THE ROLE OF VEHICLE-TO-GRID SYSTEMS IN THE ENERGY TRANSITION

Lessons from Smart Solar Charging in the municipality of Utrecht

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Preface

Before you lies the thesis for the master of environmental and infrastructure planning at the university of Groningen. During my bachelor study in spatial planning my interest in energy was born, from where the logical choice to start with this master originated. My special interest goes out to the current energy transition and its new technologies that emerge from innovation. As an admirer of Elon Musk, my subject for my thesis had been found relatively easy. When I saw an episode of the Dutch programme "Tegenlicht" about a new technology that integrates the battery of the electric car together with solar energy in a smart grid, I was determined to focus my research on that topic. In this way I arrived at Smart Solar Charging, located in the municipality in Utrecht. Studying this topic in relation to environmental and infrastructure planning was not easy, but I still finished this master thesis with satisfaction. However, I could not do it without the help of my supervisor, dr. Ferry van Kann. A special thanks goes out to him in always having confidence in my work and helping me in my process writing this thesis. Furthermore, I really want to thank the interviewees for having the time for me to have do an interview and participating in my research. And last, but certainly not least I want to thank my girlfriend and my family who were always there for me in supporting me and listening to my struggles with regard to my thesis. Finally, I hope you enjoy reading my thesis.

Steijn Coenraad van der Zwaag
17-05-2017

Abstract

Our energy system is currently undergoing a fundamental change, referred to as the energy transition. The last recent years it became evident that our current energy system is not meeting the needs of the future. Fossil fuels are currently used as the main source of energy in supplying our society. However, these sources cause serious damage to our climate and global system by emitting i.e. greenhouse gasses. In order to cope with global change the fundamental change towards an energy system based on renewables is needed. As this topic is receiving more attention recently new technologies emerge that could help us realizing this fundamental change. From those technologies is photovoltaic power the fastest growing renewable energy source in the world and are electric vehicles also a growing technology with a remarkable pace. However, these technologies also oppose challenges as they are putting pressure on our electricity system on the demand and the supply side respectively. Therefore, new energy management systems are needed that could integrate such technologies in a smart way. Vehicle-to-grid, as a new form of smart grid, is such a technology that integrates electric vehicles and photovoltaics in a smart way by using information and communication technology. In the municipality of Utrecht the world's first publicly used vehicle-to-grid system is introduced, called Smart Solar Charging. This thesis studies the case of Smart Solar Charging in order to make implications on what role and how vehicle-to-grid systems can play in the current energy transition towards renewables. Therefore the main research question of this thesis is; *"What role can vehicle-to-grid systems play in the energy transition, based on lessons from Smart Solar Charging in the municipality Utrecht?"*.

Based on the lessons from Smart Solar Charging in the municipality of Utrecht through a multi-level perspective it becomes clear that these systems as local innovations could have a catalysing effect on the current transition as it is a promising technology that could avoid a lock-in of our current energy system. However, by following the steps of the transition management-cycle, it becomes also clear that the potential role of vehicle-to-grid systems is limited due the lack of a supporting institutional framework on a national level, in a formal and informal manner. The fossil energy regime still has to much influence, which limits the potential role of these systems, which in return also has a potential constraining effect on the energy transition, although it is needed relatively fast.

Keywords: energy transition; photovoltaic power; electric vehicles; vehicle-to-grid; Smart Solar Charging; transition management; multi-level perspective; innovation; institutional design.

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Abbreviations

BEV	Battery Electric Vehicle
BNEF	Bloomberg New Energy Finance
CBS	Central Bureau for Statistics
EBU	Economic Board Utrecht
EFRO	European Fund for Regional Development
EU	European Union
EV	Electric vehicle
GEA	Global Energy Assessment
GHG	Greenhouse Gas
GW	Gigawatt
HU	University of Applied Sciences Utrecht
IEA	International Energy Agency
IenM	Ministry of Infrastructure and Environment
IPCC	International Panel on Climate Change
KNMI	Royal Dutch Meteorological Institute
LMS	Last Mile Solutions
Mton	Megatons
MW	Megawatt
NAM	Dutch Petroleum Organisation
NEV	National Energy Outlook
NGO	Non-Governmental Organization
NMU	Nature and Environment Federation Utrecht
NOS	Netherlands Broadcasting Foundation
OECD	Organisation for Economic Co-operation and Development
PBL	Dutch Environmental Assessment Agency
PHEV	Plug-in hybrid Electric Vehicle
PV	Photovoltaic
RVO	Netherlands Enterprise Agency
SER	Social Economic Council
SSC	Smart Solar Charging
TM-cycle	Transition Management-Cycle
TM	Transition Management
TNO	Dutch organisation for Applied Scientific Research
USI	Utrecht Sustainability Institute
UU	University of Utrecht
V2G	Vehicle-to-grid
WDS	We Drive Solar

1. Introduction

Energy is everywhere around us. It is one of the most needed and crucial things in life, without it we are helpless. However, our dependence on energy also brings serious risks. The generation and consumption of fossil fuels is causing serious damage and without change this is set to rise (See IPCC, 2014; IEA, 2016ba; KNMI & PBL, 2015). Therefore a fundamental change is needed in the production and consumption of energy, called the energy transition. The energy transition brings challenges and opportunities for (spatial) planners, in which many developments rise and fall in the social and political arenas.

In 2015 a new innovation has been introduced in the energy and mobility market, called Smart Solar Charging (SSC). This innovation has made it possible to integrate solar photovoltaic (PV) power with electric vehicles (EV) in order to realise a sustainable energy system on a district level. SSC is based on vehicle-to-grid (V2G) technology and the first solar controlled charging station in the world (van Hooijdonk et al., 2015; EBU, n.d.). This new concept of smart grid is realised by the SSC consortium in the municipality of Utrecht. Although SSC as innovation is promising, barriers have to be overcome to play a substantial role in the energy transition. In this challenge planners could play an important role. For this reason this thesis is about drawing lessons from the role of Smart Solar Charging in the municipality of Utrecht, in order to explore what role V2G systems could play in the energy transition. After an introduction on the topics of climate change and energy, solar PV, electric mobility, V2G systems and Smart Solar Charging, the research questions will be elaborated on.

1.1 Climate Change and Energy

Society's strong dependence on energy threatens our long term existence. The consumption of fossil fuels is causing serious damage. Emissions from greenhouse gasses (GHG) are increasing and reaching new peaks. As a result the temperatures of the atmosphere and water are increasing, icecaps melt and the sea level has been rising for years through expansion of the water (IPCC, 2014 p2). Climate change has a worldwide impact on humans and nature. According to the IEA (2016a) around 6.5 million people die because of poor air quality, which makes it our world's fourth highest threat to human health and without changes in production and consumption of energy this number is set to rise. In most industrialised countries the amount of pollutant emissions are already declining, but not fast enough to meet the projected one-third rise in global energy demand. The polluting emissions pumped in the air in developing areas, such as Asia and Sub-Saharan Africa, outweigh the progress made and projected for the coming years in the more developed OECD member countries. Through projections made by the IEA (2016a) it is expected that for the coming years the amount of premature deaths is also set to rise because of the lack of progress in limiting air pollution by developing countries. For the Netherlands the risks of climate change are worrisome. Due its i.e. high population density, intensive land use and low altitudes the majority of the Netherlands is vulnerable for flooding with potential disastrous consequences (KNMI & PBL, 2015 p43). Based on the latter reasons, the GEA (2012) argues that a transformation of the current energy system is needed to address the previously mentioned global issues.

Through the recent years there have been multiple attempts to address the issues of climate change, such as change summits in i.e. Rio de Janeiro in 1992, the Kyoto protocol in 1997 and the recent summit in Paris in 2015. The latter global attempts are means to change the way governments steer society top-down towards a sustainable energy system. Besides, there are also attempts to change the way individuals think about climate change and energy in order to initiate bottom-up change. In developed countries there is already a change noticeable over the past ten years in the attitude towards climate change of governments, policymakers and planners, as well in the attitude of individuals. Nowadays individuals and authorities are more and more willing to change towards a sustainable energy system. Moreover, the opportunities to exploit this change are increasing too, although exploiting them happens not fast enough (GEA, 2012). We still have a long way to go before we reach a significant decrease in GHG's that neutralises the current negative effects of climate change. At the moment we are attempting to constrain the continuously increasing amounts of GHG's, although a real decrease is needed really fast to neutralise the negative effects.

Besides the need for a transition due issues of climate change, the Netherlands has strong geo-political dependence issues. Currently, the Netherlands is strongly dependent on the import of fossil fuels from mainly Russia. One of these fuels is oil, which accounts for a 24.5% share of the Dutch end-consumption of oil in 2014 (CBS, 2015a). As it is hard to predict Russia's political developments we also want to become less dependent on countries like Russia. Hence, we want to avoid geo-political dependence.

Dealing with these issues of climate change and energy is often seen as a complex challenge. Still, this fundamental change needed, referred to as the 'energy transition' (Rotmans et al., 2001). In 2007 the European Union (EU) has set the target to reach a share of 20% of renewable energy of the total energy consumption by 2020. This set the objective for the Netherlands to reach a share 14% by 2020 (EU, 2009). Therefore the SER(2013) has set the goal to reach a share of renewable energy production of 14% by 2020 and 16% by 2023 for the Netherlands written in the 'Energieakkoord voor duurzame energie' (SER, 2013). However, besides other EU member states, especially the Netherlands is struggling in how to approach the energy transition in order to reach their 2020 goal. Until 2014, they only managed to reach a share of 5,6% renewable energy of their final energy consumption (figure 1). Moreover, the recent Dutch 'National Energy Outlook (NEV) 2016' found that the 2020 target will presumably not be reached. Nevertheless, the NEV also states that the 2023 target in renewable energy share is in sight (Schoots & Hammingh, 2016a;2016b). However, it remains to be seen if these targets will be reached.

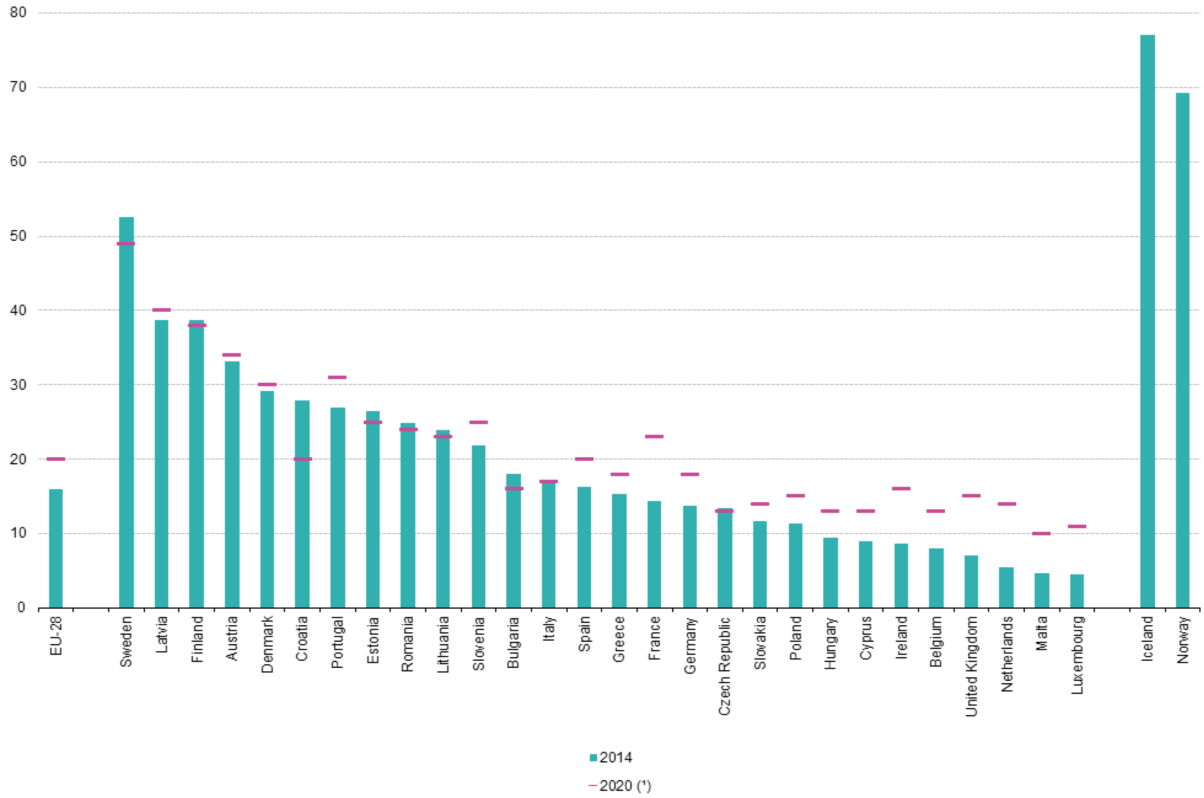

Figure 1. Share of renewables in gross final energy consumption 2014 and legally bindings targets for 2020 (%) (Eurostat, 2016).

From a planners point of view, the shift to an energy system based on renewables is also regarded far from easy (de Boer & Zuidema, 2015). The infrastructure of the current energy system is not only based on fossil fuels, it also includes multiple actors on different scales with various interests and resources**.** Moreover, ownership and power are fragmented within the current system. The latter results in the complex web that characterizes the current energy system. This complexity of the energy systems asks planners to come with new approaches. One specific challenge with regard to these new approaches for planners, according to de Boer & Zuidema (2015), is that many small scale local energy initiatives are not part of the existing energy network. This asks for reconsideration of how these can be integrated with the existing energy system. In dealing with such issues, planners have an important role.

1.2 Solar Photovoltaic Power

Wind, solar, hydro energy and biomass as renewable energy sources are on the rise. In 2015 clean energy investment records were broken and are currently more than twice the investments in fossil fuels, even excluding hydro energy (Randall, 2016). The NEV (Schoots & Hammigh, 2016a) also notes a shift in investments in the Dutch energy system, in which investments in renewable energy sources are strongly on the rise and investments in fossil energy will probably drop from the current 50 percent to approximately 30 percent by 2020.

Of all renewable energy sources, solar PV the most promising one regarding its annual growth rate. The IEA (2016b) notes that between 1990 and 2014 the primary energy supply globally for solar PV grew with 46.2% annually. This growth rate makes PV by far the fastest growing renewable energy source globally. In comparison, wind energy, the second fastest growing renewable energy source, had an annual growth rate of 24.3 % in this period. In OECD member states the growth rates are quite similar between 1990 and 2015. For PV the annual growth rate is 44.1% and 22.1% for wind energy. It further notes that there will be a quintupled use of PV until 2030. This makes PV fastest growing renewable energy source in OECD countries too (IEA, 2016b). The NEV (Schoots & Hammingh, 2016b) notes that PV growth rates are slightly lower compared to wind energy in the Netherlands. However, the difference is relatively small. The capacity of PV (see figure 2) in the Netherlands grew from 0.09 GW in 2010 to a remarkable 1.5 GW in 2015, which is more than 16 doublings of capacity since 2010. This capacity is expected to grow towards 4 GW in 2020 (PBL & DNV GL, 2014). The main reason, according to a Bloomberg analyst (Randall, 2016), for the remarkable growth of PV is that it is a technology and not a fuel. Therefore, efficiency increases and prices fall over time. Given its promising developments this thesis is focused on solar photovoltaic power.

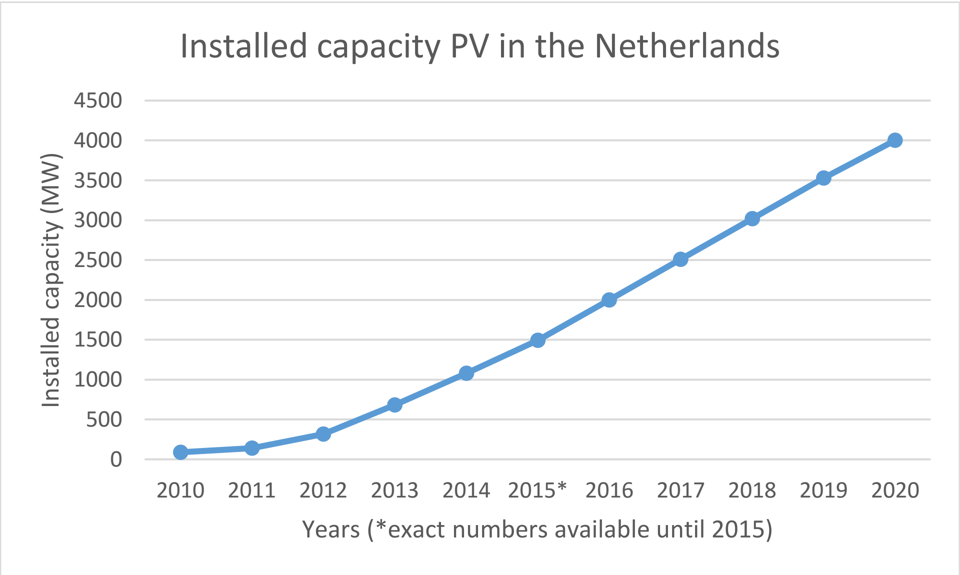

Figure 2. Capacity of PV in the Netherlands in MW (author, based on PBL & DNV GL, 2014).

1.3 Electric Vehicles

Currently, the transport sector is one of the sectors contributing most to climate change. The transport sector accounts for 23% of the global energy-related GHG emissions (IEA, 2016c). The IEA (2016c) further notes that an ambitious reduction of GHG emissions to limit climate change is unlikely to be achieved without a major contribution by the transport sector. In 2014 only 3.9% of the transport sector's final energy use came from renewable energy. Although, this percentage lies higher in OECD countries with a 10.2% within the transport sector (IEA, 2016b). The low percentage within the transport sector relates to the fact that the majority of all the vehicles worldwide currently are focussed on fossil fuels.

Nevertheless, besides PV another technology is on the rise, electric mobility. The emergence of EV's opens up a lot of opportunities in making the transport sector more sustainable. Nowadays, it is getting more attractive to drive an EV. The GEA (2012, p31) note that: *"electrically-powered transportation reduces final energy use by more than a factor of three, as compared to gasoline-powered vehicles"*. Moreover, the IEA (2016c) also note that full-electric battery vehicles can achieve an efficiency four times higher than an internal combustion engine vehicle, which is an huge improvement. In addition, TNO (2014) found that the use of an BEV (full-electric battery vehicle) over a complete life cycle results in approximately 35% less CO_2-emissions in comparison to a normal combustion car. Moreover, these CO_2 profits will grow stronger in the future as the share of renewables in the electricity generation is expected to increase. Furthermore, TNO (2014) and GEA (2012) found that the CO_2 benefits of EV's further increase when they are used in urban areas. In comparison, in these circumstances a normal combustion car normally becomes even more polluting.

For PHEV's (plug-in hybrid electric vehicle) the charging behaviour is of great influence to its CO_2-emissions, which is makes their sustainability uncertain. Through the analysis of 'charging scenario's' TNO (2014) found that, in case of charging a PHEV two times a day the CO_2-emissions were comparable to that of an BEV. However, if a PHEV is charged much less with electricity, thus uses more fossil fuels, the CO_2-emissions over its whole life cycle could transcend those of a normal combustion car. For this reason this thesis excludes PHEV's, hence the term EV also excludes PHEV's from now on. However, PHEV's are still more popular than BEV's in the Netherlands. Nevertheless, the annual growth rate of BEV's in the Netherlands lies on a promising 37% from the end of 2012 until the end of 2015 (RVO, 2016).

Still, the IEA (2016b) notes that only when EV's are coupled to a decarbonised grid the environmental benefits of EV's are fully exploited. As discussed in the first section the share of electricity produced from renewables is still only 23% in OECD countries (IEA, 2016c) and for the Netherlands this only 10% in 2014 (CBS, 2015b). The GEA (2012) argues that by the mid-century the electricity sector in particular will need to be almost completely decarbonized in reaching sustainability goals. Given the fact that EV's are much less polluting than normal combustion cars, the low shares show the potential, thus the need of electrification of the energy grid for further exploitation of the environmental benefits of EV's.

1.4 A New Innovation

In the previous chapters the rise of PV and EV's are discussed as promising technologies towards a sustainable energy system. However, the rise of PV and EV's put pressure on the current electricity grid locally, which sometimes even leads to local grid breakdowns. A recent example is the case of the municipality of Bedum in the province of Groningen (van Trommelen, 2016; NOS, 2016). As a compensation for inflicted damage by the extraction of natural gas in the region, affected inhabitants from several municipalities received a compensation of 4000 euro's from the NAM. The compensation was meant to be used to increase their properties' value through energy saving or energy generating means. This resulted in a huge increase in demand and installation of solar panels in i.e. the municipality of Bedum. The result during 'sunny days' was that the electricity grid in Bedum could not comprehend the amount of voltage in the grid produced by generated electricity by PV's. In 2016, due to too much generated electricity, electrical break-downs hit the grid several times. According to Enexis, the grid operator in the region, it was an incident. However, according to inhabitants it also happened a year earlier in another municipality. Moreover, in other nearby municipalities the voltages were also almost too high for the grid to comprehend. Similar grid issues with wind energy have already occurred in nearby countries, such as Denmark and Germany a couple of years ago (Goudsmit, 2005).

To deal with such issues adaption of the grid is needed in order to deal with the rise of PV and other renewables, and EV's that put pressure on the current electricity grid. As a result, grid operators are forced to come with new ideas in dealing with these issues. A solution could be strengthening the electricity grid. But this could lead to unexpected high investments in the grid (Schoots & Hammingh, 2016b). Nevertheless, storage of electricity as alternative becomes more interesting as the capacity of batteries increases together with the rise of EV's (IEA, 2016c). In addition, in reaching major progress towards a sustainable energy system the GEA (2012) states that we need *"Energy storage: rising requirement for storage technologies and 'virtual' systems (e.g. smart grids and demand-side management) to support system integration of intermittent wind and solar.* So, smart energy management through smart grids, is seen as a potential and needed solution for integrating local intermittent renewable energy initiatives with the current energy system.

An increasingly interesting form of smart grid is vehicle-to-grid (V2G) technology, through which the batteries of EV's are used as storage for locally produced electricity. In this way EV's function as buffer system to the local electricity grid, which ,therefore, could prevent local grid issues. Moreover, it could also has its benefits for prevention of unexpected investments for grid operators in the existing grid infrastructure. The integration of PV in the current energy system through V2G technology could also have an accelerating effect on the energy transition. Smart grids and V2G systems is more extensively elaborated on in chapter 3.

An example of a V2G system is Smart Solar Charging, located in the municipality of Utrecht. SSC is the first public V2G system based on solar PV in the world (van Hooijdonk et al., 2015; EBU, n.d.). As it is the first public V2G system in the world, potential lessons can be drawn from the case of SSC in order to explore the potential role of V2G systems within the energy transition. SSC is more extensively elaborated on in chapter 3.

