



## **A better understanding of the deployment of public charge facilities in urban areas:**

An exploration of the challenges and opportunities from a governance perspective in the city of Cardiff



**university of  
groningen**

faculty of spatial sciences

Course: Master thesis Environmental and Infrastructure Planning  
Author: Steffen van der Werf (S2356325)  
Date: 22-08-2017  
Supervisor: Dr. F.M.G. van Kann

**Abstract:**

The car is very important in current society. Nevertheless the car we use now, with an internal combustion engine, also has a major impact on our personal health and is one of the main contributors of the worldwide climate change. Furthermore, due to the increased scarcity of fossil fuels, car manufacturers are searching for alternative fuel engines. In recent years the electric engine has started to be recognised as the most promising alternative. Because of this the market share of electric cars is increasing, however, there are still people who are not willing to buy a car with an electric engine due to range anxiety. Besides better batteries, the availability of public charge facilities can also be a solution for this range anxiety. Because of the novelty of this infrastructure we don't know much about the implementation process. This research is contributing to a better understanding of this process from a governance perspective. The main focus of this research is to find an efficient way of deploying this new infrastructure while stimulating the electric car development.

For this research we have used a 3-step strategy. This means that first an exploration of this phenomenon was done to indicate planning implications; second, a hypothetical approach was formulated based on governance theory to deal with this planning implications; and lastly, a case study was conducted to compare our hypothetical approach and furthermore indicate institutional barriers that could influence the implementation process. Data for this case study has been gathered in Cardiff, Wales. Six interviews were conducted with involved professionals. Furthermore documentation analyses and observations were done.

Conclusions to this study are that market parties are willing and capable of deploying a sufficient amount of public charge facilities to overcome range anxiety. However, we have observed one service gap, namely, the on street "home" charging. Therefore the government should take their responsibility. We argue that the local authority is the best public entity to deal with this. However, in Cardiff we indicated that, due to the high costs of public chargers, there is an economy of scale issue. Based on innovation theory we argue that this deployment of on street "home" chargers only should be done when there is an actual demand. Using public chargers to stimulate electric car development is not considered right based on this research. Finally, we have indicated in Cardiff that there are some formal and informal institutional barriers that are obstructing the process or could do in the future.

**Keywords:** Electric cars, Governance, Innovation, Institutions, Cardiff.

**Acknowledgement:**

This thesis marks the end of my Masters in Environmental and Infrastructure Planning. It also hopefully marks the beginning of a successful professional career within the field of spatial planning. Of course I couldn't do this without the help of others. First of all I want to thank Ferry van Kann for all his advice, useful insights and coaching. I really appreciated his positivism and relaxedness during the (Skype) meetings we had. This always gave me the assurance that I would complete this thesis successfully. Also the fact that he was willing to come to Cardiff when needed, gave me the feeling of full support. Fortunately that wasn't necessary. In Cardiff I was primarily on my own when doing my research. Nevertheless I want to thank some people. First of all I want to thank Paul Nieuwenhuis, who was my first interviewee and furthermore was very helpful in getting me in touch with other interviewees. Secondly, I want to thank Jacob Roberts, Myles Baker, Ramesh Patel, Mariya Fuijkschot, and Mark Dale for participating as well. Finally, I want to thank the amazing group of international friends that I have made in Cardiff. Due to the many pub nights and parties, they have maybe cost me some points in my final grade, however, without them my time in Cardiff wouldn't have been so great and probably I even wouldn't have finished this thesis at all. Of all these friends, a special thank to my American friends Claudia and Andrew who were willing to revise my complete thesis to limit the amount of grammar mistakes.

Steffen van der Werf,  
Heerenveen  
10 august 2017

### **List of tables**

Table 4a: Rogers' 5 steps of innovation adoption

Table 4b: Rogers' 5 groups of innovativeness

Table 7.4a: List of interviewees

Table 7.4b: List of Emails

### **List of figures**

Figure 2.1: Development in battery costs

Figure 3.4a: The planning arena

Figure 3.4b: Contingency theory

Figure 3.6a: Most effective approach

Figure 3.6b: Most efficient approach

Figure 3.6c: Most suitable approach

Figure 4: Innovation curve + innovation groups

Figure 6: Conceptual model

Figure 7.2: Research design

Figure 7.3: Case study towards conclusion + contribution research methods

Figure 8.1.1: Political landscape Cardiff

Figure 8.2.2a: EV in the UK countries

Figure 8.2.2b: EV share UK countries

Figure 8.2.2c: EV growth UK countries

Figure 8.2.2d: Public chargers UK countries

Figure 8.2.2e: Vehicle/Charger Ration UK countries

Figure 9.2a: Transit/destination approach

Figure 9.2b: on-street "home" charging approach

Figure 9.3: Schematic electric car market

### **List of boxes**

Box 7.2: Research Questions

Box 9.1: Hypothetical approach chapter 3

### **List of abbreviations:**

(B)EV: (Battery) Electric Vehicle

DNO: Distribution Network Operator

EST: Energy Saving Trust

EV: Electric Vehicles

IEA: International Energy Agency

ICE: Internal Combustion Engine

LA: Local Authority

LCV: Low Carbon Vehicle

OLEV: Office for Low Emission Vehicles

PiP: Plugged in Places

PPP: Public Private Partnership

ULEV: Ultra Low Emission Vehicle

V2G: Vehicle to Grid

WPD: Western Power Distribution



# Table of Content

<b>1: INTRODUCTION</b> .....	<b>7</b>
1.1 PROBLEM STATEMENT.....	8
1.2 RESEARCH QUESTIONS.....	9
<b>2: CHARACTERISTICS OF ELECTRIC MOBILITY</b> .....	<b>11</b>
2.1 HISTORICAL OVERVIEW OF ELECTRIC VEHICLE MOBILITY .....	11
2.2 KEY CHARACTERISTICS OF ELECTRIC VEHICLE MOBILITY AND INFRASTRUCTURE.....	12
2.2.1 <i>Electric Vehicle</i> .....	12
2.2.2 <i>Vehicle to Grid (V2G)</i> .....	13
2.2.3 <i>Charging infrastructure</i> .....	13
2.3 TRANSLATION TOWARDS PLANNING IMPLICATIONS.....	16
<b>3: GOVERNANCE</b> .....	<b>18</b>
3.1 TECHNICAL TOWARDS COMMUNICATIVE.....	18
3.2 CENTRALIZED TOWARDS DECENTRALIZED .....	19
3.3 GOVERNMENT TOWARDS GOVERNANCE.....	20
3.4 THE PLANNING ARENA.....	20
3.5 LESSONS FROM FRONTRUNNERS.....	22
3.6 BEST SUITABLE APPROACH.....	23
<b>4: DIFFUSION OF INNOVATIONS</b> .....	<b>25</b>
<b>5: INSTITUTIONS</b> .....	<b>28</b>
5.1 WHY DO WE HAVE THEM?.....	28
5.2 EXPLOITATION VS. EXPLORATION .....	28
5.3 DUALITY OF STRUCTURE .....	29
5.4 PATH DEPENDENCY .....	29
<b>6: TOWARDS A MODEL</b> .....	<b>30</b>
<b>7: METHODOLOGY</b> .....	<b>32</b>
7.1. INTRODUCTION .....	32
7.2. RESEARCH DESIGN .....	33
7.3. RESEARCH METHODS.....	35
7.4. DATA COLLECTION AND SELECTION .....	36
7.5. DATA ANALYSIS.....	38
7.6. ETHICS AND LIMITATIONS.....	40
<b>8: CASE STUDY: CARDIFF</b> .....	<b>41</b>
8.1 INTRODUCTION .....	41
8.1.1 <i>Political/Planning system</i> .....	41
8.1.2 <i>Written policies related to public charging</i> .....	43
8.2 CURRENT SITUATION .....	44
8.2.1 <i>First impression of EV mobility in Cardiff</i> .....	44
8.2.2 <i>Current EV development in numbers</i> .....	45
8.2.3 <i>current situation explained</i> .....	48
8.2.4 <i>Application on the city of Cardiff</i> .....	50
8.3 PUBLIC CHARGERS IN RELATION TOWARDS STIMULATION EV MOBILITY .....	51
8.4 ROLE OF INVOLVED ACTORS AND THEIR ATTITUDES TOWARDS PUBLIC CHARGE FACILITIES .....	52
8.4.1 <i>Local authority</i> .....	52
8.4.2 <i>Grid operators</i> .....	52
8.4.3 <i>Car manufacturers</i> .....	53
8.4.4 <i>Charging operators</i> .....	53
8.5 WHAT CAN WE EXPECT IN THE FUTURE .....	54

<b>9: SYNTHESIS.....</b>	<b>55</b>
9.1 BACK TO THE PLANNING ARENA .....	55
9.2 INSTITUTIONAL BARRIERS AND OPPORTUNITIES.....	58
9.2.1. <i>Formal</i> .....	58
9.2.2. <i>Informal</i> .....	59
9.3 STIMULATION OF EV MOBILITY.....	60
<b>10: CONCLUSION .....</b>	<b>62</b>
<b>11: DISCUSSION .....</b>	<b>63</b>
<b>12: REFLECTION.....</b>	<b>64</b>
<b>13: REFERENCES .....</b>	<b>65</b>
<b>14: APPENDICES.....</b>	<b>70</b>

## 1: Introduction

The car has an important role in our current society. A lot of our travels rely on the car and this use is still growing (Nillson, 2012). However, the type of car we mainly use, with the internal combustion engine (ICE), is also one of the main contributors to our current air pollution. This air pollution has major impact on our personal lives. On a personal scale it causes health issues and even leads to deaths (EEA, 2015, European Commission, 2016). On a global scale it contributes to one of the biggest problems for the civil society in 21<sup>st</sup> century: global warming. So there is an urgent need for new policy strategies regards transportation. One of the possible solutions is the uptake of alternative fuel engines (Gahmami, et. al. 2016). Currently the most promising one is the electric engine (EPRI, 2013). In the last few years the electric engine has made big steps forward, which has made it a potential replacement for the conventional internal combustion engine. As a result of this the market share of electric vehicles (EV) is increasing worldwide. Nevertheless for a big group of consumers the acceptance of EV's is obstructed by range anxiety (Gahmami, et. al. 2016). The availability of public charge facilities could take this anxiety away (Schroeder and Traber, 2012). Instead of installing on every corner of the street a public charger perhaps a more efficient solution is possible. Furthermore who is willing to pay for this new infrastructure? The days of central government being responsible for everything in the public space are far behind us in northwest Europe.

This study will try to get a better understanding of the implementation process of EV charge facilities and how this can be governed most efficiently. *Efficient* in the sense that it serves the demand from electric vehicles without using unnecessary amounts of public money. The focus is first on the identification of possible planning implications that could occur during the implementation process. Then, by identifying the pro and cons between different governance approaches the most suitable can be designated. Finally a practical example will be examined to see how already existing institutional/governance arrangements obstruct or foster the implementation.

## **1.1 Problem statement**

Electric car mobility is becoming more and more of an actual theme within the field of planning and governance (Nillson, 2012; Ghamami, 2016). However, the adoption of Electric vehicles is still not very high and varies significantly between different countries (EIA, 2016). Current policies across Europe to stimulate the uptake of EV are primarily focused on the car itself e.g. subsidies (Langbroek, 2016). Nonetheless there is much less attention to the facilitation of charging infrastructure, even though this is important, according to several scientists (Yeh, 2007; Struben and Sterman, 2008; Egbue and Long, 2012; Tran et al., 2012; Ghamami et. al. 2016). However, there is still a lot of indistinctness with regards to what implications this new innovation (charging infrastructure) has for planning. Much research about charging infrastructure is focused on one specific aspect of it (costs, technique, user behaviour) and doesn't make the direct link towards planning implications. Therefore, identifying the implications clarifies what exactly the planning issue is that needs to be governed with regards to public charging infrastructure.

After knowing what implications we have to take into account in governing public charging infrastructure a new question arises: which governance approach is most efficient? With a changing role of the central government this question is starting to become more difficult than it was a couple of decades ago. Governance has made shifts in a variety of aspects: from controlling to facilitating, central to decentral and public to private (Newig and Fritsch, 2009; Roo and Porter, 2016). With these shifts a huge amount of new approaches have occurred (Lange, et. al. 2013). Each approach has its pros and cons as what is ideal for the issue of public charge infrastructure.

Additionally, the problem arises that this new innovation has to be fitted into an already existing institutions and governmental arrangement. Where in literature a lot attention is for looking for new approaches based on a theoretical background the translation towards how this could work out in a practical case is missing (Lange, et. al. 2013).

### **Research Goal**

The goal of this study is to get a better understanding of the implementation process of public charge facilities for electric vehicles by researching the aforementioned aspects. This all will be studied from the perspective of governance, which means that we are looking at how things are organised, who is involved, how they do interact with each other, and in the end if there are any opportunities to make the process more efficient or barriers that obstruct the efficiency. Therefore a 3-step research approach will be used. First the phenomenon of electric vehicle charging will be further explored. This exploration will be done by a literature study. Out of this concrete planning implications will be formulated. Secondly, a theoretical framework will be designed which will provide the theoretical background of the identified implications. Thereafter an in-depth research will be conducted in the city of Cardiff compare the theoretical findings with a practical example. This case study will include a combination of in-depth interviews with involved professionals, document research and empirical observations. A further explanation of the research methods you can find in the methodology chapter (Chapter 7).

**Societal relevance.**

As has already been made clear public charge infrastructure seems to be needed to support the development of EV mobility. The electric vehicle turns out to be a great alternative for the current ICE car to overcome our health and environmental issues and indirectly, a better understanding of the implementation process of public charge facilities, which could lead to a faster development of it, seems to be useful. First of all plan- and decision-makers in the city of Cardiff, could use the gained knowledge for their policies regards public charge facilities in the city. On a broader scale other cities could use the outcomes of this study to draw lessons upon for their own policy strategies. In the end if plan and decision makers are able to implement this new infrastructure in the most efficient way, they save public expenses, which can be used for other societal issues.

**Scientific relevance.**

As already stated in the problem statement, there is a lot of research done about specific aspects of public charging. Nevertheless, the link with planning practice is missing. This study will try to overcome this knowledge gap. Furthermore this study addresses the call from Lange, et. al. (2013). Which states that theoretical governance approaches are missing the practical evidence, which we will try to find in this case study.

**1.2 Research Questions.****Main question:**

-How can the implementation process of public charge facilities in urban areas from a governance perspective be governed efficiently while simultaneously stimulating EV mobility? -

A governance perspective means that we are going to look at who is doing what and on what scale. As has already been said in the introduction the efficient implementation means that it serves the demand from electric vehicles without using unnecessary amounts of public money. The sub questions are a reflection of the 3-step research approach that will help us to answer this main question.

**Sub questions:**

- What planning implications occur with the implementation of electric charge infrastructure?
- What hypothetical approach, based on literature, is best suitable for implementing charge facilities in an efficient way?
- What is Cardiff's approach in implementing electric charge facilities and how does this fit our hypothetical approach?



## **2: Characteristics of Electric mobility**

In this first chapter an introduction will be given about Electric mobility and its characteristics will be explained to get a better understanding of this new phenomenon. This exploration is considered to be necessary to identify the planning implications, which plan- and decision makers should be aware of during the implementation of public charging infrastructure. In the first section some historical context is given. In the second section some key characteristics of electric cars and chargers are presented.

### **2.1 Historical overview of electric vehicle mobility**

#### Early days

The electric vehicle isn't such new phenomena. In the beginning of the 19<sup>th</sup> century the first vehicle with an electric engine was founded. This vehicle was part of a series of inventions which all were related to the invention of the battery. Only in the second half of the 19<sup>th</sup> century, when they invented the rechargeable battery, the moment came that the first electric cars were released for the consumer market (US department of Energy, 2017). From that moment the number of electric cars started to increase. Especially in urban areas where the access to electricity became better, the use of electric cars was preferred above the gasoline car. In this era the gasoline car was hard to drive, noisy, emitting smelly pollutants and it took a lot of energy to start the car. The rise of the electric cars was stopped when Henry Ford released his Model T (US department of Energy, 2017). With this new car Ford reduced the cost price of the gasoline car massively. Besides that he introduced the electric starter, which made it much easier to start the car. From that moment the gasoline car took over the car industry, which also meant that the electric car didn't get much attention anymore (Business Insider, 2017).

#### Second rise of the EV.

The lack of interest for the electric vehicle continued until the late fifties when the big space programs put the innovation of electric vehicles back on the research agenda. The space programs needed electric vehicles for their moon missions. So in 1971 the first vehicle that drove on the moon had an electric engine (US department of Energy, 2017). Besides the urgency from the space programs also the shortage of oil in the early seventies was another reason for several western European countries to reduce the dependency on oil. Moreover, the first discussions about air pollution also started to arise in the political debates. From that moment more money was invested in development programs regarding the electric vehicles industry. In the early nineties, with the rising concern about the environment, big car companies started to make their cars less pollutant and started to produce electric variants (Business Insider, 2017). However, these variants were still not able to compete with the gasoline car that were faster, more reliable and the distances radius was much bigger. So not many people were buying these electric cars. Around the start of the new millennium the first mass produced electric cars were introduced. The Toyota Prius, which was a hybrid, became the most successful in the first decade of the 21<sup>st</sup> century. This was partly caused by growing concern for the environment and rising gasoline prices but also because a lot of celebrities helped to enhance the image of the car, making it cool to drive an electric car (US Department of Energy, 2017). The latest development that helped to stimulate the electric car industry was the establishment of Tesla motors. They had the ambition to create a high-class sports car that could reach the same speed as a normal sports car. They made their promises true and this stimulated other car manufacturers to improve their electric cars that meant that in the end of the first decade there was a variety of good quality electric/plug-in hybrid that was competitive with the gasoline cars (Business Insider, 2017).



## 2.2 Key characteristics of Electric vehicle mobility and infrastructure

### 2.2.1 Electric Vehicle

#### Performance

Although the technique of the electric engines, and especially the battery, is improving, there is still a gap in distance between the electric vehicle and the traditional gasoline car (ANWB, 2016) The gasoline variants of these electric cars are at least able to double this radius. Moreover there is a difference between the promised radius (full charge) from the manufacturer and the actual radius. In most cases there is a small negative difference (ANWB, 2014). One must also take in to account that battery performance is becoming worse over time (Arcus, 2016). This also has consequences for the radius of the car over time. In conclusion, if the electric vehicle has to replace the gasoline vehicle and we are taking in to account that the radius and possible loss of battery performance over time, then the importance of a reliable charge infrastructure is crucial.

#### Cost and revenues

The purchase costs of an electric car are relatively expensive compared tot those of the traditional gasoline car. The IEA (2011) found out that an average electric car is \$10.000 more expensive than the gasoline version. And a more recent practical example shows us that the conventional Volkswagen Up compared to the electric version turns out to be 16.000 euros (\$17000) less expensive (Volkswagen, 2017). Moreover where in the traditional car market a big share of cheaper occasions are available, in the electric car market this is minimal because of the young character of the electric car market. Therefore, for people it is a serious investment when they are choosing an electric car. This financial aspect reflects back in the numbers, which shows us that right now the people with a higher income have the biggest share in the total of electric car owners (Langbroek et. al. 2012; Nilsson and Nykvist 2016). Besides the costs there are also some financial benefits for having an electric car. First of all the costs per kilometre are much lower than those of the traditional gasoline car. The MPG (miles per gallon) values are for EV's two or three times higher than the average gasoline car. In combination with the lower price of electricity compared to that of gasoline the assumption can be made that over the full lifecycle of the car the owner can regain his investment. But right now several research teams show outcomes in which the Electric Vehicle only can be competitive when there are subsidies involved (EPRI, 2013). However, if the battery costs are decreasing, which is feasible according to figure 2.2.1 (UNEP, 2016), then the electric vehicle can also be competitive without subsidies. And because fossil fuel is going to be scarce which results in higher fuel prices it could even become cheaper to drive an electric car.

