industry and send signals to other actors who might be interested in exploring Washington, DC as a business opportunity.

6.5. Network
A way to communicate the vision is the creation of networks. Network building is a key message by the environmental governance framework and aims to exchange experiences, ideas and challenges. The collaboration of new networks is an important factor to enhance the learning and acceleration process of the transition (Rotmans and Kemp, 2004). Especially when the networks are broad, and the articulation of multiple visions comes together, the learning process and mobilising of underrepresented stakeholders gains momentum (Schot and Geels, 2008).
Table 14 Overview of initiatives related to network building in the electric vehicle transition in Berlin and Washington, DC (based on chapter 5)

<table>
<thead>
<tr>
<th>Type</th>
<th>Berlin</th>
<th>Washington, DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governmental Level</td>
<td>• Former case study of showcase mobility national imitative</td>
<td>• Member of the Clean Cities Coalition</td>
</tr>
<tr>
<td></td>
<td>• Creation of a dedicated agency; eMO</td>
<td>• EV use of HOV lane between Maryland and Washington, DC</td>
</tr>
<tr>
<td>Industry Level</td>
<td>• Startup community developing alternative charging infrastructure</td>
<td></td>
</tr>
</tbody>
</table>

Berlin uses eMO as a communication and networking platform for stakeholders mostly from the mobility industry. This network opens a pool for exchange on specific local issues related to policy planning and practical experiences. Moreover, during Berlins EV transition a growing network of a startup community occurred as a subsystem and helps the niche innovation to maintain the transition process.

For example, the startup Chargery was a well-established startup which developed a flexible way of charging within the urban area. They are cooperating with the local municipality openly and maintain a communicative relationship. However, by reaching for a higher level of political representation, the communication process ends quickly, and there is no clear path on who and where rising innovations and business ideas can go further (pers.com, Lang, 2018). Although this networking opportunity finishes the startup quickly, the scene finds its own way of cooperation.

Forming a greater network of startups with a similar working field, they try to find a common goal and challenge, reach out to policymakers and demonstrated their voice is not an isolated case and should be taken seriously (pers.com, Lang, 2018).

Washington, DC is a part of the Clean Cities Coalition and builds networks with other cities with the common goal of a cleaner and more sustainable city. Although there were no results published, the coalition and exchange within the network can lead to a more informed decision-making process on the governance level. Other stakeholders such as businesses and research institutions are already involved in the coalition. However, it lacks in the articulation and creates a blind spot for stakeholders interested but not aware of the networking opportunity.

The use of the HOV lane between Washington, DC and Maryland is another example of the cross-border network development. With the identification of a common challenge, for example, traffic jams and high pollution caused by motorised transport, the solution to offer a free corridor for EVs is a quick policy tool to incorporate.

The local stakeholder engagement with PEPCO creates a strong network since the electricity supply has a monopolistic position. It brings the benefit of reaching as many citizens as possible and provides an easily understandable policy cooperation. At the same time, the joined initiatives are limited to established charging infrastructure.

When cities form coalitions they are able to form a strong alliance and use their combined political strengths to pressure national policy makers (pers.com, Mock, 2018). In addition, this formed alliance can also include other stakeholders, such as new and established industries, and a joined path can be created. The lack of a strategic connection between stakeholders will create a transition process which can become messy, especially in this living urban environment where developments occur unregulated due to missing experience (Hodson, Evans and Schliwa, 2018).

Finding alternative ways of charging, investigating ways of overcoming the micro-development challenge is important to replace the regime. In fact, if the development is too much left to the niche developers and they do not see profitable or realistic chances in entering the urban market, the niche may disappear.
6.6. Knowledge

The experiments are observed as a micro-level phenomenon and interact with the established regime. That means experiments on the urban EV context are the development of alternative charging stations and alternatives ways of accessing charging equipment. This is identified as the niche innovation and is still acting on a small market where selection criteria are different from the existing regime. At the same time, the niche provides a space for learning and network building. Those newly formed networks are in a learning process and invest in its development (Schot, Hoogma and Elzen, 1994; Kemp, Schot and Hoogma, 1998; Hoogma et al., 2005; Schot and Geels, 2008)

The urban lab combines many aspects which are significant for R&D, knowledge building and the overall learning process. Academics have the possibility to study consumer behaviour, and businesses can reach consumers and apply their first innovation and observe in practice to develop the idea and technology further (Kern, 2012, Edmondson, Kern and Rogge, 2018).