With respect to the energy transition and in particular the role of V2G systems within the energy transition, planners can have different roles. A planner’s role of directing, steering, managing or mediating in the field of energy could, therefore, have many different perspectives. Although, for every different perspective it essential to know the context in which a planner acts. This thesis studies the role SSC in the municipality of Utrecht in order to explore the potential role of V2G systems in the energy transition. In this study contextual knowledge is used to build a framework in which the planner acts as an advisor. In this way the planner presents policy recommendations and new insights on the topic of the thesis. From this perspective a framework is built around Smart Solar Charging. Based on this framework the potential role of V2G systems in the energy transition is explored by drawing lessons from the role of Smart Solar Charing in the municipality of Utrecht. The findings will provide an input for the results which are finally presented from the perspective of an policy etrepreneur, and more specifically in an institutional design.

1.5 Research Outline

In order to provide the reader a pleasant reading experience this section elaborates on the research outline. Throughout this thesis the main focus is on the role of Smart Solar Charging as an innovation in the Dutch energy transition, from which implications can be made towards the potential role of vehicle-to-grid systems in the energy transition.

In the last chapter, background information on energy, solar PV and electric mobility is given as an introduction to Smart Solar Charging as a V2G system. In chapter 2 there will be elaborated on the research questions of this thesis based on the background information from the introduction. In chapter 3 background, information will be presented more extensively on vehicle-to-grid systems and the case of Smart Solar charging in the municipality of Utrecht.

In chapter 4, theoretical framework on system change, the theoretical framework will be given and discussed, which is used as theoretical guide in understanding the role of SSC in the municipality of Utrecht and the potential role of V2G systems in the energy transition. In chapter 5 the methodology of the thesis is explained and discussed. Chapter 6 will present the findings and the results of the thesis. Finally, conclusions, a discussion and a reflection will be given in chapter 7.

In the next chapter the research questions will be elaborated on given the background information from the introduction. From now on, V2G systems solely refer to systems based on PV as the scope of the thesis excludes other forms of renewable energy.

2. Research questions

The main objective of the thesis is to explore what role vehicle-to-grid systems as local innovations can play in the energy transition.

The main research question of the thesis is:
“What role can vehicle-to-grid systems play in the energy transition, based on lessons from Smart Solar Charging in the municipality Utrecht?”

The following sub-research questions are underlying the main research question:

1. *How can vehicle-to-grid systems as local innovations play a role in the integration of solar photovoltaic power and electric vehicles?*
2. *How does Smart Solar Charging as local innovation plays a role in the municipality of Utrecht?*
3. *What are stimulating and constraining factors in the development of vehicle-to-grid systems?*
4. *How can vehicle-to-grid systems play a role in the Dutch energy transition?*

2.1 Structure Thesis

This thesis consists out of the following five parts: background, theoretical framework, methodology and data collection, findings and results, and conclusions and a discussion.

First, in chapter 3 ‘background’ additional theoretical and practical information is given and discussed to create a more profound understanding on the topics of the thesis. Theoretical background is given and discussed on smart grids and V2G systems and how these can these systems can contribute to the integration of EV’s and PV. Finally, information about Smart Solar Charging in the municipality of Utrecht will be given as a case description.

Secondly, the theoretical framework is given and discussed in chapter 4. In this chapter a framework is given in which theories of planning, systems, transitions, institutions, and the diffusion of innovations are discussed. These theories constitute the framework, which provides as guiding principle in understanding the role of SSC in the municipality of Utrecht and the potential role of V2G systems in the energy transition.

Thirdly, the methodology of the research in this thesis is described in chapter 5. Direct observation and semi-structured interviews are used as means to collect empirical data. These methods are chosen in order to collect needed data.

Fourthly, the findings and results from the analyses of the data are presented in chapter 6. The analyses of the data is done on the basis of the theoretical framework.

Finally, conclusions based on the findings and results, a discussion on the limitations and recommendations from the research, and a reflection are given in chapter 7.

2.2 Conceptual Framework

Figure 3 represents the conceptual framework of this thesis. The model consists of five main parts. The first part represents existing background information that provides an understanding about the concepts that are part of the research in the thesis. These are coloured purple. Background information on the development of photovoltaics and electric vehicles can be found in the introduction. These two concepts lead to a new concept of V2G technology, called Smart Solar Charging, which is the case under research in this thesis. An extensive explanation of the case can be found back in chapter 3, the background.

The second and third part are coloured blue and represent academic literature. The second part represents background literature which can be found back in chapter 3. In chapter 3.1 the concept of V2G systems is explained and discussed as SSC is an innovation based on this form of smart grid technology. Based on the this section, sub-research question one can be answered. The green part within the energy system block, is the transition of the current energy system towards a renewable energy based system, which is still a partly unknown area.

The third part, also coloured blue, represents the theoretical framework of this thesis. The theoretical framework is represented in blue blocks at the bottom of the model and is discussed in chapter 4. First, as the energy transition is a planning issue about a system change characterized by complexity, an understanding on complex systems in relation to planning theory is essential. Complex systems are a relatively new concept within planning theory, which is derived from systems theory, which is discussed in chapter 4.2 and planning theory is discussed in chapter 4.1. Transition theory is characterized by systems thinking and is based on thinking in complex systems. Transition theory is, therefore, discussed in chapter 4.3 and it is also used to frame the findings in a meaningful way through perspective of the transition management cycle in order to say something about the potential role of V2G systems in the energy transition. Within transition theory, regimes and niches play a crucial role in the multi-level concept. Theory about institutions can help to create an understanding about regimes, while theory on innovations could help to create an understanding about niches. Institutions, therefore, are discussed as part of transition theory and diffusion of innovations theory is discussed in chapter 4.4. The theory on transitions, institutions and innovations are used to set up the interview guide for the stakeholder interviews. These interviews are used to collect empirical data about the role of SSC in the municipality of Utrecht and its relation to the energy transition.

The fourth part, coloured yellow, represents the collected empirical data regards SSC, which is collected to support the collected data from the desk research. There has been chosen for *data triangulation* (see chapter 5), in which a thorough desk research is supported by a direct observation and semi-structured interviews. In chapter 5, the methodology is further elaborated on.

The fifth and final part is coloured red and represents the findings and results of the thesis, which has been done in an iterative way. With the collected data sub-research questions two, three and four can be answered on the hand of transition theory in chapter 6. Finally, based on the answers of the sub-research questions, the main research question about what role vehicle-to-grid systems can play in the energy transition can be answered in chapter 7, conclusions and discussion.

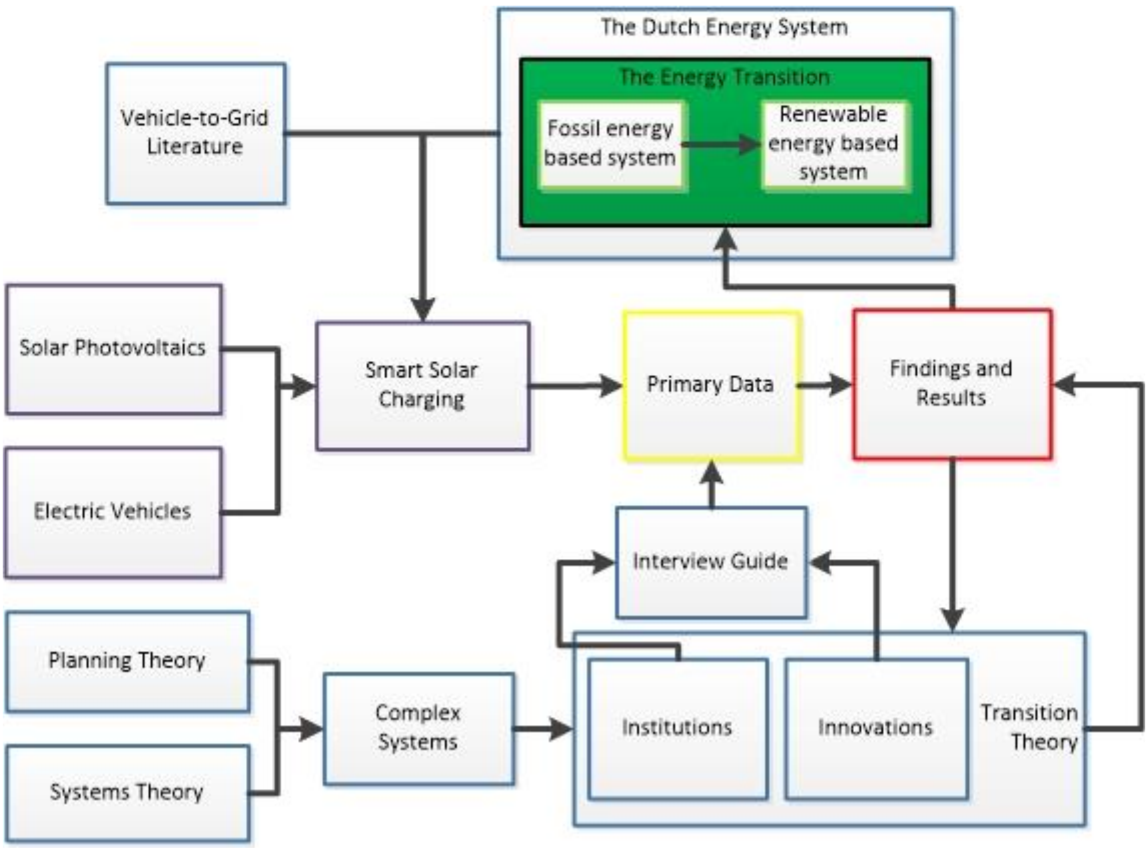

Figure 3. Conceptual framework thesis (author).

3. Background

In this chapter background information will be given and discussed on the concepts of smart grids and vehicle-to-grid systems, and the case of Smart Solar Charging. First, a discussion based on academic literature will be presented on smart grids and vehicle-to-grid systems in chapter 3.1. This will contribute to the understanding how these systems can play a role in the integration of photovoltaics and electric vehicles, and which potential effect these systems can have on the energy system. Secondly, the case of Smart Solar Charging, as vehicle-to-grid system, in the municipality of Utrecht will be explained in chapter 3.2. Finally, a summary of the chapter will be given in chapter 3.3.

3.1 Vehicle-to-Grid Systems

In chapter 1 it became clear that local energy initiatives are not part (yet) of the existing energy infrastructure, which could cause problems within the electricity grid. These challenges with the local electricity grid are expected to increase with future developments on the demand side by i.e. EV's (figure 4) and on the supply side by i.e. PV. The large scale introduction of PV and EV's is, therefore, expected to pose great challenges to the ageing electricity grids in the Netherlands (Verbong et al., 2013). However, challenges are not only related to the supply and demand side. PV as intermittent renewable energy source, also has no constant electricity generation which makes it even harder to cope with by the current grid (Bellekom et al., 2012). Therefore, van der Kam & van Sark (2015 p20) argue that: *"The transition to low carbon energy and transport systems requires not only the large-scale adoption of clean technologies and efficiency measures, but also new energy management strategies to efficiently incorporate these innovations in the existing infrastructure."* One of these new energy management strategies are smart grids. The idea of smart grids is that they control energy loads by using information and communication technologies to ensure the stability of the grid (van der Kam & van Sark, 2015). Integration challenges with renewable energy sources to the existing energy infrastructure could be ensured by implementing smart grid technologies. In smart grids residential end-users are expected to play a more active role in the management of the electricity system (Geelen et al., 2013). The role of end-user lies in the self-consumption of PV as self-consumption of PV increases the stability and functioning of the energy grid. However, this cannot just be simply controlled by residents themselves. This is where the smart grid technology brings solution. By using the information and communication technology implemented in the grid electricity loads can be shifted, which can be used to increase self-consumption of PV power (van der Kam & van Sark, 2015). This way of load shifting is then used as a way to ensure stability within the electricity grid.

A new concept of smart grids emerged recently, namely V2G systems. The generation of electricity by PV, which happens mostly during the day, causes an imbalance between the supply and demand side within the electricity grid. This is because most people leave their residents during the day. The V2G technology uses EV's connected to the grid as battery storage systems for generated electricity from solar panels. When the information system of the system recognizes a lack of electricity in the grid during the morning and evening, the load of the battery can be released. In this way the EV's within the V2G system function as a buffer system. In addition, the system also prevents overloads by reducing the peaks the electricity grid. The result is an flattened electricity demand curve which ensures more stability in the electricity grid (figure 4; figure 5).

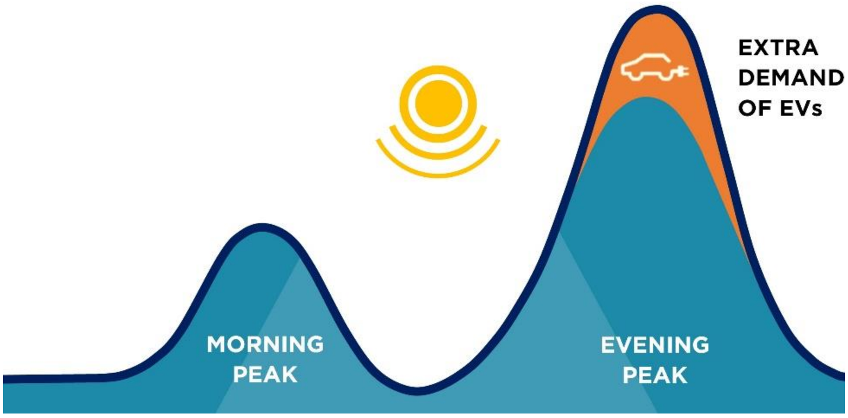

Figure 4. Electricity loads in current energy infrastructure (Resourcefully, 2016).

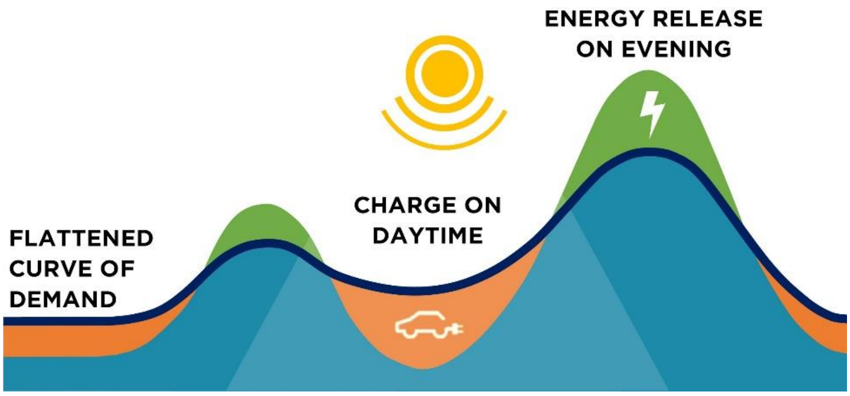

Figure 5. Electricity loads in current energy infrastructure in combination with V2G technology (Resourcefully, 2016).

Van der Kam & van Sark (2015) studied this new concept of smart grid in the district of Lombok, Utrecht. This V2G system was studied in a real life case, called Smart Solar Charging, which is also the case studied in this thesis. Based on the results from their study they argue that V2G systems clearly could have their benefits on reducing negative effects on the existing infrastructure by combining sustainable energy (PV) and transport technologies (EV) in a smart way.

In conclusion, it can be argued that vehicle-to-grid systems could have a catalysing effect on the energy transition in two different ways. First, it has a stabilizing effect on the electricity infrastructure, which enables better integration of renewable energy sources, such as PV, within the current energy system.

Secondly, it enhances sustainable mobility by encouraging the use of electric vehicles. Based on the latter it can be said this new concept of smart grid could play an important role in the transition towards a future energy system based on renewables.

3.2 Smart Solar Charging

In the district of Lombok, Utrecht the world's first public V2G system is used as a pilot, called Smart Solar Charging (van Hooijdonk et al., 2015; EBU, n.d.). This local innovation will function as case to draw lessons from in order to explore what role V2G systems can play in the energy transition. The following section will give a description of the SSC case. The case description is based on information from an official letter of intent by the SSC consortium (van Hooijdonk et al., 2015), documents from LomboXnet (2016) and the EBU (n.d.), and smartsolarcharging.eu (2016).

Before SSC existed, a local corporation in the district of Lombok was set up to realize fibre based internet based on local generated electricity from PV. This corporation is called LomboXnet and is leaded by its CEO Robin Berg. From there Robin Berg started deploying more PV on the roofs of local schools and the idea for implementing V2G technology emerged. Therefore he initiated the SSC consortium, in which LomboXnet functions as technical leader and in which many different stakeholders contributed to the realisation of the bi-directional SSC charging station. This bi-directional charging station makes it possible to charge and discharge EV's, which is essential to V2G technology. The project who launches the whole concept of SSC publicly is the organisation We Drive Solar (WDS), which technically its own foundation and part of the SSC consortium. Robin Berg is director of all three organisations (LomboXnet, SSC, WDS). The SSC consortium consists furthermore out of the different stakeholders which are shown in table 1.

Organisation	Role within consortium
LomboXnet	Technical Leader, local corporation
Utrecht Sustainability Institute (USI)	Knowledge institute on sustainability
General Electric Benelux	Developer charging station
Last Mile Solutions (LMS)	Software developer Charging stations
We Drive Solar (WDS)	Shared EV project based on SSC
New Solar	Solar Consultancy Company
Vydin	Specialist in connection technology
Jedlix	Application developer EV charging
Stedin	Regional Grid Operator
University of Utrecht (UU)	Regional Knowledge institute
University of Applied Sciences of Utrecht (HU)	Regional Knowledge institute

Table 1. The Smart Solar Charging Consortium.

The Smart Solar Charging Consortium is further supported by Renault, which provided the EV's for the WDS project and several other organisations, such as the municipalities of Utrecht, the bank of Triodos and the province of Utrecht. In January 2017, the first 20 EV's, model Renault Zoe, are in use in the municipality of Utrecht as part of the WDS project. WDS is based on a sharing concept on the basis of the V2G system of SSC. This means that the V2G system of SSC is used publicly by individuals and companies under the name of 'We Drive Solar'. The project is located in the district of Lombok, Utrecht (figure 6). The blue and green dots are the public charging stations reserved for WDS EV's in the area. The blue ones represent one parking place and the green two parking places.

The sharing concept refers to being member within the WDS project in which the EV's are used by multiple members. The sharing concept is aimed at car reduction as congestion increases in the region (van der Waard & Meijles, 2015). Nevertheless, to avoid miscommunication the term SSC also refers to WDS project in the rest of the thesis, as WDS can be seen as part of SSC.

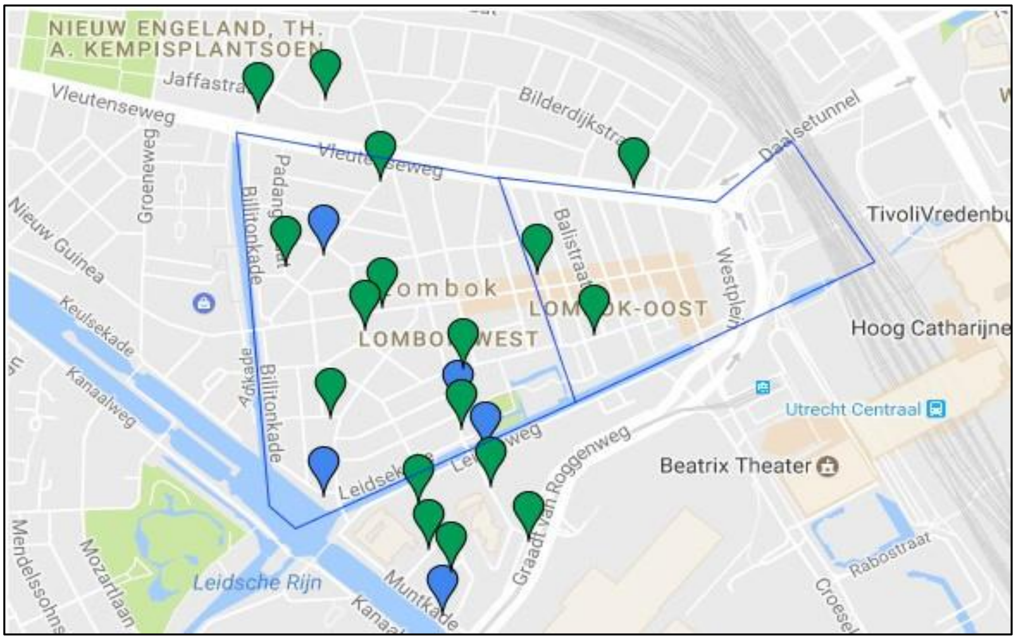

Figure 6. District of Lombok and its charging stations (Author, based on Lombox.nl, 2017).

3.3 Summary

In chapter 3.1 smart grids were discussed as a emerging technology to manage electricity systems. It became clear that smart grids are a promising technology in stabilizing our electricity grid. More specifically, vehicle-to-grid systems as a new concept of smart grid was also discussed in chapter 3.1. These systems stabilize the electricity grid by combining technologies of sustainable mobility and sustainable energy in a smart way. In doing so, vehicle-to-grid systems could ensure electricity grid stability, which therefore enables better integration of renewable energy within the current energy system. In this way vehicle-to-grid systems could act as a catalysing factor within the energy transition towards an energy system based on renewables.

A real life example of a vehicle-to-grid system is presented in chapter 3.2, which is called Smart Solar Charging. This case is the first public local vehicle-to-grid system based on photovoltaics. Local electric vehicles are used as local storage system for the locally generated electricity from solar panels. Smart Solar Charging will be used as case in this thesis the find out what role it plays in the municipality of Utrecht. On the basis of those findings the potential role of vehicle-to-grid systems within the energy transition will be explored.

However, first a holistic view about different perspectives on discussed topics has to be created. Therefore, the next chapter will provide a theoretical framework based on academic literature in order to create an understanding about the topics and make potential future implications based on the findings.

4. Theoretical Framework on System's Change

In this chapter the theoretical framework of the thesis is presented. The framework is focused on how system changes come about and by which factors these changes get constrained or stimulated from a planners perspective. First, planning theory and systems theory are discussed in chapter 4.1 and 4.2 in order to frame the energy transition as a planning issue based on complexity and complex systems. Secondly, in chapter 4.3 transitions theory is discussed as a theory that explains changes in complex systems. Thirdly, in chapter 4.3 institutions as part of the regimes are discussed and in chapter 4.4 innovations as part of niches within transition theory are discussed to get a deeper understanding of the interactions in transitions through a multi-level perspective. Finally, a synthesis and a conceptual model are given on the hand of the discussed theories in chapter 4.5 and 4.6 respectively.

