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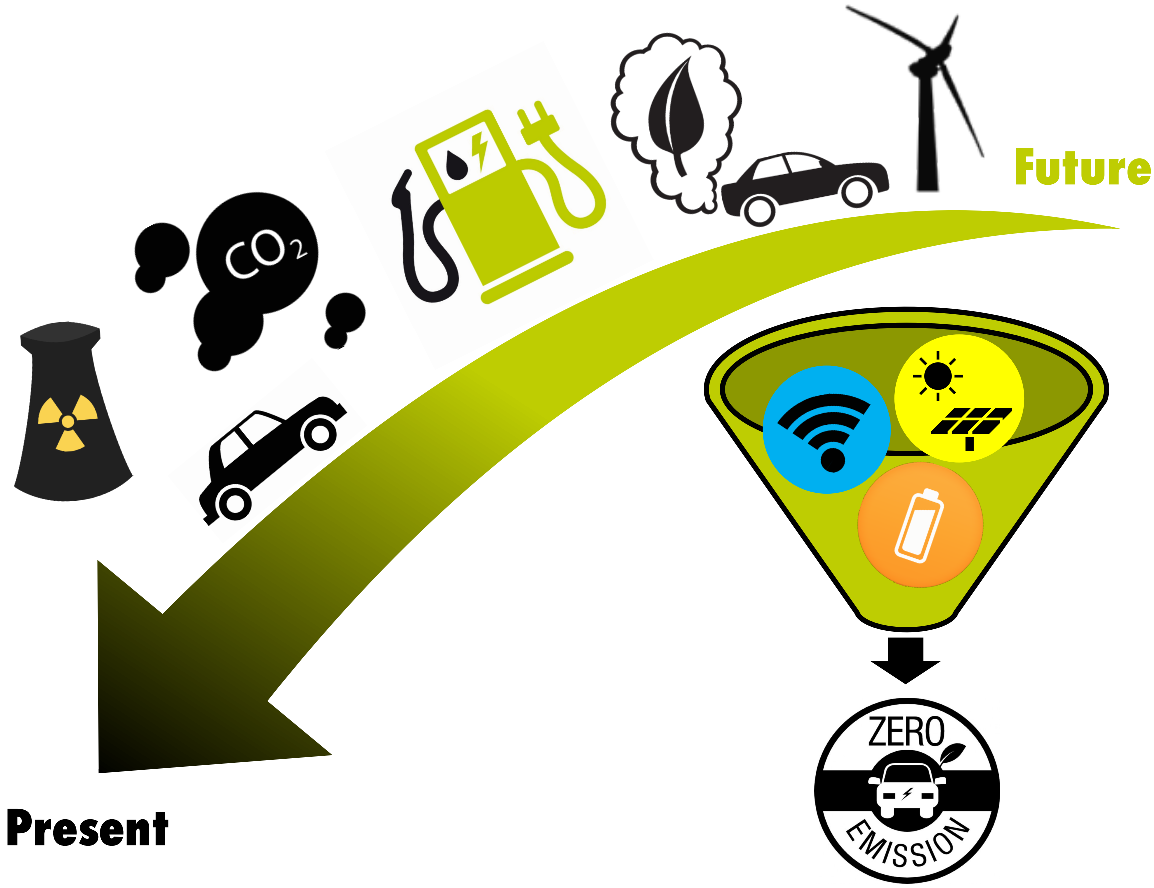

Electromobility in Gothenburg

A Backcasting Approach for Developing a Strategy towards Electrified and Sustainable Transportation in the Future

Master's thesis at the Challenge Lab

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Gothenburg, Sweden, 2016

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Cover: Representation of the transition from fossil fuel based to electrified and sustainable transportation with the backcasting arrow (inspired by Holmberg (1998)).

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Abstract

Applying sustainable development in the urban transportation system demands a transformative and integrative intervention in many different areas. In this thesis two successive processes, Phase I and Phase II, were conducted in order to investigate opportunities for sustainable development in the urban transport system. During Phase I the research question of this thesis was formulated and during Phase II it was investigated and answered.