The practical environment creates a playground not just for businesses and research institutions but also for policymakers. Applying new policies on an urban scale can become a case study with key observation and important lessons to learn. Even failed policy can become a lesson learned development and helps to sustain and govern the desired transition.

Although there have been successful examples of the urban EV transition elsewhere, the urban experimentation never ends, and the purpose of embedding something new within the built environment is an ongoing process which contributes to the learning and experimenting process.

Berlin uses a lot of resources to enhance the learning and knowledge building path. The former showcase region and current startup capital create learning processes on multiple levels. For example, the mentioned startups Chargery and Ubricity may not replace the current regime but show that a slow transition process also opens the window of opportunity for subsystems. Using the lack of urban charging infrastructure as an opportunity to develop a new business model and experiment with flexible charging possibilities. At the same time, they use the underdeveloped built infrastructure as an arena for experimenting with their technology and see where the demand and how the demand for charging is evolving. Subsidising innovations by governments is therefore key since they can serve as a long-term goal such as sustainability or reduction of air pollution (Schot and Geels, 2008).

Washington, DC coalition with other cities aiming for a cleaner and more sustainable city is a good example of cross-border knowledge and best practice exchange. As seen in Berlin, challenges can lead to opportunities and the continuous observation and discussion on that topic can bring new perspectives on the solution finding process.

The research on the EV transition is mostly focused on technological development (e.g. most efficient or low costs solution). The social aspect of the transition is left out but and information such as consumer education and engagement is missing (pers.com, Olexsak, 2018). Moreover, there should be a stronger engagement with NGOs and other stakeholders not representing the industry.

6.7. Changing focus towards the practical application

After the conceptual framework was elaborated in chapter 4, it is now time to focus on explaining the key interaction between the case study and the conceptual framework. It aims to explain how a mix of policies rather than a single policy instrument influences the development of a sustainable transition in a socio-technical system (Bulkeley and Castán Broto, 2013, p. 361).

The analysis above demonstrates that there are many aspects to consider in order to manage an urban transition. Policymakers govern the transition with policy tools and search for industry cooperations. At the same time, cities need to communicate a vision and offer educational tools to communicate the transition is an ongoing and not just a trend.
With the previous discussion in mind and looking at each city governing the transition in individual ways there came the observation that the four key aspects are often an overlapping and reinforcing process (visualised in figure, 16).

![Diagram of Vision, Communication, Network, Knowledge leading to Reconfiguration of a system transition]

**Figure 16.** Four key aspects of the reconfiguration of a system transition (authors interpretation)

Some scholars argue that the communication of a vision should be the first step to broaden networks and enhance the learning process in order to manage a niche innovation (Hegger, Vliet and Vliet, 2007; Schot and Geels, 2008). However, this analysis shows that four key aspects are not happening in a hierarchy or a specific order. The balance of all four is critical to achieving the reconfiguration of a system transition.

This leads to the questions on how to maintain the balance. For example, by offering a protected space through governance and policies. Here the potential to strengthen niche innovation and create a new formation of partnerships in the field the EV transition is occurring and needs to be shielded from old regime actors. Shielding niche innovations are also important to provide space for learning and building of networks (Geels and Kemp, 2007).

Moreover, with the share of a vision through policy interventions, a visible and traceable governmental action is communicated to stakeholders. As a result, the signal of the political will, will generate positive expectation and indicate stable investment conditions. That way the socio-technical systems matures and niche actors gain market share. Simultaneously, actors can form coalitions and challenge regime actors and their established ideas. With the niche actors improving on experience in technology performance, cost reduction and local market understanding the collaboration with policies can achieve greater support by civil society. In the case of the urban EV transition, the air quality will improve and public support which reinforces the new direction of the socio-technical system. Another policy approach would be the creation of a monetary loss for the established regime. Established actors are more willing to reform their structures and form alliances with niche developers and jump on the transition train to gain momentum and may enhance their corporate profile. Neither of the cities is currently using this opportunity; all policies are incentive-based and do not see punishment as a solution.