4.1 Planning Theory

What is planning and what is theory on planning? The answer to this question is not a simple one, as is its application in practice. Planning theory is an ongoing discussion about thoughts in and of planning (Allmendinger, 2009). Planners try to allocate these thoughts in a wider frame of reference. Moreover, planning has its roots within the realm of philosophy and general sciences in which two extreme thoughts of rationality emerged. Planning theory, therefore, could be theory about bridging the gap between these thoughts within the realm of decision-making in relation to the physical environment. These philosophical thoughts or rationalities are based on modern and post-modern thinking. In this sense we could see planning theory as a framing theory that brings the two extremes of philosophical thoughts within planning together. These movements of modernism and post-modernism keep the discussion about thoughts in and of planning going for over the past decades. Modernism, which was later linked to the philosophical thinking of Aristotle, sees the world in an object-oriented way, in which observations and facts construct reality as a certainty. In this reality there is a factual world, which can be completely understand if one has the resources. On contrary, we have post-modernism, which is linked to the ideas of the philosopher Plato. Post-modernism sees the world in a subjective-oriented way, in which there is an agreed reality based on our imagination. In this reality nothing is certain and everything is subjected to perspective.

This ongoing discussion about thoughts in and of planning instigated planning paradigms in which planners agree on a certain worldview within planning theory in a certain time. At the very beginning of planning theory everything in planning was based on facts and certainty. After the 60's it became evident that in reality not everything is completely certain, which lead to critiques from scientists, such as Herbert Simon. He putted bounded rationality as one the most principal critiques to technical rationality (De Roo, 2010). From that moment technical rationality within planning theory was more seen as the 'primitive optimism' from the '50's and other planning ideas and techniques developed. This resulted in a shift from objected-oriented to inter-subjective oriented approaches, in which post-modernism thinking was central. This more inter-subjective rationality based planning lead to the long-during communicative planning paradigm from the ‘90’s onwards (Allmendinger, 2009). The communicative rational planning approach is focused on reaching consensus among individuals through communication. Figure 7 shows the emergence of planning concepts based on the technical and communicative rationality in contemporary planning. It further shows the emergence of planning concepts based on sociology, through general sciences and philosophy.

Although the communicative paradigm was strong among planners for a long period, the last recent years planning theory moved towards a new perspective based on complexity. Where previous planning debates approaches planning issues as static problems, this new perspective includes time and non-linearity (de Roo & Porter, 2012). The current energy transition as a planning issue is much characterized by complexity. It is therefore that this thesis approaches the energy transition as a planning issue based on complexity. Complexity theory emerged out of systems theory. Consequently, a further understanding of complexity within planning can be derived from systems theory, which will be discussed in the next section. Through the inclusion of complexity thinking within planning theory, other planning concepts emerged. One of these concepts is transition theory, which will be discussed in the section 4.3.

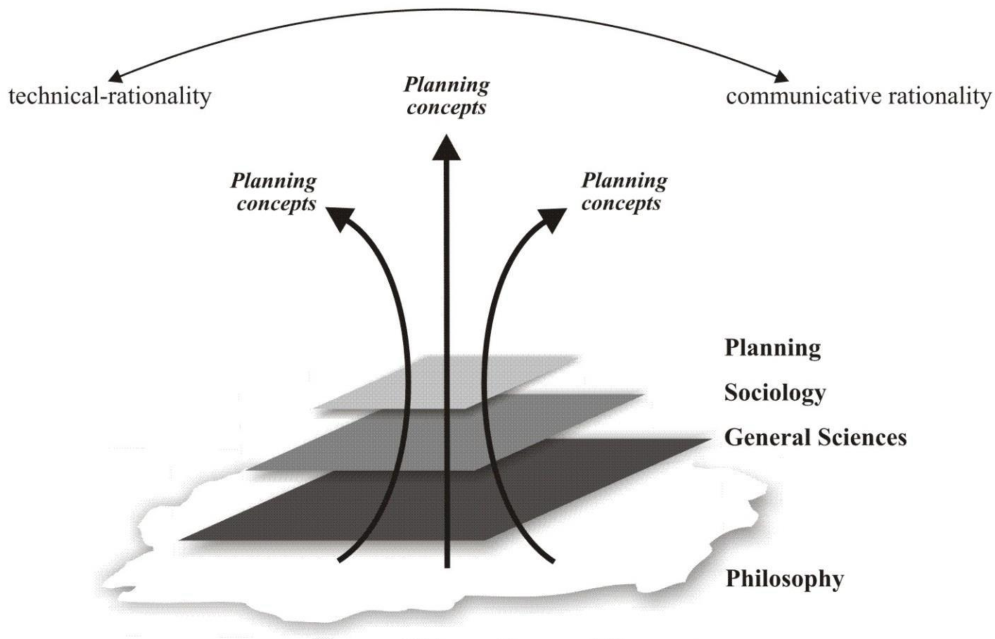

Figure 7. Contemporary planning theory (De Roo, 2010)

4.2 Complex Systems

As mentioned before is the current energy transition characterized by complexity, and therefore logically can be seen as a complex planning issue. But what is complexity and where does it comes from? This section explains that planning can be seen as interventions in systems, in which complexity thinking recently gained more attention. Moreover, de Roo (2010) even claims that systems theory surpassed planning theory in their way of thinking. He argues that systems theory already includes time and non-linearity, where planning theory remains more *'atemporal'*.

In systems theory reality consists of entities and their interactions (de Roo, 2010). These parts and their relationships define a system. Within systems theory there are different classes related their parts and their relationships. First, from a traditional, functional worldview the first concepts in planning theory were based on the idea of closed systems. These system are not subjected to change and they can be fully known. De Roo (2010) calls these class I systems. In a class I system were therefore based on the idea of direct causal relationships and clear components. During the post-war period the idea of fully known and predictable systems was left because of its primitive thinking approach. The alternative to these systems was based on the idea of feedback, or circular systems. De Roo (2010) calls these class II systems. Class II systems relate to scenario approaches in planning theory, in which planners first evaluate different alternatives prior to taken decisions. However, these feedback systems also received criticism because of their relatively technical rational approach. The alternative emerged from class II systems was based on network systems. In network systems the focus is on interaction between actors, rather than on the physical identity of the issue. In this shift, the attention also shifted from object-oriented approaches to intersubjective approaches within planning. De Roo (2010) calls these network systems, class III systems. These systems are characterized by non-predictable patterns and is related to communicative planning paradigm.

Although it seems that these classes and their related planning concepts cover all worldviews in planning, there is a class IV system. This system relates to the *'becoming'* instead of the *'being'*, as de Roo (2010) refers to it. In other words, time becomes relevant in this class, hence a non-linear kind of complexity is taken into account (figure 4.2). Class I to class III all refer to more or less static systems, whereas class IV refers to complex, non-linear systems. These complex systems are furthermore more characterized by flexibility and robustness. A complex is flexible as it is constantly subjected to changes, internal and external, while on the other hand it remains its original function, which makes it robust.

The energy transition fundamentally changes the current societal system from one state to another (Loorbach, 2010). This societal system is constantly subjected to dynamic changes over time in all aspects of society. From economics, demography to our climate. De Roo (2010) refers to these constant internal and external changes in a complex system as the *'becoming'*. Moreover, due liberalization of the market, decentralization in nation-states and centralisation to supranational levels of government the interconnectedness and complexity of the societal system even increased (Loorbach, 2010). It is therefore, that a societal system cannot be seen as a static system as its constantly subjected to changes, while at the other hand it maintains it function of being society. Thus, it can be said that the societal system, defined by its entities and nodes, refers to a complex system, which is characterized by non-linearity, self-organisation and evolutionary behaviour. It is therefore that the energy transition inherently is a complex planning issue.

A planning concept that helps us to understand complex system dynamics and how to manage them is transition theory. Transition theory is based on complexity and system thinking and will be extensively discussed in the next chapter in order to understand the dynamics of the current energy transition as a complex planning issue.

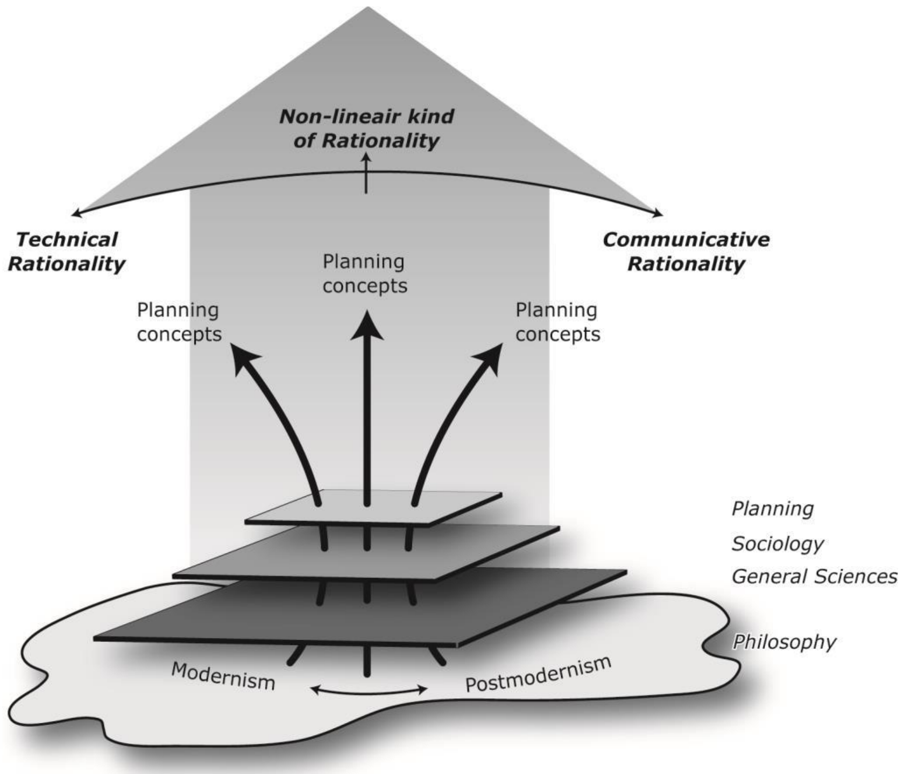

Figure 8. Beyond contemporary planning: the inclusion of non-linear development over time (de Roo, 2010).

4.3 Transitions in Complex Systems

From the previous chapter it became clear that in case of the energy transition we deal with a complex system change as a planning issue that is characterized by non-linearity. Transition theory as a planning concept could help us to understand the deeper mechanisms of such system changes and how to potentially manage them. The following chapter will first explain what transitions are and how they are related to complex systems. After that a concept will presented that explains how to steer or govern these complex systems through transition management (TM).

Transition theory emerged from complexity theory and is based on systems thinking, as mentioned previously. Rotmans et al. (2001) and van der Brugge et al. (2005) describe transitions as gradually continuous changes that change the structure of a complex system, such as a social system. This happens over a period of at least one generation or 25 years. A complex system could also refer to a sub-system part of a wider system, such as the energy system. Transitions develop from one relatively stable dynamic equilibrium to another relatively stable dynamic equilibrium. Between these equilibria slow long-term trends and quick short-term developments result in the co-evolution of the different sub-systems of society (ecological, socio-cultural, economic, institutional, technological). *Co-evolution* is the interaction of these developments between different complex systems in society. A pre-requisite for a transition to happen is that these developments interact in such a way they reinforce each other.

From a systems point of view transitions have three different dimensions. The first dimension is the *speed of change*, which relates to the pace of a transition from one to another relatively stable dynamic equilibrium. The second dimension is the *size of change*, which relates to the size of the system where the transition takes place. The last and third dimension is the *time period of change*, which relates to the time period the transition moves from one to another relatively stable dynamic equilibrium. Besides a systems point of view, van der Brugge et al. (2005) mention three key concepts that form the basis of transition theory, namely the *multi-stage concept*, the *multi-level concept* and *transition management.*

First of all, transitions develop in very distinctive manner. Their development is characterized by an S-curve divided in four different phases, which is called the *multi-stage* concept (figure 9). The first phase is the *pre-development* phase where there is no visible change in the status quo of the social system. The second phase is the *take-off phase*, where the transition process gets on his way because the structure of the system starts to change. In the third phase, the *breakthrough* or *acceleration* phase, visible changes take place because of the accumulation of socio-cultural, economic, ecological and institutional changes, that are interrelated. In this phase there are also learning, diffusion and embedding processes, which will be discussed in the next section. In the fourth and final phase the transition reaches the *stabilization* phase, where the speed of the change decreases and a new dynamic equilibrium will be reached. Although these phases seem very deterministic, the concepts of speed and acceleration are relative. In other words, transitions contain periods of slow and fast development, which are like shocks in time. Nevertheless, although these concepts are relative it can be implicated in what the state of the current energy transition is according to the previously discussed characteristics. It also may be clear that co-evolutionary behaviour in every societal sub-system should reinforce each other in order to enable the transition towards renewables.

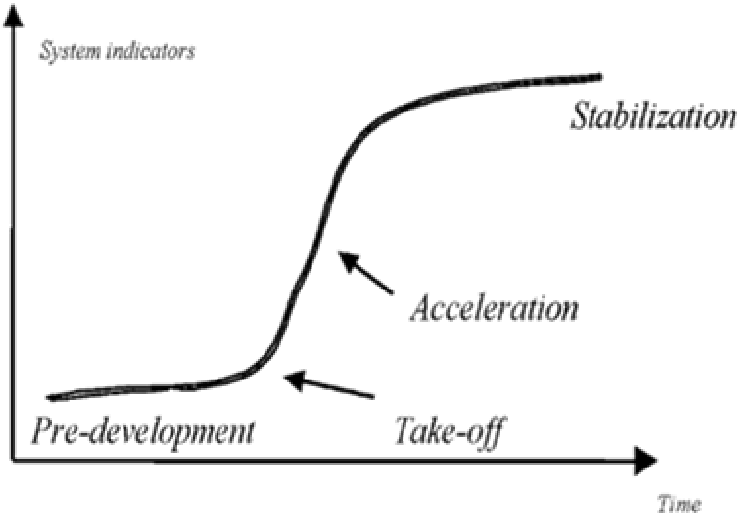

Figure 9. Multi-phase concept (Rotmans et al. 2001).

4.3.1 A Descriptive Approach

The second key concept of transition theory is the *multi-level* concept. From an organizational point of view, changes on the long- and short-term happen on three different societal levels, which interact with each other. Rotmans et al. (2001) describe these levels as the micro, meso, and macro-level. The lowest level, or micro level compromises the level of individual actors such as individuals and companies. The middle level, or meso level compromises the networks, organizations and communities. The highest level, or macro level compromises the nations and states. According to Rotmans et al. (2001) these levels are very useful in the analysis of broad societal changes. Transitions can be analysed through the *multi-level* concept (figure 10) based on the multi-level perspective from Geels and Kemp (2000, in Rotmans et al., 2001). The macro level relates to the *socio-technical landscape* where elements such as the macro economy, demography and the natural environment develop. These developments are characterized by relatively slow trends and dynamics. The meso level relates to the *regimes*, which are the dominant structures in our society, such as regulations, rules and shared assumptions. Important here is that the regimes also guide our private actions and public policies, which is often towards optimising rather than transforming a system. That is why regimes often act as the inhibiting actor within a transition. Besides, as the regimes guide our private actions, institutions play an important role on this level. The micro level relates to the *niches*. These niches, formed and created by individuals and individual actors, are the new ideas or innovations that deviate from the status quo.

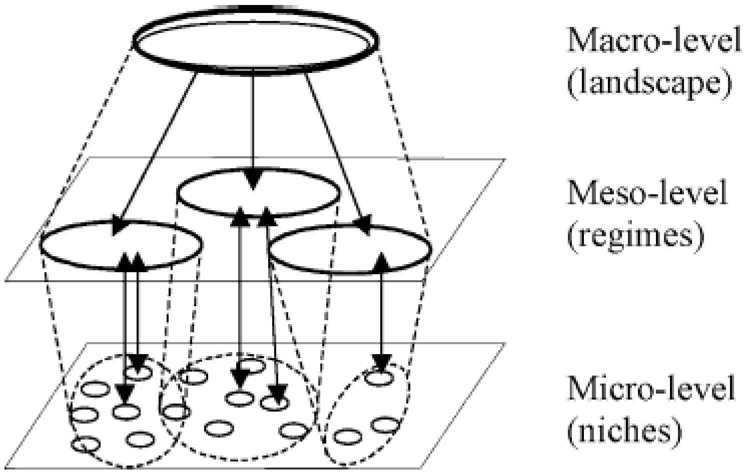

Figure 10. Multi-level concept (van der Brugge et al. 2005).

The continuously interaction of the macro-, meso-, and micro level could result in a transition (Rotmans et al., 2001). On a macro-level, slow long-term trends change the socio-technical landscape, which exert external pressure on the meso level through top-down developments. The pressure is put on the existing regimes, which react to these changes. Social technical change could lead to changes within the existing regimes, such as behavioural or policy changes. These changes could unfold in the take-off phase, starting a transition. On a micro level, niches create new techniques and practices that deviate from the status quo, which exerts pressure on the regimes from bottom-up. If such a new techniques or practices are surrounded by learning processes and they are well established on the micro level, it could break through into the meso level as a *niche-regime*. Such a niche-regime could further enable a transition that has been started due external pressures from the macro level on the regimes at the meso level. As a result from these internal bottom-up and external top-down pressures the regimes gradually change, resulting in a transition. However, dependent on the resistance of the regimes towards these pressures they can contribute actively to the transition or not, which could be crucial for a transition to happen.

However, it is until now that the Dutch energy system has been driven more by liberalisation and Europeanisation as trends from the social-technical landscape rather than by environmental concerns (Kern & Smith, 2008; Verbong & van Vleuten, 2004). The latter caused the problem that the social-technical landscape until now has not put any serious pressure on the regimes from a macro-level.

Moreover, the regimes are often the inhibiting factor in a transition, which especially applies to the Netherlands, where the energy regime is a strong one (Kern & Smith, 2008). This has to do with the path-dependency of its energy system, which is determined by past experiences and is place dependent. Due to the discovery of large supplies of natural gas in the Northern part of the Netherlands and later on in the North Sea the gas market grew enormously. Crucial for the expansion of the gas market was a political agreement between the Dutch government and two oil companies as a new institutional framework (Verbong & van Vleuten, 2004). This resulted in a public-private companies, such as the Gasunie and the NAM, which also became an exporter of gas across national borders. The NAM is still important to the Dutch government with the extraction of natural gas in the province of Groningen. The gas field located in the east of the province of Groningen and is regarded as one of the biggest gas fields in the world (van der Voort & Vanclay, 2015). Although the gas and electricity markets competed they became increasingly interlinked, leading to their strong market positions today (Verbong & van der Vleuten, 2004; Verbong & Geels, 2007). The latter shows the existence of strong fossil energy regime today in the Netherlands.

Besides strong market positions, the institutional framework plays an important role in the fossil energy regime due to the path-dependency of the current energy system. This means that over time the institutions created and designed are based on the fossil energy regime. The concept of institutions relates to formal and informal laws and regulations and organizational structures that guide our actions in society (Verbong & van der Vleuten, 2004). Because institutions structure behaviour and guide our actions, institutions are also referred to as the 'rules of the game'(Koppejan & Groenewegen, 2005). However, it is also argued that institutions often are a source of inertia (Olsen, 2009; Kim, 2011), as similar to the regimes which often aim at optimizing the system rather than changing it. It that sense it can be said that institutions are often part of the regimes. For that reason institutions are a crucial aspect for planners as Alexander (2005) states: *"to be effective actors, planners must understand something about institutions in general, and know their specific institutional contexts in particular."* So if planners want to enable or guide change effectively they have to be aware of the specific institutional context in which they act.

Based on the latter the multi-level concept is an important concept of analysis in this thesis. First, to further understand the current regime in the energy system and secondly to analyse how niche-innovations could exert bottom-up pressures to force change within the regimes. However, by analysing the energy transition in a descriptive approach does not tell anything in how to steer or govern the energy transition. Therefore, a more prescriptive approach of transition theory will be discussed in the next section.

4.3.2 A Prescriptive Approach

The question on how transitions can be governed bring us to the last and third key concept of transition theory, *transition management.* This approach, described by Loorbach (2010) and van de Brugge et al. (2005), focuses on *governing* transitions. In case of the energy transition, TM could be helpful in understanding how to deal with changes over time within the complex energy system. However, as the degree of complexity of transitions is too high to manage it is more an anticipative and adaptive management approach instead of command and control approach. The high degree of complexity of transitions and guiding them relates to the emergence of governance networks. Due to decentralisation and centralisation of governance powers, the power of the national governments decreased, resulting in a lack of direction and coordination. Theories on governance over the last 15 years were rather descriptive and analytical, and lacked a prescriptive basis for governance. TM therefore is an innovative governance concept; it is offers a prescriptive governance approach while at the same time it offers a descriptive framework.

As previous mentioned transitions are processes of structural change, which occur when dominant structures *(regimes)* are put under pressure by external changes, as well by endogenous innovation *(niches)*. Furthermore, the previously discussed concepts of *multi-level* and *multi-phase* concept will be used to analyse the energy transition. Through the understanding of both concepts Loorbach (2010) describes the tenets for a form of governance based on complexity. From these tenets the important ones are; long-term thinking (at least 25 years), timing of interventions, creating space for innovation, and interaction and participation of stakeholders. However, although the timing of interventions is crucial in governing complex systems, Loorbach (2010) describes this tenet rather vaguely.

As this thesis is based on a planners point of view, (spatial) interventions and their timing are of great relevance. In order to analyse timing of interventions within the current energy transition, a further understanding of the concept within a multi-level perspective could essential. In addition, as the focus is on a new innovation, that of SSC as V2G system, interventions around this niche-innovation within the energy transition is of special interest.

Schot & Geels (2007) discuss this aspect in governing transitions more extensively, with a specific focus on niches. They describe four proxies as indicators for the viability of niches that are ready to break through more widely. Table 2 shows and explains the indicators from Schot & Geels (2007). The first three indicators are based on niche development theory on processes of learning, network building and articulation of expectations, which will be further discussed by TM. The fourth indicator refers to diffusion of innovations theory, which will be further explained in chapter 4.4. Nevertheless, interventions in niche development and the timing of interventions could be guided by these indicators. Thus, on the basis of these indicators it can be said how viable SSC is as a niche and when interventions should be made or not, guided by institutions. In addition, Schot & Geels (2007) argue that if a niche is not 'viable' or fully developed it cannot take advantage of the *windows of opportunities* within a transition as they are not competitive enough yet. However, whether a niche is fully developed remains not entirely objective.