The main purpose of this study is to demonstrate a way of co-creating a strategy for scaling up electromobility in the city of Gothenburg by implementing the backcasting methodology in a participatory multi-stakeholder environment. The sequence of steps of this methodological framework can be seen as a proposal of an approach when future strategy studies are required for solving similarly complex challenges and therefore may be adopted and adjusted.

By collecting data through literature reviews and by interviewing local triple-helix actors (the public, private and academic sector) a picture of the current transportation system is given. This analysis generated a set of barriers for the diffusion of electromobility in the city of Gothenburg. Most noticeably, the immaturity of electromobility, the need for standardisation of the charging infrastructure and the need for visible showcases of electromobility solutions stood out amongst other barriers.

In the next steps, an attempt to reduce the uncertainties of the future, scenario design is applied and the most sustainable scenario is chosen, where proactive policies and a collaborative transport behaviour co-exist. In parallel, solutions and concepts in form of policy and technology measures for overcoming the aforementioned barriers are designed and quantitatively evaluated based on ① their level of sustainability, ② their ability to overcome the barriers and ③ their robustness in the proposed future scenario.

Finally, a strategy path is proposed depicting an interdependency among technology, policy and society in the short-term (2016-2025) as well as the long-term (2025-2050). For that a stakeholder dialogue was conducted and the results acquired were used as input for building the strategy. In this strategy the final concepts, such as trialability programmes, standardised charging infrastructure and the development of a common vision and strategy, are included.

It is ultimately concluded that applying a participatory backcasting methodology is highly appropriate when co-creating s strategy to overcome complex sustainability challenges. Furthermore, it is important to take into consideration the interplay between technology, policy and society and how they influence each other when developing a strategy for the future. Moreover, policy measures that aim at a mental shift for the users are considered of high priority, therefore they have to be applied in the short-term. Last but not least, merging isolated actions from stakeholders attempting to scale up electromobility into cross-boundary collaborations under a common vision and strategy is essential in order to accelerate the phasing-out of fossil fuel based transportation.

Keywords: Challenge-Lab (C-Lab), backcasting, electromobility, Electric Vehicle (EV), sustainability, scenario design, stakeholder engagement, strategy planning, systemic transition.

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Furthermore, we would like to thank Malin Andersson, Alexander Sjöberg and Mats-Ola Larsson from Trafikkontoret, the Urban Transportation Administration of the City of Gothenburg for their close collaboration with us and for providing us with very useful data. Also, sincere thanks to all the experts from different fields related to electromobility for sharing their indispensable knowledge and experience during the interviews and for participating in the dialogue session to make this project happen.
We would also like to thank Marin Sande, founder and facilitator at Dialogues, for giving us some highly valuable feedback in advance of the dialogue session to reach the anticipated outcome.
Lastly, we are taking this opportunity to thank the whole group of C-Lab master thesis students of 2016 for making this multi-cultural and interdisciplinary journey an unforgettable experience.

Philipp Hofmann & Spyridon Ntemiris, Gothenburg, June 2016

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1 Introduction

1.1 The Challenge Lab

'The Challenge Lab (C-Lab) is where master students take on the planet's biggest challenges together with industry, government and academia.' (The Challenge Lab, 2016)

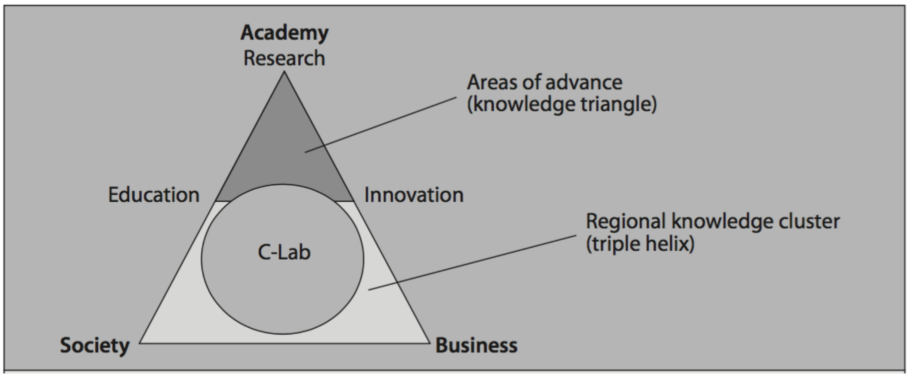

Figure 1.1: Challenge Lab in the centre of the regional knowledge cluster (Holmberg, 2014).