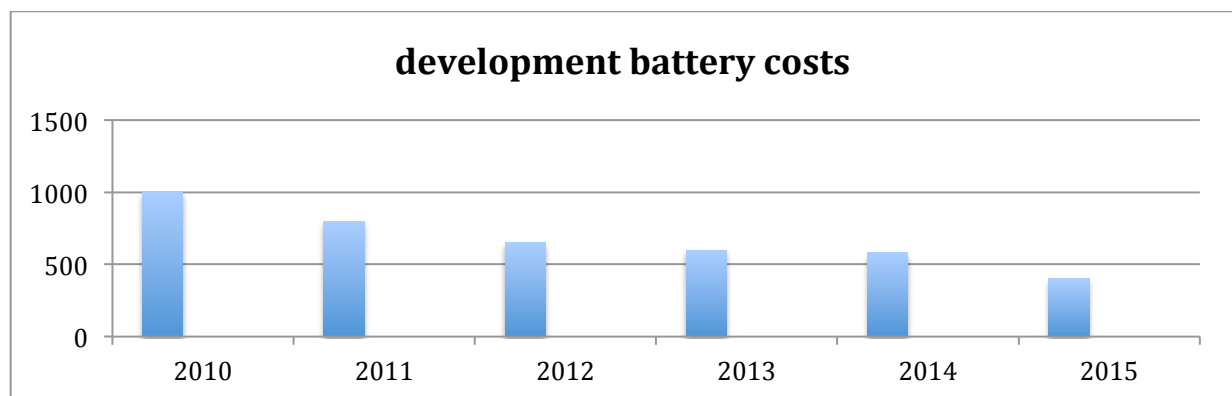


Figure 2.2.1: development battery costs (UNEP, 2016)

### **2.2.2. Vehicle to Grid (V2G)**

Between the EV and the charger also an interesting development occurs, namely, vehicle 2 grid. This technique makes it possible to give energy, stored in the battery of the car, back to the energy grid (Kettles, 2015). In the light of the transition from fossil energy towards renewables this could be a very promising innovation. Renewable energy sources like wind and solar are characterised by a variable production. This means that for grid management extra balancing possibilities are needed to store the production surplus of energy (during a sun or wind peak). This stored energy can be used during a consumer surplus. Because a car, and in our case an EV, is parked for 95% of the time (Shoup, 2011), and thus can be connected to the grid, the battery of an EV is an ideal storage possibility. In a further stage of both EV and V2G development consumers could be paid for providing their car to the electric grid when the grid operator needs storage capacity or needs the stored energy in case of a gap between consumption and production.

### **2.2.3 Charging infrastructure**

#### Performance

Currently there are 3 different types of chargers on the market (Chang, et al. 2012). These types are divided, based on charging speed. Type I is the slowest and Type III is the fastest. Where the first two types are suitable for charging at home the last one is in generally only used for public charging (Morrow et al, 2008). The reason for this is because the type III is able to charge a car within half an hour. A lot of energy is needed in a short amount of time and therefore the grid needs some reinforcements (Ghamami, 2016). For home charging this seems to be too much effort compared to the actual need to charge your car in half an hour when you're home, which there isn't normally. Nevertheless the Type II charger could also be used for public charging. For example if you go shopping or visit an event and you park your car for 3-4 hours a type II charger is sufficient enough to fully charge your car. Also when people don't have a private off street parking possibility, a type II charger is convenient enough to charge the car in the night.

Besides these 3 chargers that are operational also a new technique is tested right now. This technique is called inductive charging, which means that cars can be charged wirelessly (Kettles, 2015). This idea is based on the idea of charging of an electric toothbrush. This idea could have some advantages compared to current charging system. First of all, you don't have to connect or disconnect your car. Second, the charger is hidden in the surface, which makes it invisible, and therefore it has a positive effect on the public environment. Third, in a future stage it could be used to charge your car while driving (Kettles, 2015). However, this technique is in an early stage, which in it's current form can't compete with the wired techniques due to efficiency issues. Also in relation with V2G development a lot of uncertainty occurs (Madawala, 2011).

### Costs and Revenues

There is a big price difference between the 3 chargers that are operational right now, namely \$400, \$2000 and \$40000 (Chang et. al. 2012). Car owners who are able to install on their own property have to make an extra investment in addition to the investment for the car itself. Depending on how fast they want to charge, this investment can reach \$2000. From business or public organisation perspective the costs for providing a charging facility are even higher (Chang et. al. 2012). Theoretically an electric charge facility could also gain some revenues. These revenues we can split up into direct and indirect revenues. The direct revenues include the earnings you can get from taxation of your service. People who are using your charge facility are paying for the electricity and some extra for the service. However, right now there aren't much practical examples that show a well functioning business model (Chang, et al. 2012). According to Schroeder & Traber, (2012) a public charging point won't be profitable without financial subsidy or financial exemptions. However, besides the direct revenues in the case of, for example a shopping mall or city centre it could gain some indirect revenues. By providing a charging facility, this service could be functioning as pull factor to do their shopping in your city centre or mall instead of somewhere else (Chang, et al. 2012, Madina et al, 2015).

### Organisational aspects

With the re-entry of the EV's new business-models also occurred. Both in the car manufacturing and the car charging facility. The latter is especially interesting because it contains a whole new market. However, what can we expect about how this new market is going to organise itself? Aspects that need to be considered are: the market structure we can expect regards the charging infrastructure and if it be competitive or is the market prone for an oligopoly? Where are charging facilities the most remunerative and does this align with the preferred locations? However, due to the young character of EV's and especially the deployment of charging infrastructure most of the scientific literature that is discussing these aspects is making conclusions or recommendations based on assumptions (San Roman et. al., 2011; Kley, 2011; Schroeder & Traber, 2012.). Nevertheless it will give some guidance about what needs to be considered by researching this phenomenon. It is reasonable to believe that the commercial car charging market will develop the same way as the standard gasoline market. According to Schroeder & Traber (2012) who analysed the German system it is not reasonable to believe that market power exertion will occur in the public car charging market. So depending on how many companies will provide public charging it will be perfect competitive with maybe some small regional monopolies but with a small amount of standard rules set by the government to ensure universal access this will not lead to market power exertion (NPE, 2011 in Schroeder & Traber, 2012).

### Business possibilities

How remunerative could a charging facility be? Therefore two variables are important. First the costs of the charger and second the users frequency. A type II charger is much cheaper and could be recouped very fast however, you also need more of them to serve all the potential customers (Schroeder & Traber, 2012). In case of the type III the single costs for one charger are much higher and furthermore, as already mentioned earlier, the grids needs some upgrades to provide the needed voltages. However, each charger can serve more cars a day so you will need less chargers, which will result in lower costs in total compared to the Type II chargers (Schroeder & Traber, 2012). According to Morrissey (2016) based on user behaviour the Type III charger shows the most potential to function as a public charger. However, he also observes a big gap in charge rates and what is needed to make such charger viable.

### Charging behaviour

In this study the information of charging behaviour is valuable for an efficient deployment of public chargers. Important factors that could vary between EV owners are location of charging, sort of charger and moment of charging (Morrissey, 2016) Literature shows that current EV owners are charging their car mostly in the evening at home (Smith, 2011; Spoelstra, 2014; Morrissey, 2016.) Overall the percentage of public charging is much lower than home charging (Smart, 2012; Morrissey, 2016). Furthermore, this shows that there are strong routines in their charging behaviour, which means that most of the time they are using only 1 or 2 different chargers (Franke & Krems, 2013; Spoelstra, 2014). Car park locations were also preferred over on street parking locations (Morrissey, 2016) In this there could be bias. First because of the availability of open street charge location compared to car park locations and second, it is reasonable to believe that people who are visiting a new place, who are in need of a charger, are likely to play it safe and utilize a car park. During the day EV owners are likely to charge their car using a type 1 or 2 charger (Morrissey, 2016), this could be explained by the fact that they charge their car at home or at work where they will stay for a longer period of time. The fast chargers are used mainly later in the day, due to the fact that people miscalculated their battery capacity during the day.

## **2.3 Translation towards planning implications.**

However, what does all this information now mean for decision makers and planners who are dealing with this public charging issue? From the car perspective it is becoming more clear that the electric car is becoming more competitive with the ICE car, The electric car is still currently subsidised, however, it's reasonable to believe that within the near future these subsidies will dissipate. With that in mind it's now up to the "public charging" side to do their job not tamper the development of electric cars and to deal with the range anxiety problem. Based on the characteristics of these public chargers we can identify 4 planning implications where planners should be aware of when implementing this new kind of infrastructure. In this section I am going to discuss each of these implications.

### 1: Uncertainty

Despite the fact that most of the developed countries in the world recognise EV's as the substitute for the current gasoline cars history has shown that one invention could tear down the whole sector (referring to the Ford T, which set the EV on hold for 40 years). Even when electric cars become the replacement for the conventional gasoline car, it seems that some uncertainties will continue in the short term. First of all, we can state that electric cars, which are competitive with traditional gasoline cars, are still a very young phenomenon in which there is constant succession of new innovations. This means that the innovation we take into account now could become 'useless' when a new invention is introduced. For example, right now it seems that charger types 2 and 3 will be used for public charging facilities. But what if inductive charging will become a better option? Or what if the car industry solves the problem of range anxiety with the development of a "super" battery. This would mean that the need for public chargers would decrease. So how from a government perspective can we deal with the paradox between the need for public chargers to overcome current range anxiety that tempers the uptake of electric cars and the uncertainty whether the solution we have now will be the same in the next 10 years?

### 2: Early adopters

Another disadvantage of a young phenomenon is that it's difficult to identify hard facts about user behaviour that could be used for planning and decision-making. The reason for this is that there is just a small group of people who owns an electric car right now. From an innovation perspective we could argue that the electric vehicle phenomenon is in its early stages because the group of people with an electric car is relatively small compared to the total car owners. Even in Norway, which is known as the world leader concerning the adoption of EV vehicles, the percentage of EV owners reached just 3% in 2016 (electrek, 2016). Therefore, how can we consider user behaviour characteristics of current EV owners? Perhaps do these pioneers have different characteristics? In other words how could planners, who want to stimulate EV adoption and so are serving the new group of EV owners, use this information for planning and decision-making?

### 3: Grid improvements and management

Assuming that type 2 and 3 chargers will be the minimal standard for public charging, could this mean that the current energy grid needs physical upgrades? Who is responsible for the costs of these reinforcements? Also with the expected increase in use, the demand for energy will increase during certain times of the day. For example, right now most people are already using their charger in the evening. Furthermore, taking in to account the development of the transition towards renewable energy sources, which is currently taking off (read 2017), are characterised by irregular production of energy, and the ideas about V2G. The managing capacity of the grid will also be important. Who is going to implement this?

### 4: Costs

The instalment of public chargers costs money and currently without public money some public chargers aren't remunerative. Depending on the type of charger the costs can rise up to 40.000 euros. Therefore would private parties be interested in providing these public chargers, when the user rates aren't high enough to recoup the costs? Furthermore, are the amount of chargers the market is willing to provide sufficient enough? In the case where the government should be involved the question is which public entity is able to pay for the deployment of public chargers?

These implications make it clear that there is a need for further research in regard to the implementation process of public charge facilities. In the following chapters I am going to elaborate on the important theoretical debates that can help us to better understand this planning issue and how to deal with it. First of all we are going to look at current governance theories and approaches to see which approach could fit best in dealing with the planning implications. Furthermore, as we are dealing with an innovation some better understanding of the diffusion of innovations is useful. Lastly, this new planning issue has to fit in with the already existing institutions. In our case study we are more than likely to find some institutions that could obstruct the implementation of public chargers. By exploring the characteristics of institutions we are able to examine if we can change the institutions observed in our case study.

### **3: Governance**

For planners, the biggest question for each issue they are planning or solving is, who is doing what? Which body of government or actor would be best suitable to govern new activities in the public space? The perspective about how to govern planning issues has changed over the past decades (Roo and Porter, 2016; Zuidema, 2016). This perspective has changed from a positivist point of view, in which planners thought they understand the world completely and could coordinate it in the way they wanted, towards a post positivist point of view in which planners acknowledge uncertainties in their own knowledge and in the outcomes of their plans. With this changes of perspectives, there is also a shift in approaches became visible. However, with this shift it doesn't mean that the older approaches and perspectives are no longer useful. These older approaches have proved that they function well for certain planning issues. In the next sections I am going to discuss the shifts, which became visible in the past decades, in how to deal with planning issues. Next I will explain how these perspectives help us to choose between different approaches. Lastly, I will try to fit our planning issue in this discussion with the help of already existing examples and come up with a hypothetical best suitable approach.

#### **3.1 Technical towards Communicative**

The first shift is the rationality of gathering knowledge and coming up with solutions. Over the years we have shifted from a technical rational towards a communicative rational. The first rational can be linked to the positivist view and latter to the post positivist view (Roo and Porter, 2016). The technical rational is characterised by a strong believe in finding universal truths. In the context of planning, they could set up planning approaches that were applicable in every case and would always result in the same outcome. Therefore, they measured quantitative data and created standard procedures, often referred to as the "blue print planning". However, in a world that is starting to become more and more interrelated, the presumed single fix problems and solutions were no longer such. Plans in one predefined area turned out to have influence in others. In the end, this led to unexpected or undesired outcomes. Due to this, planners started to realise that for some planning issues specific qualitative data was needed to adapt to the place-specific context.

Therefore, planners started to involve other stakeholders in the planning process, often called the communicative turn in planning. The communicative turn has many different known manifestations (Allmendinger & Tewder-Jones, 2002). It varies between just including stakeholders before setting up plans, which is called communicative planning (Healy, 1993) and collaborative planning, which designates the whole planning process to the communities, and as a result the role of the planner is strongly diminished (Healy, 1997). However, the central idea behind this communicative turn is looking for agreement and consensus. By sharing each other's opinions the most desired outcome shall be found. The *how* question in this is replaced by the *why and wherefore* question (Roo and Porter, 2016). According to Zuidema (2016) the communicative rational has 3 advantages. First it reduces uncertainties in what exactly needs to be addressed or what the real problem is that needs to be solved. By agreeing on what we know and what we agree on planners can set up an agenda which most people agrees upon. Second it helps to integrate different interests and objectives into one plan. For example, we could reduce air pollution and make cities more liveable simultaneously. Third, the plans that are coming forward from a process of negotiating and bargaining are characterised by open-end solutions. This gives the opportunity to reflect, critique and redefine plans, which makes the planning approach adaptive.



### **3.2 Centralized towards Decentralized**

With the shift from positivist to post positivist and making a communicative turn in planning also the ways of how to govern planning issues changed. As with the rationales also here a spectrum between two extremes arises. On one side, we have a centralized governance approach and on the other side the decentralized governance approach. Both sides have their pros and cons.

The centralized governance approach is characterised by a small group of actors with responsibilities that has a routine in plan- and decision-making. They are operating mostly, using standard procedures and a strong hierarchy, which make their way of working efficient and fast. Secondly, when things are centrally guided the resources (money, knowledge, man power, etc.) are also centralised, which makes it possible to solve bigger problems. This idea of central guidance is strongly related to the idea of the technical rational (Roo and Porter, 2016; Zuidema; 2016). A disadvantage of this way of governing is the difficulty to come up with tailor made solutions. This is because this small group in general lacks place specific knowledge. The absence of place specific knowledge can lead to a discrepancy between policy and reality. Also, because of the small group of people with responsibilities the chance of failing is bigger. This is because centrally guided plans are often executed by entities on a lower scale. However, because these entities don't have responsibilities, the need to provide good work is lower because in the end everybody is still looking at the central government when a policy fails.

On the other hand, decentralised governance fits more the idea of the communicative rational (Roo and Porter, 2016; Zuidema; 2016). Decentralised governance is based on solving the problem on the scale where the problem occurs. The advantage of a decentralised approach is that it can deal with the discrepancies between policy and practice that could occur with a centralised approach. Because of the lower scale the place specific knowledge can be included which leads to tailor made solutions. This lowers the chance of a mismatch between the written policy and reality. The place specific knowledge from local stakeholders is gathered easier because government is better accessible due to the lower scale of planning and decision-making. A decentralised approach with the involvement of local stakeholders also increases the chance of success because if the opposition gets the idea of being heard during the planning process their acceptance of the final decision, even it's not in their favour, is much higher (Sabatier et al., 2005 in Newig, 2009). However, this decentralised idea also means that the decision process will take longer than the traditional central governance. You have to find all the actors that are affected, set up new discussion arenas where each actor can be heard and create a consensus with a large group of actors. This process will obviously take longer than the traditional central governance approach in which you only have to create a consensus within a small group of actors. Also the arenas of decision-making are already set which also makes it faster.

### 3.3 Government towards governance.

The last shift that occurred that fits within the broader shift in perspective is the one from government towards governance. The idea that the government, strongly related to central guidance principle, is the only relevant actor when it comes to the management of societal issues has changed (Newig and Fritsch, 2009). Over the past decades scientist began to agree upon the fact that governing has become a shared responsibility between state, market parties and civil society (Rhodes, 1997; Stoker, 1998; Pierre & Peters, 2000; Kooiman, 2003 in Newig and Fritsch, 2009). So besides the trend of acting on a lower level of government also new governing arrangements have been created between public and non-public actors. With this new idea of governing societal issues a variety of new governing approaches were generated. All those new approaches, in which the division between public and private has become blurred, are accommodated in the concept of 'governance' (Lange et al. 2013). This has some similarities with the communicative rational, which also includes more than one party in the planning and decision-making process. However, the responsibility part is slightly different. Communicative planning is about coming to an agreement between different stakeholders while maintaining a central public body that could make the final decision. In governance the focus is on shared responsibility, collaborating with each other and having duties in executing the plan. Besides the shared responsibilities, there is also an economic perspective in the involvement of market parties in providing public services. In general a market party provides their product/service cheaper than a public organizations due to the aim for making profit as well as market forces. The only area where public organizations have to be aware of is that the service remains publicly available.

Along this trend Public Private Partnerships (PPP) are popping up. PPPs are a cooperation between public and private actors who believe that by sharing costs, risks, and benefits extra value can be created, which outweighs the costs of the cooperation itself (Klein and Tasman, 2003). Especially in the case of infrastructure projects a faster and more efficient implementation is possible through PPP (Kenniscentrum, 1998 in Klein and Tasman, 2003). Nevertheless PPPs are not always successful. The reason for this is a difference in motives and expectations between the public and private sector, which results in tensions and inactivity (Klein and Tasman, 2003).

### 3.4 The planning arena

The shift from the positivist worldview towards a post positivist has made a switch from the technical rational towards the communicative rational. With this switch new governance approaches occurred on lower scales. But it didn't mean that we couldn't use the older perspectives and approaches anymore (Roo, 2004; Zuidema, 2016). So we end up with two extreme spectrums, which de Roo (2004) combined into one spectrum that he called **the planning arena** (figure 3.4a). In this abstract visualisation he shows how the two extremes, discussed before, in combination with the end goal, are related to each other. To decide how communicative or decentral the approach has to be, scientists used the contingency theory (Porter and Roo, 2016). This theory helps to pick the right approach by determining the degree of complexity. The idea behind this theory is that the more complex the situation, the more decentralised the approach has to be (Figure 3.4b). Reasoning behind this statement is that complex situations need more context specific knowledge and adaptive capacity. As discussed in the earlier sections the communicative rational could have this adaptive capacity and generate this context specific knowledge, which in-turn relates to the decentralised participative governance structure.

This way of thinking has led to a trend in which a lot of issues were delegated towards lower scales of government. Zuidema (2016) comes with a perspective that looks further than only complexity. Reason for this is that he noticed that the decentralised approach does not always leads to the desired outcome. He thinks that in some cases decentralised governments lack the ability to cope with certain issues because of the economy of scale or the local decentralised governments lack the willingness because of a weak interest. In case of EV charging infrastructure both can be relevant. Depending on the amount of public money that is needed for the establishment of public chargers the economy of scale of a local government can be an issue. In general, the budgets of national governments are bigger than those of local authority. There is also a possibility that a weak interest exist in the case of EV mobility. Because cars are often used for trips to other places in other jurisdictions, policies of neighbour jurisdictions could have influence both positively and negatively. The idea behind providing public charge facilities is to take away range anxiety and as a result stimulate EV mobility. However, if you are the only municipality that provides charge facilities and others do not, range anxiety will continue to exist because EV users can't charge their car at the final destination of their trip. The other way around is that if each municipality is providing chargers and one doesn't the overall EV uptake will still be stimulated. So this municipality is acting like a free rider, which means that they are taking advantage without paying.