	Indicator	Relates to process of
I	Learning processes have stabilised in a dominant design	Learning processes of the niche's development
II	Powerful actors have joined the support network	Network building around the niche's development
III	Price/performance improvements have improved and there are strong expectations of further improvement	Articulation of expectations regards the niche's development
IV	The innovation is used in market niches, which cumulatively amount to more than 5% market share	Diffusion of the niches, which estimates that an innovation becomes self-sustaining and take of between 5 and 205 of cumulative adoption (see also chapter 4.4)

Table 2. Indicators viability niches ready for breakthrough. (Geels & Schot, 2007).

Based on the tenets for governing complexity, a descriptive multilevel framework is developed by Loorbach (2010). The framework is based on four different levels of governance activities; strategic, tactical, operational and reflexive. These levels differ in time scale, focus of change, problem scope and level of activities. The *strategic* level focuses on the long-term (30 years), in which culture is the focus of change. This level, therefore, has as problem scope the whole societal system in an abstract way. TM aims to integrate long-term governance activities into the realm of policymaking, such long-term goal formulation. The *tactical* level focuses on the mid-term (5-15 years), in which the (dominant) structures are the focus of change. This level, therefore, has *regimes* as problem scope and its level of activities to enable change the subsystem. However, as mentioned previously part of these regimes are also the existing institutions. Thereby, institutional change is also seen as far from easy to enable (Koppejan & Groenewegen, 2005; Kim, 2011). Moreover, as it is difficult to enable institutional change, the question to it is core to planning (Kim, 2011). The answer of institutional change lies is institutional design (Alexander, 2005). Even Innes (1995, in Alexander 2005) argues that planning is institutional design.

Institutional design is, according to Alexander (2005); *"devising and realization of rules, procedures, and organizational structures that will enable and constrain behavior and action so as to accord with held values, achieve desired objectives, or execute given tasks".* Thus, through realizing or devising new institutions social change could be enabled. Crucial is the specific institutional context in which a planner acts as discussed previously. Only then it is justified to come with an institutional design or planning suggestions in a prescriptive manner. For this reason the focus of enabling change in the form of an energy transition is by an institutional design.

Furthermore, there is the *operational* level, which focuses on the short-term (0-5 years), in which practices and experiments are the focus of change. Therefore, the problem scope of this level is concrete projects. Through realizing concrete innovative projects change is enabled, which is the level of activities here. The focus of this thesis is the realization of an innovative V2G system, the project of SSC. To get a further understanding how these innovations diffuse in society the next section will provide a discussion in diffusion of innovations theory.

The last level is not an actual level but it is the *reflexive* part of TM, which includes all the previously levels discussed. The reflexive activities relate to monitoring, assessing and evaluating ongoing policies and social change. By applying this part, adjustments or interventions can be made appropriately in managing the transition on the different levels as complex systems continuously change over time. This makes TM an adaptive approach.

By linking the descriptive framework to a prescriptive approach, Loorbach (2010) developed the transition management cycle (TM-cycle) (figure 11). This cycle is flexible for adaption but prescriptive enough to be functional in practice. By using the descriptive framework discussed previously and discussed in the next section according to the diffusion of innovations, the current role of SSC in the municipality of Utrecht can be analysed in order to draw lessons from its role. However, the prescriptive approach can help to understand and formulate future implications based on the lessons drawn from SSC. In that sense the TM-cycle will be used to analyse the findings of the case analysis in different steps in order to make implications about the potential role of V2G systems in the energy transition.

The different levels of governance activities from TM are linked to prescriptive actions. First, on the strategic level the *transition arena* is established. This transition arena is a small network of frontrunners with different backgrounds and various perceptions of possible solutions. It is an open and evolving process of innovation and based on variation and selection the best solutions come forward. Through discussion and interaction between involved frontrunners, problems are structured and long-term sustainable visions are developed based on the variation and selection process.

Secondly, on the tactical level the *transition agenda* is set. On this level strategies, from the transition arena, will be fine-tuned. Furthermore, coalitions and transition paths are developed, or scenarios are created to further translate the future images developed at the strategic level. As these paths come closer towards intermediate objective they can be formulated more quantitatively. On this level the planner has its most valued role as planning could be seen as institutional design, which relates to devising and realization of organizational structures (coalitions), procedures (transition paths), and rules.

Thirdly, on the operational level *experiments* are carried out. On this level transition experiments and actions are deepened and scaled up. Important is that these have to be in line with the previously developed visions and transition paths. At this level variation and selection is also an important aspect. If an experiment has been successful it can be broadened or scaled up, if not it should be left out. This is the scale on which SSC acts, which also will be analysed as an experiment. Focus of analysis will be, thus, the alinement with visions of involved actors, and successfulness of SSC as an innovation experiment. The latter will be analysed through innovation theory, which will be explained in the next section.

Finally, the reflexive aspect focuses on *monitoring and evaluation*. There are two aspects in the TM-cycle that have to be continuously monitored and evaluated. First, the transition process itself has to be monitored, which involves changes in the system under scope. For this thesis this is the energy system in which V2G system potentially play a role. Secondly, the TM process has to be monitored. This involves monitoring and evaluating the transition arena, transition agenda and experiments. From monitoring and evaluating social lessons can be learned through cooperation and interaction of actors involved. From these lessons next steps can be set in the TM-cycle process. For that reason the TM-cycle is an iterative process, which is continuously subjected to changes from the transition process and from the TM process. This step is essential, as an analysis of the energy transition is crucial to have an understanding of that fundamental change. Moreover, the process of this thesis is an iterative process. The whole process of doing research is monitored and evaluated, which therefore refers to an iterative process. This is essential in doing research as will be discussed in the next chapter.

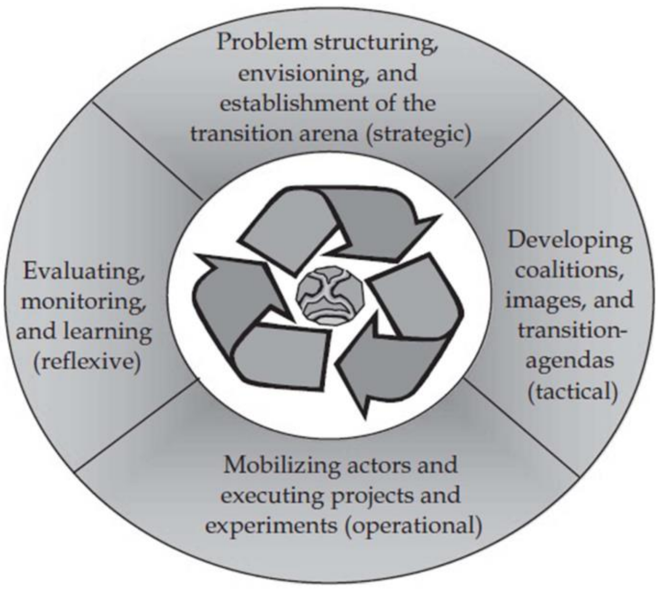

Figure 11. Transition management cycle (Loorbach, 2010).

4.4 Diffusion of Innovations

It can be said that SSC as a V2G system is a niche-innovation within the energy transition. In transition theory such niches-innovations play an important role in the development of a transition. From transition theory it became clear how these niches exert endogenous pressure on the regimes. However, transition theory does not explain the successfulness or survival of the innovation itself, although this is essential for an innovation, thus a transition to succeed. To get an insight in what the successfulness and survival of SSC determines, it is framed as an innovation as described by Rogers' *diffusion of innovations* (2010). His theory gives a more in-depth explanation on the aspects of innovations that determine their survival and adoption in society. This theory can therefore be helpful in analysing SSC as an innovation in the municipality of Utrecht, which therefore adds up to the descriptive framework of transition theory.

According to Rogers (2010) the diffusion of a new idea or innovation consists of four main elements. There is (1) an *innovation,* (2) that is *communicated* through certain *channels* (3) over *time* (4) among members of a *social system.* The first element, the *innovation* itself, is described by Rogers (2010) as; "*an idea, practice, or object perceived as new by an individual or other unit of adoption".* In this case SSC is the innovation that gets adopted in the municipality of Utrecht. The second element is the use of *communication channels*, which are the means by which messages get from one individual to another. Thus, by which an innovation diffuses depends on its communication channels, whereas mass communication channels are more effective in creating knowledge about an innovation reaching lots of individuals. However, interpersonal communication channels are more effective in affecting attitudes towards innovations. Important here is that the evaluation of an innovation by most individuals is not on the basis of scientific research but by people in their system which already adopted the innovation. These people, or near peers as Rogers (2010) describes them, serve as role models whose behaviour tends to be imitated by others in their system.

The third element is *time*, which is involved in the *innovation's rate of adoption* and *innovativeness*. An *innovation's rate of adoption* is the relative speed by which an innovation gets adopted by members of a social system, determined by its characteristics. Thus, the rate of adoption of an innovation can be predicted on the hand of individuals' perception of these characteristics. There are five characteristics which determine the rate of adoption; relative advantage, compatibility, complexity, trialability and observability. These characteristics can be used to analyse the potential of SSC as an innovation.

First, the *relative advantage* is the degree to which an innovation is perceived better than the idea that it supersedes. The higher the relative advantage the higher the likeliness of adoption. Secondly, the *compatibility* is the degree to which an innovation is perceived to be in line with existing values and past experiences, or the informal institutions. These informal institutions could be seen as the needs of the potential adopters, which are also dependent on values and shared assumptions among individuals. The higher the compatibility the higher the likeliness of adoption. Thirdly, the *complexity* is the degree to which an innovation is difficult to understand and use. The higher the complexity the less the likeliness of adoption of the innovation. Fourthly, the *trialability* is the degree to which an innovation could be experimented with on a limited basis. The higher the trialability the higher the likeliness of adoption. This aspect has much to do with the experimental freedom, which is also crucial to transitions. It is less likely that SSC as an innovation succeed when there is little experimental freedom, which consequently means it could not have an positive effect on the energy transition. And lastly, the *observability* is the degree to which results of an innovation are visible to others. The higher the observability the higher the likeliness of adoption, provided that the results are positive. The degree of observability is also dependent on the use of the second element, communication channels. Together these elements can be used for analysing SSC, which could say something about the potential of SSC as an innovation, although not completely objective.

The second aspect of time is an innovation's *innovativeness*, which is the degree to which people or other units are relatively early in adopting an innovation in comparison to other members of their social system. This is where Rogers (2010) divides the degree of innovativeness into five categories, namely; innovators, early adopters, early majority, late majority and laggards (see Figure 12). The first three categories are of interest in this thesis because those tell something about the successfulness or maturity of an innovation in a social system. Thus, it tells us something about the maturity of SSC as an innovation. According to its maturity it can be said whether interventions are needed in TM. The first category *innovators*, represents the first movers towards using SSC and accounts for 2.5% of the social system under scope. The first movers use the innovation even if there are no regulations or markets based on the innovation. The second category represents the *early adopters*, followed by the third category of *early majority*, which account respectively for another 13.5% and 34.0% of the social system. The phase of the second category is characterized by a fast increase of adoption, where in the phase of the third category the innovation is getting adopted by the mass of the population and in which the innovation becomes mature. After this phase the adoption of the innovation will slowly decline.

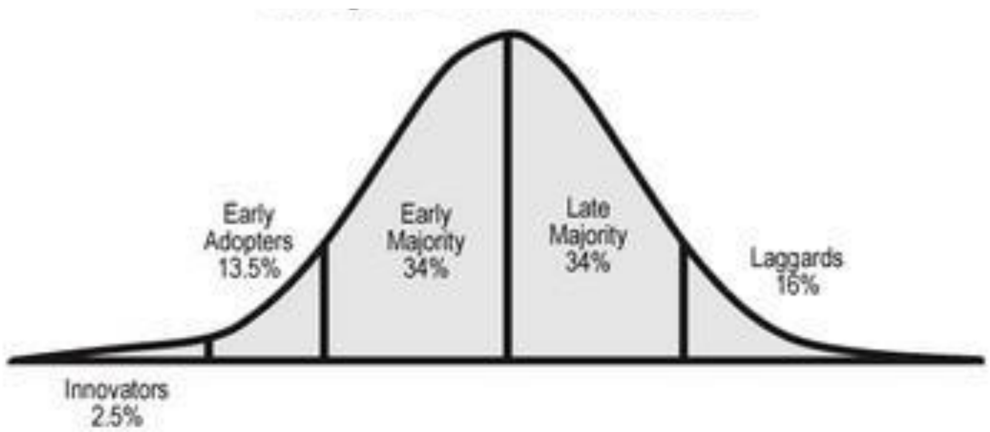

Figure 12. Categories of Innovativeness (Rogers, 1995 in Rogers, 2010).

The fourth and last element is the *social system* in which the innovation gets adopted. The social system in this thesis refers in the first place to the municipality of Utrecht, as the second research question is about the role of SSC in Utrecht. On the basis of the lessons drawn from this case a further exploration on the potential role of V2G systems can be made, in which the social system refers more to the Netherlands as a nation.

4.5 Synthesis

In the past chapter theories have been given and discussed, which will function as the theoretical framework of this thesis. In the following part a synthesis of the discussed theories is given to provide a concise overview of the theoretical framework. Finally, a conceptual model on the basis of the theoretical framework is given.

In section 4.1 and 4.2 planning theory and its connection to systems theory is discussed. Based on that discussion, it became clear that the energy system is a complex system and the energy transition could be seen as a planning issue with a high degree of complexity, which is characterized by i.e. non-linearity and co-evolution. To come to an understanding about this complex change within the energy system, transition theory is used. Theory on transitions is given in section 4.3. In this chapter it is explained that transition theory, in the first place can be used to create a framework of understanding in a descriptive approach. It explains how transitions develop over time, and how interactions take place between different societal levels potentially unfolding in a transition, explained by the multi-level concept. Secondly, a more prescriptive approach of transition theory is discussed in order to understand how transition can be governed through transition management. Within transition management, the transition management-cycle can function as a functional framework of analysis in which its steps can be used as input for analysing the findings in a prescriptive approach. Within transition theory, the focus of planning is much on the regimes, which in the Netherlands is a strong one in the current energy system focused on fossil fuels. To act as an effective planner a deeper understanding about the institutional context is needed as institutions play an important role within these regimes. However, an extensive understanding about Smart Solar Charging as an innovation in the municipality of Utrecht is needed to explore the potential role of vehicle-to-grid systems in the energy transition. This part is not well explained in transition theory. Therefore an extensive discussion is presented in 4.4 on the innovation theory of Rogers (2010). The theories discussed in 4.3 and 4.4 will also be used as a basis for the interview guide, which will be explained in the next chapter. Together these theories provide a framework that guides the collection and analysis of data to come to a satisfying result in answering the research questions. Below you find the conceptual model of the theoretical framework.

4.6 Conceptual Model

The conceptual model of the theoretical framework consists of four parts. First, *complex systems*, which emerged from *planning theory* and *systems theory*, are used to create an understanding about the energy system as a complex system. Secondly, *transition theory*, as a planning concept based on systems thinking and complexity, is used to create an understanding about fundamental changes within the complex systems, referred to as transitions. Within transitions, institutions and innovations play an important role in the multi-level concept of transitions. To complement the understanding about innovations in transitions the *diffusion of innovations theory* is used. Thirdly, theory on transitions, institutions and innovations are also used as a basis for the interview guide, by which empirical data is collected. Through the analysis of the data, the findings are formulated. Finally, these findings are analysed through the multi-level concept and transition management-cycle, from which results are formulated. The feedback system in the model represents the iterative process, part of the TM-cycle.

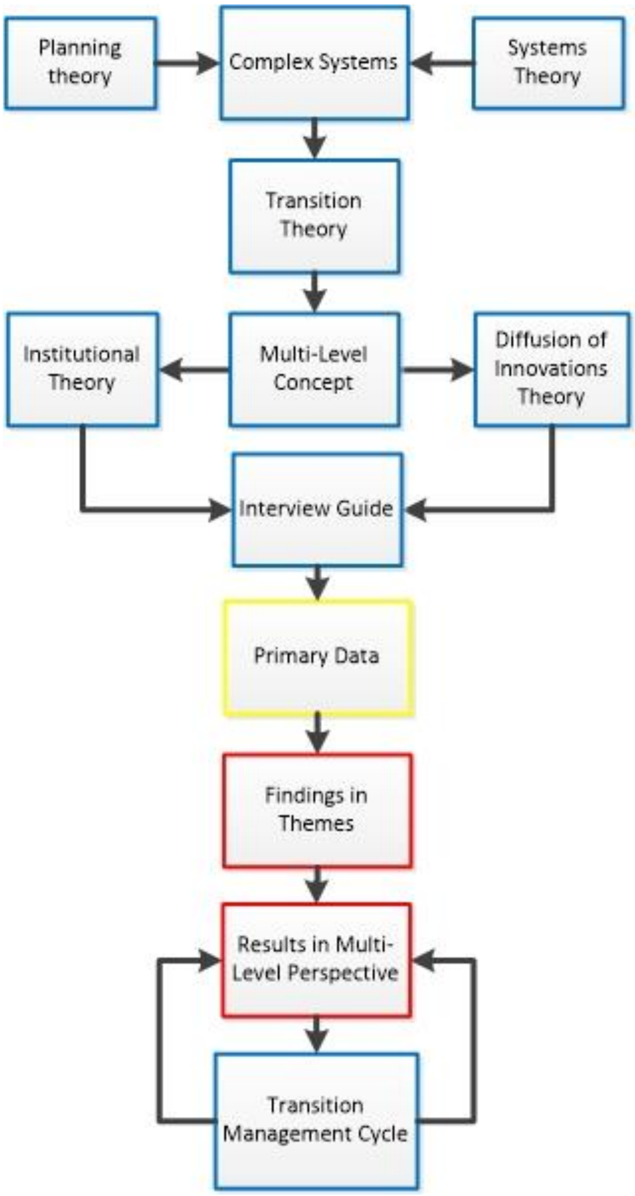

Figure 13. Conceptual model theoretical framework (Author).

5. Methodology

In order to answer the main research question of this thesis a certain research strategy has been chosen. The chosen strategy includes research methods for a case study research. The case study of this thesis is Smart Solar Charging, which is studied to draw lessons from in order to explore the potential role of vehicle-to-grid systems in the energy transition. This chapter will describe the research strategy and process that has been chosen for this thesis as well as it describes the chosen research methods for doing research in order to achieve a satisfying result in answering the research questions.

5.1 Research Strategy and Process

In order to answer the main research question "*What role can vehicle-to-grid systems play in the energy transition? Lessons from Lombok, Utrecht*", several research strategies were considered. First, a comparative research on SCC and a comparable V2G system elsewhere is considered. However, since it is an innovation which is the first of its kind in public use it has no similar cases to do a comparative research with. Secondly, a single case study research strategy has been considered and chosen. Case study research is chosen because it is, according to Yin (2009, p4); *"relevant the more that your research questions require an extensive and "in-depth" description of some social phenomenon."* This thesis has its focus on the role of V2G systems in the energy transition, which focuses on a fundamental change within a social system in which many social phenomena exist as became clear from the previous chapters. Hence, a case study is highly relevant to this main research question.

With this research strategy, the research process has also been set. Before the research questions could be answered this research process is maintained. First, background information is searched for by a thorough desk research, presented in chapter 1 and chapter 3 to understand the relevance of this research. In addition, theoretical background information has been searched for in academic literature from journal articles for chapter 3 to complement the understanding about complex issues such as V2G systems. Besides, academic literature has been further searched for to construct a theoretical framework in chapter 4, which guide our understanding on the topics under research. This theoretical framework will also be used as input for the interview guide as well as it will be used to analyse data and findings in an iterative process. This is because the process of case study research is not a linear but an iterative process according to Yin (2009). This means that during the thesis there has been looked back and forth constantly as a result from new insights during the research process. Furthermore, empirical data is collected through semi-structured interviews and direct observation. Documents are used to collect data on the basis of data triangulation in order to complement and increase the reliability of the empirical data. The methods used for collecting data are explained further in section 5.2 and 5.3.

5.2 Research Methods

In order to answer the research questions of the thesis, data is collected for analysis. According to the first principle of case study research of Yin (2009) different sources of evidence are used for collecting data. The first principle recommends using multiple source of evidence in order to increase data reliability, called *data triangulation.* First, direct observation has been done during an information meeting of WDS. This has been done as it was not an option to do a survey among the attendants due ethical issues. For this reason the direct observation as the best option for collecting comparable data. In this meeting empirical data is collected during the presentations given by Robin Berg, director LomboXnet and an expert of Mobility Heroes, a direct partner company in the We Drive Solar project. Furthermore, observations have been made from the reactions and behaviour of the attendants. The minutes from the observation can be asked for at the author of the thesis (see colophon).

Secondly, it was intended to conduct semi-structured interviews with organizations that are member in the SSC consortium. This qualitative research method is useful in getting insights in the way the interviewees think (Longhurst, 2010). This is helpful in a qualitative oriented research. In addition, it is also chosen as it gives qualitative data with a high reliability (Yin, 2009). However, it was only possible to conduct an interview with Robin Berg from the direct partners within SSC consortium. Although, only one interview with a direct partner within the SSC consortium was conducted the data has a relative high reliability with regard to Robin Berg's position within the SSC consortium and related WDS project. Nevertheless, more semi-structured interviews with supporting organisations were conducted. The minutes of the interviews can be asked for at the author of the thesis. An explanation of the semi-structured interviews that have been conducted and a justification are given below.

- ❖ Expert Economic Board of Utrecht (EBU) – *22-12-2016.* The EBU is an organization founded by governments and other organizations from the region of Utrecht, which brings coalitions together and has the ability to provide i.e. loans, subsidies to sustainable projects. The EBU also gave a financial boost to SSC and is therefore closely involved with the project.
- ❖ Expert Nature and Environment Federation Utrecht (NMU)– *03-01-2017.* The NMU is a non-governmental organisation (NGO) that facilitates green local initiatives in the province of Utrecht. The NMU is not a direct partner within the SSC consortium, however they take part in the WDS project organisation as it connect local energy corporations to WDS.
- ❖ Expert Municipality Utrecht – *10-01-2017.* The municipality of Utrecht is a supporting organization in the SSC project and has a broad focus on air quality, in which electric mobility is one of their main focus aspect.
- ❖ Robin Berg - Director LomboXnet and leader and initiator of the SSC consortium – *12-01-2017 & 18-01-2017.* The director of LomboXnet has been the initiator of the whole project from internet corporation, LomboXnet, based on solar energy for the district of Lombok towards the

WDS project which is based on the SSC project. He also leads the SSC consortium in the project as well as he leads the WDS team.

❖ Expert province of Utrecht – *12-01-2017*. The province of Utrecht is a supporting organization in the SSC project and has a broad focus on sound & air quality in which electric mobility is one of their main focus aspects.