'Think big, start small, act now!' (The Challenge Lab, 2016)

The C-Lab was launched in 2014 to provide a space for master students to engage themselves with global challenges of the 21st century aiming to change the way we live together on this planet. To solve these complex socio-technical challenges the students seek for critical transitions which are transformative, by aiming for challenging the status quo, and integrative, by bringing together actors from academy, business and society, the so-called triple helix (s. figure 1.1).

The idea of C-Lab evolved out of the Areas of Advance (AoA), a matrix organisation at Chalmers for transitions towards sustainability based on connecting research, eduction and innovation (the knowledge triangle), and the five knowledge clusters in the region of West Sweden (Urban Future, Marine Environment and Maritime Sector, Green Chemistry and Bio-based Products, Sustainable Mobility and Life Science) (Holmberg, 2014).

This year, in 2016, 14 international students with various study backgrounds took on regional challenges by combining their interdisciplinary knowledge to propel sustainable development in the urban sector of the Gothenburg region. This was done by challenging existing mental models in order to break *'unsustainable path-dependent trends'* which evolved over many years (Holmberg, 2014).

As defined by Holmberg (2014) the mission of the C-Lab is to:

- *'Strengthen the educational dimension in the knowledge triangle within the Areas of Advance.'*
- *'Provide a natural hub for the triple helix actors within the five regional knowledge clusters, where all parties are drawn because of the students, as they all have a stake in the students.'*
- *'Build trust within the clusters through students. A defining feature of students is that they are simultaneously non-threatening and challenging, a feature crucial to the kind of change society greatly needs, positioning the students to be powerful change agents.'*
- *'Give the students the opportunity to develop unique skills in working across disciplines and from a challenge-driven perspective.'*

The students' unique role as 'change agents' allows them to engage with regional stakeholders on a neutral basis to openly discuss, receive a very transparent response on eventual deficits in the current system and shift the current state. Such position can usually not be taken by anyone labelled as a representative of a particular company or institution. Therefore, the students of the C-Lab are challenged to make use of their powerful position as 'change agents' by reaching out to relevant stakeholders and bringing them together into an environment of openness and trust to ultimately induce transformative change.

According to the approach followed in the C-Lab all Master theses are conducted in two phases. Phase I is supposed to increase the students' awareness and knowledge about regional challenges around sustainability to be able to formulate their independent research questions in accordance to their study backgrounds. This research question will be investigated during Phase II by incorporating a large share of the methods and tools acquired during Phase I.

1.2 Project Background

Climate change is one of the most complex global challenges that our planet is facing nowadays, being at the top of United Nations (UN) priorities and has become a major issue for many organisations and forums dealing with climate change mitigation. Climate change is also occurring in Europe and some of the observed changes have established records in recent years. The last decade was the warmest decade since global temperature records became available (EEA, 2014). According to NASA (2016) *'9 of the 10 warmest years on record have occurred since 2000'*. Human influence, primarily emissions of Greenhouse Gases (GHG), such as CO_2, but also changes in land use, has been the dominant cause of the observed warming since the mid-20^{th} century. Human influence on the climate system has been

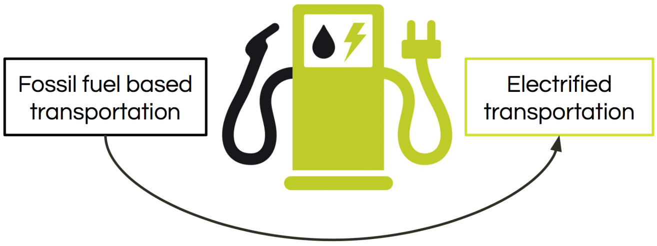

Figure 1.2: A systemic transition from fossil fuel based transportation to electrified transportation (electromobility).

detected in the warming of the atmosphere and the ocean, in changes of the global water cycle, in reductions of snow and ice, in the global mean sea-level rise and in changes of some climate extremes (EEA, 2014).