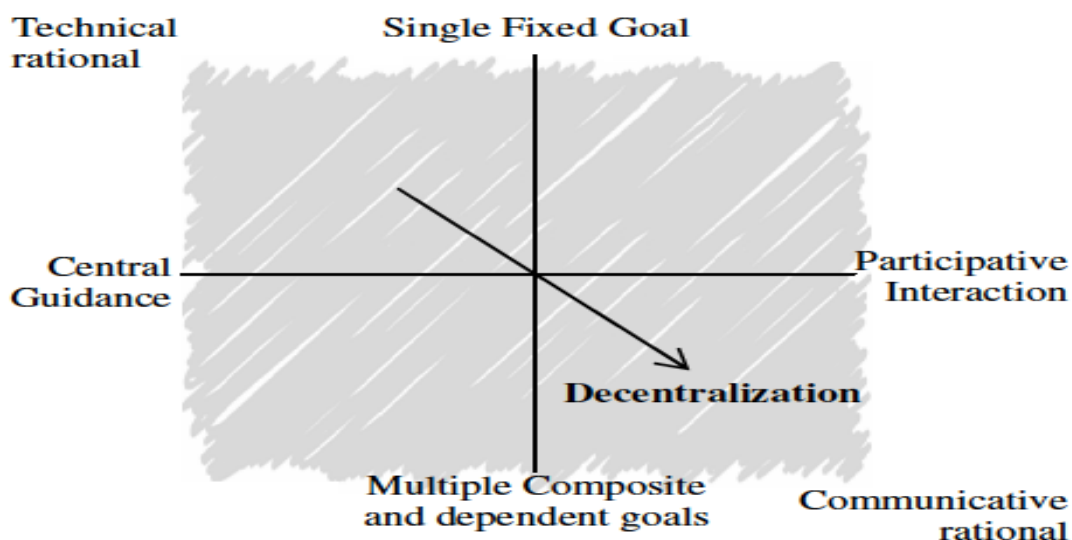


Figure 3.4a: The planning arena, Zuidema (2016)

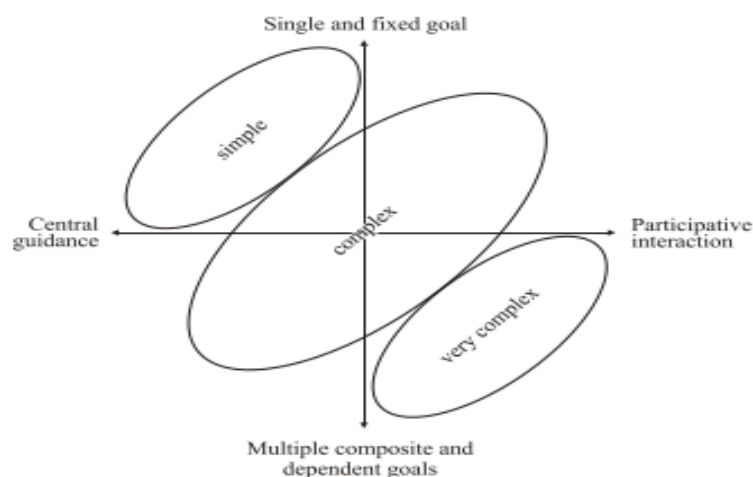


Figure 3.4b: Contingency theory, De Roo, (2003)

### 3.5 Lessons from frontrunners

Because EV mobility is a worldwide phenomenon we could also see how other countries are dealing with this phenomenon. Especially the countries that are frontrunners in EV development can be learned from. The world leader in EV mobility is Norway with their capital, Oslo, being the EV capital of the world. Even though their percentage of EV's is under 4%, it is still twice as much as the runner up, The Netherlands. The reasons behind this EV development in Norway, and to a lesser extent the Netherlands, can be helpful in indicating effective approaches.

The first reason that could explain their development is the early recognition of EV mobility as a substitute for current ICE cars. Already in the early nineties the first policies were introduced to stimulate EV development (Norwegian EV association, 2017). Regarding EV charge infrastructure, big steps were made in the end of the first decade. Oslo introduced a policy plan to establish 400 public charging facilities in the city (Molmen, 2008). After this the development of charge infrastructure went on which resulted in 1100 public chargers in 2015 (van der Pas, 2014) Furthermore, a national platform was created by the government, which established another 1900 public chargers across country. Both initiatives were initiated and financed by the state government (Norwegian EV association, 2016; Molmen 2008). Norwegian politicians, and Oslo in particular, believed that with this approach they would give a kick-start to the development of EV mobility (City of Oslo, 2017). Nevertheless this approach is part of a bigger range of approaches regarding EV development. For example EV cars are highly subsidized, have a lot of practical advantages (e.g. privileged parking, privileged parking and permission to drive on bus lanes) and have a lot of financial benefits (free parking, free charging, no toll road charge) (Holtmark and Skonhoft, 2014). The Oslo approach can be identified as very effective because of the fact that they established in a relatively short period of time a more than average amount of public chargers. Nevertheless they also used a significant amount of public money to build this number of public chargers. From an efficiency perspective this approach (spending a lot of public money for public chargers) is questionable.

In Amsterdam almost the same amount of public chargers are built as in Oslo (Bardok et. al, 2016). As in Oslo also here the city itself realised these chargers, proactively, like Oslo to make it more visible and take away range anxiety. However, instead of continuing to install new charging facilities they recently changed to a more demand driven approach (Bardok et. al., 2016). This means that each new request is checked for its necessity. And only if there is not an, already existing, charger in the neighbourhood, a new charger is established (Bardok et. al., 2016). As in the example of Oslo, as well as Amsterdam, an active role of the central government is recognisable. And it also involves a significant amount of public money. Nevertheless the example of the city of Amsterdam shows also that in a later stage a more tailor made and more efficient approach is possible.

### 3.6 best suitable approach

With all the different perspectives, approaches and examples in mind we can try to come up with a hypothetical ideal approach, which can function as guide for our case study. The main objective is to provide public charge facilities to decrease range anxiety, which is tempering the development of EV mobility. In essence this seems to be a very straightforward procedure with low complexity. So for an effective deployment our planning issue should be located in the top left of the planning arena (figure 3.6a). However the aim of this study is to look for a more efficient approach. This means inclusion of market parties to lower the public expense. Furthermore, with that in mind, you don't want to install more chargers than needed. So each local authority needs their own tailor made approach. This all means that we're shifting from the top left of the planning arena towards the bottom right. The most ideal situation should be that market parties provide the chargers without any involvement of public actors or money. This would mean that our "charger" box would be located in the bottom right (figure 3.6b).

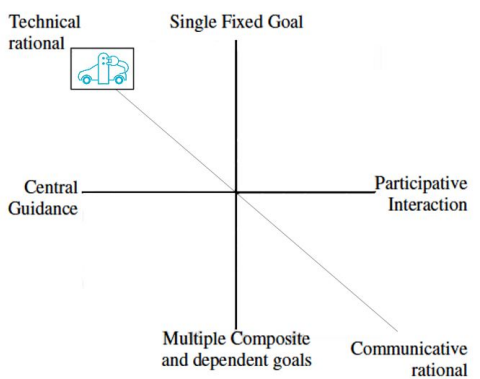


Figure 3.6a: Most effective approach

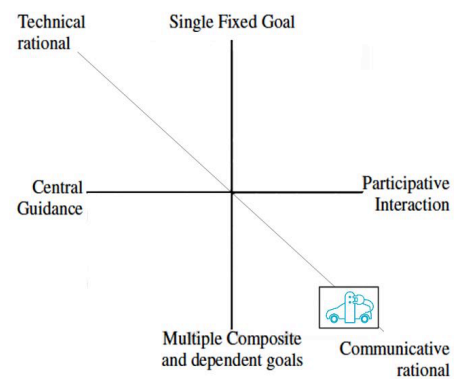


Figure 3.6b: Most efficient approach

However, a fully market operated approach is not realistic due to the fact that the chargers need to be installed within the public space, which is normally owned by a governmental entity. Nevertheless, a decentralised approach still seems more suitable for implications like *uncertainty* and *grid improvements*. According to the literature a decentralised communicative approach is best able to deal with *uncertainty* and it's able to detect new developments easier because of their better accessibility and tighter connection with reality. Furthermore, not every place needs to have the same *grid improvements*. A local government should be better able to know where improvements are needed in the grid. Also in case different grid operators are operating in one country, a central government would have to deal with all of them while a local government probably has to deal with only one local operator. Finally, a decentralised government should be better able to register and manage all public charger requests and decide if new chargers are needed (Amsterdam example). However, we know from chapter 2 the *high costs* of public charge facilities and a low penetration level of EV's, create uncertainties over whether market parties will invest. Furthermore, the Oslo and Amsterdam examples show us that active government participation leads to an effective deployment of chargers. So public money and thus involvement of a governmental body seems to be needed at the moment. Then the question is which body of government would be most suitable? In other words, do we need a central (national government) or a more decentralised (city government) approach or a combination of both? Based on Zuidema's idea (2016) a central approach is favoured when a larger amount of money is needed so a weak interest or an economy of scale can be prevented, which could lead to inefficiency.

Based on what we currently know about EV mobility and Governance the best actor seems to be the local government (municipality/city level). They will most likely be best able to deal with *uncertainty*, *grid improvement* and *efficient deployment*. Also the local city government should, according to the governance theory, best be able to include local market parties in this process. These local market parties should be actively involved to reduce the amount of public money. Depending on the amount of chargers and thus the amount of money that is needed for the deployment of chargers or reinforcements of the grid, the national government should be included to overcome issues like economy of scale and to prevent a weak interest, which could lead to inefficiency (figure 3.6c).

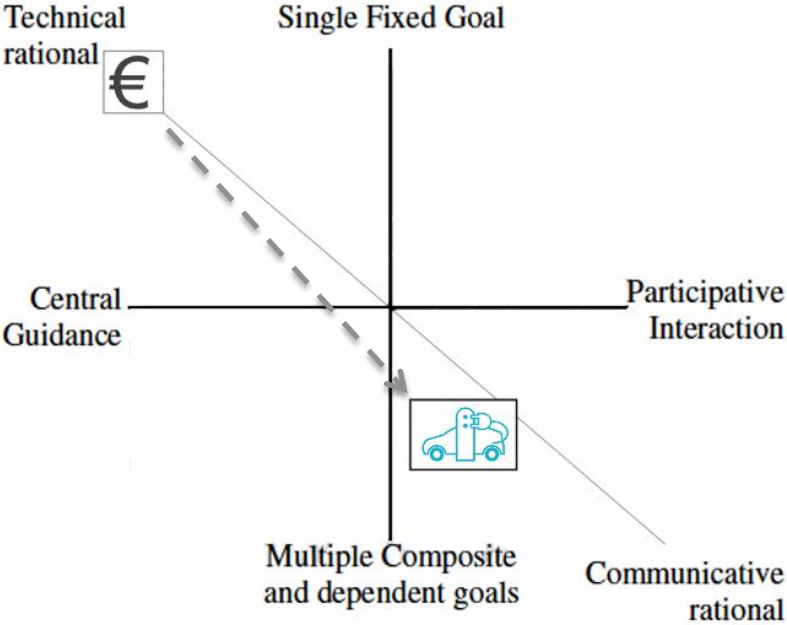


Figure 3.6c: Most suitable approach

#### 4: Diffusion of innovations

As already mentioned shortly in Chapter 2 the Electric Vehicle is a technological innovation (Nillson, 2012). Getting a better understanding about how innovations develop, will help with the stimulation aspect of our research question. Innovations in general have a characteristic that they develop in a certain pattern, the “s-curve” (see figure 4).

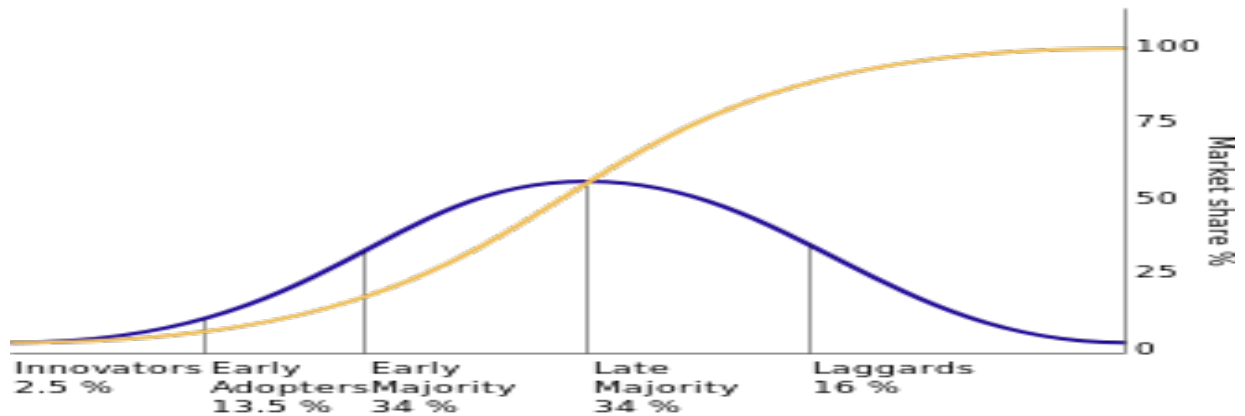


Figure 4: Innovation curve + innovation groups

Everett Rogers has tried to explain this “s-curve” pattern with his theory called diffusion of innovation. According to Rogers the diffusion of innovations occurs through a 5 steps decision-making process. In table 1 you see the 5 steps with their meaning. Every individual takes these 5 steps before adopting a new innovation. The pace in which these individuals go through these steps is called the degree of innovativeness.

Stage	Definition
<b>1: Knowledge</b>	The individual is first exposed to an innovation, but lacks the information about the innovation. During this stage the individual has not yet been inspired to find out more information about the innovation
<b>2: Persuasion</b>	The individual is interested in the innovation and actively seeks related information/details
<b>3: Decision</b>	The individual takes the concept of the change and weighs the advantages/disadvantages of using the innovation and decides whether to adopt or reject the innovation. Due to the individualistic nature of this stage, Rogers notes that it is the most difficult stage on which to acquire empirical evidence.
<b>4: Implementation</b>	The individual employs the innovation to a varying degree depending on the situation. During the stage the individual also determines the usefulness of the innovation and may search for further information about it.
<b>5: Confirmation</b>	The individual finalizes his/her decision to continue using the innovation. This stage both intrapersonal and interpersonal, confirmation the group has made the right decision.

Table 4a: Rogers’ 5 steps of innovation adoption



The decision making process suggests that we can stimulate the development. For example if we can make the innovation more visible the chance of getting exposed to the new innovation is increasing, and so, independently of the pace they go through these step, the amount of people who start the process is getting bigger. Also the third step is a step that looks like we can influence and what has been done already in practice. As we have read in previous sections subsidies are provided to lower the purchase costs of electric cars and furthermore, in Oslo and Amsterdam for example, chargers are installed to take away range anxiety. By taking away disadvantages the chance of people making the decision to take an electric car increases.

However, personal characteristics seem to be also very important regards the degree of innovativeness. This is something policy makers do not have much influence. Rogers has identified 5 groups of people who share the same characteristics. Each group is adopting the innovation in later phase. In table 2 you see the 5 categories with their main characteristics.

Adopter category	Definition
<b>Innovators</b>	Risk-takers, highest social status, have financial liquidity, social and have closest contact to scientific sources and interaction with other innovators.
<b>Early adopters</b>	Higher social status, have financial liquidity, advanced education and are more socially forward than late adopters.
<b>Early Majority</b>	Above average social status and contact with early adopters.
<b>Late Majority</b>	Sceptical about an innovation, have below average social status, little financial liquidity, in contact with others in late majority and early majority.
<b>Laggards</b>	Lowest social status, lowest financial liquidity, oldest among adopters, and in contact with only family and close friends.

Table 4b: Rogers's 5 groups of innovativeness

According to the current statistics we could assume that the current owner of an electric car is an innovator/early adopter. Several studies have been done about the characteristics of the current owners (Campell et al. 2012; Econ, 2006; Pierre et al. 2011; Rødseth, 2009; Vågane et al. 2011). Out of all these analysis there could be made some generalisations about this group (Hjorthol, 2013). According to Hjorthol the current owner, in his study called 'early adopter' (further explanation follows in chapter 4), can be described as follows:

- Early adopters of electric vehicles (EVs) are relatively young, a majority are men, and they have high education and income, and belong to households with more than one car. The majority also live in, or in the vicinity of, larger cities.
- Commuting is the most often cited reason for using EVs in most countries
- Adjustments drivers have to make when driving an EV include better planning of journeys – due to battery limitations – and adoption of a smooth (non-erratic) driving style.
- Motives behind the purchase are the special regulatory advantages (such as in Norway), environmental considerations, lower operation costs and simply the convenience and fun it is to drive these vehicles.

This tells us that the early adopters regards electric do have a high income, and thus probably also more financial liquidity, and are higher educated. This seems be an indication that the EV innovation fits Rogers' theory. When accepting these characteristics we also need to accept that we can't control everything. Even if we increase the chance of exposure, the persuasion step is all based on the eagerness of people to take action after exposing. Furthermore, even with subsidies an electric car is still an expensive car and so it is currently only available for a limited amount of people.

The third part of Rogers' theory identifies change agents or opinion leaders within the first phase of an innovation. These agents are according to Rogers (2003) able to affect positively or negatively the adoption of a certain innovation. In the case of EV mobility you saw this also with the active involvement of celebrities to promote the Toyota Prius in the early 2000, which contributed positively to the image of the electric vehicle, which in the end stimulated the uptake of EV.

In conclusion we can argue that there are possibilities of stimulating this new innovation, based on Rogers' theory. However, it's also highly depending on personal characteristics, especially in the beginning.

## **5: Institutions**

This last part of the theoretical framework will elaborate on institutions. Our hypothetical approach is build up from scratch and we have excluded already existing arrangements between different actors or organisations in the real world. These arrangements we call institutions. According to North (1991) institutions are “humanly devised constraints that structure political, economic and social interactions” and these constraints he is dividing in *formal rules* (e.g. constitutions, laws, property rights) and *informal restraints* (e.g. customs, traditions, codes of conduct). Simply said we could say that institutions are the ‘rules of the game’; how do we manage things; who is doing what; what is okay and what isn’t. By understanding these institutions we can indicate how easy we can fit our hypothetical approach in the already existing system with institutions.

### **5.1 Why do we have them?**

Why and how do institutions emerge? Like North (1991) already stated in his definition institutions are humanly devised. Therefore the reason we have them is because we invented the term. With the question we asked, we indirectly ask the question why and how formal rules and informal restraints emerge? Formal rules are there to make things clear and avoid uncertainty (Olsen, 2009). It is a written agreement between members of one and the same system (like a nation, society, etc.). The reason for this kind of formal rules is to give legal obligations or responsibilities to certain actors or organisations. When someone is neglecting one of these obligations or responsibilities then people are able to legally appeal on someone. Informal restraints are unwritten agreements between individuals. According to Pejovich (1999) informal institutions (‘restraints’ is in a lot of scientific literature has already been replaced by ‘institutions’) are part of community’s culture. It is about certain beliefs, values, habits, etc. and they emerge as a result of repetition and solidification (Buitelaar et. al., 2011). The question for planners and policy makers is to understand how institutions function and if we can change them when needed. Because when they are being aware of the institutional context they can operate more effectively (Alexander, 2005)

### **5.2 Exploitation vs. Exploration**

How do institutions function? Or in other words what are the main characteristics of institutions? In the ideal situation a well-designed institution standardises certain procedures to make it more effective or efficient. However, it should also be easy changeable when needed. Nystrom and Starbuck (1981) and Gupta (2011) call this the ultimate balance between exploitation and exploration (Nystrom and Starbuck, 1981, Gupta, 2011). Exploitation gives a system the ability to gain from their solutions by setting up rules and routines that makes processes faster and easier. Exploration is an on-going process of experimentation, which keeps institutions adaptive to new developments but isn’t able to gain from new discoveries. In general institutions are mainly seen as robust and resistant to change which is in line with exploitation (Alexander, 2005; Gupta, 2010; Olsen, 2009). Reason for this is that current institutions are agreements out of long debates and if these institutions could disappear the next day, the need for institutions wouldn’t be there (Gupta, 2010). So current institutions are characterised mainly as rigid and robust and hard to change.