The data collected from the semi-structured interviews with these organisations are regarded as sufficient the reach a satisfying amount of reliable data. Hence, all relevant segments regards the SSC project is reflected on regards the case study. Important here was getting insights in thinking of market parties, which initiate bottom-up change (niches) and thinking of more dominant structures of authorities (regimes). In addition organisations were interviewed that support bottom-up change, to create a broader view on niche development in the region of Utrecht. Due to time constraints of the interviewees and distance all the interviews were conducted by telephone. Table 5.1 gives a summary of the interviews.

Interviewee	**When, where and how?**	**Type Organisation**	**Involvement SSC**
Expert Economic Board Utrecht (EBU). (Appendix III)	22-12-2016, Groningen, Telephonic.	Governmental and Market. Niche supporting organisation	Supports project with loans and coalition development between actors
Expert Nature and Environment Federation (NMU). (Appendix IV)	03-01-2017, Groningen, Telephonic.	Non-Governmental Organisation. Niche supporting organisation	Supports project with searching for potential local PV corporations (niches) for extension PV generation
Expert Municipality Of Utrecht. (Appendix V)	10-01-2017, Groningen, Telephonic.	Local Governmental Organisation. Local Regimes	Supports project with subsidies and regulations
Director LomboXnet. (Appendix VI)	12-01-2017 & 18-01-2017, Groningen, Telephonic.	Market Organisation. Niche market organisation	Technical leader of the SSC consortium and director LomboXnet and We drive Solar
Expert Province of Utrecht. (Appendix VII)	12-01-2017, Groningen, Telephonic.	Regional Governmental Organisation. Local Regimes	Supports project with subsidies

Table 5.1. Summary of the conducted interviews.

Finally, to complement the empirical data from the direct observation and semi-structured interviews, documents are used as a third data source with regards to the *data triangulation* (Yin, 2009). Through a thorough desk research policy documents, official letters, official reports and presentations are intensively studied for collecting the complementing data.

The order in which the different methods of research are applied to this study are in order of the latter section. This means that first observations have been made, where after interviews have been conducted and finally all is complemented with a desk research on documents. Although, documents were already used in a thorough desk research to collect more superficial data in order to collect further data from the observations and interviews. There has been chosen for this strategy of methods as empirical data is the most direct and reliable, thus it is aimed to collect most data from the observation and interviews.

5.3 Interview Method

For the interview method there has been chosen to do semi-structured interviews. The questions from the interview guide are based on the theoretical framework. The stimulating and constraining factors for the development of SSC are also derived from the theoretical framework. Stimulating factors are positively contributing to the development of SSC and constraining factors negatively. Leading in setting up the interview guide was knowing the institutional context and innovation aspects of SSC. Furthermore, as institutions mostly refer to the regimes in transitions and innovations to niches, institutions were regarded mostly constraining and innovations aspects mostly stimulating. Furthermore, to collect additional data Robin Berg from LomboXnet is asked some additional questions with regard to his potential additional knowledge on SSC. The interview guide with explanation is given on the next pages. The stimulating and constraining factors are summarized in figure 5.1.

Interview guide

1. What do sustainability and sustainable energy mean to your organization?
2. What role has SSC in relation to your organization?
3. What other stakeholders are concerned with SSC?
4. What is your vision on the municipality and province of Utrecht?
5. What are your expectations with regard to SSC in the future for Utrecht and the Netherlands?
6. What is your vision on the role of SCC in the Dutch energy transition?
7. To what degree do you identify the following stimulating and constraining factors for the development of SSC:
    a. stimulating factors
        i. Supporting regulations
        ii. Environmental benefits
        iii. User advantages
        iv. Additional advantages
    b. constraining factors
        i. Constraining regulations
        ii. Lack of political will
        iii. Inertia
        iv. Insufficient knowledge

Stimulating factors:

Supporting regulations: are the financial or political incentives. This could be forcing regulations to shift from fossil energy to alternatives. Or this could be financial supporting regulations in the form of subsidies.

This stimulating factor is chosen as it relates to experimental space in transition theory and innovation theory for SSC as an innovation provided by formal institutions.

Environmental benefits: What makes SSC such strong innovation, environmentally and are those benefits a stimulating factor? These are benefits with regard to emissions, air quality and renewable energy production for example.

This stimulating factor is chosen as it relates to the relative advantages of the innovation together with environmental pressure from the social technical landscape.

User advantages: are advantages related to the relative benefits for users of SSC, for example financially.

This stimulating factor is chosen as it relates to the relative advantages of the innovation compared to other systems it supersedes with regard to its users. In addition, it also relates to the needs of the units of adoption, the users, dependent on the informal institutions on a local level.

Additional advantages: are other advantages with regard to SCC compared to other smart grid or V2G systems.

This stimulating factor is chosen with regard to additional relative advantages of SSC compared to similar energy systems it supersedes and additional needs of the units of adoption, the users. These additional advantages will be found during the conduction of the interviews.

Constraining factors:

Constraining regulations: are the regulations that could inhibit the development and upscaling of SCC. These could also be unclear or conflicting regulations that cause a constraining effect.

This constraining factor is chosen to analyse the constraining formal institutions within the current regimes with regard to SSC on different levels.

Lack of political will: is the lack of political willing to support SSC with regard to their own interests in i.e. energy.

This constraining factor is chosen for analysing the public institutional bodies and their formal and informal institutional support to the development of SSC.

Inertia: is the potential resistance in the form of inertia, from mainly the public to engage in driving an EV or taking part in a sharing concept. This could also be related to the complexity of the system to use SCC.

This constraining factor is chosen to analyse the informal compatibility of the units of adoption.

Insufficient knowledge: is when citizens and organizations do not know the benefits from SSC or do not know SSC or V2G systems at all, which could result in a constraining effect.

This constraining factor is chosen to analyse the communication channels used to diffuse the innovation among potential units of adoption.

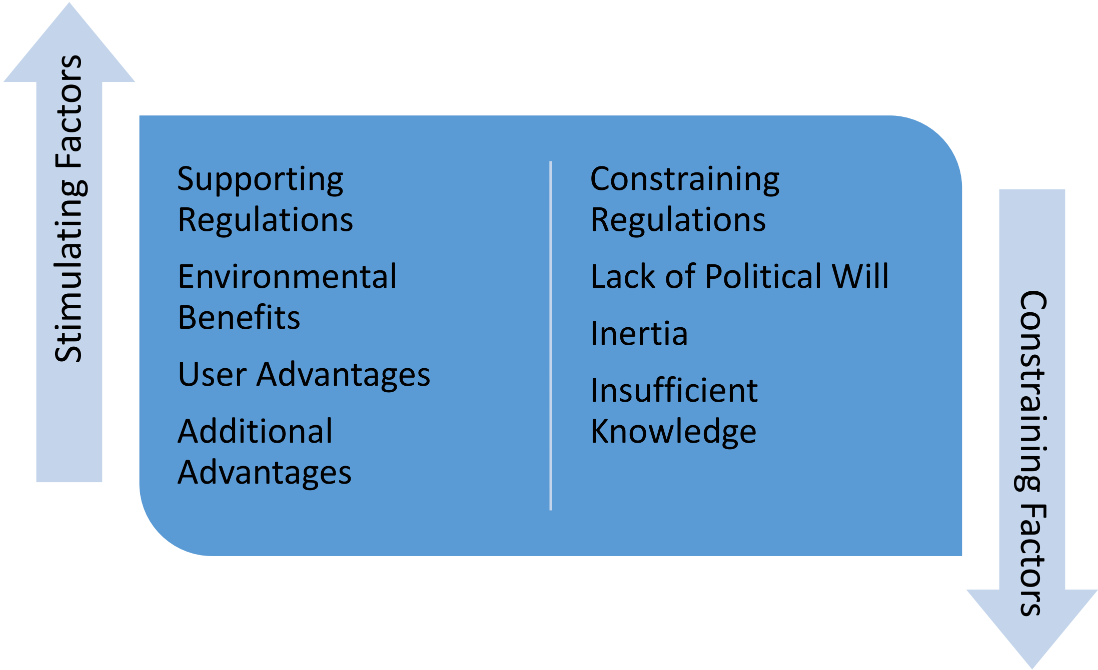

Figure 14. Stimulating and Constraining factors Smart Solar Charging interview guide (author).

5.4 Data Analysis and outcomes

The analysis of the collected data is done through two cycles as an iterative process. First, data is analysed and structured on the hand of transition theory in a descriptive way. In this part institutions and innovations within a wider frame of transition play an important aspect of analysis. The recorded interviews were typed out and thoroughly analysed, as well as the direct observation. That data is then, structured and analysed according to different themes that come forward in the interviews and observation in an inductive way, which will be presented in chapter 6. These findings are complemented with the findings from the analysed documents. In further structuring the data the multi-level perspective is used, in which the final findings are presented.

Following, the findings are analysed according to the theoretical framework. On the hand of the TM-cycle the findings will be analysed in different steps, starting on an operational level where the results on the role of SSC in the municipality will be discussed and presented. After that the results are discussed in a wider of the energy transition and V2G systems on a strategic level, where findings are analysed to structure problems, visions and future images of the interviewees. This is followed by a synthesis of the results and outcomes which will be discussed and presented on a tactical level in a transition agenda. The synthesis represents the policy recommendations as a final result. All these steps are monitored and evaluated in a reflexive and iterative way, which is essential to TM.

5.5 Ethics

The data collection in this thesis is done according to the three principles of data collection (Yin, 2009) in order to increase the reliability of the collected evidence as much as possible. As discussed previously, the first principle is the use of multiple sources of evidence, referred to as *data triangulation*. In this thesis three sources of evidence are used, namely semi-structured interviews, direct observation and documents. By making cross-references between the data collected from these data reliability increases. The second principle is creating a case study database. The minutes of the direct observation and the semi-structured interviews can be found in the appendices at the end of the thesis or asked for at the author. The documents used as data are referred to in the text and putted in the reference list. The third and last principle is maintaining a chain of evidence. This means that every step taken in studying the case has to be followed as easily as possible by an external observer. This has been done by explaining the steps taken in studying the case as much and clearly possible.

Furthermore, with the interview method the interviewees are anonymised and the received information is handled carefully. These two issues are important ethical issues in doing research with semi-structured interviews according to Longhurst (2010). All interviewees are anonymised except Robin Berg as this was hardly possible as he is the leading actor within SSC and its related projects. Therefore, anonymising him could only work adverse in justifying the interview.

6. Findings and Results

This chapter presents the findings and results of this thesis. First, findings will be presented from the analysis of the collected data from direct observation, semi-structured interviews and a thorough desk research on documents. These findings will be presented in eight different themes that are inductively derived from the observations and semi-structured interviews, in which the analysed documents have a complementing role. A further explanation will be given in section 6.1. Consequently, the findings will be structured according to the multi-level concept in section 6.2. In this way the findings are structured according to three governance levels, to give a concise synopsis of the findings.

After structuring the findings in multi-level perspective, the results will be presented and discussed on the hand of the theoretical framework in section 6.3. This happens by following the steps of the of the transition management-cycle. First, results and outcomes on the role of SSC in the municipality of Utrecht will be presented and discussed. Secondly, on a strategic level results will be presented in a wider frame of the energy transition based on future images and visions. Finally, a synthesis of the results will be presented as an outcome on a tactical level. In this transition agenda, policy recommendations will be given as a final result in the form of an institutional design.

6.1 Themes

In chapter 5.3 the interview guide was presented including the stimulating and constraining factors, which had been summarized (figure 14). An overview of the factors from the interview guide and the identification of the interviewees on these factors is presented in table 6.1 and 6.2. Although the factors from table 6.1 were the input for the semi-structured interviews, they will not be the exact output for the themes in this chapter. As these factors were based on prior knowledge before the collection of empirical data slight differences were found in the degree of importance, for which they are sharpened. Based on the output of the direct observation and the semi-structured interviews eight different themes came forward. As a result from the identification of interviewees on these factors and based on the overlap between subjects or themes in the interviews searched for by the researcher these themes were found, which are presented in table 6.3. The degree is based on the perception of the researcher while keeping the research questions and goals in mind. These degrees has been translated to the values presented in table 6.3. Furthermore, in some of the sections footnotes are given, which refer to the document used as complementing the data from the direct observation or semi-structured interview. Furthermore, statements from the interviews are given to support the findings. It should be noted that these statements are translated from Dutch to English as literally as possible. However, for this reason it could be that interpretations could differ. In case of confusion or whenever something is unclear, information can be asked for at the author of the thesis.

Factor's number	Factor
I	Supporting Regulations
II	Environmental Benefits
III	User Advantages
IV	Additional Advantages
V	Constraining regulations
VI	Lack of Political Will
VII	Inertia
VIII	Insufficient Knowledge

Table 3. Stimulating and Constraining factors from the interview guide.

Factor	I	II	III	IV	V	VI	VII	VIII
Expert EBU	-	-	+	+	+/-	+	+	+
Expert NMU	+/-	-	+	+	+/-	+/-	+	+
Expert Municipality of Utrecht	+/-	-	+	+	+/-	-	-	+/-
Expert Province of Utrecht	+	+	-	-	+/-	+	+	+
Director LomboX-net	-	+	+	+/-	+	+	+	+

Table 4. Degree of identifying with the stimulating or constraining factor for the development of Smart Solar Charging.

Theme's number	Theme
I	Regulations
II	Policy
III	Societal Inertia
IV	Cooperation
V	Environmental Advantages
VI	Economic Benefits
VII	Innovation Potential
VIII	Additional Advantages

Table 5. Findings in eight themes.

Regulations

An evident stimulating and constraining factor is regulations. In all the interviews regulations came forward as an important factor. Differences in the regulations locally, regionally and nationally also came forward. Although, regionally there is not much to regulate as the province of Utrecht (appendix VII) has little formal regulative power in comparison to the central government and municipalities. Nevertheless, the interviewee of the province of Utrecht did underline the influence of regulations on the development of SSC together with the EBU, NMU, Municipality of Utrecht and LomboXnet (appendix III, VI, V, VI). Although, these interviewees did underline the influence of regulations they had different answers in identifying them as stimulating or constraining.

In the first interview, the interviewee of the EBU (appendix III) underlines that regulations that subsidize SSC are not necessary anymore for the further development of SSC as a project. The expert argues that is more important that SSC is getting scaled up, instead of getting subsidized. Stimulating regulations could work adverse the expert argues, which is a striking paradox. The EBU expert further notes that the project WDS receives a subsidy for letting people experiment with the car sharing concept. From other interviews with LomboXnet and the province of Utrecht, it is confirmed that the project WDS receives a subsidy from the programme VERDER[1] from the province of Utrecht for letting people experiment with the car sharing concept of WDS (appendix VI; appendix VII). Car reduction through car sharing is one of the pillars of the SSC project and the VERDER programme.

In the interview with NMU (appendix IV) it came forward that regulations work both stimulating and constraining for the development of SSC. The interviewee of the NMU points out that the SDE[2] regulation is a stimulating regulation for projects in solar energy, but there is no continuity. This makes it hard to predict how regulations will change the coming years, which probably works constraining for the development of SSC. According to the expert of the NMU, the municipality of Utrecht is more proactive with supportive regulations. This is partly explained by the expert of the municipality of Utrecht (appendix V), in which the expert explains that they recently adjusted their local parking regulation to provide the shared EV's of WDS with an exclusive parking place. The interviewee of the municipality of Utrecht further argues to not frame regulations as a constraining factor for the development of SSC. In arguing the latter the municipality expert states:

[1] Het VERDERpakket 2010 - 2020 Projectenboek (programmabureau VERDER, 2010). Programme in which governmental organisations from the region of Utrecht collaborate to improve the accessibility of the region 'Midden-Nederland' (Central Netherlands).

[2] Stimulering Duurzame Energieproductie (SDE+) (Kamp, 2016a). National regulation to stimulate the development of renewable energy projects, with exception of offshore wind energy. Regulation has two rounds a year for subsidy, first round in 2017 has a budget of 6 billion euro. In 2016 the budget of the first round was only 4 billion euro.

"The whole regulations system has to facilitate everything. Because the tax system is focused to fill in the household expenses. Where we have a lot of money because of the natural gas in Groningen now, the electric vehicles should not fill in the fuel taxes later. It takes time to organise this in a good way. On the one hand it is a constraining factor indeed, but you should not formulate it like that because the government does see chances." (appendix V)

The interviewee here argues that there is a will to organise the system of regulations towards electric vehicles and solar energy, but it takes time because the government has not the knowledge doing that. In that sense the regulations still do work as a constraining currently. The interviewee of LomboXnet notes that he clearly experiences no stimulating effect from regulations by stating:

"concerning the regulations and laws, they work very constraining. We experience no real stimulation from regulations and laws." (appendix VI).

This is striking as it is argued in other interviews that there are stimulating. However, the latter statement shows that there is a feeling that the stimulating effect of those regulations is by far not enough. Related to this statement the interviewee of LomboXnet gives example to a point mentioned by the interviewee of the municipality of Utrecht (appendix V). These interviews explain that there currently are a lot of double tax regulations on energy, which has to be adjusted according to both to stimulate sustainable energy projects, such as SSC.

Another interesting and important regulation, partly related to ineffective tax regulations, is the regulation on energy balancing (salderen[3]), which came forward in almost all the interviews as important factor. The opinions on this regulation provide a lot of inconsistency and differences. The interviewee of the EBU (appendix III) argues that the regulation has to remain in order to hold the business case of the project, while the interviewee of the NMU (appendix IV) and the municipality of Utrecht (appendix V) argue that there is a lot to win for the development of SSC if the regulation disappears. However, later the interviewee of the NMU states:

"I think that balancing has an advantage in the deployment of solar energy. That is why I am a big advocate for keeping the balancing regulation. But lately the price of solar has dropped significantly which makes solar energy attractive enough without balancing. Concerning SSC it would be beneficial when balancing disappears. If your house has a roof full with solar panels and you have to redeliver, than the concept to charge your car with it is much better." (appendix IV)

[3] Salderen (ACM, 2016). Regulation that obligates to redeliver overproduced PV to the regional grid controlling energy company against a minimum of 70% of the price that is set by the company for energy.

This statement shows that the interviewee thinks it is good for the growth of PV. However, for the development of local sustainable energy systems, such as SSC, balancing could have an adverse effect as it becomes more attractive for individuals to invest in storage systems if the regulation disappears. The interviewee of the province of Utrecht (appendix VII) also argues it will be one of the crucial developments in our regulations system the coming years.

From the interview with the province of Utrecht a contradiction came forward with the point made by the expert of EBU. The expert of the province of Utrecht (appendix VII) explains that they decided to subsidize the charging infrastructure only once until the market picks it up, which did not work out. The subsidies are still needed but they do not know for how long. This is striking as the EBU argues that the those regulations are not needed, while the expert of the province of Utrecht argues that they are clearly needed. Furthermore, the interviewee of the province of Utrecht (appendix VII) points out that through a supporting declaration from the province, LomboXnet received subsidy from the EFRO[4] (European Fund for Regional Development) for the development of SSC. This shows that the province of Utrecht did have little formal power to support the project of SSC, although it is not much.

Furthermore, there are regulations found through the desk research, which are relevant mentioning in order to complement the previously presented findings. In a study on the balancing regulation by PWC (2016), several concluding remarks were presented on the existence and operation of the regulation (Kamp, 2017; PWC, 2016). First, partly due the balancing regulation PV has grown strongly between 2011 and 2016. Between 2004 and 2011 PV grew a 13% a year against 91% between 2011 and 2016. However, the study also notes that balancing clearly limits the incentives to invest in storage or smart energy management systems. It therefore limits the innovation incentive to shift to a more efficient and reliable energy system. Furthermore the study found that PV is the renewable energy source with the most public support, which therefore provides opportunities for further development. Moreover, PV is one of the most popular means for production of renewable energy that individuals could deploy relatively easily. However, the effect of the regulation on this effect remains unclear. Moreover, it also has a limited effect on the reduction of CO_2-emissions in the Netherlands, only 0.5% in 2015. In addition, the regulation is relatively expensive for the central government (PWC, 2016). Where the SDE+ regulation costs are 159 euro per avoided Mton CO_2, are the costs 269 euro per avoided Mton CO_2 for the balancing regulation. Thereby, the study found that the SDE+ regulation seemed more effective for the deployment of PV than the balancing regulation. Finally, the study notes that the balancing regulation probably contributes to the employment of the energy sector due its contribution to the growth

[4] The Europees Fonds Regionale Ontwikkeling (EFRO) Kansen voor West II. (Managementautoriteit Kansen voor West, 2015). This fund is focused on the stimulation of investments in R&D, the extension of the use of renewable energy sources and boosting of investments in energy saving measures for the period of 2014 – 2020.

of PV. However, this also implies that if the amount of PV grows without balancing, employment still grows.

On a municipal level there is a programme with regard to sustainable energy production mentioned by the interviewee of the municipality of Utrecht (appendix V). This programme is called 'Utrechtse Energie'[5], which is the energy programme from the municipality of Utrecht which started in 2001/2002. It is a fund to enable entrepreneurs to initiate sustainable energy projects in the city of Utrecht.

In conclusion, it can be said that are a lot of regulations that should stimulate the development of green initiatives, thus SSC. However, many times these regulations are not perceived as such or work adverse. The constraining regulations are mostly centrally regulated, from which the balancing regulation is the most outdated and probably constraining. Nevertheless, the SDE+ regulation is considered stimulating. Locally, there are stimulating regulations but have too little impact.

Policy

In all the interviews the factor of policy and political will is discussed. Nevertheless, as similar to the regulations, the views on political will and policies are inconsistent. In the first interview with the EBU (appendix III) it comes forward that there exist differences in constraining or stimulating policy on different scales as the expert states:

"Economy and sustainability are often coherent, however also much of the time inconsistent. The government has no consistent integral policy on that. Local and regional there is political will, that is why we get are programs done. However, within the legal arrangements it crumbles down. With the new parliament we will probably make steps forward." (appendix III)

Nevertheless, the interviewee argues that economy and sustainability do not have to be conflicting. However, due the inconsistency in national policy, the national government does not facilitates it efficiently. Local and regional there is much more done is this sense, however there is much less power.

The interviewee of the NMU (appendix IV) notes that political will does not has to be a constraining factor due to a change in the sense of urgency, through i.e. climate summits and the lawsuit of Urgenda[6]. This lawsuit influences policy on a national scale as they are now more obligated to do something about

[5] Utrechtse Energie (Energiefonds Utrecht, 2016). Foundation that is established by the municipality of Utrecht that aims to support innovation and entrepreneurship with regard to small sustainable energy projects. Part of the energy fund is 1.25 million euro from the EFRO.