A key focus in the urban transition and the discourse on urban socio-technological systems has been mostly on the special scale (Hodson and Marvin, 2010). This limits the perspective of a successful implementation of policies over time and how the transition is adjusted or adjustable over time. With directing the focus more on time-sensitive analysis, the uncertainty within a transition can be managed in a more coherent way. This comprehensive case study offered a new spatial perspective to the discourse and demonstrated the difficult and complex process of the urban EV transition.
Taking the findings and analysis into consideration, the dynamics of the EV transition can be illustrated in the socio-technical system by Geels and slightly altered (see figure 17):

Applying the Geels socio-technical system to the conducted research, the application would look as follow:

- The landscape layer receives pressure from external shocks such as increasing climate change, public health concerns due to air pollution and industry frauds (diesel gate).
- The niche level emerges simultaneously with embracing the development of the electric vehicle and related innovations such as charging infrastructure or battery capacity.

However, the graphic seems to be incomplete to adopt it to the urban transition. As investigated numerous policies are designed for a temporary period of time or have short/ mid-term goals. The governance process is set with time stages to reflect how policies have been implemented efficiently and how to reflect on how the market is reacting. Therefore, the model should include a reflection period on the timeline as well to bring more emphasis on transition stages and also examine how the regime level is reacting and maybe merging with the niche innovation. The red lines in figure 17 demonstrate the years which are used as a reflection period for governance approaches.

In conclusion, this study contributes to the research of the urban EV transition in a socio-technical system and takes further the perspective of Geels and Schot (2007). By adding a time component (see figure 17), the conceptual framework becomes applicable for policy and industry leaders as a reflection and adjustment tool. This is particularly important since the urban living lab, and the transition is an ongoing process and needs responding measures to ensure the success of the implementation of the new regime. Moreover, when urban policies adopt over time in accordance with niche innovations success, industry leaders can estimate the potential of the emerging technology and may merge with them rather than compete or depress.
7. Discussion
This chapter aims to address the research questions raised in chapter 1. A number of additional discoveries that occurred during the research phase and analysis are also considered.

7.1. Challenges and opportunities for the EV transition identified in the literature
The pre-identification in the literature on the EV transition was important because it outlines challenges and opportunities which can either vary or are common. With answering this research questions is addressing the gap of research on how the policymaking process can influence the direction of a socio-technical transition towards sustainability within an urban context (Schot, Hoogma and Elzen, 1994; Edmondson, Kern and Rogge, 2018). Especially with looking at more than one policy instrument (e.g., car purchase subsidy or charging station deployment policy) is a missing aspect in the academic literature and is now addressed with the comprehensive case study approach (Edmondson, Kern and Rogge, 2018).

The results of this study represent common challenges and approaches and were conducted with different urban policy approaches. They can be used to prepare, compare and analyse the answers given in the interview conducted for this thesis. They highlight that there is a lack in the research how likely it is that policy interventions are enhancing the urban transition to an EV dominated market. It discovers the interaction between policy instruments implemented by the municipality and the behaviour, perception as well as the characteristics of the local consumer (Silvia and Krause, 2016, p. 106).

The revision of the literature also highlights that the EV transition is different from the conventional idea of the socio-technical system. This is because the EV is not a superior technology in respect to the ICEV. It “only” provides a different motor and different energy source but the ideology of car ownership, flexible driving when needed and the general operational use of the car remains (Schot, Hoogma and Elzen, 1994). This factor can be crucial for the communication to the potential consumer, a challenge to distribute this knowledge on the EV but opportunity to quickly convince unenthusiastic technical drivers (Steinhilber, Wells and Thankappan, 2013).

This research question concludes that several policy instruments are needed to simultaneously enhance the communication of a vision, network building on various levels (social and business) as well as gain access to knowledge building process (Geels and Kemp, 2007). Consequently, active governance and policy-making with the provisioning of resources needs to remain flexible to address the challenges the niche innovation is experiencing and in order to foster a sustainable urban transition (Schot and Geels, 2008; Pinkse and Kolk, 2012; Edmondson, Kern and Rogge, 2018).

7.2. Challenges for cities to achieve an EV transition
With the approach of multidisciplinary research and the socio-technical system, this study shows that an emerging technology such as the EV is going through difficult phases and urban leaders need to develop a variety of policy tools to govern the transition. A combination of political decisions, infrastructure change and network building, brings a complex transition in the living city forward. The key challenges cities face are the high purchase price and limited consumer awareness of the EV technology as well as the limited charging station deployment.