### **5.3 Duality of structure**

Another characteristic of institutions is that the two types (formal and informal) of institutions are interconnected with each other, the so-called “duality of structure” (Giddens, 1974). Because both institutions are humanly devised (North, 1991) they can influence each other. If a common believe (informal) is widely accepted it could be turned into a written statement (formal). The other way around a rule (formal) can change or influence a habit or believe (informal) of certain group individuals. This idea indicates that we should be able to change institutions both ways. However, the last characteristic shows why this isn't always true.

### **5.4 Path dependency**

Last characteristic of institutions that is important for our study is the existence of path dependency (Rose, 1991). Path dependency is the principle in which decisions from the past obstructs or temper new developments right now. In the case of spatial planning the most visible are decisions about the physical environment, which could make it easier but also more difficult to implement EV infrastructure. But also decisions in the past about governmental or organisational structures could lead to solidification of habits and believes. A good example is the planning culture that is according to Buitelaar (2011) `a set of informal institutions that guide, and are (re)produced by, decisions by government, private actors, and citizens on the ends and means of planning'. In this the idea of duality of structure results in an on-going process of solidification because people formed by informal institutions are creating the formal institutions, which on his turn confirms the informal.

## **6: Towards a model**

With the planning implications of chapter 2 we have improved the understanding of what the public charging planning issue is all about. From this we have argued that 3 theoretical debates are useful to understand how to govern this new planning issue. Based on these theories we have already set up a hypothetical best suitable approach in chapter 3. Furthermore, we have created a better understanding of the development of innovations. It looks like that in a certain way the development of innovations runs autonomously due to the characteristics of the innovation and the people who are adopting them as well. Finally, in the institution chapter we have seen that institutions occur in two different ways, namely, formal and informal, and that they are interrelated. Due to this interrelationship they also seem to be hard to change which means that they could function as a barrier when a new planning issue, with different needs, has to be included. In the case study we will try to see how this all works out in practice. Based on the theoretical debates, four chapters are created in the case analysis. In the conceptual model you can see which theoretical debate is linked to which chapter. With the outcome of the case study we are able to reflect back on our hypothetical findings and thus synthesise theory and practice. What in each chapter will be discussed and how this relates to the theory will be presented now.

Throughout the whole case study we are able to determine if our planning implications are still implications we have to take in to account. As we already mentioned in chapter 2 the electric car development develops really fast so the implication based on literature from 2015 could already be out-dated. Furthermore, we could find new implications that we did not indicate based on the literature research.

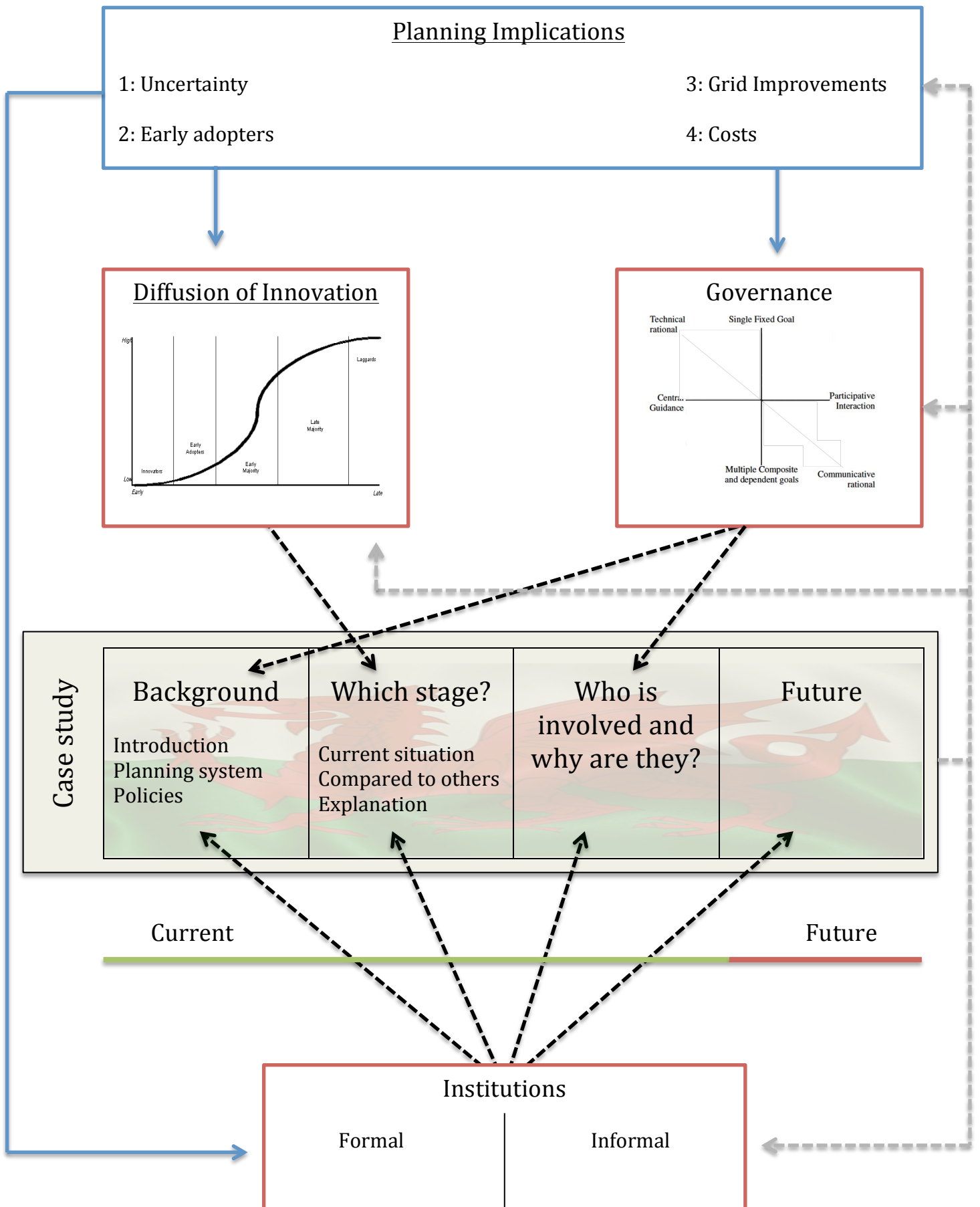
In the first chapter we are looking at the background of the case to create some context. Useful context are the city characteristics, planning system and the policies that apply in Cardiff regards EV mobility. The first is useful to see how reasonable it is to believe that people in Cardiff buy electric cars and how big the need for charging infrastructure is. The latter gives us a first impression of the way planning issues are governed in general and which formal institutions apply.

Second, the current stage of development in Cardiff has to be included. This is necessary to determine if Cardiff is doing a good job. For example is there a sufficient amount of chargers compared to the demand? How do other cities in the same planning system dealing with this planning issue? And if there is a difference, what are the explanations for it? The latter helps us to see how institutions are influencing the process of implementing public charge facilities.

In the third chapter we are going to look at the involved actors and their attitude towards public charge facilities. In chapter 3 we have positioned the public charging issue in the planning arena. Looking at the pros and cons of different approaches we have argued that the most ideal situation would be a decentralised approach with involvement of market parties. The feasibility of this approach in practice depends mainly on the attitudes and capabilities of different actors to involve. If market parties or local entities are not willing or capable to involve, a shift towards the right bottom is hard to achieve. Furthermore, the attitudes of different actors could help us finding informal institutions.

In the last chapter we are focussing on the future. A better understanding of the future will help us to refine our uncertainty implication from chapter 2. Furthermore, we can determine how current institutions maybe need to change to cope with these future developments.

Figure 6: Conceptual model



## 7: Methodology

In this section will elaborate on the way this study has been conducted. First, the reasons to choose for a case study as method of research and why Cardiff is chosen as research area will be explained. Second, the research design will be showed. After that the exact method of how the data has been collected will be presented and how it has been analysed will be elaborated on. At the end of this chapter the ethical issues and limitations will be discussed.

### 7.1. Introduction

The aim of this study is to understand how the implementation of public charge facilities can be governed most efficient, therefore only a theoretical explanation is not sufficient. An actual case study can help to overcome the gap between theory and practice. There are several methods to study a practical example. According to Yin (2014, p.9) 5 methods can be used: Experiment, Survey, Archival Analysis, History and Case study. Based on the type of research question the best method can be chosen. The main research question is a “how” question. According to Yin (2014, p.10) therefore one of the following three methods is preferred: Experiment, History and Case study.

In this study we are examining a contemporary event, namely, the implementation process of public charge facilities in the city of Cardiff. This enables the possibility to conduct interviews with involved persons and direct observations as an extra source of data besides documentation, which is the main source for History research (Yin, 2014, p.12). Because we are not aiming to control behaviour of involved actors, which is a characteristic of experimentation as research method, the case study is the best option to answer our research question.

The reason to take Cardiff as a case is based on the fact the researcher lived in Cardiff. Therefore he was able to include an extra source of data, namely, observations. Of course cities nearby like Swansea or Bristol could also be a possibility do include observations due the fact that these cities were relatively similar to each other. However, the other would have required more financial resources for traveling. Furthermore, spontaneous observations weren't possible.

### Quality of the research

To ensure the quality of the research some research criteria have to be taken into account. For empirical social research 4 tests (Yin, 2014 p. 45) can be used to establish the quality of our research.

***Construct Validity:*** (identifying correct operational measures for the concepts being studied)

In this study this part is less applicable. The test forces researchers to use well defined set of measures to prove their statements. Yin (2014) uses the example of measuring neighbourhood change in which he first defines what kind of neighbourhood change he is researching and identifies some operational measures that match this definition. Nevertheless this research doesn't look for hard causalities; instead it tries to get a better understanding of implementing public EV infrastructure in Cardiff.

***Internal Validity:*** (Seeking to establish a causal relationship, whereby certain conditions are believed to lead to other condition, As distinguished from spurious relationships)

As the definition given by Yin (2014) already says this is about making rightful conclusions regards causalities. Is it only factor x that led to y or is there maybe another factor which you



didn't include in your research design. The problem of internal validity is mainly a concern for explanatory case studies. As this research is more an exploratory study, the problem of internal validity is less applicable.

***External Validity:*** (defining the domain to which a study's finding can be generalized)

This research is based on one case and so it will be hard to identify generalizable rules or theories for other cities. Therefore, the conclusion of this study will be most useful for the city of Cardiff itself. Nevertheless, our conclusion can be helpful for the general understanding of the implementation of public charge facilities in other cities. This is because the factors that influenced Cardiff's process are identified and so other cities can see in which way these factors could also play a role in their implementation process. Other aspect that could be used outside the case of Cardiff is the research method itself. If the research turns out to be a successful tool to research new planning issues it could be applied for other new planning issues.

***Reliability:*** (demonstrating that the operations of as study, such as the data collection procedures, can be repeated, with the same results)

This definition is quite self-explanatory. This study has covered this issue by explaining all steps of the research methods, case selection and analysis.

## 7.2. Research Design

As already mentioned in chapter one this research is divided in three different research steps. Figure 7.2 gives a visualisation of this research. In the first step an exploration is done about the phenomenon that is central in this research, namely, EV mobility with a special emphasis on public charging. This exploration has been considered necessary to identify the planning implications and thus being able to answer sub-question 1. Sub-question 2 has build upon sub-question 1 and has explored the current theories about governance with regard to efficiency. With the help of these insights a hypothetical best suitable approach has been determined. Furthermore, in this chapter theories about institutions and innovations have been discussed because these two themes have been considered as important for answering sub-question 3 in combination with the case study. Down here a box with the main research question and the 3 sub-questions are given again.

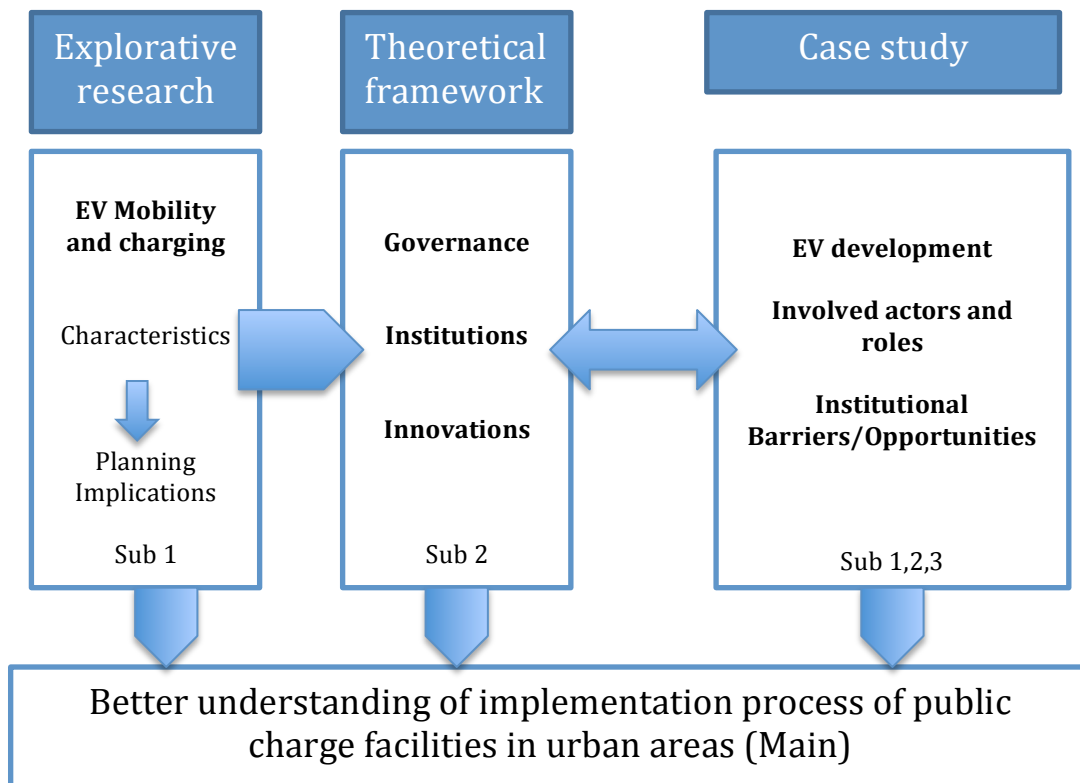
### **Main question:**

How can the implementation process of public charge facilities in urban areas be governed efficiently while simultaneously stimulating EV mobility?

### **Sub questions:**

- What planning implications occur with the implementation of electric charge infrastructure?
- What hypothetical approach, based on literature, is best suitable for implementing charge facilities in an efficient way?
- What is Cardiff's approach in implementing electric charge facilities and how does this fit our hypothetical approach?

Figure 7.2: Research design



By conducting a case study we could choose between a single or multi case design. For this research a single case study is seen as sufficient enough. This based upon one of the rationales given by Yin (2014, p. 52), namely, the *common case*. The objective here is to capture circumstances and conditions of an everyday situation. This everyday situation is in our research the implementation of public charge facilities. This will provide some lessons for theoretical interest. Nevertheless a multi-case study can be considered as more compelling and robust in comparison to a single case design (Herriot & Firestone, 1983 in Yin, 2014 p. 57). However, a multiple case study also requires extensive resources and time beyond the means of a single researcher. Due to this the decision is made is to conduct a single case study.

### **7.3. Research Methods**

As already mentioned shortly in the introduction of the methodology the case study gave the opportunity to use different sources of data. Besides the documentation also real life observations and interviews with involved actors were possible. Besides the fact that it expands the possibilities of gathering useful information also triangulation can be applied. Using triangulation avoids bias in your analysis because facts of one source can be checked using the other two. Furthermore, it can give more value to each source separately. For example an interviewee could recommend other interesting persons to interview or documents for the document analysis, which in the end will give you a better understanding of the case. In this study not each source has generated the same amount of input. This research is mainly based on document analysis combined with in depth interviews nevertheless observations were useful to understand what was said in the interviews or in the documents.

#### **Interviews**

Interviews can be seen as one of the most important sources of evidence in a case study (Yin, 2014). The power of interviews is that helps you gather personal opinions, experiences and attitudes that could help you better understand the case you are studying. The interviews that were conducted with different stakeholders have provided valuable insights about the attitudes regards public charge facilities. Also personal experiences helped to understand how policies were working out in practice. At the end the interviews with experts also gave a better understanding what is important in the implementation process. The interviews were semi structured, which means that each interview covered all the research topics (See appendix). However, depending on the knowledge of the interviewee, certain issues were elaborated on more thoroughly then other parts.

#### **Document analysis**

Document analysis is almost always applied in case studies. In this case study, documents were also used as an iterative tool. The sorts of documents that were used are administrative documents, reports, news clippings, statistics and other articles that appeared in mass media. In the case analysis references are made to the source of the information. First the documents contributed to the general understanding of the case. Furthermore, by having already a general idea of the case, it helped indirect with conducting better interviews. For example events that were discussed by the interviewee did not need extra explanation because of the pre-work. Finally, as already mentioned in the introduction, documents gave the opportunity to check quotes from interviewees to generate stronger evidence.

#### **Observations**

Observations in this research were mainly unconsciously used because of the fact that the author lived in the research area for five months. In this way, by experiencing the daily street life, information that was generated by documentation or interviews could be placed in perspective. Furthermore, the data became more meaningful. For example the number of electric cars or chargers is from behind the desk just a number. However, in real life you can actually experience what this number means regards visibility. In some cases a personal visit to the location could help to better understand the stories that were told by the interviewees.

## 7.4. Data Collection and Selection

### Interviewees

The first way of selecting potential interviewees for this study was by doing a document analysis. Out of this document analysis some knowledge was gathered about involved actors in Cardiff. Reason for this was that the researcher was not familiar with the study area and so did not had a personal network to make use of. Based on this analysis three stakeholder groups were indicated: government, car industry and the grid operator. Furthermore, some individuals were indicated that seemed to have expertise about the EV development in Cardiff or UK cities in general. A second way of finding potential interviewees was making use of snowball sampling. Which means that interviewees, who responded in the first round of case selection, were asked if they had some useful contacts of who they thought could make some contributions to this study.

All selected actors were first be approached by sending them an email. In case people did not respond, a personal visit was conducted in case the potential interviewee was working in Cardiff. In the end the selection was all based on peoples willingness and availability to do a 30 minutes interview. During this research the author conducted four recorded interviews and two unrecorded interviews. These two unrecorded interviews were more difficult to use for the data analysis because a transcription could not be made. Nevertheless by making notes during the interview as much as possible data has been stored. Furthermore, three people, who were not able to do an interview, have sent useful information by email. The information I have actual used in my analysis is referenced.

### Interviews

Name	Function
<b>Dr. Paul Nieuwenhuis (PN)</b>	<i>-Co-director of EV centre of excellence-</i> The EV centre of excellence is a research facility focussed on EV mobility. It's collaboration between 3 different departments of the university of Cardiff: business, engineering and sociology. As a co-director of this centre, Paul knows a lot about EV mobility. Furthermore, Paul was part of the Low Carbon Vehicle Steering Group who made report for the welsh government. In this report recommendations were given for the stimulation of LCV's. finally, as a citizen of Cardiff he also has knowledge about EV mobility in context of Cardiff.
<b>Mark Dale (MD)</b>	<i>-Innovation manager Western Power Distribution-</i> The WPD is the DNO in Wales. Mark Dale works at the WPD as innovation manager with a current focus on EV mobility and the impact on the grid.
<b>Jacob Roberts (JR)</b>	<i>-Technical Project Manager Energy Savings Trust-</i> The energy savings trust is an independent consultancy bureau that focuses on clean energy solutions. EV mobility is also one of their specialties. Because of this the OLEV has hired the EST to help local authorities to bid for the funding schemes. Besides Jacob is working for the EST he also has worked for the Coventry city council where he had EV mobility in his portfolio.