[6] The lawsuit of Urgenda (Rijksoverheid, 2016a). It is a lawsuit against the central government by foundation Urgenda, which claims that the central government is doing too little in fighting climate change. The judgement in 2015 was that the central government indeed acted unlawful in their climate policy. The Dutch government appealed against the judgement. The lawsuit still runs.

climate change. However, the interviewee also points out that there is no continuity in policy, which makes it hard for citizens and entrepreneurs to engage in sustainability projects, such as SSC. Although, the interviewee thinks the constraining force will decrease as the energy transition is gaining mass.

On the contrary, the interviewee of the NMU (appendix IV) notes that a lot of investments of the central government are still focused on fossil energy. This is also subscribed by the interviewee of LomboXnet (appendix VI). As similar to the interviewee of the EBU, the interviewees of the NMU and LomboXnet note a more proactive and political willing local and regional government in comparison to the central government.

In contrast to the latter, the interviewee of the municipality of Utrecht (appendix V) argues that there is absolutely no lack of political will. The interviewee supports its argument with the notion that minister Schultz from the department of infrastructure and environment (IenM) showed much dedication towards a mobility transition to electric mobility recently. In addition, the interviewee of LomboXnet (appendix VI) argues that the political will regards electric mobility is relatively progressive although he claims that the true lack of political will is on sustainable energy as previously discussed. This is, however not mentioned by the interviewee of the municipality of Utrecht.

Besides, the interviewee of the province of Utrecht (appendix VII) explained that resistance is growing towards innovative initiatives due the increasing power of conservative political parties, to which the interviewee refers to as the 'PVV-effect'. However, the interviewee has no explanation for the negative attitude from these conservative parties towards innovative developments.

Besides the findings from the interviews, documents are analysed to complement the previously discussed findings. First, the interviewee of the municipality of Utrecht (appendix V) explained that electric mobility is organised by the air quality programme since 2009/2010 and from 2014/2015 it is organised through the new 'Action plan Clean Mobility'[7], which is based on the programme 'Clean Air Utrecht'[8]. The municipality of Utrecht aims mainly at a reduction of soot according to 'Clean Air Utrecht'. Within the 'Action plan on Clean Mobility' the municipality aims to improve the health through improving the air quality by committing to clean mobility. Their key focus in clean mobility is electric mobility, which is also shown in the following statement from the Clean Air Utrecht programme: *"Electric, unless there is no alternative"* (van der Waard & Meijles, 2015 p9). In the first place their role is facilitating and stimulating clean mobility. However, when it turns out this is not going to work

[7] Utrecht Aantrekkelijk en Bereikbaar: Actieplan Schoon Vervoer (2015-2020) (van der Waard & Meijles, 2015). Action plan to increase health through improvement of air quality by committing to cleaner mobility in the municipality of Utrecht.

[8] Gezonde Lucht voor Utrecht (Mileudefensie en Kracht van Utrecht, 2015). Action plan that aims at soot reduction through car traffic reduction and cleaner traffic.

they are willing to use additional policy instruments in order to improve clean mobility, noted by the expert of the municipality of Utrecht.

Furthermore, the interviewee of the municipality of Utrecht mentioned that Europe had set air quality standards to which the municipality needed act a couple of years ago (appendix V). As a relative radical solution they implemented environmental zones, which also aims to increase electric mobility growth. The expert further notes that as the municipality currently meets the standards due clean mobility policy and environmental policy, they focus on further improvement of the air quality to increase not only the people's health but also the sustainability of the city. Furthermore, the policy of the municipality of Utrecht regards PV is focused on a continuing increase of the amount guided by their programme 'Utrechtse Energy' (see regulations). Moreover, they also aim to increase the awareness among companies and citizens (van der Waard & Meijles, 2015). Finally, they have incorporated policy on increasing car sharing projects in their 'Mobility Plan Utrecht 2025'[9]. The policy aims at encouraging car sharing by offering financial contributions to individuals who engage in the concept (municipality of Utrecht, 2016 p50). The latter findings confirm the progressive and proactive attitude of the municipality of Utrecht towards green initiatives and especially to electric mobility.

On a provincial level, the interviewee of province of Utrecht mentioned some policies relevant to SSC (appendix VII). The province of Utrecht has a programme 'energietransitie'[10], which focuses on energy transition through the built environment and not mobility, which is mentioned by the interviewee of the province of Utrecht. Thus, little intersection is there with SSC, although it does have little intersection with PV as solar panels are part of the built environment. The province of Utrecht further started with a project around electric mobility or hydrogen, or a combination of both, as explained by the expert of the province of Utrecht. However, no decision is made yet about their focus on either one of them. The province further controls two bus charters in the region. The regional bus charter and the bus charter of the municipality of the Utrecht. They strive in their policy to have electric busses exclusively when the charters expire (appendix VII). This can also be found back in the programme document of 'energietransitie' of the province Utrecht (provincie Utrecht, 2016 p28/29). To realize a further reduction of car use in Utrecht, the province takes part in the programme VERDER, through which the province of Utrecht realized a subsidy for the car sharing concept of WDS (see regulations). The latter findings confirm that the province of Utrecht also has a relative progressive and proactive attitude towards green initiatives and especially to electric mobility.

[9] Utrecht Aantrekkelijk en Bereikbaar. Slimme Routes, Slim Regelen, Slim Bestemmen. Mobiliteitsplan Utrecht 2025 (municipality of Utrecht, 2016). Mobility Plan of the municipality of Utrecht to organise the mobility networks that contribute to a high valued and healthy city.

[10] Een Klimaat voor Energietransitie: Energieagenda provincie Utrecht (provincie Utrecht, 2016). Energy agenda of province of Utrecht that aims at becoming energy neutral by 2040.

In addition, the municipality and province of Utrecht both aim at a lobby on electric mobility in their lobby agendas, included in their policies (van der Waard & Meijles, 2015; provincie Utrecht, 2016). They both aim to increase the priority of electric mobility in the political arena, nationally and internationally. Moreover, the province of Utrecht even lobbies for SSC directly as one of their five lobby points (provincie Utrecht, 2016 p31). This also shows the positive intentions and confidence of the local and regional authorities towards SSC as an innovation.

On a national scale the policies on electric mobility and renewable energy are more complex. First, there still is a lot disagreement, inconsistency and uncertainty about policy on PV. A recent study argued that the slow spread of PV in the Netherlands can be related to the inconsistent regulations, unpredictable behaviour and lack of a clear vision from the national government (Negro et al., 2012, in PBL & DNV GL, 2014). In particular with regard to the energy balancing regulation (see regulations). Minister Kamp of Economic Affairs announced in an official letter that the regulation will be evaluated relatively quick. However, potential adjustments to the regulation are not announced yet and will probably not being implemented before 2020 (Kamp, 2017). Furthermore, the Dutch government still relies heavily on natural gas in their policy. However, they aim at a reduction of the dependency on natural gas as they want to become less dependent on Russia regards potential geo-political risks (Kamp, 2014).

Besides policy on energy, the national government also has policy on electric mobility, which is also part of a programme on air quality as similar to the municipality and province of Utrecht. These policy aims are incorporated in a 'Green Deal', which is an agreement between the central government and other organisations (private parties, governmental organizations, NGO's etc.) with regard to sustainability goals and ambitions (see Rijksoverheid.nl/greendeals). The idea of Green Deals is a more collaborative approach in green initiatives and projects towards reaching policy goals.

For public transport the national aim incorporated in a green deal is that all new busses have to be running on electricity or hydrogen by 2025. Besides, energy used for the busses has to be fully sustainable, hence coming from wind or PV. The central government, all provinces and bus companies has signed an agreement on 15-04-2016 with regard to this ambition. This ambition is part of 'Green Deal 198[11]', on electric mobility. This 'Green Deal' furthermore aims at a 15% share of BEV of new sold passenger vehicles by 2025. Another interesting Green Deal is 'Green Deal 183[12]', which contains the ambition to realise an amount of 100.000 shared cars by 2018. The Green Deal is signed by i.e. the municipality of Utrecht and the NMU. The latter shows that the national government has progressive

[11] C-198 Green Deal Elektrisch Vervoer 2016-2020 (Rijksoverheid, 2016b). Contains goals and ambitions to improve and increase electric mobility for the period of 2016 - 2020.

[12] C-183 Green Deal Autodelen: naar 100.000 deelauto's in 2018. (Rijksoverheid, 2015). Contains goals and ambitions to increase 'car sharing' in the Netherlands by 2018.

intentions towards issues such as SSC. However, it also shows that the government expects a lot from other organisations through their ambitions. It could therefore be that the government has no clear vision and no decisive strategy themselves. This implies that policy on a national scale could be more pretence than real ambition, which means ambitions will probably not be reached.

In conclusion it can be said that policies regards clean technologies are complex and differ per governance level. Mobility and energy generation are divided, which makes it even more complex for a system which is a combination of those two. Nevertheless, on a local and regional level policies are positively focused on EV's and PV, and even specifically on SSC. However, political power and policies are not strong on these levels. This means that the complex, inconsistent and sometimes contradictory policy on a national scale currently negatively outweigh the positive approach of the lower governments.

Societal Inertia

Another factor that comes forward in most of the interviews are potential societal inertia. First, many of the interviewees have their second thoughts about the will of the public driving an EV. The interviewees of the EBU (appendix III), the NMU (appendix IV), LomboXnet (appendix VI) and the province of Utrecht (appendix VII) argue that people still have a certain fear about the range and technique of an EV. The interviewee of the NMU calls it 'habitual behaviour' that people are not willing to drive an EV in general. However, the expert of the NMU does acknowledges the positive future perspective of EV's. The interviewee of the municipality of Utrecht (appendix IV) is more positive regards the public will in Utrecht locally. The expert argues that the technique of the system has to give the public confidence. Besides, the expert has more doubts about the sharing concept of WDS, while the municipality of Utrecht is aiming at car reduction through car sharing projects in their policy (see previous section). This point was also made by the interviewee of the EBU (appendix III, p54). About the car sharing concept the interviewee of the EBU states:

"but people are not ready anyway for sharing things. I think it is not the ideal way of entering the market, but you are located in the centre of the city where you have to deal with it." (appendix III)

In other words, the car sharing concept part of SSC could be a serious constraining factor for the development of SSC as people are not ready for sharing things at all.

Furthermore, several interviewees underline the difficulty of the system as potentially constraining. This could lead to inertia as the people find it easier to stick to their 'habitual behaviour', as argued by the expert of the NMU. The use of an application on your phone for WDS and sharing an EV are potential complex (technological) systems, which are hard to understand for an ordinary citizen, argued by the interviewees of the EBU (appendix III) and the province of Utrecht (appendix VII). In arguing this, the interviewee of the province of Utrecht states:

"Because it is a technical hassle with all those terms and plugs. If you going to delve into it as naïve citizen, you quickly see no wood for the trees anymore." (appendix VII).

In making observations during the discussion (appendix I, p51) people were already quite well informed about the project and how it works. However, as the interviewee of the NMU (appendix IV) states:

"now it is still something for the 'innovators' if you follow the innovation-curve".

This could be an explanation for the enthusiasm and positive attitude of the attendants as most of them could be people that are more interested than others due their interest in this innovation or in innovations in general. In the section 'Innovation Potential' there will be further elaborated on this part.

That people do not engage in electric driving could also be related to the insufficient knowledge among most people besides the behavioural aspect. This is stressed by the interviewees of the EBU (appendix III), the NMU (appendix IV) and LomboXnet (appendix). Moreover, the interviewees also argue, that besides the public, many authorities also have too little knowledge about electric mobility and its possibilities, which could have a constraining effect on the development of SSC. In relation to their point the NMU states the following:

"There is insufficient knowledge at different parties. The possibilities are not always that insightful for the greater public. But, at the municipalities the advantages are also not that insightful for what is possible. This applies for the issues and the possibilities." (appendix IV)

It implies a serious potential constraining factor. As the public has insufficient knowledge about the issues it makes sense that the public has no almost no knowledge about the possibilities at all. The interviewee of the EBU states the following in relation to the latter:

"The public opinion is absolutely not that far. There are enough people that take solar panels, but few take the next step. And there are far less people that know what you can do with your EV. So I hope that we can get WDS or SSC quick in the publicity to reach the greater public." (appendix III)

The point made by the interviewee is that SSC and related innovations as EV's and PV need publicity to create awareness and knowledge within the public. In conclusion can be said that, until mass knowledge and awareness creation takes place, projects as SSC are less successful as societal inertia remain a constraining factor.

Cooperation

Another stimulating factor is argued to be an important factor for the SSC consortium. First, the interviewee of the EBU (appendix III) notes that energy projects are often leaded by consortia in which parties complement each other through cooperation. A combination of bigger and smaller companies leads to scaling up a project. For example, smaller companies, such as LMS, develop the detailed software and the big companies have the needed distribution network.

Secondly, the interviewee of the NMU (appendix IV) argued for the efficiency of bottom-up projects in energy saving, generation and mobility. Hence, the expert argues for an energy transition through bottom-up developments. In chapter 5 it is explained that the NMU connects local energy corporations to SSC's project WDS, which shows the need for cooperation to expand and scale up the project.

Thirdly, the interviewee of the municipality of Utrecht (appendix V) notes that SSC has an important role for them as SSC's goals contribute to their policy goals. From electric mobility and car sharing to the sustainable energy generation (see policy and politics). In return the municipality gives the SSC consortium reserved parking spaces for their shared EV's (see regulations). In this sense it shows that innovations already contribute to local and regional ambitions. This could lead to a relative fast growth of SSC as cooperation between these two is already active.

Finally and probably most important, the interviewee of LomboXnet (appendix VI) as leader of and former of the SSC consortium also subscribes that it is the combination of the parties involved that made the projects succeed until now. Local governments were important with their support and small tech developers were important for the needed software etc. So, it is an important interplay of by cooperation between the local corporations, governments, NGO's, knowledge institutes and small and big companies that made the SSC consortium and project reality until now. In conclusion, it can be said that a broad network of actors that cooperate in a progressive and successful way could be a real stimulating factor for the development of SSC. Thereby, it is also needed for upscaling, thus growth and succeeding of the SSC.

Environmental Advantages

The environmental advantages were discussed in all the interviews as stimulating factor for the development of SSC. However, different answers were given in identifying it as a stimulating factor or not. The interviewees of the EBU (appendix III), the NMU (appendix IV) and the municipality of

Utrecht (appendix V) argued that the environmental advantages are not the factor that convinces to engage in the project of SCC in general. According to the interviewee of the EBU (appendix III) and the municipality of Utrecht (appendix V), it is for their organisation and for other organisations the economic benefits that convinces them to engage in SSC and not the environmental advantages (see economic advantages). However, they also note that when a certain point is reached and the concept could be applied on a larger scale, the environmental advantages matter. This implies that environmental advantages are more a relevant stimulating factor on the long-term.

For citizens the environmental advantages are not one of the main factors that convinces them in participating in WDS, hence it is not regarded as an important individual incentive (appendix III). According to the interviewee of the EBU (appendix IV) the financial incentive is the most important to individuals. The environmental aspect could be second as an individual incentive. The interviewee of the NMU (appendix IV) is more clearly in stating that there are no environmental advantages and also argues that it is the financial attractiveness that convinces individuals to participate. Where the interviewee of the EBU argues for the environmental aspect as a stimulating factor in second place, does the interviewee of the municipality of Utrecht (appendix V) argue it is inferior to all other incentives. The interviewee of the NMU argues that the financial system and participating in something new and exciting are more stimulating as factors.

On contrary, the interviewee of LomboXnet (appendix IV) is more positive about the environmental aspects as a stimulating factor. According to this the interviewee states that:

"The environmental advantages are an important stimulating factor in the further development of SSC". (appendix IV).

He argues that important environmental advantages are clean air locally, the limiting effect on the GHG's and fossil fuel extraction by integrating sustainable energy in the energy system. However, the scale on which the projects run is still very small, hence, it has a very limited effect yet, which subscribes the previously discussed part.

In the last interview, the expert of the province of Utrecht (appendix VII) has a contradictory opinion on environmental advantages as a stimulating factor. The interviewee notes that everything that they supported SSC or WDS with until today was from an environmental perspective. However, the interviewee sees a change from environmental budgets towards innovation and employment budgets. An explanation could be that today's green initiatives could generate economic benefits besides environmental advantages, which people are not always aware off. This has also been noticed by the interviewee of the EBU (appendix III). However, the expert of the EBU also noticed that these sometimes still are contradictory, for which the central government has no consistent policy (see policy). Related to the latter is the point that all policy on electric mobility is part of the programmes on air quality. This applies to every scale, from a municipal to a national scale. This means that all regulations and policies on EV's are made from an environmental point of view, although this is not seen as an stimulating factor by more than half of the interviewees.

In conclusion, environmental advantages are not there as a result of SSC and will not be on a relative short-term as the project is still relatively small. Therefore it cannot be seen as a real stimulating factor yet. However, it definitely will be on the long run as SSC expands to a larger scale and the environmental aspect only becomes more important.

Economic Benefits

What repeatedly was discussed in the interviews and found back in the observation are the economic benefits as a stimulating factor, which has already been introduced shortly. From the observation (appendix II) and in the interviewees (appendix III, IV, VI) the financial incentive for individuals to participate in WDS was confirmed. Individuals participating in a car sharing concept are financially better off than having an own car. During the observation it became clear that it could also be cheaper than using similar companies, such as Green Wheels (appendix II). However, this point was contradicted by the interviewees from LomboXnet and the province of Utrecht afterwards (appendix VI, VII). Nevertheless, it is interesting that similar car sharing companies, such as Green Wheels do not use EV's but normal combustion cars. Then the environmental aspect could convince individuals to become member of WDS instead of Green Wheels, which then could be an stimulating factor for SSC.

Furthermore, more regional economic benefits could act as a stimulating factor for SSC. First of all, the interviewee of the municipality of Utrecht (appendix V) notes that SSC is a project of the market, which therefore needs revenues. In addition, the expert of the EBU notes that SSC does not need subsidies anymore and needs to get scaled up to exploit its economic benefits, as mentioned previously (see regulations). In this sense the product of SSC is, or could become, economically interesting for the region of Utrecht and the SSC consortium as it could be sold as such. SSC could then become an relevant export product for the market parties and for the region of Utrecht. Not only with regard to the Netherlands, but also to Europe and even to the world. The interviewees of the EBU (appendix III) and the NMU (appendix IV) also argued the latter. In arguing this the interviewee of the NMU states;

"The 'smart grid' here on district level surely belongs to the future and will be an example" (appendix IV).

It shows the strong confidence of the expert of the NMU that SSC or its smart grid system of V2G technology potentially will be our future system. As already discussed could this be an important stimulating aspect for the region of Utrecht as the expert of the province of Utrecht states:

"The region of Utrecht has to have it from its innovative knowledge and knowledge focused economy". (appendix VII)

For this reason it could be stimulating factor for the development of SSC as part of a wider context of knowledge focused economy, which also applies to the Netherlands in general.

Furthermore, on the basis of the observation (appendix II) and argued by the interviewees of the EBU (appendix III), the NMU (IV), the municipality of Utrecht (appendix VI) and LomboXnet (appendix VI) there are economic benefits for grid operators. Because of the buffering effect of the V2G system of SSC the grid operators do not have to invest in strengthening the energy grid (see chapter 3.3). They could invest in these systems as a potential solution instead. This is more sustainable and probably less costly argued by the interviewees and based on the literature in chapter 3. However, not only the grid operators are better off with SSC as a system as the interviewee of LomboXnet states:

"Concerning the whole energy transition I think that due to the fast growth of EV's, batteries could play an important role in making energy systems more sustainable. Because you could grow further with solar and wind energy locally, but also nationally and internationally. Those cars provide many possibilities to take away the peaks from the grid and with that you could integrate a lot more sustainable energy in your system. So, that gives an enormous opportunity". (appendix VI).

So together with the economic benefits for grid operators this system could provide further growth of PV and wind energy, which could have increasing returns for sustainable energy production. Moreover, it also shows that the environmental advantages could take a leap as these systems provide more sustainable energy integration.

Finally, an important factor related to the economic benefits as stimulating factor is the renewable energy growth and its growth of employment. Besides, employment is also identified as an additional stimulating factor by the interviewee of the EBU (appendix III) and province of Utrecht (appendix VII) for the development of SSC. This seems a logical for the development of SSC as the employment grows together with the growth of renewable energy (Kamp, 2016b). Moreover, the RVO (2016) also notes that employment within electric mobility increased by 25% in 2014 in comparison to 2013. The latter shows that not only due the growth of renewables but also due the growth of EV's the employment grows, which could be a real stimulating factor for SSC.

As a conclusion it can be said that the economic benefits are, but more could become a real stimulating factor in the development of SSC. It has its benefits on every level of society, from individuals and grid operators to the Netherlands as a whole.

Innovation Potential

Another factor that comes forward in the interviews has already been shortly introduced in the previous sections, namely innovation potential. This has been identified as stimulating factor in two ways. The innovation potential of SSC towards the region of Utrecht and the innovation potential of the region of Utrecht towards SSC. In the previous section it is extensively discussed that the region of Utrecht is strongly focused on innovation and has an knowledge based economy. The interviewee of the municipality of Utrecht (appendix V) notes that the municipality is a real frontrunner in their integrated and progressive policies on i.e. clean mobility, CO_2-reduction and air quality in comparison to other municipalities. Thereby, the municipality aims to have the first electric public busses driving in the Netherlands in March or April 2017, which is also connected to SSC (appendix V, VII). The latter shows the innovation focused region of Utrecht that could be a real potential stimulating factor regards the development of SSC.

Besides, LomboXnet's Robin Berg is currently working on setting up a study track at the UU, in collaboration with the University of Utrecht (UU) related to SSC (appendix II). Thereby, the USI, the UU and the HU are direct partners within the SSC consortium (see 3.3). This shows the strong connection of SSC to knowledge institutes from the region, which potentially increases the innovation growth of the SSC.

Furthermore, as mentioned earlier another incentive for individuals to participate in SSC could be the innovation potential of SSC. This has been argued in the interviews with the NMU (appendix IV) and the municipality of Utrecht (appendix V). Related to this argument the interviewee of the NMU states:

"people engage because it is the future, because it is financially attractive and because it is practical" (appendix IV).

So, in conclusion it can be said that besides the financial attractiveness, could being part of the future be an important stimulating factor in engaging in SSC. Thereby, there possibly are regional innovative advantages regards SSC and advantages of SSC as an innovation to the region. Based on the latter it can be said that the innovation potential could be a real stimulating factor for the development of SSC.

Furthermore, besides the potential regards SSC as an innovation it is important that the innovation which constitute SSC are promising. Some calculations are made regards the growth of PV as an innovation (appendix VIII). These projections show the potential for SSC and V2G systems for further growth and could be a stimulating aspect regards their innovation potential.