High purchase price: consumers often put off by the high purchase price of the EV. The selling price is set by the car manufacturer and municipalities do not influence the production costs, nor the origin of the product because the car manufacturing business is a very globalised industry. The only way of lowering this barrier is going beyond national approaches and design an incentive policy. As seen in case studies from small German communities (see chapter 5.2.1) cooperation with the local electricity supplier would be a feasible option.
Limited consumer awareness: although the industry and policymakers are developing initiatives to enhance the transition, the consumer is still left aside in this process. The need to educate and communicate about the benefits of the EV is crucial to achieving a higher interest and uptake.

Charging station deployment: the access to charging facilities is key for the use of an EV, and the provisioning of those charging stations is an ongoing process in the urban built environment transition. Charging facilities are a subsystem to the EV and bring with an effective deployment at a readiness level to the city. Even if a city has no local purchase incentives designed, the readiness level of the charging infrastructure is needed either way. As soon as EVs become more affordable and consumers better educated on the matter, the city needs to respond or preferably already equipped for the rapid change (Steinhilber, Wells and Thankappan, 2013).

The case study shows that in order to address these common challenges the inclusion of urban transport development in the sustainability agenda can become a key component of the policies and regulation frameworks (Hodson, Geels and McMeekin, 2017). Especially with respect to the built environment the active provisioning of governance can assist to include other stakeholders in the transition process (Bulkeley, 2011). Consequently, a new partnership of actors is not just participating but also addressing learning gaps and assists in modifying policy or incentive initiatives which may hinder a sustainable urban transition (Huijstee, Francken and Leroy, 2007; Pinkse and Kolk, 2012). However, the provisioning of policies and incentives should not be seen as the ultimate solution or path for the management of a transition. Finding local actors with a common vision striving for an EV transition can form voluntary collaborations and bring bottom-up perspectives to light (Waddock and Bannister, 1991; Gibbs and Jonas, 2000).

Bringing the socio-technical system theory to the spatial focus, the urban living lab provides the space for the experimental transition and offers opportunities for niche innovations to grow beyond its origin (Hodson, Geels and McMeekin, 2017). Here the challenge becomes an opportunity and creates an arena for the niche innovation (Nevens et al., 2013; Frantzeskaki, Kabisch and McPhearson, 2016; Bulkeley et al., 2017; Menny, Palgan and McCormick, 2018).

7.3. Milestones and obstacles identified in the EV transition in Berlin and Washington, DC

7.3.1. Milestones
With the help of multidisciplinary research and the theories of the socio-technical system, this comprehensive case study shows that the EV transition in both cities has overlapping approaches. With policy frameworks focusing on the deployment of charging infrastructure (public or private) the groundwork for an EV transition can be organised (Schot, Hoogma and Elzen, 1994).

Even with Washington, DC not being on the top of the transition path, there will be a lot to gain from their experience. For example, the inclusion of the electricity supplier PEPCO can create a smooth and coherent transition when the same goal is identified, and a strong network formed. The municipality maybe starts with a small target of public infrastructure but demonstrates that the governance of this transition is happening with cautiousness. At the same time being a part of the Clean Cities Coalition, the exchange of knowledge and experience is helping to shape the transition in the future. Learning from various policy experiments can help to make policy modifications elsewhere (Edmondson, Kern and Rogge, 2018).

Berlin has a more proactive approach during its EV transition and acts as an experimentation arena for charging solutions and mobility related startups. Moreover, with reviewing Berlins empirical results, several other milestones and discussion points appeared. Different charging innovations offer new approaches of contributing to a successful EV transition. This observation is in line with Bergman et al. (2010) theories on the bottom- up, social innovation. While the actual EV is
continuously improved elsewhere, and merely a technical development, the overlooked but potentially significant development of alternative charging facilities gains momentum (Bergman et al., 2010). The bottom-up/ social niche becomes evident with a startup community bringing new ideas to the market and allowing new actors, such as electricity supplier Innogy with deploying charging stations, to enter the transition process (Geels and Kemp, 2007). The vision comes from individual actors and gets practically implemented in the urban living lab. This development of the social niche acts as a building block for the ongoing urban EV transition and support changes towards sustainable development. (Schot and Geels, 2008). The urban bottom- up niche innovation is a significant observation because urban policies cannot influence the EV or battery capacity technology.