<b>Ramesh Patel (RP)</b>	-Cabinet member Transport, city council Cardiff- Ramesh has been the cabinet member for transport for the last 5 years (2012-2017).
<b>Myles Barker* (MB)</b>	- <i>Business development manager E-volt</i> - E-Volt is a company that provides charging solution for public and private parties. Myles Barker task is to help local authorities with the deployment of charge facilities
<b>Mariya Fuijkschot* (MF)</b>	- <i>BMW I Sales Executive, BMW Sytner Cardiff</i> - Mariya is specialised in the electric car part of BMW.

Table 7.4a: List of interviewees

**\*Unrecorded**

<b>Email</b>	
<b>Company/person</b>	<b>Function/Description</b>
<b>Gwen Roberts</b>	- <i>Head of energy and steel, Welsh Government</i> -
<b>ZECTRA</b>	- <i>Electric taxi company in Cardiff</i> - Zectra is one of the few EV initiatives in Cardiff. They're trying to introduce some electric taxis in the city centre of Cardiff.
<b>Polar</b>	- <i>Charging service provider</i> - Polar is the biggest charge operator of the UK. Also all the public chargers in Cardiff are run by Polar.

Table 7.4b: list of email contacts

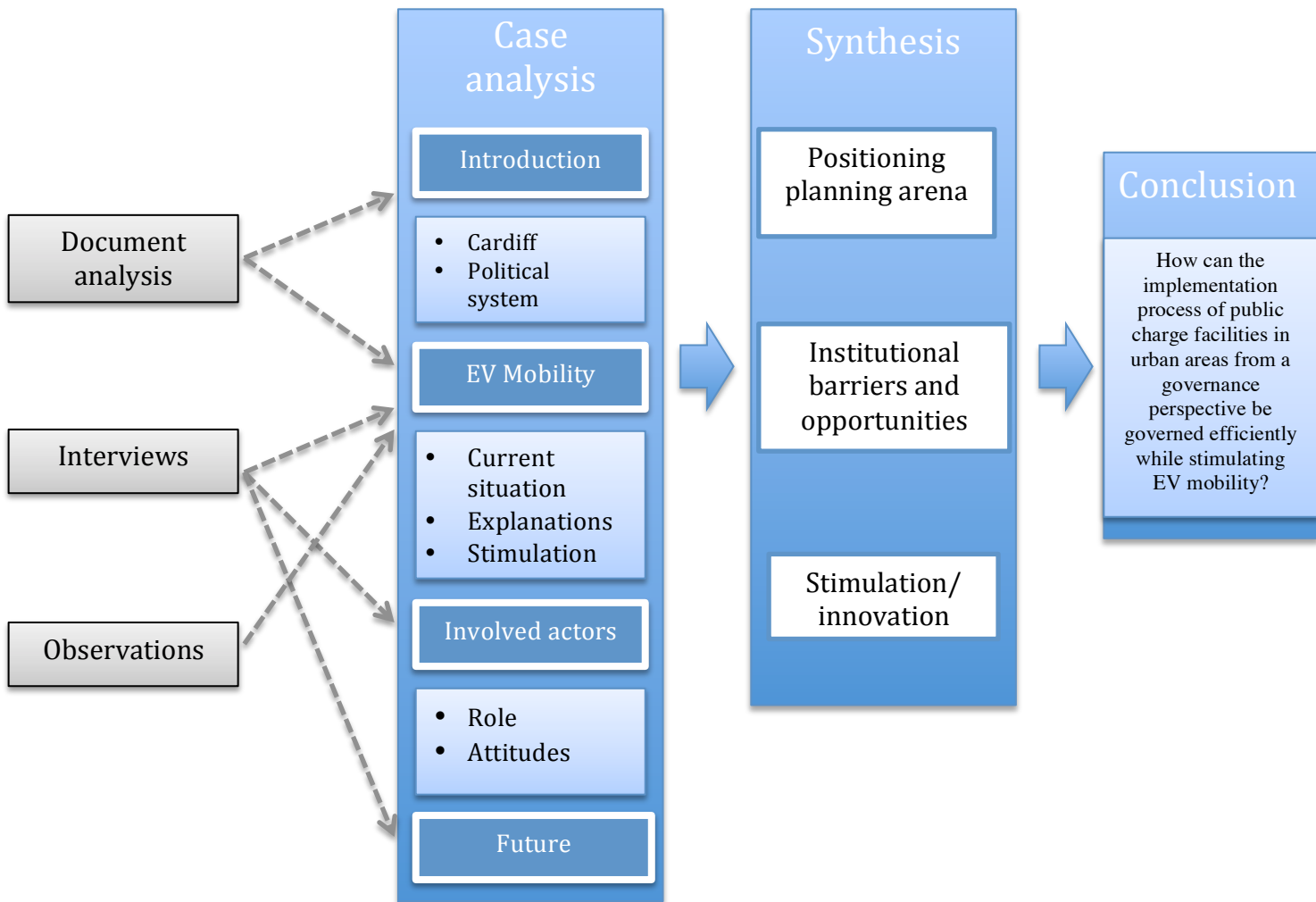
### **Observations**

Several locations have been visited for observation during the research period. For example locations of charging points were being visited to check their accessibility. Or certain neighbourhoods where interviewees were talking about during the interviews were visited to check their stories. Finally, because of the long period of staying, unconsciously a lot of observations have been made which in the end contributed to the final results.

### 7.5. Data analysis

In this section, a discussion of how each research method has contributed to the analysis of this study will be explained. In figure 7.5 a visualisation is given of the different aspects of the analysis and how which methods has contributed to each individual aspect and how it all contributed to the final conclusion.

Figure 7.5: Case study towards conclusion + contribution research methods



The case analysis is divided into four different “sections” which in the end have to lead to a better understanding of the implementation process in Cardiff. First a general introduction is given about the city of Cardiff. Therefore a document analysis has been conducted. Important aspects that needed to be covered in the introduction were besides some general information about the city, also the characteristics of the planning system of which Cardiff is part of. The second section is about the EV mobility in Cardiff and surrounding areas. First the policies of the different governmental entities that could influence or explain current EV development will be explored and the actual numbers of EV development will be presented. Other countries of the UK are also included because they are all influenced by the same policies and planning system. When differences are observed it becomes clear that aspects other than written policies do influence the process of implementing public charge facilities. This can be relevant information for our analysis. Furthermore, the ideas from experts of how to stimulate

EV development are presented. The third section is about the different actors that are involved in the implementation process of charger facilities in Cardiff. To find out what the motives and attitudes were with regards to public chargers in depth interviews are used. The fourth chapter presents the expectations for the future regards EV development.

In the synthesis chapter we're going to relate our case analysis back to the theoretical debates in chapter 3,4 and 5. First we are going to reposition our planning issue again and see how it fits the hypothetical approach of chapter 3. Second part of our analysis will elaborate on the potential institutional barriers and opportunities and relate this back to chapter 5. The last part of our analysis will elaborate the stimulation question. With this analysis we are able to get an answer for our main question. This will be presented in chapter 10.

### **Interviews**

Each interview that has been done was different, however, each interview covered the same general topics. Each interviewer that had knowledge about Cardiff was asked about the current development of EV mobility in Cardiff. For people who did not have knowledge about Cardiff specifically, questions were asked about general development of EV mobility in the UK. Each of the interviewees was asked about the specific role that they are playing in the deployment of public charge facilities in Cardiff or in general. Because it was clear that there were differences between Cardiff and the other cities in the UK, all the respondents were asked about possible reasons for this difference.

### **Document analysis**

Examples of used documents are policy documents, EV statistics, reports, and media.

### **Observations**

As already mentioned before the observations have mainly contributed to a better understanding of the case and have helped to put the outcomes into perspective. For example the statistics are reinforced by observing them in reality. I was also able to ask for clarification in case I had observed something different from what an interviewee was saying. Furthermore, I could check these quotes after the interviews.

## **7.6. Ethics and limitations.**

During the interviews some ethical aspects are taken into account. First of all the interviewees are asked up front if it was possible to record the interview. Furthermore, for this research the use of names and function was considered as valuable. Nevertheless the author has asked permission first to actually be able to use it in this document. In the end it turned out that each respondent was okay with this. Also all the interviewees are given the opportunity to get a copy of the final document if they wanted it. The emails that have been sent and used for the analysis can't be included to this document because of letter confidentiality.

During this research also some limitations occurred. First because the electric car and the charge infrastructure are a relative new phenomenon the amount of involved actors or people with knowledge about the topic was relatively small, especially in the case of Cardiff specific. This made the number of potential interviewees small. Furthermore, during the period of doing research local elections and national elections took place, which had influence on the willingness and availability of people from the local government and welsh governments.



## 8: Case study: Cardiff

This section presents the analysis of the case study. As has already been mentioned in the chapter 6 and 7 the analysis is build up out of four separate chapters. First an introduction will be given about the city of Cardiff and the planning system of which it is part. Second the current situation will be presented and explained. Third an elaboration will be given about the role and attitude of different stakeholders who are involved in the implementation process of public chargers. At the end some important developments we can expect for the future will be discussed.

### 8.1 Introduction

Cardiff is the capital of Wales and with 346.000 inhabitants it is also the biggest city. In comparison to the rest of the UK it is the 10<sup>th</sup> biggest city. Cardiff is relative young city that celebrated just their 100-year anniversary as a city in 2005. In the beginning of the 19<sup>th</sup> century Cardiff counted only 1817 inhabitants. Due to the founding of the docks, Cardiff became the biggest coal exporter of the UK and because of this a lot of migrants settled in Cardiff. These docks are all closed during the 20<sup>th</sup> century, nevertheless, the people stayed and Cardiff even has grown bigger. Nowadays Cardiff economy consists of mainly the service sector. Furthermore, it has 3 universities, houses most of the governmental buildings and national sports and entertainment venues. Compared to other UK cities the average income is lower (ONS, 2015). Also the area that surrounds Cardiff is relatively less wealthy then other regions in the UK (ONS, 2015).

#### 8.1.1 Political/Planning system

##### Governmental bodies

There are 5 political entities that affect plan- and decision-making in Cardiff (see figure 8.1.1) The lowest level of government is the city council. They are providing statutory services and services that are empowered by laws set up by UK and Welsh government. Nevertheless, they have some discretion in the way they are providing this services. Examples of delegated tasks are (strategic) planning, local transport, education and waste management. One governmental level higher you have the Welsh Government, which is an executive board that makes legislation for the country of Wales. This Government is compiled and controlled by the National Assembly for Wales. This assembly has to be re-elected each 4 years. Because Wales is part of the UK also the UK government (Officially the Her Majesty's Government) is able to influence the planning and decision making process in Cardiff. Even though the UK wants to leave the EU; they are currently still part of it. Therefore policies and regulations made by the EU could also affect Cardiff.

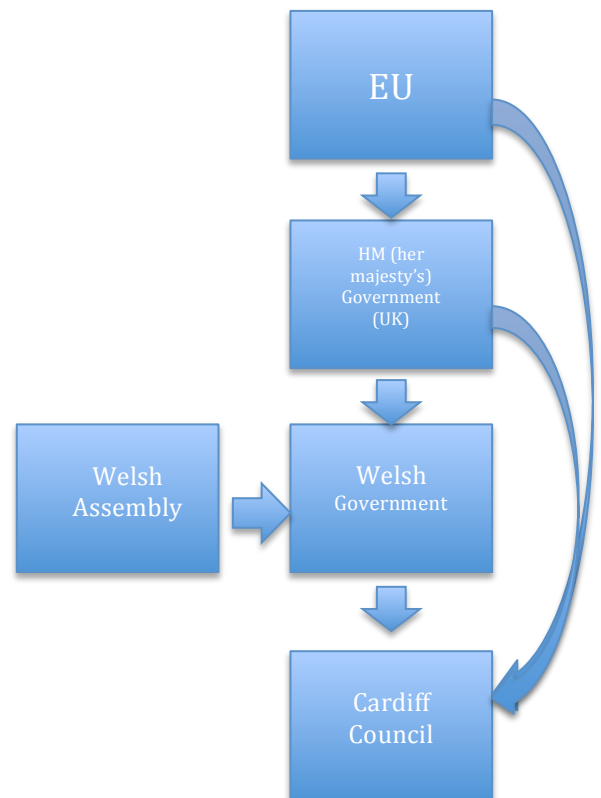


Figure 8.1.1: Political landscape Cardiff

## Devolution

Until 2006 the Welsh government did not exist and before 1998 the National Assembly did not exist either. Before 1998 the UK Government made the legislative rules and decisions. This was the government of the United Kingdom, which is a combination of the countries England, Scotland, Northern Ireland and Wales. Around mid 20<sup>th</sup> century the first actions had been taken to devolve certain tasks of the UK Governments towards the level of the country itself. However, it took almost 30 years till the first steps of devolution of powers actually took place. With the act of Wales government in 1998, Wales got his first governmental entity: The National Assembly for Wales. Nevertheless this assembly wasn't allowed to make primary legislation, which means that they only could make legislation that fitted with the primary legislation made by the UK Government. In 2006 the national assembly gained more power and an executive board was also created: the Welsh Government. From 2006 the Welsh Government and Welsh Assembly were able to make primary legalisation in 20 different policy fields (e.g. housing, health and environment). However, there are still some fields that are attributed to the UK Government, namely, Energy, Defence, Constitution, Foreign Policy and Immigration. This also means that issues regards the energy grid are governed by the UK government. However, this would also assume that the Welsh government makes policies with regard to electric mobility. Nevertheless, as will be elaborated on later in the policy section, this turns out to be different for this particular field.

## Privatisation

Another important aspect in the political system of the UK and because of the recent devolvement on the Welsh system as well, is the big wave of privatisation. Since the early 80's a lot of public services have been privatised. State owned companies in sectors like telecom, cars, energy, transport and health were all sold to market parties. Reasons for this privatisation were to reduce the costs of the state and to make the public services more efficient. However, right now the real effects of this massive privatisation are debatable. For example in the public transport sector the profit margins are low due to competition (Paul Nieuwenhuis). More important for this research is that the state governments have narrow responsibilities and also less influence on certain sectors. How this could influence the implementation process of public charge facilities will be discussed in the analysis chapter.



Welsh Assembly Building, <http://www.bbc.co.uk/programmes/b0070w6q>

### **8.1.2. Written policies related to public charging**

- European Union

From the European Union there are no direct directives regards the deployment of public charge facilities. Nevertheless, they still have a role in the process. For example, they have created directives in other field that, indirectly, is influencing the development of EV mobility and thus EV charge facilities. For example the directives regards urban air pollution, which forces European cities to reduce their emissions to meet with the accepted limits of air pollution (EC, 2008), functions as a stimulator of cleaner transport possibilities (UK Government, 2017). Furthermore, they stimulate and support the electrification of transport by funding R&D projects, which in the end probably lead to standards regards e.g. charging connections (EC, 2009)

- UK government

As already mentioned the Welsh government is a devolved country. Nevertheless there are still some fields in which the UK government influences developments in Wales. Transport is not one of these; however, there are some exemptions and promoting EV development is one of these. The Department for Transport and Department for Business, Energy & Industrial Strategy have together established a new department called Office for Low Emission s. This office deals with issues regarding ultra low emission vehicle (ULEV) development, manufacture and use in the UK. The incentive behind this initiative is to make the UK one of the world leaders regards ULEV development. To make this possible they have reserved 900 million pound. Part of this money is or will be used for the deployment of private and public charge facilities. In 2013 the first grant schemes were introduced to encourage local authorities to provide public charge facilities. However, this scheme was only meant for local authorities in England (OLEV, 2013). In 2013 the OLEV introduced another big funding program called plugged in places (PiP). For this program eight regions in the UK were chosen, after a selection procedure, to deploy public charge facilities, to give an impulse on the roll out of Electric Vehicles in this regions. Nevertheless Cardiff was not one of them. In 2016 another big funding program was introduced by the OLEV, which was called the Ultra Low Cities. In this program four cities were chosen after a selection procedure. As well as in the PiP program Cardiff was not one of these cities and furthermore, they did not even apply (Go Ultra Low, 2017) At the same time also a new round of the grant scheme for local authorities was announced to help them provide on street charge facilities for residences who were not able to charge their car in their own garage or drive way. This time the scheme was meant for the whole UK.

- Welsh government

The Welsh government has no direct plans to use their own funds to stimulate the EV uptake (Gwen Roberts). Nevertheless, according to themselves, they committed to explore opportunities for increasing the uptake of low carbon vehicles. Currently they mainly let it up to the OLEV and the local authorities. Nevertheless they have installed a research group in 2015 to investigate the needs for Wales to stimulate low emission vehicles development. Recommendations out of this report are barely about charging infrastructure. They stated that current stock of chargers provided by market parties is sufficient enough to serve the current demand from the people (Low Carbon Vehicle Steering Group, 2015).

## 8.2 current situation

### 8.2.1. First impression of EV mobility in Cardiff

Walking through Cardiff makes clear that EV mobility developments is highly invisible, currently. Charging infrastructure is not present in the street and the amount of electric cars that are driving around in the city is scarce. While doing this study the author has been keen on trying to observe electric cars. He lived next to one of the main entrance roads towards the city centre with congestion every day during peak hours. However, on a weekly base two or three electric cars were the maximum that have been observed during the 5 months. Furthermore, within the public fleet also no electrification has been taken place. Busses do all have internal combustion engines and also taxi's are for 99% non-electric. Therefore, on first sight, to understand the implementation process of public EV charge infrastructure in Cardiff would mainly be about why it is not there.



-North road -



- Average taxi-



-bus company-

## 8.2.2. Current EV development in numbers

### Electric vehicles

EV mobility is increasing in the UK. The numbers of sold Electric Vehicles has increased massively in the last 3 years. In the beginning of 2014 less than 10,000 EV were registered in the UK, in the end of 2016 this number was 90,000 (OLEV, 2017). Exact numbers for the registered EV's in city of Cardiff has not been made publically available since 2013. Before 2013 it was, however, since 2013 the amount of sold electric cars has been ten-folded so the numbers have not been considered useful. Only indicator that is considered useful for electric car development in Cardiff is the number of cars in Wales, which was 2012 in the end of 2016 (figure 8.2.2a). Compared to other countries in the UK only Northern Ireland has less electric cars. However, when we take into account the total amount of cars in each country, Wales has the lowest share of electric cars. Nevertheless in general the share of electric cars in the UK is very low. Also when we are looking at the growth of last two years, then Wales is growing much slower than the other three countries.