First, the municipality of Utrecht focuses on PV as one of the main aspects in their policy (see policy and politics). Figure 15 shows the strong increase of PV in the municipality and the projected future growth. Currently WDS has a capacity of 1 MW (appendix VI). This means that in theory there is a potential for WDS of more than 13 MW in the municipality of Utrecht only.

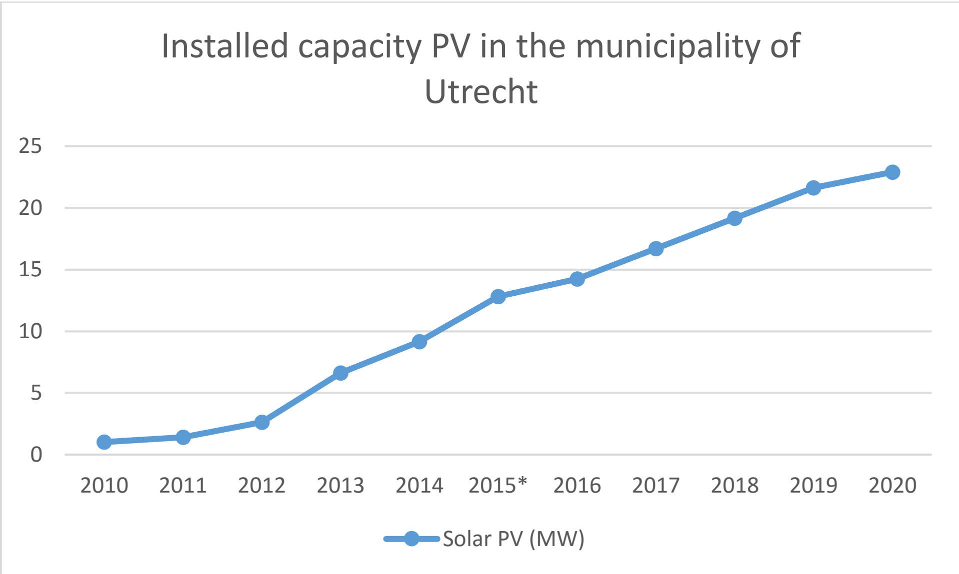

Figure 15. Capacity of PV in the municipality of Utrecht in MW (author, projections based on Municipality of Utrecht, 2016).

For the province of Utrecht the projections towards 2020 are also promising regards SSC (figure 16). However, the potential could be limited because SSC has its focus on a district level, which therefore potentially limits the scope to urban areas.

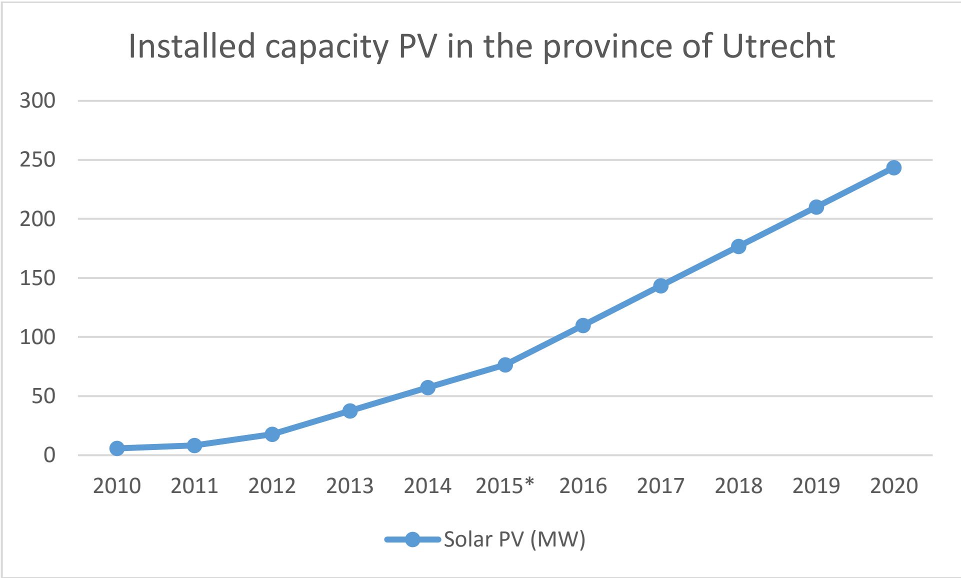

Figure 16. Capacity of PV in the Netherlands in MW (author, projections based on NMU, 2014).

Nationally (see figure 2, p11) the projections are that an amount of 4 GW installed PV will be reached by 2020 (PBL & DNV GL, 2014). However, in the projections by PBL & DNV GL (2014) they estimated the capacity of PV on 700 MW by 2014, which was already more than 1 GW (klimaatmonitor, 2017). It shows that PV grows even stronger than expected. However, as similar to a provincial level, the potential will be limited due the focus of SSC on a district level in high dense urban areas. Furthermore, the capacity PV by corporations is expected to grow from 13 MW, with an additional 26 MW, to a capacity of 39 MW nationally (NEV, 2016). As SSC mainly focuses on the generation of solar energy from energy corporations it provides a promising growth potential. Furthermore, it is also expected that PV generation for households will grow strongly. By 2030 it will account for 20 to 30% of the household consumption.

In conclusion, it can be said that besides the innovation potential as a stimulating factor regards SSC itself, the innovation potential of PV is promising on a local, regional, national and even international scale (see also chapter 1.2). Besides the developments around PV we also have seen in the last section and chapter 1.3 that the developments around EV's is promising. Altogether, it can be said that the innovation potential could be a real stimulating factor for the development of SSC.

Additional Advantages

Finally, this theme presents the findings on additional advantages that were discussed in the semi-structured interviews but could not be attributed to another theme, although they could be an important factor regards the development of SSC. First, the interviewee of the NMU (appendix IV) argues that the dependence on natural gas could be a stimulating factor for SSC. The interviewee sees it as a societal trend instead of an ecological or environmental aspect. Currently, our national government is still strongly focused on natural gas as discussed previously. However, the interviewee of the NMU notes a growing resistance towards natural gas in many societal layers of the population. This is, according to the interviewee, related to the earthquakes in Groningen and the rising prices of natural gas. In addition, we want to become less dependent on the import of natural gas, from, for example, Russia (appendix IV). Although this seems a relevant point, until now only the municipality of Amsterdam has a policy, which aims to completely ban the use of natural gas by 2050. Nevertheless, the national government only focuses on limiting the dependence on Russia and not limiting the extraction of natural gas (Kamp, 2014).

Another additional advantage, mentioned by the EBU (appendix III), NMU (appendix IV) and LomboXnet (appendix VI), is the car sharing concept part of WDS. As our transport infrastructure receives a lot of pressure from our mobility system due to the increasing congestion new concepts have to reduce car use (gemeente Utrecht, 2016 mobiliteitsplan). One of these concepts is car sharing, which is also picked up by the national, provincial and municipal governments as a policy aim in the future (see policy and politics). Therefore, the car sharing concept could be a stimulating factor the development of SSC. However, it was also showed that the char sharing concept could work adverse as individuals in the Netherlands do not prefer sharing a car or sharing anything as a result of habitual behaviour (see societal inertia). Therefore could the concept of sharing a car in SSC also have an adverse effect. In conclusion, it cannot be said whether it will work stimulating or constraining.

Finally, as a last stimulating factor the interviewee of the municipality of Utrecht states:

“A person as Robin Berg is the most important stimulating factor.” (appendix V).

The interviewee argued that an initiator, entrepreneur or change agent in the person of Robin Berg is also an important factor in the realisation of projects such as SSC. A leading figure within the development of SSC could therefore be an additional advantage, thus stimulating factor.

6.2 Synopsis themes in multilevel perspective

The following part structures the findings from section 6.1 through the perspective of the multi-level concept of transition theory. As a result, the findings from the themes will be presented in a synopsis for the different levels of governance with regard to the Dutch energy system. The reason to structure the findings from an organizational point of view is to create a concise overview of the effects of the themes on the different levels towards SSC. Later these findings will be used as input for the transition management-cycle.

Regulations

Macro level: regulations on this level have the most influence. However, laws and regulations nationally are inconsistent and complex, which results in the adverse effect of the intended stimulating effect of regulations. There is no continuity in stimulating regulations on PV and regulations on energy taxes, and especially the balancing regulation are proved to be ineffective and outdated. Most important is that latter regulation constrain potential investments in smart grid systems, thus SSC.

Meso level: on this level there is not much to regulate as provinces have little regulative power. the municipality is proactive in supporting SSC with local regulations. They adjusted some regulations, such as their parking regulation, to stimulate the development of SSC. Moreover, other progressive regulations are implemented here, such as environmental zones. Ineffective and inconsistent regulations on a macro scale, therefore, outweigh the few stimulating effects of regulations on this level.

Micro level: the complexity and inconsistency of the regulations cause uncertainty, which results in disagreement between companies and organizations on this level regards regulations. Thereby, the balancing regulation has a constrains the incentive to invest in smart energy system, thus SSC, which logically has a negative effect on the development of SSC.

Policy

Macro level: there is no continuity and uncertainty in national policy, especially towards PV. It further lacks of political will and a clear strategy. Policy on EV's is relatively more clear but are not very ambitious. Moreover, national policy still focuses too much on the short term and fossil fuels rather (natural gas) than on the long term and sustainability, which also results in a lack of coherent policy on economy and sustainability. Currently these policies compete with each other, which is unnecessary.

Meso level: regional politics potentially constrain the stimulating policies as a result of growing influence of conservative parties. However, policy regards SSC is much focused on PV and EV's. Thereby, authorities have SSC explicitly on their lobby agenda towards national and European policy. Besides, the municipality of Utrecht is a relative frontrunner on policy integration, which results in a more coherent policy approach. Still, there is a much greater political power on the higher levels, which has a possible negative influence on the development SSC.

Micro level: policies regionally do contribute to the development of SSC as companies and organizations receive much support from these policies from regional authorities. However, due to the inconsistent and constraining policies on a national scale SSC receives a higher constraining effect than a stimulating effect.

Societal Inertia

Macro level: there is still a trend within the public, where fear regards the range and technique of EV's exists. Thereby, there is still a lot of 'habitual behaviour' within the public. People are not willing to participate in a sharing concept. People stick to their 'habitual behaviour' as they lack knowledge about environmental issues and possibilities of EV's and PV. The lack of knowledge also exists within local authorities. The possibilities of smart grids is even less known.

Meso level: the main reason for the habitual behaviour is a lack of publicity and awareness, where the government lacks to contribute to. However, awareness on higher levels on these issues is growing. The sharing concept of SSC could receive support nationally from governmental organizations as congestion is a serious issue regionally and nationally. In that case could the governments support car sharing, which could inhibit inertia regards car sharing.

Micro level: the complexity of the technological systems is a potential source of inertia. However, individuals have are more positive attitude towards driving an electric vehicle and its possibilities in the region of Utrecht. The relatively knowledge focused and progressive municipality could be a stimulating factor with regard to behaviour locally. However, the car sharing concept is still a persistent issue.

Cooperation

Macro level: No real adequate cooperation from national government is there towards the ambitious goals of the regional and local parties. Interaction between the macro level and lower levels is therefore not well organised and could constrain the development of SSC.

Meso level: regional authorities, regional market parties and NGO's cooperate proactive regards SSC. Regional authorities act as supportive organizations towards SSC as it also contributes to their own policy goals. Market parties and NGO's proactively support and SSC in expending its market position. Cooperation on this level is relatively adequate and successful as networks are well-established around SSC.

Micro level: small market parties, corporations, local authorities, knowledge institutes and individuals (Robin Berg) cooperate within the SSC consortium and projects. Most involved actors have an complementing role regards each other. The interaction between the meso level and micro level is also well organised, however the lack of cooperation from the national government potentially constrains the stimulating effect on SSC.

Environmental Advantages

Macro level: liberalisation and Europeanisation played were trends that received more attention than environmental issues the last past years. Furthermore, because this level focuses more on fossil fuels and short-term developments, environmental issues also receive less attention. For this reason there are no real environmental advantages as this level towards SSC.

Meso level: the real advantages are also relatively small due to the focus on the economic aspects competing with environmental aspects. However, it did persuade regional authorities support the project financially as SSC contributes to reaching environmental policy goals. Furthermore, the scale to which the project is applied is still too small to have a real effect.

Micro level: although environmental advantages are inferior as incentive to the financial and innovation aspect to engage in SSC it does persuade people as environmental awareness is slowly growing among individuals. Moreover, the project is still relatively small, which limits the environmental advantages yet.

Economic Benefits

Macro level: as renewable energy and electric mobility grow, the employment within these sectors grow as a national trend, which is potentially beneficial to the development of SSC. Furthermore, the Netherlands could become an international example as SSC could become an export product. However, the moment when this will probably could become reality is still far away.

Meso level: several economic benefits are related to SSC. First, the system of SSC could be a potential solution to increasing electricity grid issues. Thereby, it stimulates employment regionally as similar to national growth in employment in the energy and mobility sector. Besides, Utrecht regionally could become a leading example nationally and internationally, which could generate economic returns. However, these effects are still relatively small.

Micro level: on this level the financial aspect is the real incentive for participating in WDS. Participating in WDS is relatively less costly than owning a car and thereby it avoids double tax regulations. However, the sharing concept and car range could limit the financial aspect. Thereby, it should also be noted that the environmental aspect could become a leading aspect when sharing concept projects are have the same financial attractiveness. Therefore, on this level the economic or financial benefits are strongly stimulating regards SSC.

Innovation Potential

Macro level: PV nationally and internationally has grown incredibly and is set to grow even more the coming years, which could have a stimulating effect on the development of SSC. Innovation trends also are positive towards electric mobility, thus potentially to SSC

Meso level: as the region of Utrecht is a knowledge, thus innovation focused economy it has a potentially stimulating effect on SSC. Together with the potential of PV regionally, it can be said that the innovation potential is a stimulating factor towards SSC on this level. However, the balancing regulation proved to be ineffective and limits innovation incentives to invest in energy storage systems, which potentially constrains the development of SSC

Micro level: after the financial aspect the innovative aspect works as incentive for the 'innovators' locally. This makes environmental aspect inferior as individual incentive, although it could have an stimulating effect. The innovation potential of SSC towards the region of Utrecht is also there, which is probably also stimulating for its development.

Additional Advantages

Macro level: more resistance is growing nationally towards natural gas due to the earthquakes in Groningen and dependence on Russia. The urge to look for alternatives could be therefore an additional advantage on this level that could stimulate the development of SSC.

Meso level: the car sharing concept could be an advantage to authorities as growing congestion needs potential car reduction solutions. However, the societal attitude towards car sharing is not beneficial for its development as it receives resistance. On this level there are, therefore, less additional advantages that potentially stimulate the development of SSC.

Micro level: an entrepreneur and initiator in the person of Robin Berg, as director of LomboXnet, could be an important stimulating factor behind the developments of SSC. Therefore, additional advantages on this level act as a stimulating factor.

Concluding remarks

From the last section it becomes clear that in most of the themes there is clearly a difference between the trends on a macro level and the developments on the meso and micro level. Where the macro level in most cases has a constraining effect, or no real stimulating effect, does the meso level variate and micro level mostly has stimulating effects. However, it becomes also clear that the development of the different themes on a national scale have more influence than the lower levels, which is often at the expense of the stimulating effects on a regional and local scale. The findings of the latter section will be analysed further as they will be related to the theoretical framework in the next section.

6.3 Towards a Transition Agenda

The previous part presented the findings from the direct observation, semi-structured interviews and the thorough desk research in themes. In the following part the findings will be related to the theoretical framework. The results will be presented and discussed according to the steps of the transition management-cycle. By starting on an *operational level* the role of Smart Solar Charging as local innovation in the municipality of Utrecht is elaborated on according to the innovations theory of Rogers (2010). Secondly, on a *strategic level* visions and future images from the findings and lessons from the previous step will be described and discussed in a wider frame of vehicle-to-grid systems and the energy transition. In the final step a synthesis is given on a *tactical level* in the form of a *transition agenda*. This transition agenda will be a synthesis in the form of an institutional design with policy recommendations on the potential role of V2G systems in the energy transition.

The Diffusion of Smart Solar Charging

In order to answer the second research question this section will elaborate on the role of SSC in the municipality of Utrecht. From a multi-level perspective, SSC is a niche-innovation on a micro-level, which exerts pressure on the regimes on a meso-level. Through the analysis of the case of SSC in municipality of Utrecht implications can be made about the potential role of V2G systems in the energy transition. The analysis of SSC will be done extensively, first according to innovations theory, where after it will be related in a wider frame of transition theory.

First, the innovativeness as the first element of analysis an estimation has been made, which gives an indication of the maturity of SSC as an innovation. Currently, only 0,68% of the total population of Lombok is member of SSC (appendix VIII). However, as SSC started as pilot very recently in Lombok there are just a handful of members. Moreover, the first members are not necessarily all from the district of Lombok as anyone from the province of Utrecht is allowed to participate. Although all current charging stations are located in the area of Lombok or just outside the district (see chapter 3.2). So it is more likely that potential members are living in or close to Lombok. Keeping the latter in mind the innovativeness of SSC for the whole municipality of Utrecht is estimated. However, with less than 0,2% the margin of 2,5% of the next category of adopters will by far not be reached. The shares of units of adoption of SSC as an innovation show that it is still in the start-up phase. For this reason it can be said that SSC is a very young innovation, which is only for the *innovators* if we follow the *innovation curve*.

Furthermore, the SSC consortium has formulated ambitions for 2018 with regard to the amount of cars, users and charging stations within the province of Utrecht (appendix VIII). According to these ambitions the innovativeness is also estimated and will account for a little less than 2,5% if all the members live in the municipality of Utrecht. This is, however, probably not the case as their ambition focuses on the whole province of Utrecht. The estimated innovativeness will than account for approximately 0,8% for the province of Utrecht, which is still far below the margin of 2,5% until the next category. In conclusion it can be stated that SSC is still for the *innovator*s for now and until at least 2018 within the municipality of Utrecht. The degree of maturity, therefore, of SSC will remain relatively low for the coming years.

Secondly, with regard to time, the rate of adoption can be analysed by five characteristics of SSC in the municipality of Utrecht. The perception of its characteristics are first discussed, where after the results and input for the results are given in table 6.

Relative advantages

The first characteristic is the relative advantage, which says something about SSC in comparison to systems or technologies it supersedes. From the findings it is clear that SSC has a several relative advantages in comparison to the current energy infrastructure, PV and EV's regards its economic benefits, environmental advantages, innovation potential and additional advantages. The result of this characteristic is therefore clearly positive.

Compatibility

The second characteristic are the needs of a potential adopter. The fear of the technique and range could be an issue, which could also be accounted to insufficient knowledge. Furthermore, the car sharing concept of the project could limit the compatibility as individuals are not willing to share. Moreover, the latter constraining effects could quickly lead to habitual behaviour, which results in inertia. However, the financial, innovation and sometimes environmental incentives could increase its compatibility as it is a relative cheap, innovative and environmentally conscious to participate in SSC. Nevertheless, the result is that its compatibility is positive on the hand, due the latter positive incentives, while on the other hand the compatibility is negative, due to the sharing concept, insufficient knowledge and inertia, which results in a lack of meeting the needs of the potential adopter.

Complexity

The third characteristic, complexity is found back several times and could be an potential constraining factor. The complexity of new innovations as PV, EV's could also lead to inertia due habitual behaviour. Moreover, the combination of both in SSC could even lead a higher complexity which could lead to even higher habitual behaviour. A lack of knowledge is also here a potential issue. The result based on the latter is negative results regards the complexity of SSC.

Trialability

The fourth characteristic, trialability, is relatively constrained by regulations and policy on a national level that also have a direct effect on a meso and micro level. The constraining effects of those regulations negatively outweigh the stimulating regulations implemented regionally and locally. This does not mean the stimulating regulations do not have any effect, however still too little. The cooperation from the macro level also constrains the trialability as the central government does not adequately provides space for experimenting, hence innovation development due its focus on fossil fuels and ineffective regulations as balancing. The local and regional authorities do subsidize SSC's experimental phase, where it still is as discussed earlier. However, the result for the trialability for SCC based on the latter is negative as little experimental freedom and support exists regards SSC.

Observability

The fifth characteristic observability also relates to the use of *communication channels*. The use of communication channels is done more face to face in this case, through information meetings for example (appendix II). This has been proven effective based on the observation, however the big mass is not getting reached through mass communication, which is partly related to the lack of cooperation from the authorities on a macro level. Mass communication is needed to reach more possible units of adoption through awareness and knowledge creation. However, it proved to be a challenge to convince the national authorities in doing so.

As a result it remains difficult to say whether SSC as an innovation is a successful in the municipality of Utrecht based on its characteristics. Also because SSC is still in a starting phase, where only the innovators will engage in the project. However, based on the result in table 6 it can be said that the complexity and trialability regards SSC are negative, which has much to do with the existing structures on a national scale. The regimes regionally and locally are in favour of the innovation, as well as the advantages and needs regards SSC and its potential units of adoption. However, much of its developments and effects get constrained by existing regimes nationally, which also apply to the lower governance levels.

Characteristic	Input Findings	What?	Result
Relative Advantage	Environmental Adv. Economic Benefits Innovation Potential Additional Adv.	Does it supersedes the existing energy system?	+
Compatibility	Societal Inertia Economic Benefits Innovation Potential Environmental Adv.	Is compatible to daily life?	0
Complexity	Societal Inertia Regulations	Is it not too complex to use?	-
Trialability	Regulations Cooperation	Is it easy to experiment before using it?	-
Observability	Cooperation	Is it visible to others?	0

Table 6. Results of the characteristics of Smart Solar Charging in the municipality of Utrecht.

The put the latter results more in a transition perspective, the indicators described by Schot & Geels (2007) can be used to analyse the viability of a niche based on the multi-level concept. These indicators are related to SSC to in order to make implications related to its viability and hence, its maturity in a multi-level perspective (see table 7) .

First, it can be said that learning processes locally are present due to the knowledge intensive region in which SSC is located. The project functions within a design in which learning processes are enabled through different actors, such as the UU and HU. However, based on its trialability it can be said the learning processes get constrained by the current regimes. Nevertheless, many characteristics of a dominant design are present in which learning processes take place, which implies that the first indicator is present. Secondly, powerful actors certainly joined the support network of the SSC consortium. Renault as multinational supports the network together with the municipality and province of Utrecht for example. Furthermore, the network also is supported by other organizations such as Triodos, which is a Dutch bank. From the latter it becomes clear that actors from knowledge institutes and governments to banks and multinationals joined the support network around SSC. Based on their cooperation, also discussed previously it can be argued that this indicator is certainly present. Thirdly, it could be said that the price/performance improvements have become better. This is derived from its economic advantages and it was already mentioned that strong expectation do exist towards SSC. It can also be argued that this indicator is present if we look to its relative advantages discussed previously. Finally, if we look to the market share of SSC it can be related to the innovation curve discussed earlier. In that case it certainly not reaches a 5% market share by far in the municipality of Utrecht. This indicator is, therefore, certainly not present as we relate it to the current and even its expected innovativeness for the coming years.