A more short-term approach is the efficient deployment of charging infrastructure the range anxiety can be reduced. The real-world experiment or the use of the urban living lab is an arena that leads market niche developments (Schot and Geels, 2008)

7.3.2. Obstacles

Some obstacles appeared in this study. Being well aware of the biggest barrier and having a vision of urban street dominated by EVs, the high purchase price, there is no additional incentive. As a result, the vision becomes weak and reduces the credibility of the ambition. The regime will remain the dominating force, and niche innovation experiences a postponed transition.

Although positive initiatives on the deployment of charging infrastructure were identified, both cities have the largest accumulation at locations where profits are more likely to occur such as the city centre which creates some charging deserts.

The education on the EV and articulation of the cities vision is in both cities not well communicated. Both cities lack in promoting their incentives more publicly and under

Berlin is now empowered to use its local authorities to ban ICEV in order to protect their citizen's health and the environment. Currently, there is no plan (no long-term strategy either) to simply ban ICEVs (pers.com Günther, 2018). This can be seen as a weak signal to the national government and citizens.

An obstacle remains, the market share of EVs is double as high in Washington, DC compared to Berlin. Despite all the initiatives and efforts, Berlin is introducing; the EV market share transition is continuing with a slow pace (a reminder and summary of the current EV transition in Berlin and Washington, DC is demonstrated in table 15).

<table>
<thead>
<tr>
<th>Table 15. Berlin and Washington, DC electric vehicle transition in numbers</th>
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<tbody>
<tr>
<td><strong>Berlin</strong></td>
</tr>
<tr>
<td><strong>EV market share (2017)</strong></td>
</tr>
<tr>
<td><strong>Public or semi-public charging stations deployed</strong></td>
</tr>
</tbody>
</table>
8. Conclusions

The aim of this study is with the help of interdisciplinary and case study research as well as the conceptual framework socio-technical system theory to explore the urban EV transition in selected case studies. The last chapter reconnects to the aim and summarizes the key findings. Moreover, the practical implications and the suggestions for future research are offered.

It has been illustrated that an experimental process of an urban EV transition is a complex process. At the same time, a spatially-specific attempt can contribute to a solution and decision-making process which addresses the local geographical, cultural, political and economic circumstances. Moreover, it was shown that not a single innovation could shape a transition. Also, the multiplicity of innovations in a city can lead to a sustainable and successful transition process. The urban living lab offers a solid arena for a diverse range of innovations. Here, transitions can act open-ended rather than experiencing a sharp cut and offers a greater frame for the transitions grow.

With the ongoing urban EV transition, the urban environmental governance with the aim of sustainability and climate change mitigation becomes an initiator and a replication model for other cities. Maintaining political support through governance is key for a sustainable transition. In addition, with the collaboration of stakeholders, the destruction of the established artefact can lead to either cooperation or adoption of practices towards the desired urban EV transition. Moreover, by observing the EV transition through the lens of environmental governance, the importance of tackling global climate change on a local scale with the inclusion of different stakeholders becomes evident. The EV transition is an example of how urban experimentation leads to new forms of political space and creates a way for public and private authorities to enact through forms of technical intervention. Drawing attention to the importance of an urban living lab and the experiments taking place is needed to enhance the transition to sustainability.

In addition, the research also showed there is a demand for a multi-level policy approach. The promotion of complementary niche innovations requires with incentive programs and other initiatives enhance the transition of various levels. The formation of new coalitions plays an important part in the transition. Thus, the exchange of knowledge and results during the experimentation process can be exchanged and lead to better governance of the transition. Finally, the findings of this thesis also point to an emerging research field on urban environmental governance and the experimentation process in the urban living lab as well as the socio-technical system and how it engages within the diversity of experimentation process and how they are conducted in practice on an individual case by case study.

8.1. Methodological reflection and future research

The social-technical system provides a valuable framework for urban case study research. The research applies the transition theories and includes perspectives from political representatives and businesses and NGOs; this has not been done by researcher so far. Furthermore, the variety of data collection methods provides a pool of valuable empirical material which served as the foundation for the analysis.