Figure 8.2.2a: number of EV's in UK (Source: OLEV)

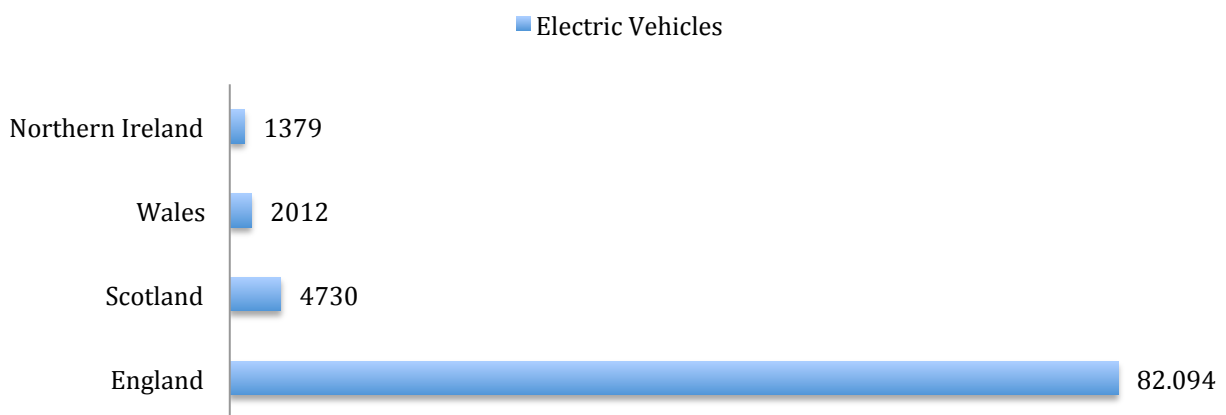


Figure 8.2.2b: EV shares in UK (source: OLEV)

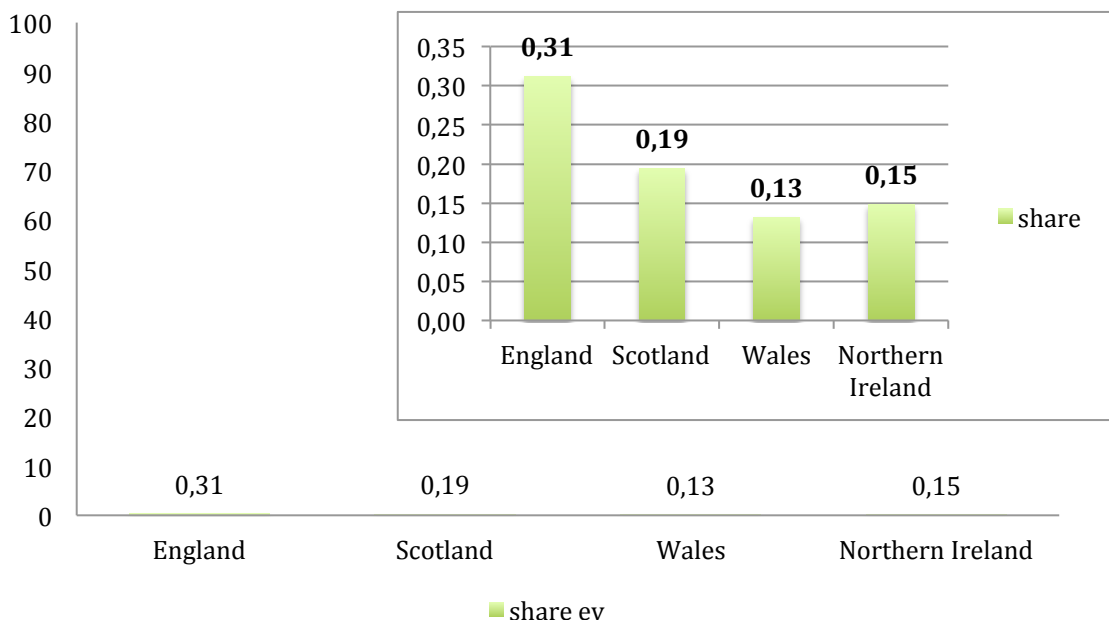
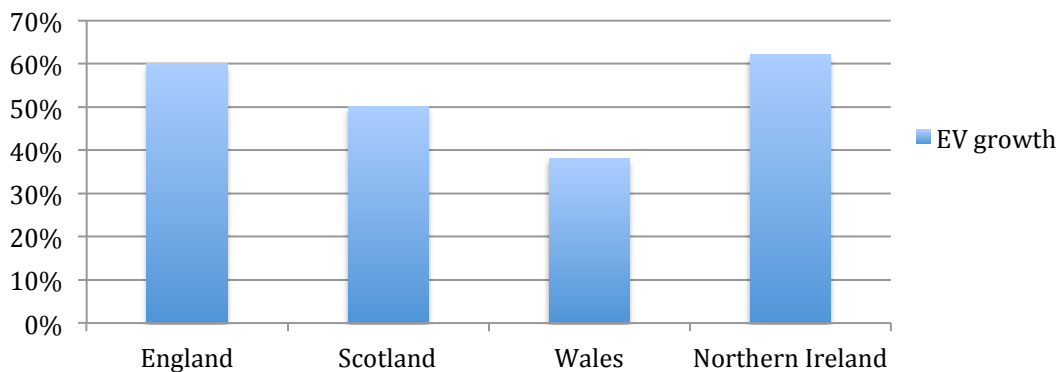




Figure 8.2.2c: EV Growth in UK (2015 – 2017) (source: OLEV)



Looking at how Cardiff is doing regards the electrification of the public fleet not much is going on in first sight. There has no electrification taken place in the bus fleet of Cardiff Bus. Right now all busses have an ICE. Also the recently added (read 2017) busses aren't electric. Also the taxis, which are driving around in the city, are mainly petrol cars (observation). Hard statistics are not available due to the fact that the taxi companies in Cardiff are private hire. Finally, the fleet owned by the government are mainly ICE cars. Even though they have started to replace some of their cars with an electric version (Ramesh Patel). Nevertheless this is barely visible (observation)

### Public chargers

Currently there are 22 (semi) public chargers available in Cardiff (Zap-map, 2017). Most of these chargers are installed in secured car parks. To get access to these chargers you are forced to pay for the car park as well. The chargers are all part of the Polar plus network. Polar is part of Chargemaster, which is an operator who installs and maintains public charge infrastructure in the UK. This means also that the car park company itself does not own these chargers. The chargers who are not located in a car park are situated at Ikea, some hotels and some car dealers are providing chargers, however, these are customer only and thus not accessible for all EV users. None of the chargers are located on street, which means that residents with no off street parking possibility, where they can install their private charger, do have to go to car parks or service points to charge their car.

### Development related to others.

Compared to other Welsh cities as Swansea and Newport, Cardiff is having more chargers, namely, 10 (Swansea) and 8 (Newport). However, it is reasonable to believe that this is caused by the fact that Cardiff as the capital of Wales and so a bigger service area has than the other cities (examples are national sport venues, governmental buildings etc.). And so more chargers are viable for market parties. In total there are 395 chargers in Wales (zap-map.nl). Compared to the amount of EV's this is slightly more than average. However, hotels or fuel stations owns most of these chargers (Zap-map, 2017). Furthermore, there is a EV project in Wales which is called the eco travel network. This network provides around 40 chargers in national park Brecon Beacons, however, most of these chargers can only be used by tourist who rented a twizzy (see picture). The motive behind this project is to do something with the little amount of extra power that is generated by the hydropower plant in this area.



Renault twizy, ecotravelnetwork.co.uk

As already has been observed, compared to the other countries in the UK, Wales together with Northern Ireland is running behind on Scotland and England. England is, regards the number of vehicles and regards the share of the total fleet, frontrunner followed by Scotland. Regards the number of public chargers the same ranking is visible. Nevertheless, if you look at the ratio chargers/vehicles England is the worst. In which way we can use this as an indicator for EV development is difficult. If you compare it to the number one and two regards EV development; Norway and the Netherlands they have v/c ratios of 14 and 3 (EAFO, 2017). Furthermore, if we look at how different cities are dealing with EV mobility you see also differences between English and Scottish cities and Wales and Northern Ireland. Cities like Milton Keynes, Dundee, Nottingham and London are actively trying to promote EV usage in their city (Go Ultra Low, 2017, Paul Niewenhuis, Mark Dale).

Figure 8.2.2d: Public chargers in UK (Source: Zap Map)

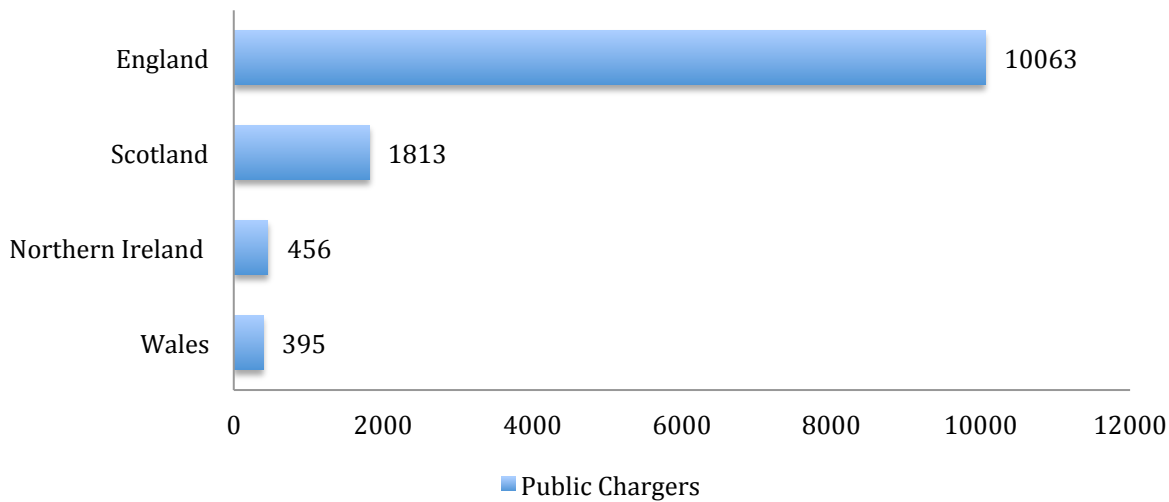
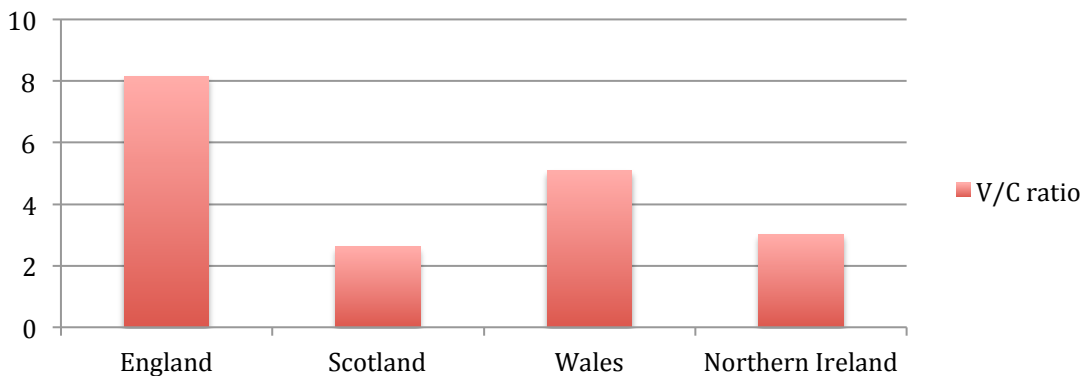


Figure 8.2.2e: Vehicle/Charger ratio in UK



### **8.2.3 current situation explained**

How could be explained the differences between countries and cities regard the development of Electric car mobility and charge infrastructure? Based on the planning system and policies it could be assumed that everybody should develop in the same way. According to the interviewees there are four important reasons (which are partly interrelated) that could explain the difference.

#### **Money**

As we know from chapter 2, public chargers are expensive. One of the reasons that are given by the local authority in Cardiff is that they do not have money for chargers because of their financial resources. However, this is not only the case in Cardiff. Due to economic crisis and other budget cuts in the UK, most local authorities are having not much money to spend (Mark Dale, Jacob Roberts). That is why they have to rely on national government funding to provide charging infrastructure, however, this also applies for other projects that relate to EV mobility, like for example electric busses or taxis. Nevertheless, there is not enough funding for every local authority and therefore bidding procedure take place in which each interested local authority can apply for the money. Depending on the quality of the bid and the amount of money that is available a limited number of local authorities is getting the money. Remarkable enough, if you look at the winners of recent major schemes regards EV mobility and public charge infrastructure, most of them are already very progressive regards EV mobility. For example the most recent big funding for EV mobility and infrastructure in the UK was called the Ultra Low City scheme. For this scheme was 40 million pound of funding available. However, only four cities could get this funding according to the funding conditions. After two rounds of bidding the cities Milton Keynes, Bristol, London and Nottingham won. All of these cities did already a good job in stimulating EV usage in their jurisdiction before they got this new funding. Also the selected cities after the first round were mostly cities that were already 'EV active'.

So how does it come that within same institutional context, in which each local authority has the same chances for money, that most of the time the same authorities get the money? The interviewees were asked for reasons that could explain the differences. Only the reasons are included that were mentioned in more than one interview.

#### **Lack of ownership**

Lack of ownership means that there is not someone within the local authority (LA) who is taking responsibility of this new phenomenon. According to Jacob Roberts this is very important because it makes sure that on the one hand people from the community with questions about EV mobility know whom they have to ask and also people from the local authority itself know where questions have to be redirected. On the other hand someone who takes the responsibility for EV mobility will also be keen when new funding comes available.

“That is the biggest problems for LA outside of London, having somebody willing and capable of taking ownership of a project” (JR)



## **Education**

The level of education regards EV mobility in city councils is an aspect that could also influence the degree of development in city centres. A new phenomenon as EV also knows a lot unknowns. And as city council you have to stay up to date about all these new developments and about what is possible, what is needed and what is effective. In this the earlier you start with paying attention to EV mobility to more educated you will be and in the end you are also able to write more convenient bidding procedures in case new funding comes available. Nevertheless the OLEV tries to do something to help local authorities in writing good bids. They appointed the Energy Savings Trust, an independent organisation that is specialised in sustainable energy and mobility, to help local authorities applying for funding. According to Jacob Roberts some local authorities lack the skills of asking the right questions or they don't even know what to ask.

“Which is personally one the biggest problem LA face is not that they don't know the answers to questions, they don't actually know the questions to ask in first place” (JR)

## **Political attitude**

There is difference in political attitude between different authorities. In the end authorities can spend the money only once and each political party has their own ideals and preferences. Regards EV mobility there are cities that have more the attitude of taking initiative to support EV mobility while other authorities are more demand driven. In other words they wait till locals or local businesses ask them for support or permits.

The first and the most important thing is the politically there is some interest within the council. (JR)

Based on the cleaner air directives from the EU every city has their own ideas how to meet these directives. Cities that think that EV mobility is the solution will be more EV supportive while other have less air pollution problems or have different solutions.

## **Shape of the city & demography**

The shape of the city is also a factor that is mentioned several times during the interviews. This is about the possibility for citizens to charge their car at home yes or no. Home charging is right now the most used way of charging. Therefore in cities where most of the residents have an off-street parking possibility the demand for public charging is much lower (Paul Nieuwenhuis, Mariya Fuijkschot, Jacob Roberts). Besides the shape of the city also the demographic characteristics can be important. For example, in a neighbourhood with no off-street parking possibility and low-income residents, there will be no demand for on street charging facilities. This is due to the fact that these people can't afford an electric car in the first place.

### **8.2.4 Application on the city of Cardiff**

The question now is how do these general explanations apply on the situation in Cardiff?

#### **Lack of ownership**

For Cardiff there is a strong suspicion that lack of ownership could be the case. Paul Nieuwenhuis and Jacob Roberts declared both separate from each other that Cardiff council does not have someone who is responsible for EV affairs. Furthermore, Paul Nieuwenhuis talks in his interview about a company who struggles with setting up an electric taxi company in the city of Cardiff. This company declared later that in their contact with the city council they haven't found the right guy yet, who could help them (Zectra).

Yes, I didn't see anyone there (Cardiff) who was taking proper ownership of it. What happens when nobody takes ownership in essence is that you're never sure where the whole electric vehicle charging responsibility should sit. You could say its part of transport or street lighting or electrical services or environment or even as far as economic development. So if you don't have someone who brings everything together nobody will do anything because it's not his or her job. (JR)

#### **Education**

It was hard to find out exactly what the level of education is regards EV mobility. However, they went to Copenhagen to see how they were doing regards EV mobility, in that case you could think of some extra effort to educate themselves. Furthermore, they have a well motivated strategy regards the stimulation of EV mobility.

#### **Political Willingness**

Based on the interview with Ramesh Patel, the interviewer would describe the political attitude of Cardiff as mainly demand driven, especially during the last five years. With the new cabinet they have just made a small start to encourage others to switch towards electric vehicles. However, regards public charge facilities they embrace the idea of charger follows vehicle. People who want to install a public charger can do a planning application for a permit.

#### **Shape of the city & demography**

Cardiff is a compact city, which makes it possible to drive around the city on one full battery, which makes the need for public chargers lower. However, the compact characteristic of the city does not mean that many residents do not have an off-street parking possibility. Most neighbourhoods in Cardiff do have houses with a driveway. Only in Cathays and Canton off-street parking spots are scarce. However, in Cathays mainly students are living, which is a group of which not can be expected that they buy EV's. Canton more families and working-class people are living. Nevertheless the richest people in Cardiff are living outside the city in more spacious neighbourhoods. Furthermore as has already been mentioned in introduction the region of Cardiff, and Wales in general, is relatively less wealthier than other regions in the UK. Which could explain the lower amount of electric cars and so also less demand for public chargers and in particular on-street chargers for residents.

### **8.3 public chargers in relation towards stimulation EV mobility**

This section is going to look further than the numbers and see what the amount of chargers actually means. The 22 (semi) public chargers in Cardiff are according to the interviewees (Paul Nieuwenhuis and Jacob Roberts) sufficient enough for EV owners that are able to charge their car at home in the UK this around 60% and according to Paul Nieuwenhuis this number is even higher in Cardiff due to the shape of the city. For these people range anxiety seems not to exist objectively. However, the chargers are not visible due to the low number of chargers, which is due to the amount of cars, and the location (in car parks). Therefore we could assume that there is subjective range anxiety. This is also something Jacob Roberts said in his interview.

I think for the current demand it might even be more than enough. But it is almost a case of to actually encourage people to purchase the vehicles and use them. We need to provide more infrastructure than we actually need. We need to provide so much that it almost comforts people to stop them from having range anxiety (JR)

This idea aligns with the approach of Oslo who used the charger to make EV development more visible and so encouraged people to buy a car. Also Paul Nieuwenhuis agrees with the idea that you can encourage EV development by making it more visible. He bases this on personal experiences in which he spoke to people who do not even notice that electric vehicles are already there.

On a regular base, journalist are asking me: “there aren’t driving any electric cars?” then I’m asking if they would recognise an electric car, because if you want to recognise a Nissan leaf or BMW I3 you need to know something about cars. Normal people aren’t noticing that electric cars driving around in the city. The moment you install charging points and electric cars are plugged in you make it all visible. That’s the most important task for charging points in Cardiff. (PN)

Question is if there are maybe other mechanisms to encourage EV development. The local authority for example tries to encourage this development by electrifying their own fleet. Furthermore, electrification of public transport is a mechanism that could work (Jacob Roberts) because they represent a big part of the city fleet and furthermore, they could function as a stimulator of public chargers. Nevertheless due to privatisation the investment possibilities of the public transport sector are low (Paul Nieuwenhuis).

## **8.4 Role of involved actors and their attitudes towards public charge facilities**

Besides the OLEV, as big funder of most of the public chargers in the UK and so possibly for Cardiff on the local scale, four other actors are or could be involved in the deployment of public chargers in Cardiff. These actors are the local authority, distribution network operator, car industry and the charging operator. This section is going to introduce each of them and explain in which way they are or could be involved.

### **8.4.1 Local authority**

In Cardiff the local authority has the authority about everything in the public space. Therefore for the instalment of public charge facilities in the public street, also known as on-street charge facilities, the local authority is also involved. As already mentioned before, right now there aren't any on-street charging points in Cardiff. Therefore, practical examples or experiences of their involvement aren't available. The current attitude of the city council regard public chargers can be described as demand driven. And in case of demand, no public money will be spend to contribute to the instalment of these public chargers (Ramesh Patel). Furthermore, according to Ramesh who, as cabinet member of transport, could have a major influence on EV policies, the responsibility is for the car industry. He believes that the car industry has to push the EV market harder. Besides that also local businesses like taxi and the bus company should start to make the switch first. Special aspect regards the bus company is that the bus company is half owned by the city council. Nevertheless the city council doesn't have the money to invest in it. If this happens then perhaps the local authority is willing to install some on-street chargers. Because then they are sure that the chargers will be used. Otherwise they won't be used, which makes it a waste of public money. This relates to the philosophy of chargers follow the cars instead of cars follow the chargers. Basically the local authority in Cardiff is currently involved on the basis of issuing permits. Therefore potential installers can do an application at the planning department and then the planning committee will decide if the permit will be given yes or no. The only way Cardiff council is stimulating EV mobility is by starting to look at the possibility of electrifying their own fleet and install some chargers on their building sites for these cars. With this they hope to encourage others to make the switch as well.

### **8.4.2. Grid operators**

In Cardiff the Western Power Distribution (WPD) is the distribution network operator (DNO). As a DNO WPD has to make sure that the grid has enough capacity to meet with the energy demand of each citizen. The uptake of electric vehicles and the instalment of charge facilities have an impact on the current grid. Therefore for each charger that is going to be installed and asks more than 3.6KW, which are most of the public chargers, there has to be done an assessment by WPD to see if the network is able to cope with the extra demand. In case the network has to be upgraded, the customer has to pay for it. Therefore in case of the instalment of public chargers in Cardiff, the one who is installing the chargers pays for the potential upgrade.