Transport consists of a critical support system for the smooth functioning of our societies and economies. It facilitates accessibility of services that are vital for business and for the quality of life of citizens. It also enables economic growth and job creation (EEA, 2014). However, transport is one of the main contributors to GHG-emissions and therefore to climate change. As a result action to mitigate these emissions has been taken both on the global, European Union (EU) and national level of Sweden. A central part of these mitigation actions is the transition to alternative cleaner transport technologies such as electrified transportation (electromobility).

On the national level, in Sweden 28% of all household emissions come from private transportation, meaning the emissions resulting from a family driving their car(s) (Minx et al., 2008). In addition, ambitious goals have been set from the government regarding a fossil-independent national vehicle fleet for the future by 2030 and a goal for a fossil-free national fleet by 2050 (Government proposition 2008/09:163, 2009).

Meanwhile, on the local level our interaction with local stakeholders during Phase I demonstrated that there is a need for action towards more sustainable transport solutions in the city of Gothenburg. More specifically, the Urban Transport Administration of Gothenburg (Trafikkontoret) expressed their intention to initiate the procedures for the determination of a strategy that is currently lacking, to further scale up electromobility in the city of Gothenburg. Consequently our enthusiasm and our compatibility of our study backgrounds with electromobility along with opportunity to deal with a tangible need for a sustainable transformation were the main drivers for the realisation of this thesis.

1.3 Purpose and Research Questions

This thesis is investigating the main research question *'How to develop a strategy for scaling up electromobility in the city of Gothenburg by applying the backcasting methodology'*. Based on backcasting process secondary research questions were formulated, such as:

- *'How could a vision for the transportation system of 2050 look like?'*;
- *'Which criteria have to be fulfilled to ensure ecologically, economically and socially sustainable transportation when scaling up electromobility?'*;
- *'What are the local drivers and barriers for scaling up private electrified transportation in the city of Gothenburg?'*;
- *'How could potential future solutions and concepts look like and how sustainable are they?'*
- *'How could a desirable and sustainable future scenario for electromobility look like?'*

The main purpose of this thesis is to demonstrate a way of co-creating a strategy for scaling up electromobility in the city of Gothenburg by taking a systemic perspective and implementing the backcasting methodology in a participatory multi-stakeholder environment in order to propel the transition into a more sustainable transportation system. Therefore the methodological framework provided by this thesis has to be considered as an essential result as it can be adopted and adjusted for the realisation of projects with similarly complex challenges. The acquired results throughout the backcasting process are representing a possible outcome of its practical application for the case of Gothenburg.

Finally, this thesis project also aims to raise awareness about the necessity of replacing fossil fuel based transportation with electrified transportation (electromobility) by demonstrating the feasibility of such a transition as well as the superior attractiveness of electromobility based on sustainability criteria.

1.4 Scope and Delimitation

This thesis project focuses on the investigation of electromobility inside the Gothenburg municipality as geographical delimitation. However, as this thesis is taking a systemic perspective on the transportation regime of the Gothenburg municipality, external influences have to be taken in consideration leading to an occasional extension of the geographical boundaries up to the national or even EU level.

Furthermore, the scope of this thesis is the investigation of electromobility as a new solution for the private or personal transportation of people, focusing on the car. More specifically, the challenges of replacing the conventional Internal Combustion Engine Vehicle (ICEV) with a zero-emission BEV while ensuring a transition into a holistically more sustainable transportation system are investigated. However, the scope is adjusted throughout the thesis project as the investigation is initiated by including both public (buses, trams, etc.) and private modes (cars, bicycles, etc.) of transportation after realising the higher complexity and criticality of electrifying the car as the currently most popular mode of private transportation.

For the realisation of the participatory aspect of this thesis project local stakeholders were engaged while maintaining the geographical boundaries of the city of Gothenburg.

1.5 Outline of the Thesis

This section gives an overview of the content of this thesis, excluding Chapter 1 'Introduction'. This outline may be considered as a guide for the reader to understand the purpose behind each of the following chapters.