	Indicator	Result Smart Solar Charging
I	Learning processes have stabilised in a dominant design	Present
II	Powerful actors have joined the support network	Present
III	Price/performance improvements have improved and there are strong expectations of further improvement	Present
IV	The innovation is used in market niches, which cumulatively amount to more than 5% market share	Not present

Table 7. Results of the indicators regards the viability of Smart Solar Charging as a niche in the municipality of Utrecht.

Based on the results of SSC as an innovation in the municipality and SSC as a niche, put in a multi-level perspective lessons can be drawn in order to make implications on the role of SSC in a wider frame of the energy transition. The following lessons can be formulated based on the results about the role of Smart Solar Charing in the municipality of Utrecht.

I. Learning processes around the development of Smart Solar Charging are well established. A network of knowledge institutes and market parties enable and stabilise these processes as a result of good cooperation. However, these processes could be really accelerated by a more experimental freedom from the national government. The government should take a guiding role here through regulations.

II. The support network around the development of Smart Solar Charging contains variety of actors, from small technological developers to multinationals, knowledge institutes and governmental organizations. This makes the support network around the development of Smart Solar Charging powerful and promising. However, the network could achieve much more through adequate cooperation and a clear vision of the central government.

III. The price/performance improvements around Smart Solar Charging are promising and improving. Expectations are furthermore high for Smart Solar Charging self, as for photovoltaics and electric vehicles. However, these improvements could also increase together with expectations by the adaption of regulations on balancing and double taxations which constrain innovation incentives.

IV. Smart Solar Charging as a niche is used by a relative little group of adopters. It shows that the niches is not viable enough for breakthrough to the meso level. It seems that Smart Solar Charging is a proven technology. However, its niche market share has to increase before certain supporting measures can be removed. Moreover, without the disappearance or adaption of national regulations the innovation has less chance of breakthrough.

The latter formulated results can be used make implications about V2G systems in a wider frame of the energy transition on a tactical level. In doing so, a *transition agenda* for further successful development of vehicle-to-grid systems can be formulated as a synthesis of the results. However, a *transition arena* has to be established on a strategic level first. Therefore, the following part presents this transition arena with respect to vehicle-to-grid systems and the energy transition.

Transition Arena on a strategic level

On a strategic level of the TM-cycle, future images and visions are formulated and given to come to a synthesis of the results in the next section. The transition arena is characterized by bringing frontrunners together to create these future images and visions. The interviewees were asked what their visions and future images are regards the current energy transition and SSC. On this strategic level a group of frontrunners, represented by the interviewees, formulated their future images and visions, which have been translated in a transition arena according to the theoretical framework regards the current energy transition and V2G systems. In this arena the results in the form of a the synthesis of their visions and future images are presented below. An overview of the input of the interviewees for the visions and future images is given in table 8.

I. The energy transition is happening now and cannot be stopped. It can only be accelerated.
II. The energy transition happens through decentral bottom-up initiatives in which a variety of actors is involved.
III. Systems that link renewable energy generation with storage systems based on EV’s are the means to accelerate the energy transition.
IV. V2G systems prevents the whole system for becoming too costly to keep working. (prevents lock-in as a result of its path dependency of a central organised system)
V. V2G systems accelerate developments around PV and the other way around.
VI. V2G systems do not need to only generate costs but could generate economic benefits instead.
VII. V2G systems first generate environmental benefits on the long term after generating economic benefits on the short term.
VIII. Electric mobility and car sharing are important means in realizing cities with clean air.
IX. V2G systems will be successful on the relative short term in urban areas. On the long run it will be successful everywhere.

Interviewee	I	II	III	IV	V	VI	VII	VIII	IX
EBU			x		x	x	x		
NMU	x	x	x		x				x
Municipality			x		x			x	x
LomboXnet			x	x	x			x	
Province	x		x		x	x	x	x	

Table 8. Input interviewee for vision/future image on a strategic level.

The formulated visions and images are put relatively straightforward. However, to put them in perspective of TM in the form of a transition agenda, these images should be sharpened or fine-tuned. This will be done in the next section, which will present the final policy recommendations in the form of an institutional design on a tactical level of the TM-cycle.

Transition Agenda for the role of V2G systems

The previous results on an operational and strategic level create an image of Smart Solar Charging's current role in the municipality of Utrecht and what lessons can be drawn from its role, as well as it shows the visions and future images on a strategic level regards V2G systems and the energy transition. The following part will present a synthesis on the basis of these results on a *tactical level* of the TM-cycle to formulate policy recommendations on how V2G systems could play a role in the Dutch energy transition. This step is an important step to planners, as they often act as policy entrepreneurs or policy makers. In this step, the latter is used as the point of view to formulate these policy recommendations in the form of a institutional design.

"There is only one way to effect significant and lasting social change: changing the people who make up society. And there are only two ways of changing people: changing individuals, and changing institutions" (Alexander, 2005).

The latter statement of Alexander (2005) underlines once more the way which social change is enabled, which will be aimed at in this thesis through as an institutional design. The synthesis will be based on an institutional design through policy recommendations in order to recommend changes to effect significant and lasting social change in the form of an energy transition, and what role vehicle-to-grid systems could have in the energy transition and how they can play this role in the energy transition.

First of all, adaptation of the institutional framework towards a more facilitative institutional framework on laws and regulations in favour of PV and experimental freedom is desired on a national level in order to provide space for V2G systems in the Dutch energy system. From the results it became clear that, societal inertia limit the incentives for individuals to drive an EV or participate in SSC. However, this could be solved when the national government plays a more guiding role towards renewable with consistent and long term policy, which currently lacks. Therefore a change regards enabling a more important role to the V2G systems in the Dutch energy transition, lies in, first, changing the formal institutions and structures that constrain its potential development from a national level. If these adaptations will be introduced, people could change, which in return will effect significant and lasting social change in the form of an energy transition. In this change V2G systems could be used as a mean to accelerate this energy transition towards renewables.

In doing so, the government has to focus on adaptation of its institutions as main aim. The necessity for adaptation on the relative short run is on the balancing regulation on photovoltaic electricity and on double energy taxes on an operational level regards individuals. Adaptation of the regulation could lead to the several changes. First, as it constrains innovation incentives in the form of i.e. investment regimes as grid operators probably only optimize the systems rather than changing it to its future needs, as they are part of the current fossil energy regimes. The adaptation of the regulation could prevent potential costly and unnecessary grid investments by the grid operators. Grid adaptation through implementation of V2G systems instead, could lead to an even more stable energy grid on the long term.

Secondly, individuals are now the consumers within the energy system. However with the adaption of the regulation individuals could become prosumers within the energy system, where smart grid systems aim at. Currently, regulations prevent V2G systems to become profitable as balancing is obligated by the central government. A change, therefore, of the regulation could enable individuals to become a stakeholder in the energy system which could in turn create knowledge and awareness as they become part of the system.

Thirdly, the regulation constrains the experimental freedom. As the regulation currently lacks of regulative freedom, adaptation could lead to more innovation and entrepreneurship towards storage and V2G systems. Finally, the latter two effects could provide growth of PV and EV's as V2G systems could integrate these innovations in a more profitable way.

Besides the latter results on the constraining balancing regulation, results on stimulating regulations also imply another part of the institutional design. SSC is the first V2G system publicly used in the world, which therefore, as found earlier, V2G systems have no sufficient markets and market share yet. This means that stimulating regulations should not be taken away for upscaling. The viability of the niche is not strong enough for breakthrough in a wider sense of a multi-level perspective. By taking away stimulating regulations too early, the niche of V2G systems could have to compete with the existing regimes, which are far more mature which could lead to failure of the innovation.

As a second main aim of the institutional design is the construction of an facilitative institutional framework towards knowledge and awareness creation and more cooperation from a national level. The design of a national facilitative institutional framework should focus on the informal institutions. In supporting significant and lasting change through the formal institutions, informal institutions could be changes that could in return could change behaviour and attitudes of individuals towards EV's and renewables more in general.

What came forward as an evident constraining factor for the development of SSC is the current lack of awareness and knowledge among individuals and local authorities, which leads to societal inertia. On this point also, it is the national government that is the constraining actor. The following institutional design should increase the awareness and knowledge of the individuals and local authorities. First the national government should use mass communication channels in reaching the public. Nowadays the national government lacks a strategy in making individuals and local authorities aware of the current issues at play, but also the current possibilities as technologies as V2G systems are proved technologies but not known by the greater public.

Furthermore, the national government should implement a more proactive strategy towards cooperation with market parties and dynamic changes within energy markets. Currently, the national government lacks adequate cooperation towards new promising niches from a multi-level perspective. Due to the lack of adequate behaviour of the government, the time width between innovation creation and real upscaling in order to create niche-regimes is relatively high.

7. Conclusions and Discussion

Integration of technological developments of photovoltaics and electric vehicles is made possible by vehicle-to-grid systems. The potential role of vehicle-to-grid systems in the energy transition, and what effect that role could have in the energy transition has been the main focus of this thesis. A real life example has been recently set up in the municipality of Utrecht, named Smart Solar Charging. By doing a case study research on Smart Solar Charging the potential role of vehicle-to-grid systems is studied. For this reason the main topic of this thesis was to find a satisfying answer on the main research question:

"What role can vehicle-to-grid systems play in the energy transition, based on lessons from Smart Solar Charging in the municipality Utrecht?"

The following chapter will first elaborate on the sub research questions of this thesis in 7.1 in order to come to an general conclusion in chapter 7.2. In the general conclusion the answer on the main research question is presented and discussed.

7.1 Sub conclusions

Sub research question 1 "How can vehicle-to-grid systems as local innovations play a role in the integration of solar photovoltaic power and electric vehicles?" is answered in chapter 1 and 3. The transition towards an energy system based on renewable not only requires large scale adoption of clean technologies but also new energy management strategies. Vehicle-to-grid systems are a relatively new form of such energy management technology in which the electric vehicles are connected to the grid as storage system. In this sense the battery of the electric vehicle could be used as storage system for generated electricity from i.e. photovoltaics, which enables electricity load shifting through the use of information and communication technologies. Moreover, it also, therefore, enables stability within the electricity grid by shifting these electricity loads, which can be used to increase self-consumption of electricity that could reduce peaks within the electricity grid. Vehicle-to-grid systems could, therefore, play an important role as integration technology by enabling a buffer system based on electric vehicles and photovoltaic power.

Sub research question 2 "How does Smart Solar Charging as local innovation plays a role in in the municipality of Utrecht?" is answered in chapter1, 3 and 6. In the municipality of Utrecht, Smart Solar Charging as a local innovation is the first public vehicle-to-grid system based on photovoltaics in the world. The case of Smart Solar Charging is an example as potential accelerator in reaching regional ambitions and goals of the municipality of Utrecht towards an energy system based on renewables. However, the diffusion of Smart Solar Charging as a local innovation is discussed which results in the following conclusion. Regards the innovativeness and rate of adoption of Smart Solar Charging it remains to be seen what role it plays and can play in the municipality of Utrecht. Currently, it is still something only for the innovators, with regard to the innovation curve of Rogers (2010) and will be until at least 2018. Therefore, the role of Smart Solar Charging is still relatively small, which makes it hard to make predications. Nevertheless, regards its rate of adoption it can be said that it does have relative advantages in comparison to other systems it supersedes. However, its complexity and the trialability around Smart Solar Charging still are issues for further expansion.

Besides, several lessons were drawn from its role in the municipality of Utrecht. First, the learning processes have stabilised in a dominant design due the active participation of knowledge institutes. However, the process could be accelerated by more including end-users and individuals. Secondly, the support network is present with a variety of actors, including powerful actors as Renault. However, the network needs more adequate cooperation from the national government. Thirdly, the price/performance of Smart Solar Charging did improved and expectations are high. However, regulations on balancing and double taxations on a national scale constrain improvements and expectations. Finally, the system of Smart Solar Charging is used by a too small group of adopters, representing the innovators. The latter lesson means that from a multi-level perspective the niche market of Smart Solar charging is not viable enough for upscaling to a niche-regime and still needs niche 'nurturing' from stimulating policies and regulations.

Sub research question 3 *"What are stimulating and constraining factors in the development of vehicle-to-grid systems?"* is answered in chapter 5 and 6. First, based on the theoretical framework and background knowledge, the potential stimulating and constraining factors were given for input in the interview guide. Through the findings of the data analysis the stimulating and constraining factors for the development of Smart Solar Charging we identified in themes in chapter 6.1. Based on further analysis of these findings the main factors were found. The implied main stimulating and constraining factors for the development of vehicle-to-grid systems, based on the lessons from Smart Solar Charing in the municipality of Utrecht are as follows; regulations, policy, societal inertia as main constraining factors and cooperation, environmental advantages, economic benefits, innovation potential and some additional advantages as main stimulating factors. Within these constraining and stimulating factors are clear difference was found between the national macro level established regimes and lower meso established regimes. On a micro level the factors are often more stimulating, which is as expected according to transition theory.

Sub research question 4 *"How can vehicle-to-grid systems play a role in the Dutch energy transition?* is answered in chapter 6. The synthesis from the results in the form of an institutional design are given based on the results of the constraining factors on the development of vehicle-to-grid systems from on an operational level and the results of the visions and future images on a strategic level. The following results were presented in an institutional design as synthesis, which also represents the main results from a planning perspective. There is a need for an institutional framework based on formal an informal institutions on a national scale in the Dutch energy system to cope with the incumbent regimes on a national level. Within these frameworks the most essential institutions that have to be adapted or planned are the balancing regulation, double taxes, cooperation of the national government and creating knowledge and awareness by the central government. Currently the national government lacks this framework which has a constraining effect on the potential role that vehicle-to-grid systems could play in the Dutch energy system. Without policy recommendations to the current regimes, a transition will probably not enfold as a result of the strong incumbent fossil energy regimes that inhibit change and vehicle-to-grid systems will hardly reach a position within the regimes.

7.2 General Conclusion

The following part will elaborate on the main research question of this thesis; *"what role can vehicle-to-grid systems play in the energy transition, based on lessons from Smart Solar Charging in the municipality Utrecht?"*, as we answered the sub research questions in the previous section. The energy transition is happening, which means were currently are in the between one relatively to another relatively stable equilibrium in which our complex energy system undergoes a fundamental change. However, the transition is faster needed than it currently develops to meet sustainability goals in order to shortly said, save our planet. As a main conclusion, based on lessons drawn from Smart Solar Charging in the municipality of Utrecht, with regard to the latter fundamental change, it can be argued that vehicle-to-grid systems as niche-innovations could play a significant role as catalyst in the energy transition as it probably positively contributes to a change within the current energy regime. Based on the latter, implications on several potential effects towards the current energy transition can be made with regards to the role of vehicle-to-grid systems.

The emergence of niche-innovations as electric vehicles and especially in photovoltaics offer great opportunities in the current energy transition as niche-innovations that deviate from the status quo. Vehicle-to-grid systems, as recently originated niche is in use for the first time in world publicly in the municipality of Utrecht. Within the current energy transition, struggles in approaching it are still existing, especially in the Netherlands. This has to do with existing strong fossil energy regimes in which institutions often play a constraining role on a national and international level. New ideas and innovations, in the form of niches have to change that. Vehicle-to-grid systems could have that ability, which could lead to a more sustainable energy system. However, the application of the niche is still relatively small which therefore currently cannot have any significant impact and will not have until at least 2018. To increase the likeliness of playing a significant role adaptation of the institutional framework on a national scale is needed as currently the national government lacks of a well-structured institutional framework. A complex, ineffective and inconsistent institutional framework as the constraining regimes on a national level currently inhibit the ability of vehicle-to-grid systems to play an effective role in contributing to a complex system change towards an energy system based on renewables.

The previous conclusion can be dealt in the light of a planning approach that deals with complex system change by using a prescriptive approach, the transition management-cycle. As a planner, the point of view of a policy entrepreneur and advisor has been taken in this thesis, by presenting an institutional design on a tactical level of the transition management-cycle. Within this institutional design the most important aspects were realizing experimental freedom on a micro level for niches and creating a change of attitude towards electric mobility and clean energy technologies among the public on a macro level. In doing so, the inhibiting regimes that constrain the current potential role of vehicle-to-grid systems as a local niche-innovation could be dealt with, by increasing the bottom-up pressure and top-down pressure on the regimes on a meso level. The latter, in return, could potentially accelerate the current happening energy transition by gaining mass due system integration and co-evolution of the electric mobility system and renewable energy generation system. The next section provides a discussion on the process of the thesis and its contribution to planning and theory.

7.3 Discussion

In this section a discussion in given on the literature used and the validity and reliability of the empirical data, findings, results and conclusions. Finally, a discussion will be given on the contribution of this research to planning and theory.

First of all, with the literature used in this thesis some struggles emerged in integrating these into a wider frame of theory. Smart grids and vehicle-to-grids are new spatial concepts, but are relatively new and unknown subject within planning. These highly technological concepts were, therefore, not easy to relate to planning theory in general. It has therefore been chosen to discuss them separately in chapter 3. Furthermore, transition theory always remains a point of discussion due its high level of abstraction. This also putted some serious thinking on how to translate the empirical data into findings through a multi-level perspective, where the difference between real scales and the scales implicated by transition theory were hard to separate. To create a better understanding about the dynamic processes within transitions and the multi-level concept, theory on institutions (part of the regimes) and innovations (part of niches) were used. However, institutions as a concept is extremely broad and therefore hard to integrate and relate to transitions. Besides, innovations theory was at first also hard to connect with transition theory. However, with theory from Schot and Geels (2007) on niche viability these theories could be connected by closing the gap between innovation theory of Rogers (2010) on a micro level and niches ready for breakthrough on a higher level within the multi-level perspective of transition theory. Nevertheless, it sometimes was more integrating theories in a creative way than that the really supposed to be aligned as within transition theory it is not supposed that niches always refer to concrete innovations and institutions are too broad to directly link them to niches. Still a concise and interesting theoretical framework was the final result despite the latter challenges.

Secondly, with the chosen research strategy and methods there were a couple constraints with regard to the collection of the empirical data, which possibly decreased the validity and reliability of the data, findings and results and, thus, the quality of the thesis in general. The option to collect empirical data with semi-structured interviews was aimed to do with the direct members of the SSC consortium. However, the director of the consortium Robin Berg explained that it was not possible to do so because of the work pressure from the WDS project on the partners of the SSC consortium. Thereby, they received too much research requests from other students and researchers. Furthermore, it was allowed to participate in an information meeting for interested inhabitants and other interested people about WDS. Then the idea came up to have a survey among the (potential) participants of WDS in order to collect data related to the end-users of SSC/WDS. In this way the innovation's decision process and rate of adoption could be measured for example. However, the WDS project team explained that it was not possible due ethical reasons towards their clients. These constraints are understandable and acceptable, however it could have resulted in a lower amount and a potential lower validity and reliability of the collected empirical data, which could have affected the quality of the thesis.

Furthermore, the contribution to theory and planning by this thesis can be seen from several perspectives. Firstl, as within planning theory a shift can be noticed from the communicative paradigm towards planning theory more based on complexity thinking, this thesis already has much to do with the current debate on and about planning. The focus of this thesis is on a complex system change, the energy transition within the complex energy system. For this reason this thesis shed light on a very actual planning issue. Moreover, within this planning perspective, transitions are also more and more becoming a concept by which planning issues are described and analysed as complexity and complex systems are gaining more attention.

However, the energy transition from a planners perspective is not often tried to be analysed from a innovation's perspective. In this sense I think this thesis could have contributed to the wider field of theory by including innovation theory in analysing the energy transition from a planning perspective. Nevertheless, it can also be said that it is not completely fair to just include theory on innovations and institutions within the multi-level perspective of transitions as has been done in this thesis. It did, however, provide a frame in which the gap could be closed between practice and theory as discussed earlier.

Finally, by trying to grasp the complexity of the energy transition as a planning issue this thesis certainly had some interesting aspects in the holistic approach towards the transition, such as the role of innovations and institutions in this transition.

7.4 Reflection

Throughout the process of writing this thesis I had my positive and negative feelings as a researcher from which I have learned. From the beginning I had the feeling that nothing could stop me from achieving the result that I had foreseen. However, the moment that I heard that it was not possible to conduct interviews with direct member within the Smart Solar Charging consortium was a real disappointment. From that moment I found it hard to pull through and look for alternatives for my research approach. This made me feeling me relatively insecure for the final result as my amount of empirical data remained limited. Still I did everything to get as much and reliable data as possible. In that sense I could not do more than I have done right now. The only thing I missed was trying to get an interview with someone from the national government in clean mobility or/and clean energy.

Furthermore, I saw and still see many shortcomings to my own writing, analysis and presenting results. Nevertheless, I am still glad what I achieved here still. All the hours I have putted in this thesis represented this final result I am happy with, although I am still insecure of the final result. Especially bridging gap between findings and results was tough. Relating all the findings explicitly to theory was harder than I imagined from the start. Another issue during my writing process was moving on to a next chapter. It never felt that I had finished or completed a certain chapter, because there is always room for improvements. The latter resulted in the effect that I did, and partly still not do, see it as completely satisfying to finish my thesis as it has still many shortcomings. Furthermore, I think that the amount of words used in this thesis is too high, but reducing the amount to increase the quality was hard and often turned into more words. Finally, I am proud of the final result presented here and I am motivated to study further in the world of energy as I also have many more questions as a result of this research. There are several suggestions related to these questions, which are explained in the next section.

7.5 Suggestions for further research

For further research I have three suggestions. First, the national government is often mentioned and discussed as an important factor within this thesis, although they had not been included in the stakeholder interviews. For further research it would probably contribute to the analysis of the data and findings to directly include the central government in the stakeholders interviews for collecting empirical data. Secondly, as it was not possible to include a survey among users of the Smart Solar Charging concept it would interesting to find out in further research what factors persuade individuals to engage in the project of We Drive Solar as part of the Smart Solar Project. Thirdly, the focus of this thesis is much on a planning and therefore on more qualitative data focused, however it would be interesting in further research to look for the contribution of vehicle-to-grid technology in the electricity grid, locally, regionally and even maybe even nationally. These quantitative data can be found and analysed through macro models to investigate the impact of the technology on the electricity system.

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