### **8.4.3. Car manufacturers**

Currently most of the well-known car manufacturers are selling BEV or hybrids. Nevertheless they only sell these cars if there are also chargers available. That is why most of manufacturers include a home charger with the purchase of an EV. These chargers are cheap ones that can be installed at home. However, for people who don't have an off street parking possibility the service of providing a charger is not possible. Reason for this is that the installation of an on-street charger is much more expensive than the home charger. It is even that expensive that it is not a viable business for them. In the end of the day they have to make profit of each sold car and with the provision of public charger they rather do not sell an EV. The only service they provide for this type of customers are some chargers at the dealers' car park, which customers can use without paying. Nevertheless they also say that currently most of the electric cars that are sold to people with an off street car park and so are not depending on public chargers. And as long as this market is still big enough there is no need for car manufacturers to actively involve in deploying public chargers.

### **8.4.4 Charging operators**

At the moment charging operators are the actors that provide most of the public chargers. However, they only provide chargers if they are assured that they will get their investment back. This means that they install public chargers in places where a lot of potential users are available and who are not staying for long periods of time so more customers per day can use the charger. That is why currently most of the public chargers are installed in car parks in city centres and in petrol stations along the highroads. At these places both conditions are met. Furthermore, no permits are needed because they are installed in private property. Regards on street public chargers, the only remunerative ones are in for example cities where electric taxis and busses are driving around. In case of on-street public chargers, meant for residences, none of these conditions are met. First, only one or two residents in the street make use of the charger. Second, the cars are parked for a long period of time in general. Another aspect is the instalment on public land, which includes some extra procedures, regards the permit. Nevertheless charging operators are providing on-street public chargers. However, only in cases where the government is paying a major part of the instalment cost. For example with the new OLEV funding, the government covers 75% of the costs.

## **8.5 What can we expect in the future**

Now we know what the current situation is regards public charging infrastructure and what the attitudes are of involved actors. Nevertheless in chapter 2 we have indicated some uncertainty regards the future. This was mainly about if we would use the same charger or if we maybe are going to switch towards inductive charging. Mark Dale and Paul Nieuwenhuis foresee that inductive charging will not be available on a large scale within the next 10 years due to costs and functionality. Only for busses it could be very useful because they can install them at bus stops and so busses can charge the bus when they stop at the bus stop without taking the bus out of service. With wired charging they need to take the bus out of service to charge (Jacob Roberts). Regards the actual need of chargers is not any sign that says that cars do not need chargers anymore in the future.

Another aspect that seems to be important is the future demand of the grid and how the grid operator can deal with that. The WPD has to do general upgrades to cope with a higher peak demand caused by a higher uptake of EV's. According to Mark Dale with a penetration of 40-60% the costs to upgrade will be around 2.2 billion pounds. However, the money that the WPD has for these upgrades is fixed till 2023. This is due to the regulated character of the company. Due to the monopolistic position of DNO's, the Office of Gas and Electric Markets (Ofgem) has regulated the energy market. The Ofgem is just as the OLEV a governmental body from the UK government. Because of this regulation, the WPD gets money from the Ofgem to maintain the electric grid. The Ofgem gets his money from the energy taxes of UK citizens. These taxes are fixed for 8 years and so also the budgets that are available for the DNO's are set for 8 years. After 8 years a new prize review will be done. Due to all of this, a major uptake, within the next 8 years of EV's and with them a higher uptake of charge facilities could lead to major problems for the grid.

To reduce the amount of reinforcements, the WPD and other DNO's are doing experiments with 'smart' chargers to see how they can manage energy demand for electric vehicles and if customers notice any difference in charging time. These 'smart' chargers make it possible to regulate the supply for car charging during peak demand without doing major upgrades for the grids. However, it isn't required right now to equip chargers with communication devices. From the perspective of the DNO's this needs to be required to safe as much as possible public money. Besides the money issue the WPD also has to deal with a regulatory barrier. The WPD is not allowed to reinforce the grid ahead of the actual demand. If they foresee problems within 3 years for a certain part of the grid they are not allowed to reinforce it now. This could mean that with an rapid increase (think about the s-curve) in penetration of electric cars all the reinforcement have to be done at the same time which could lead to major hindrance in the city when all the streets need to be broken up.

## 9: Synthesis

In this analysis we're going to link back our findings from the case study to the theoretical discussions in chapters 2,3,4 and 5. We can separate 3 aspects first the governance approach will be discussed; second the institutional barriers that can lead to inefficiency are presented and last the stimulation of the innovation will be discussed. These three aspects together will help us answer the main question of this research in the conclusion.

### 9.1 Back to the planning arena

In this chapter we are going to bring everything we have learned from our case study back together in the planning arena.

#### What?

In chapter 2 we have indicated some planning implication based on literature research. Based on the case study we can confirm, refine and make some additions. This in the end will help us formulate a good conclusion.

First we can separate the public charge planning issue into three categories: Transit Charging, Destination Charging and On-street home charging. With transit charging I mean the charging of cars that are on their way from A to B. This kind of charging you'll mainly find along motorways. Nevertheless, in case where public transport in the city electrifies this could also occur in the city centre, because then taxi and busses would need these chargers to rapidly charge their vehicle between shifts (Jacob Roberts). Destination charging means the charging of cars that are visiting the city. These kinds of chargers you'll mainly find in car park facilities. Reason for this is that most people who are visiting the city are parking their cars in these facilities. On street home charging means the charging of cars by people who are living in the city but don't have an off-street parking location. So you'll find these chargers mainly in neighbourhoods. Transit charging and destination charging are characterised by a high frequency of users per day, while on street home chargers only have one or two users. In Cardiff we did not see transit chargers due the fact that there are no electric taxis and busses within the city. Without electric public transport you only see transit chargers near the motorway. Also on street home charging did not exist in Cardiff. Only destination charging in car parks exists in Cardiff.

The cost of transport chargers is indeed high, which makes it a serious investment compared to revenues for the investors. These costs could even rise for these actors when some adjustments have to be made to the grid. Nevertheless, transit and destination charging seems to be remunerative for market parties. In Cardiff the amount of destination chargers was considered sufficient enough for the current amount of electric cars.

If we look at the stage of which Cardiff's electric car development was, we could assume that they are in a very early stage. Moreover if we look at the total amount of electric cars in the UK, none of the four countries have passed a 1% share of electric cars. Therefore from an innovation point of view we could state that none of the countries in the UK has passed the innovators stage. This will be discussed further in the 3rd part of the analysis.

According to Mark Dale it is also in the case of Cardiff reasonable to believe that grid reinforcements have to be executed because of a higher penetration of electric cars and thus more charging. Nevertheless at what point and how much upgrades are needed he couldn't

tell. He only assumed that based on the fact that urban areas already have a high quality grid that the amount of upgrades would be less than in other regions.

In conclusion the indicated uncertainty about if the chargers we use now will be the charger of the future has become less uncertain. The idea of charging while driving which could make the current charging useless, will not be reality within next 15 years. Furthermore, this would be very expensive to install this on every road.

### Who?

Now the question is raised who is involved in the case of Cardiff and how this fits with the hypothetical approach of chapter 3 (see box 1)? Due to the fact that electric car development and the deployment of public chargers in Cardiff are very low, we weren't able to examine the actual process of installing public charging facilities. For example it is hard to tell if the lack of public chargers is due to the fact of a not functioning local authority or just because there is no demand. Therefore this analysis of Cardiff's approach is based on how it should work according to the policies instead of real experiences.

“Based up what we currently know about EV mobility and Governance the best actor seems to be the local government (municipality/city level). They will probably be best able to deal with uncertainty, grid improvement and efficient deployment. Also the local city government should according to the governance theory best be able to include local market parties in this process. These local market parties should be actively involved to reduce the amount of public money. Depending on the amount of chargers and thus the amount of money that is needed for the deployment of chargers or reinforcements of the grid, the national government should be included to overcome issues like economy of scale and to prevent a weak interest, which could lead to inefficiency.”

### Box 9.2: hypothetical approach chapter 3

In Cardiff the market is perfectly capable of deploying a sufficient amount of transit chargers and destination chargers. These market parties are charging operators who are specialised in deploying chargers and also in providing the back office system, which makes sure that people who are using the charger are also paying for the energy they have used. In case these chargers are installed in car parks or private properties (like petrol stations) no involvement of a public actor is needed. In case a charge operator wants to install a charger in a public space within Cardiff they need to go to the permit commission of the local authority. How this works in practice we can't say because of the absence of public chargers in the public space in Cardiff. For the instalment of on street home charging the involvement of a public actor is needed. We argued in chapter 3 that the local authority would be best capable of dealing with this. All the interviewees in this research also confirm this. Regarding the permit for the charger the local authority in Cardiff is indeed involved. However, the local authority isn't willing to pay for this new charger because they don't have the money for it. In other words there is an economy of scale issue. However, in our hypothetical approach we have argued that in that case the central government should support the local authority financially. This is also the case in Cardiff. There are subsidies available in the case of on street home chargers have to be installed. In conclusion, where we thought that the local authority should also be involved because of the grid reinforcements it turns out to be the responsibility of the regional grid operator who is regulated by the national government.



If we use the planning arena again to visualise everything of this section we end up with two separated planning arenas. One that shows the planning issue of transit/destination charging (figure 9.2a) and one that shows the planning issue of on-street “home” charging (figure 9.2b). The on-street “home” charging is similar to our hypothetical approach while the transit/destination charging excludes the financial support from the central government and thus matches the most efficient approach.

Figure 9.2a: Transit/destination

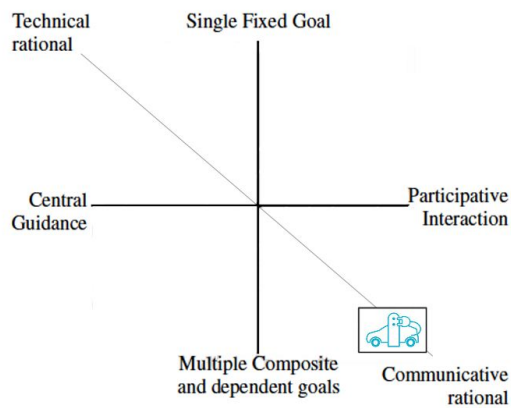
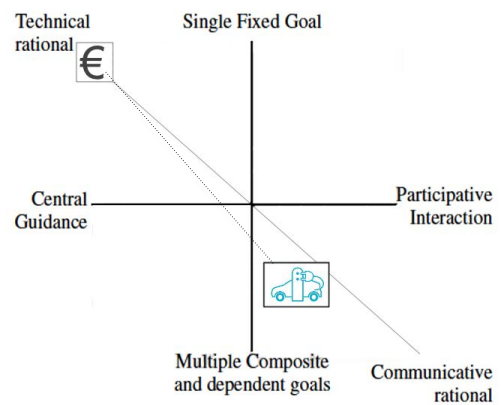


Figure 9.2b: On-street “home” charging



## **9.2 Institutional barriers and opportunities**

Which barriers and opportunities can be observed out of all the findings in chapter 5 and how do or could they influence the implementation process of public charge facilities.

### **9.2.1. Formal**

#### **Indistinctive planning system**

We have indicated in the previous section that due to a low economy of scale the government should provide money to support the local authority in deploying on street home charging. Due to devolution a lot of responsibilities are delegated in the direction of the Welsh government. Because of this, Cardiff needs to go to the Welsh government for most planning issues if they need financial support. However, in the case of EV mobility the responsibility is still with the UK government. Therefore Cardiff has to focus on two different organisations for money. Based on the interview with Ramesh Patel some indistinctiveness about where to go for the money regards public chargers was noticeable.

#### **Bidding procedures**

Another issue regards getting the money is the bidding process. On the one hand you could argue that it's an efficient way of spending money because you are only spending money on good initiatives. However, the requirements for local authorities in applying for funding for public chargers to the UK government is different per scheme. Were the first schemes only for England and not for Wales? At first this doesn't seem like a big thing however we know from institutions that they have a duality of structure, which means that this formal institution influences individuals, which creates informal institutions. With the competitive character of the bidding process this seems to have major influence.

#### **Privatisation**

Another formal institution that obstructs the deployment of public chargers is privatisation in the UK. This influences the implementation process in several ways. First the government only focuses on key subjects and so they rely much more on market initiatives compared to other European countries (Paul Nieuwenhuis). An example of this in Cardiff is that Mr. Patel thinks that the businesses do have to push the EV market first. One of the examples he gave is the public transport fleet that should electrify and so they stimulate the deployment of public charge facilities. However, another effect of privatisation on the deployment of public chargers is that taxi and bus companies are privatised. Because of this the margins are low as well as the room for investments. Therefore, the electrification of this fleet is not possible without governmental support (Paul Nieuwenhuis). In conclusion privatisation produces on the one hand inactivity at the governmental level while on the other side it also results in low investment possibilities of private companies. This all gives a strong feeling of path dependency.

#### **Lack of ownership**

Another formal institution, or the absence of one in Cardiff, is the appointment of someone who takes the responsibility regarding EV issues. Currently it isn't clear who deals with EV issues in the city council. Therefore initiatives and questions from local residents and companies aren't heard and so it obstructs the development of EV mobility.

## **Energy system**

A good example of how hard it is to balance institutions between exploitation and exploration can be observed in the British energy system. The budgets for DNO's are fixed for eight years. Based on this budget, the amount energy taxes for citizens are determined. From an efficiency perspective this is of course very efficient because you only have to do a price review one time per eight years. Furthermore, it gives an incentive for DNOs to operate efficient as possible because they know that they can't get extra money in between reviews. However, the development of electric mobility is increasing so fast that the current budget probably isn't enough even with all the experiments with smart metering. It seems that without extra money from the government the DNOs aren't able to pay for all the reinforcements. However, if they do this they take away the incentive for DNOs to work efficiently as possible.

### **9.2.2. Informal**

#### **Political willingness**

The informal institutions that are observed can act as an opportunity or a barrier as well. First the political willingness of people in the city council is crucial for the implementation of public charge facilities. When people in key positions don't believe in EV mobility no action will be taken. On the other side if there is some political willingness it can promote the implementation process. The political willingness also is strongly related to the lack of ownership. We can assume that when there is political willingness also one person in particular would be appointed to deal with this issue.

#### **Degree of innovativeness**

Another important aspect is the degree of innovativeness of people. This is important throughout all the different actors. When the local community has a low degree of innovativeness no demand for public chargers will be recognised. When the city council has a low degree of innovativeness no action will be taken to promote EV mobility. This relates to the political willingness.

#### **Level of education**

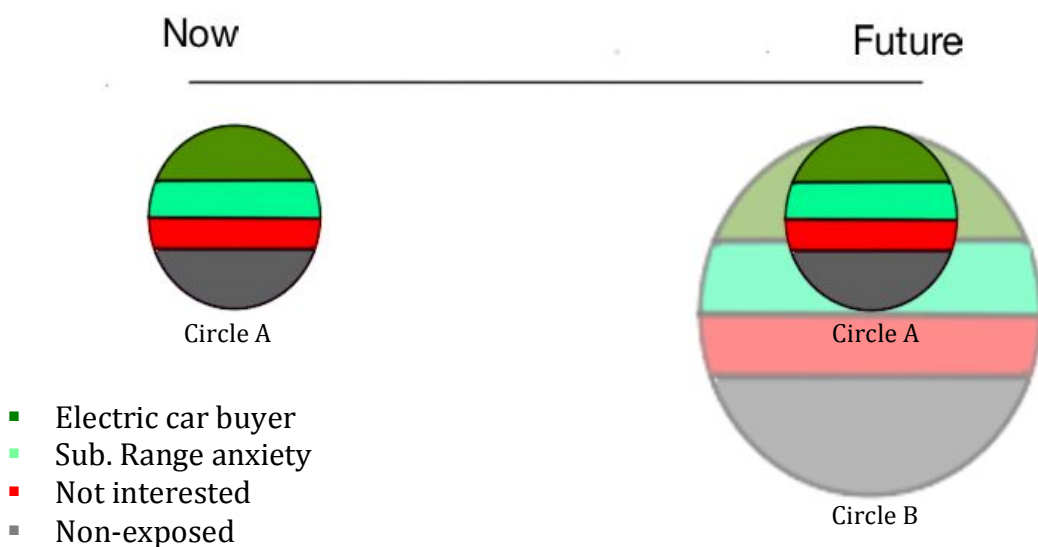
In conclusion, the level of education is important, which overlaps a little bit with the degree of innovativeness. Knowing what needs to be done to promote EV mobility and how you do this most efficient is an important factor according to the interviewees (see chapter 5.4). Part of learning is to practice. By experimenting with EV mobility you are gaining knowledge, which can be used to promote EV more efficiently. Here the bidding process story comes back. In the bidding process a small pattern could be observed in which some cities repeatedly win and other do not even compete. As in the formal institution part it could be read that the first schemes regards EV mobility were only available for local authorities in England. The 8 authorities that applied were able to experiment earlier with this EV mobility than LA outside of England. From this experiments these cities learned a lot about EV mobility and furthermore, the development of EV mobility started earlier. These regions thus have head start in knowledge and in the demand for charge facilities. Because of the competitive character of the bidding procedures these regions have an advantage over the regions like Cardiff. Therefore it's hard to get funding for EV projects like the deployment of public chargers. This problem was also acknowledged for the funding for greener busses from OLEV. The LCV steering group recommended that the Welsh government start their own funding for green busses because the local authorities from Wales weren't able to compete with other local authorities in England.

### 9.3 stimulation of EV mobility

This research started with the idea of the existence of range anxiety. This range anxiety was tempering the adoption of electric cars and therefore we needed more public chargers. However, according to the findings in our case study the amount of chargers in Cardiff and in the UK in general is sufficient enough. Based on what we have observed, range anxiety is not real according to the numbers. It seems that we are dealing with subjective range anxiety. With this is meant that there are enough chargers however, people have the feeling that there aren't because they aren't widely visible. We must ask the question, is the public charger the tool to take this subjective range anxiety away or are there any other tools? According to the interviews the first option is favourable. First, it comforts people (Jacob Roberts) and second it makes EV mobility more visible, which makes the chance of exposure higher (Paul Nieuwenhuis). Furthermore, examples from Amsterdam and Oslo show that instalment of public chargers in the inner city stimulated the uptake of electric car use.

However, looking at the innovation theory by Rogers and the current users of electric cars then you see that financial liquidity is also a very important factor. This relates more with the other variable that influences electric car development, namely, costs of the car. This could mean that even if you are increasing the amount of chargers and increasing the chance of exposure you'll still have a limited amount of people who are able to buy an electric car. Figure 15 shows a schematic visualisation of the potential electric car market. The left circle shows the current group of people who are able to buy an electric car and right the group of people that is able to buy an electric car in the future. Due to the fact that costs of the electric car decreases over time (lower battery costs, higher stocks, second hand market) the potential group that can afford an electric car will grow. Lets assume that in each circle that there is a group that buys a car, a group that doesn't buy it because of range anxiety, a group that is not interested and a group that is not exposed. By installing public chargers the range anxiety group probably buys an electric car and part of the non-exposed maybe buying one. However, this all takes place within a very small group of potential buyers and public money is needed to install these "expensive chargers" because the market only provides what is needed.

Figure 9.3: Schematic electric car market



Assuming that in the near future the prices of the electric car and chargers decrease. The potential group of buyers will increase and this group you will have the different indicated categories as well. However, due to the fact that more people are buying an electric car the amount of public chargers will increase provided by the market (due to more potential users and lower investment cost). Therefore, the chance that the non-exposed group of circle A is getting exposed increases. The only concern is if the range anxiety group gets smaller. Therefore you still could install extra public chargers. You also could teach people that the amount of chargers is sufficient enough and in doing so taking away the subjective range anxiety without installing public chargers with public money.

Finally, there is the group on-street home chargers. This group really needs a charger, which probably needs to be funded using public money. However, without demand you can't install these chargers. The only thing you could do is to make clear that the possibility is there for this group to get a charger in their street.

## 10: Conclusion

This study started with the exploration of the electric car and charging phenomenon. Based on this exploration we were able to define 4 planning implications, which had to be taken into account when governing this new planning issue. After those relevant theoretical debates were discussed which insights were used for the case study analysis. With the synthesis of last chapter we have finalised the 3 step-research strategy. In this chapter we're drawing up conclusions, which mostly means that we are giving an answer to our main question.