There is a strong need for urban case studies in the field of socio-technical transitions. In particular, how policies have an influence on the transitions and how the dynamics of a changing policy framework affects characteristics such as public acceptance/engagement. Furthermore, urban case study research is important because it implements national and local policies and considers local cultural aspects. With deeper observing multiple levels of governments, a more inclusive policy framework can be developed in praxis. In addition, it would deepen the conceptual understanding of policy effects on the socio-technical transition.
9. Acknowledgement
I would like to thank all interviewees for their time and input. My gratitude goes also to my supervisor Cecilia Mark Herbert, my evaluator Peter Söderbaum and Uppsala University for supporting this research project. Without their passionate participation and input, this thesis could not have been successfully conducted.
10. References


Deutscher Bundestag (2017b) *Förderung der Elektromobilität durch die Bundesländer*. Available at: https://www.bundestag.de/blob/504150/6f645b9dd6e876b8a5f6260d4ca034ae/wd-5-029-17-pdf-data.pdf.


Lutsey, N. (2017b) ‘Update: California’s electric vehicle market’, *The ICCT*, p. 16.


Public Service Commission of the District of Columbia (2017) FORMAL CASE NO. 1143, IN THE MATTER OF THE COMMISSION’S CONSIDERATION OF A DEMAND MANAGEMENT PROGRAM FOR ELECTRIC VEHICLE CHARGING IN THE DISTRICT OF COLUMBIA. Available at:


elektromobilitaet.org/de/content/ueber_das_programm/foerderung_schaufensterprogramm/foerderung_sch aufensterprogramm_1.html (Accessed: 23 August 2018).


Appendix 1: Case study protocol

As Yin (2013) points out, a case study protocol should be included in the sturdy. This includes the timeline of field work, reminders for ethical considerations and a potential outline of interview questions.

Case Study
Field Trip in Washington, DC October 2017 until January 2018
Field Trip Berlin February and March 2018

Case Study background
Presented in Chapter 4

Research Questions
Presented in chapter 1

Data collection methods/ sources
Semi-structured personal and phone interviews
Documents (governmental reports and social media, academic publications)

Data collection procedure and history

Ethical considerations
- Some interviewees requested not to be quoted in the thesis but agreed to have their names and positions reflected
- Interviewees should know they are recorded
- Interviews should be aware of study purposes and how data will be used
- Receive approval for interview from a person

Interview guide
Appendix 2

Special preparations
- Phone and application for recording interviews (headset is needed for better sound quality);
- Print out interview guidelines and bring materials to face-to-face interviews;
- Notepad and pen for taking notes;
- Pre-book phone interviews to talk in more comfortable conditions;
- Book exact time to increase sense of commitment

Full list of interviews
Presented in chapter 4
Appendix 2: Interview guide

The interview guide was the guiding tool to formulate questions for each interview.

- Introduction of person and organisation/ institution
  - introduction to the institution and relation to EV transition field

- Overview of current status of US/ German EV transition
  - broad reflection/ opinion on the current EV transition in the US/ Germany
  - identify different stakeholders and their role (public, policy makers, industry)
  - focus on drivers, their motivation, & overall engagement

- Case Study Washington D.C./ Berlin
  - introduction to Washington, DC/Berlin development of EVs (history & future outlook)
  - include policy examples and their affects
  - public acceptance and accessibility
  - investment opportunities (automaker, charging stations)

- Critical Questions
  - final thoughts on how to promote the EV transition in Washington, DC/ Berlin
  - what is missing or needs to be addressed/ introduced
### Appendix 3: Overview of interpretations of governance, environmental governance, multi stakeholder engagement in context to sustainability transition and urban development