In essence the public charging issue isn't very complex and therefore, according to the contingency theory (Porter and Roo, 2016) it could have been governed in very technical rational way and very centralised. However, by aiming for an efficient approach the complexity increases. Reasons for this is that this approach tries to include other actors to share costs and risks, and it aims for tailor made solutions in the way that it only provides what is actual needed. These two aspects do fit a more communicative and decentralised approach (Porter and Roo, 2016; Zuidema, 2016).

Based on the case of Cardiff we can argue that the public charging planning issue can be divided into two separated issues: The transit/destination charging and the on-street "home" charging. The first issue is fully organised by the market. The expectations were that the market would not be interested in deploying public chargers due the high investment costs. However, in our case study it turns out that they are able and willing to deploy a sufficient amount of public chargers. The on-street "home" charging is a different story. For this type of charging market parties are not willing to invest in this type of chargers due to the low users rate. Therefore the government needs to be involved to cover this "service" gap. Still with the idea of tailor made solutions we argue for the decentralised approach. Nevertheless in the case of Cardiff the local authority didn't have to money to pay for these chargers. Therefore, for this planning issue we have to be aware of an economy of scale issue (Zuidema, 2016).

One of the reasons to include a case study was to see how already existing institutions influence the implementation process of this new planning issue. In our case study we have found 4 formal and 3 informal institutions that directly or indirectly influence the process. Some these institutions seem to be easy to change. For example the indistinctive planning system can be clarified or organised in an easier way. Also appointing someone within the local authority who has the responsibility for public charging issues isn't that hard. On the other side the privatisation has already created a certain degree of path dependency, which is according to Rose (1991) harder to change. Furthermore, this research shows that the exploitation character (Nystrom and Starbuck, 1981; Gupta 2011) of the UK energy system could function as barrier for further development of EV mobility in the future.

In conclusion if we look at the "stimulation" part of the question we can argue that range anxiety is subjective instead of objective. Therefore the tempering in electric car adoption is based on a feeling instead of real facts. Question is how to take away this feeling. A successful method in other UK and European cities is the massive deployment of public chargers to comfort people. Furthermore, this strategy increased the visibility of electric cars, which made the chance of exposure greater and thus stimulated the electric car development according to Rogers (2003). However, this strategy involves a lot of public money, which is not desirable and also not reasonable to believe that each city is capable of investing such money. Currently we are in the early stage of the innovation curve used in Rogers' innovation theory (2003) and based on that idea we can assume that the current group of potential buyers

isn't that big, which means that investing in public chargers at the moment would cost a lot of money and would only stimulate a small group of potential users.

In conclusion with this all in mind how can the implementation of public charge facilities in urban areas from a governance perspective be governed efficiently while simultaneously stimulating EV mobility?

For the most case the market is capable of deploying a sufficient amount of public chargers and so range anxiety doesn't exist objectively. For the deployment of on-street home chargers the government, as in the local authority, is best suitable to deal with it. Nevertheless in case of an economy of scale financial support is needed from a higher governmental entity. Furthermore, you have to acknowledge that there are already institutions that could influence the process. Due to the absence of objective range anxiety it's questionable to use public chargers as measurement to stimulate EV mobility. Rather, due the early stages of innovation, I would suggest waiting until a larger group of people is able to buy an electric car. This will save money and will serve more people.

## **11: Discussion**

In general this research has given us a better understanding of the implementation process of public charge facilities. However, there are also still some questions that remain unanswered. From the governance perspective this research tried to answer the what, who and how question. For each question this research made some contributions however, some aspects still remain unanswered. For the "what" question this research has provided the planning implications and also tried to check this in practice to look for confirmation or additions. However, there also still aspects that remain unclear. This research gives the suspicion that range anxiety doesn't exist according to the numbers and therefore extra chargers provided by the government are not needed. However, more research is needed to find out what this range anxiety is based on and if there are different ways of taking it away. Regarding the "who" question this research gives a good insight of the attitudes of different stakeholders and how this eventually could obstruct the most ideal approach. Nevertheless, we have only spoken to one person in each stakeholder group and therefore the evidence is not very strong. Finally, the "how" question in this study couldn't be answered in the way it was aimed for. As in chapter 1 this research tried to address the call from de Lange et. al. (2013) to come up with practical evidence for governance approaches. However, due to the absence of public chargers in the public space no evidence could be generated. With the results of the case study we were only able to come with a more precise hypothesis of how the process will probably work out.

Also in general the very early stage of electric car development in Cardiff has made it hard to come up with good results. For example the lack of ownership could also be caused by the fact that nothing is going on. Our only example of a local demand for public chargers started just a couple of months ago. There is always one that gets the ball rolling and makes the local authority aware of setting up procedures to make the process easier. The lack of ownership is real in Cardiff. However, has this contributed to the low development of electric cars or that the low development of electric cars and thus the lack of demand is the reason that the local authority hasn't attributed someone with this task? Perhaps this case study should be done 5 years from now when there is some more natural demand for public chargers.

## **12: Reflection**

Unfortunately not everything went as anticipated for this study. First of all was Cardiff as a case might not have been the most suitable place for researching the implementation process of public charge facilities. Due to the absence of public chargers an actual analysis of the process itself was not possible. Therefore, I could only talk with interviewees about the a hypothetical process. Furthermore, due to the absence of public chargers involved actors were hard to find and therefore the group of respondents was low. This made it hard to come up with generalised conclusions.

If could have done this research over I would have done things differently. First of all I would have started earlier in contacting potential interviewees, even if it was not yet the research phase. The reason for this is that the interviewees all provided contacts that might also be useful, who I couldn't interview because of time constraints. Secondly I would have instructed my interviewees before the interview about the topic. This would have been much more efficient and saved me a lot of precious interviewing time. During my interviews it sometimes took a while before it was clear what I was looking for due to the language barrier, which was sometimes present.

I think that in general that this study has resulted in very useful insights. Due to the inclusion of all the different actors, it gives a full oversight of the playfield in which this new type of infrastructure is situated. Furthermore, in general I believe that the research strategy itself has proven to be a successful strategy to study new planning issues from a governance perspective and so I would recommend this strategy to others who want to study new planning issues.



### 13: References

Alexander, E. (2005). Institutional Transformation and Planning: From Institutionalization Theory to Institutional Design. *Planning Theory*, 4(3), pp.209-223.

Allmendinger, P. and Tewdwr-Jones, M. (2002). The Communicative Turn in Urban Planning: Unravelling Paradigmatic, Imperialistic and Moralistic Dimensions. *Space and Polity*, 6(1), pp.5-24.

ANWB. (2014). ANWB - Actieradiusproef. [online] Available at: <https://www.anwb.nl/auto/themas/elektrisch-rijden/actieradius-test-elektrische-autos> [Accessed 26 Mar. 2017].

ANWB. (2016). Alle elektrische auto's op een rij - ANWB. [online] Available at: <https://www.anwb.nl/auto/themas/elektrisch-rijden/elektrische-autos/welke-autos-zijn-er/welke-autos-zijn-er> [Accessed 26 Mar. 2017].

Arcus, C. (2016). Battery Lifetime: How Long Can Electric Vehicle Batteries Last?. [online] CleanTechnica. Available at: <https://cleantechnica.com/2016/05/31/battery-lifetime-long-can-electric-vehicle-batteries-last/> [Accessed 26 Mar. 2017].

Bardok, D., van der Giesen, A., van der Linden, C. and Bart, V. (2016). *Plan Amsterdam The Electric City*. Amsterdam: City of Amsterdam.

Buitelaar, E., Galle, M. and Sorel, N. (2011). Plan-Led Planning Systems in Development-Led Practices: An Empirical Analysis into the (Lack of) Institutionalisation of Planning Law. *Environment and Planning A*, 43(4), pp.928-941.

Business Insider. (2017). *The fascinating evolution of the electric car*. [online] Available at: <https://www.businessinsider.nl/electric-car-history-2017-2/?international=true&r=US> [Accessed 21 Feb. 2017].

Campbell, A., Ryley, T. and Thring, R. (2012). Identifying the early adopters of alternative fuel vehicles: A case study of Birmingham, United Kingdom. *Transportation Research Part A: Policy and Practice*, 46(8), pp.1318-1327.

Central Intelligence Agency. (2017). *The World Factbook* — Central Intelligence Agency. [online] Available at: <https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html> [Accessed 26 Mar. 2017].

Chang, D., Erstad, D., Lin, E., Falken Rice, A., Chun Goh, C. and Tsao, A. (2012). *Financial Viability Of Non-Residential Electric Vehicle Charging Stations*. Los Angeles: UCLA.

EC (European Commission) (2008). New air quality directive. Available at: [http://ec.europa.eu/environment/air/quality/legislation/existing\\_leg.htm](http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm) [accessed 16 may 2017].

EC (European Commission) (2009). *R&D involvement in the EU Economic Recovery Plan: focus on the three Public Private Partnerships*. Brussels: European Commission.

Econ analyse (2006) Elbileriernes reisevaner (Travel behaviour of EV owners) Rapport 2006-040. Oslo

Edelstein, S. (2017). How much have electric-car battery costs fallen? This much!. [online] Green Car Reports. Available at: [http://www.greencarreports.com/news/1108199\\_how-much-have-electric-car-battery-costs-fallen-this-much](http://www.greencarreports.com/news/1108199_how-much-have-electric-car-battery-costs-fallen-this-much) [Accessed 26 Mar. 2017].

Egbue, O. and Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, 48, pp.717-729.

EPRI, (2013). *The total cost of ownership model for plug-in electric vehicles*. Palo Alto: EPRI.

Franke, T., Krems, J.F. (2013a) Understanding charging behaviour of electric vehicle users. *Transportation Research Part F*, 21 (2013) pp. 75 – 89.

Ghamami, M., Nie, Y. and Zockaie, A. (2015). Planning charging infrastructure for plug-in electric vehicles in city centers. *International Journal of Sustainable Transportation*, 10(4), pp.343-353.

Giddens A, 1984 *The Constitution of Modernity* (Oxford University Press, Oxford)

Go Ultra Low. (2017). *Who will be the UK's first Go Ultra Low Cities? - Electric cars, low emission motoring - Go Ultra Low*. [online] Available at: <https://www.goultralow.com/who-will-be-the-uks-first-go-ultra-low-cities/> [Accessed 18 May 2017].

Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S. and Bergsma, E. (2010). The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy*, 13(6), pp.459-471.

Healy, P. (1993) The communicative work of development plans, *Environment and Planning B*, 20, pp. 83–104.

Healy, P. (1997) *Collaborative Planning: Shaping Places in Fragmented Societies*. London: Macmillan.

Hjorthol, R. (2013). Attitudes, ownership and use of Electric Vehicles—a review of literature. National Academy of Sciences.

Holtmark, B. and Skonhøft, A. (2014). The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries?. *Environmental Science & Policy*, 42, pp.160-168.

International Energy Agency, 2011. *Technology Roadmap Electric and Plug-in Hybrid Electric Vehicles*. [online] Paris: International Energy Agency. Available at: [https://www.iea.org/publications/freepublications/publication/EV\\_PHEV\\_Roadmap.pdf](https://www.iea.org/publications/freepublications/publication/EV_PHEV_Roadmap.pdf)

International Energy Agency, (2016). *Global EV Outlook 2016 Beyond one million electric cars*. [online] Paris: International Energy Agency. Available at: [https://www.iea.org/publications/freepublications/publication/Global\\_EV\\_Outlook\\_2016.pdf](https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf) [Accessed 17 Mar. 2017].

- Kettles, D. (2015). Electric Vehicle Charging Technology Analysis And Standards. [online] Cocoa: University of Central Florida. Available at: <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1996-15.pdf> [Accessed 26 Apr. 2017].
- Kley, F., Lerch, C. and Dallinger, D. (2011). New business models for electric cars—A holistic approach. *Energy Policy*, 39(6), pp.3392-3403.
- Kim, A. (2011). Unimaginable Change. *Journal of the American Planning Association*, 77(4), pp.328-337.
- Low Carbon Vehicle Steering Group (2015). *Low Carbon Vehicle Report For The Minister for Economy, Science and Transport*. [online] Cardiff: Government of Wales. Available at: <http://gov.wales/docs/det/publications/160322-lcv-steering-group-report.pdf> [Accessed 3 Apr. 2017].
- Lambert, F. (2017). Norway is reaching tipping point for electric vehicles as market share reaches record breaking 37%. [online] Electrek. Available at: <https://electrek.co/2017/02/15/norway-electric-vehicle-market-share-record/> [Accessed 26 Mar. 2017].
- Lange, P., Driessen, P., Sauer, A., Bornemann, B. and Burger, P. (2013). Governing Towards Sustainability—Conceptualizing Modes of Governance. *Journal of Environmental Policy & Planning*, 15(3), pp.403-425.
- Langbroek, J., Franklin, J. and Susilo, Y. (2016). The effect of policy incentives on electric vehicle adoption. *Energy Policy*, 94, pp.94-103.
- Madina, C., Zamora, I. and Zabala, E. (2016). Methodology for assessing electric vehicle charging infrastructure business models. *Energy Policy*, 89, pp.284-293.
- Madawala, U. and Thrimawithana, D. (2011). A Bidirectional Inductive Power Interface for Electric Vehicles in V2G Systems. *IEEE Transactions on Industrial Electronics*, 58(10), pp.4789-4796.
- Molmen, M. (2008). 400 public charging points in 4 years 2008-2011. EV Charging Points Oslo. [online] Oslo: Agency for Urban Environment. Available at: [http://urbact.eu/sites/default/files/import/Projects/EVUE/outputs\\_media/LAP\\_Electric\\_vehicle\\_charging\\_points\\_in\\_Oslo\\_Final\\_01.pdf](http://urbact.eu/sites/default/files/import/Projects/EVUE/outputs_media/LAP_Electric_vehicle_charging_points_in_Oslo_Final_01.pdf) [Accessed 28 Apr. 2017].
- Morrissey, P., Weldon, P. and O'Mahony, M. (2016). Future standard and fast charging infrastructure planning: An analysis of electric vehicle charging behaviour. *Energy Policy*, 89, pp.257-270.
- Morrow, K., Karner, D., & Francfort, J. (2008). Plugin hybrid electric vehicle charging infrastructure review (Technical Report). U.S. Department of Energy Vehicle Technologies Program Advanced Vehicle Testing Activity. Under DOE Idaho Operations Office, Contract DE-AC07-05ID14517.
- Newig, J. and Fritsch, O. (2009). Environmental governance: participatory, multi-level - and effective?. *Environmental Policy and Governance*, 19(3), pp.197-214.
- Nilsson, M. and Nykvist, B. (2016). Governing the electric vehicle transition –Near term interventions to support a green energy economy. *Applied Energy*, 179, pp.1360-1371.

- North, D. (1991). Institutions. *Journal of Economic Perspectives*, 5(1), pp.97-112.
- Norwegian EV Association. (2017). Norwegian EV policy. [online] Available at: <http://elbil.no/english/norwegian-ev-policy/> [Accessed 29 Apr. 2017].
- NPE (2011) Nationale Plattform Elektromobilitaet. Zweiter Berichtder Nationalen Plattform Elektromobilit Berlin, May 2011, p.50.
- Nystrom, P.C. and W.H. Starbuck (1981), 'Designing and understanding organizations', in P.C. Nystromand W.H. Starbuck (eds), *Handbook of Organizational Design*, Vol. 1, *Adapting Organizations to their Environments*, Oxford: Oxford University Press, pp. ix–xxii.
- Olsen, J. (2009). Change and continuity: an institutional approach to institutions of democratic government. *European Political Science Review*, 1(01), p.3.
- ONS. (2015). *Regional gross disposable household income (GDHI)- Office for National Statistics*. [online] Available at: <https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/bulletins/regionalgrossdisposablehouseholdincomegdhi/2015> [Accessed 3 Jun. 2017].
- Pejovich, S. (1999). The effects of the interaction of formal and informal institutions on social stability and economic development. *Journal of Markets and Morality*, 2(2).
- Pierre, M., Jemelin, C. and Louvet, N. (2011). Driving an electric vehicle. A sociological analysis on pioneer users. *Energy Efficiency*, 4(4), pp.
- Rogers, E. M. (2003). *Diffusion of innovations*. New York, Free Press 511-522.
- Rødseth, J. (2009) Spørreundersøkelse om bruk av og holdninger til elbiler i norske storbyer (survey of use and attitudes toward EV in larger cities in Norway). Notat. Asplan Viak AS. Trondheim
- Roo, G. (2004). *Environmental planning in the Netherlands*. 1st ed. Aldershot, Hampshire: Ashgate.
- Roo, G. and Porter, G. (2016). *Fuzzy planning*. 1st ed. London: Routledge.
- San Román, T., Momber, I., Abbad, M. and Sánchez Miralles, Á. (2011). Regulatory framework and business models for charging plug-in electric vehicles: Infrastructure, agents, and commercial relationships. *Energy Policy*, 39(10), pp.6360-6375.
- Schroeder, A. and Traber, T. (2012). The economics of fast charging infrastructure for electric vehicles. *Energy Policy*, 43, pp.136-144.
- Schroeder, A. and Traber, T. (2012). The economics of fast charging infrastructure for electric vehicles. *Energy Policy*, 43, pp.136-144.
- Shoup, D. (2011). *The high cost of free parking*. Chicago: Planners Press, American Planning Association.
- Smith, R., Shahidinejad, S., Blair, D., Bibeau, E. L. (2011) Characterization of urban commuter driving profiles to optimize battery size in light-duty plug-in electric vehicles. *Transportation Research Part D*, Vol. 16 No. 3, pp. 218 – 224.
- Spoelsta, J. (2014) Charging behaviour of Dutch EV drivers. Msc. Utrecht university.

Struben, J. and Sterman, J. (2008). Transition Challenges for Alternative Fuel Vehicle and Transportation Systems. *Environment and Planning B: Planning and Design*, 35(6), pp.1070-1097.

The City of Oslo. (2017). The Electric Vehicle Capital of the World. [online] Available at: <https://www.oslo.kommune.no/english/politics-and-administration/green-oslo/best-practices/the-electric-vehicle-capital-of-the-world/> [Accessed 29 Apr. 2017].

Tran, M., Banister, D., Bishop, J. and McCulloch, M. (2012). Realizing the electric-vehicle revolution. *Nature Climate Change*, 2(5), pp.328-333.

UK Government. (2017). Office for Low Emission Vehicles - GOV.UK. [online] Available at: <https://www.gov.uk/government/organisations/office-for-low-emission-vehicles> [Accessed 18 May 2017].

UNEP (2016). Global Trends in Renewable Energy Investment 2016. [online] Frankfurt: Frankfurt school of finance and management, p.38. Available at: [http://fs-unepcentre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment20161owres\\_0.pdf](http://fs-unepcentre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment20161owres_0.pdf) [Accessed 7 Apr. 2017].

US department of Energy. (2017). *The History of the Electric Car*. [online] Available at: <https://energy.gov/articles/history-electric-car> [Accessed 21 Feb. 2017].

van der Pas, J. (2014). Oslo: electric vehicle capital of the world (Norway) | Eltis. [online] Eltis.org. Available at: <http://www.eltis.org/discover/case-studies/oslo-electric-vehicle-capital-world-norway> [Accessed 29 Apr. 2017].

Vågane, L., Brechan, I., Hjorthol, R. (2011) Den nasjonale reisevaneundersøkelsen 2009 – nøkkelfrapport. TØI-rapport 1130/2011. Oslo: Transportøkonomisk institutt.

Yeh, S. (2007). An empirical analysis on the adoption of alternative fuel vehicles: The case of natural gas vehicles. *Energy Policy*, 35(11), pp.5865-5875.

Zuidema, C 2016, Decentralization in environmental governance: A post contingency approach. Routledge, Abingdon

## **14: Appendices**

### **Interview guide:**

What is your role/organisation's role regards public charge facilities?

What do you think of the current development of Electric cars in Cardiff/UK?

What do you think of the current amount of public chargers in Cardiff/UK?

Who should be best able to implement public charge facilities?

How would you explain the difference between different UK Cities?

What needs to be done to stimulate electric car development?