<table>
<thead>
<tr>
<th>Author &amp; Year</th>
<th>Title</th>
<th>Summary of findings and citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bleischwitz, 2004 p. 13)</td>
<td>Governance of Sustainable Development: Co-Evolution of Corporate and Political Strategies</td>
<td>Governance reveals its greatest strengths where long-term innovatory tasks with low immediate damage potential are pursued. Such processes usually result in new actor coalitions and the formulation of new rules of the game. Areas of application are climate change policies.</td>
</tr>
<tr>
<td>(Bulkeley, 2011 p. 77)</td>
<td>The Role of Institutions, Governance, and Urban Planning for Mitigation and Adaptation</td>
<td>Review of the evidence on urban climate change mitigation and adaptation strategies new “wave” of urban climate change response, encompassing a broader geographical range of cities and placing adaptation on the agenda, the emphasis remains on mitigation in both research and policy. Municipal provision of low-carbon transport infrastructures is another key means through which local governments can combine local priorities and climate change agendas. Municipalities are deploying multiple modes of governing climate change, with more emphasis on regulation and provision than is in many cities in the North, and that there is evidence, especially with respect to the built environment, that urban responses to climate change are being undertaken by other stakeholders.</td>
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<tr>
<td>(Pinkse and Kolk, 2012, p. 176)</td>
<td>Addressing the Climate Change—Sustainable Development Nexus: The Role of Multi-stakeholder Partnerships</td>
<td>Multi-stakeholder partnership is a form of governance with the potential to address existing regulatory, participation, resources and learning gaps as it harnesses the strengths of private, public and non-profit partners explores the role of multi stakeholder partnerships in addressing climate change and sustainable development.</td>
</tr>
<tr>
<td>(Corrêa de Faria, Fernando Macedo Bessa and Corrêa Tonet, 2009, p. 643)</td>
<td>A theoretical approach to urban environmental governance in times of change</td>
<td>Environmental governance should be understood in its three dimensions: Social governance, democratic governance and economic governance. Urban environmental governance aims to contribute on citizens and organizations of civil society’s practice of public and democratic control of the state and market, as a way to guarantee adequate, fair and sustainable social and environmental conditions for human development discuss the ideal meaning of good governance for cities sustainability, basing itself on the international consensus of governance as the most important issue when facing urban environmental problems.</td>
</tr>
<tr>
<td>(Huijstee, Franckcen and Leroy, 2007, p. 77)</td>
<td>Partnerships for sustainable development: a review of current literature</td>
<td>Collaborative arrangements in which actors from two or more spheres of society (state, market and civil society) are involved in a non-hierarchical process and through which these actors strive towards a sustainability goal.</td>
</tr>
<tr>
<td>Author(s) and Source</td>
<td>Title</td>
<td>Description</td>
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<tr>
<td>Waddock and Bannister, 1991</td>
<td>Correlates of effectiveness and partner satisfaction in social partnerships</td>
<td>The voluntary collaborative efforts of actors from organisations in two or more economic sectors in a forum in which they cooperatively attempt to solve a problem or issue of mutual concern that is in some way identified with a public policy agenda item.</td>
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<td>Bäckstrand, 2006a</td>
<td>Democratizing Global Environmental Governance? Stakeholder Democracy after the World Summit on Sustainable Development</td>
<td>The call for ‘stakeholder participation’ is associated with a shift in governance, namely that from top-down steering to informal, bottom-up and voluntary approaches. Multi-stakeholder dialogues and partnership agreements represent key innovations in this shifting context. These new modes of governance bring together governmental and non-governmental actors, and offer unfamiliar and hybrid takes on constituency, representation and deliberation.</td>
</tr>
<tr>
<td>Gibbs and Jonas, 2000</td>
<td>Governance and regulation in local environmental policy: the utility of a regime approach</td>
<td>National governments also emphasize the local level of environmental policy. Local administrations have developed their own policies and strategies not only as a response to these higher-level policy initiatives, but also from their own bottom-up perspective. At a variety of levels, then, there is a discernible move towards local solutions to conflicts between environmental protection, urban growth, and economic development. Environmental policy making has itself become more socially and politically inclusive of local organization. Rather than state-imposed regulation and the expectation that local government is the principal delivery organization for the environment, local environmental initiatives these days involve a wide range of local organizations, including local governments, business organizations, environmental groups, community organizations, and other local stakeholders.</td>
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<tr>
<td>Kronsell and Bäckstrand, 2015</td>
<td>Rethinking the Green State. Environmental governance towards climate and sustainability transitions</td>
<td>It seldom argues explicitly what the role of the state is, or is expected to be, to mobilize environmental governance arrangements towards climate and sustainability objectives.</td>
</tr>
<tr>
<td>Bulkeley and Betsill, 2005</td>
<td>Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change</td>
<td>Uses multi-level governance perspective to examine the discursive and material struggle which takes place in creating a sustainable city.</td>
</tr>
<tr>
<td>Schreuers (2008 p.353)</td>
<td>From the Bottom Up: Local and Subnational Climate Change Politics</td>
<td>[…] the kind of climate change initiatives that local governments can most easily do appear to be such activities as climate change and renewable energy target setting, energy efficiency incentive programs, educational efforts, green local government procurement standards, public transportation policies, public-private partnership agreements with local businesses, and tree planting.</td>
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