Chapter 2 'Theory Phase I and II' describes the theoretical concepts and tools from various acknowledged authors that were applied in both Phase I and Phase II of the thesis project. After a short introduction of the technical concept of electromobility in section 2.1 further theoretical tools, such as stakeholder engagement (s. section 2.2) or the Multi-level Perspective (MLP) as a tool for system analysis (s. section 2.3), are described. Furthermore, scenario design is introduced (s. section 2.4) as well as backcasting (s. section 2.5) as the overarching methodology applied in this thesis into which the previously mentioned theoretical concepts are implemented.

Chapter 3 'Methodology Phase I' describes the methodology followed during Phase I in the C-Lab based on backcasting with the purpose of investigating regional sustainability challenges and finally formulating the research question of this thesis.

Chapter 4 'Results Phase I' presents the intermediary results acquired throughout the backcasting process during Phase I concluding with the final research question of this thesis.

Chapter 5 'Methodology Phase II' describes the methodology followed during Phase II aiming to solve the research question of this thesis. Similar to Phase I the backcasting methodology was adopted providing the framework for the realisation of the whole project. The purpose of this chapter is to describe the way how theoretical tools, as presented in Chapter 2, were incorporated into the process and to describe independently developed methodologies, such as the the organisation and execution of semi-structured interviews (s. section 5.4.1) and the stakeholder dialogue (s. section 5.6.1) or the evaluation of potential future concepts (s. section 5.5.4).

Chapter 6 'Results & Analysis Phase II' presents the intermediary results acquired throughout Phase II of the thesis project including their analysis. Similar to Chapter 5 'Methodology Phase II' this chapter follows the same structure based on the backcasting process. The purpose of this chapter is to display the outcome of backcasting steps 1 to 4 as a result of following the described methodology and incorporating presented theoretical tools and concepts.

Chapter 7 'Discussion' is mostly dedicated to the discussion of the C-Lab as an alternative learning environment and the validity of the applied methodology and attained results throughout the thesis project during Phase II.

Chapter 8 'Conclusion' gives some concluding remarks on both the overall methodology followed throughout the thesis project and interesting results that were acquired.

Chapter 9 'Recommendations for Future Studies' provides a set of recommendations on how this project could be continued and which aspects should to be investigated further.

2

Theory Phase I and II

In this chapter theoretical concepts and tools applied in Phase I and II of the thesis project are described. Firstly, a brief description of electromobility is given (s. section 2.1), then a set of theoretical concepts incorporated in this thesis is presented separated between an inside-out perspective (s. section 2.2 on page 8) and an outside-in perspective (s. section 2.3 on page 15). Furthermore, *design thinking* (s. section 2.4 on page 18), including *scenario design*, as well as the backcasting methodology (s. section 2.5 on page 24) is introduced.

2.1 What is Electromobility?

As described by Grauers et al. (2014) *'Electromobility is defined as a road transport system based on vehicles that are propelled by electricity'.* In such a system different technologies for both electricity production and vehicles have to be considered. Electromobility as a new solution of transportation uses electricity from the grid generated by different sources, such as fossil fuels and nuclear or preferably renewable energy sources like wind, solar, hydro and biomass. As illustrated in figure 2.1 on page 8, there are various technologies that are able to use electricity from the grid to propel a so-called Electric Vehicle (EV).

The Battery Electric Vehicle (BEV) is completely run on electric energy and has a fully electric drive-train (Grauers et al., 2014). It is either charged while parked, quick- or rapid-charged or usees a battery-swapping set-up to reduce the 'recharging' time. BEVs have zero local emissions, however, still have limited driving range and heavily depend on a well-spread charging infrastructure to allow for flexible intercity travel.

The Hybrid Electric Vehicle (HEV) or the Plug-in Hybrid Electric Vehicle (PHEV) is basically a range extender vehicle that combines the EV with a conventional Internal Combustion Engine Vehicle (ICEV) (Grauers et al., 2014). The main difference between HEVs and PHEVs is the battery capacity which is larger and therefore more powerful for the PHEV allowing it to solely run on electricity as it can also be 'plugged in' to a power outlet similar to a BEV. The main advantage of HEVs is that they are not relying on charging infrastructure and have considerably lower emissions while maintaining the driving range of a conventional ICEV.

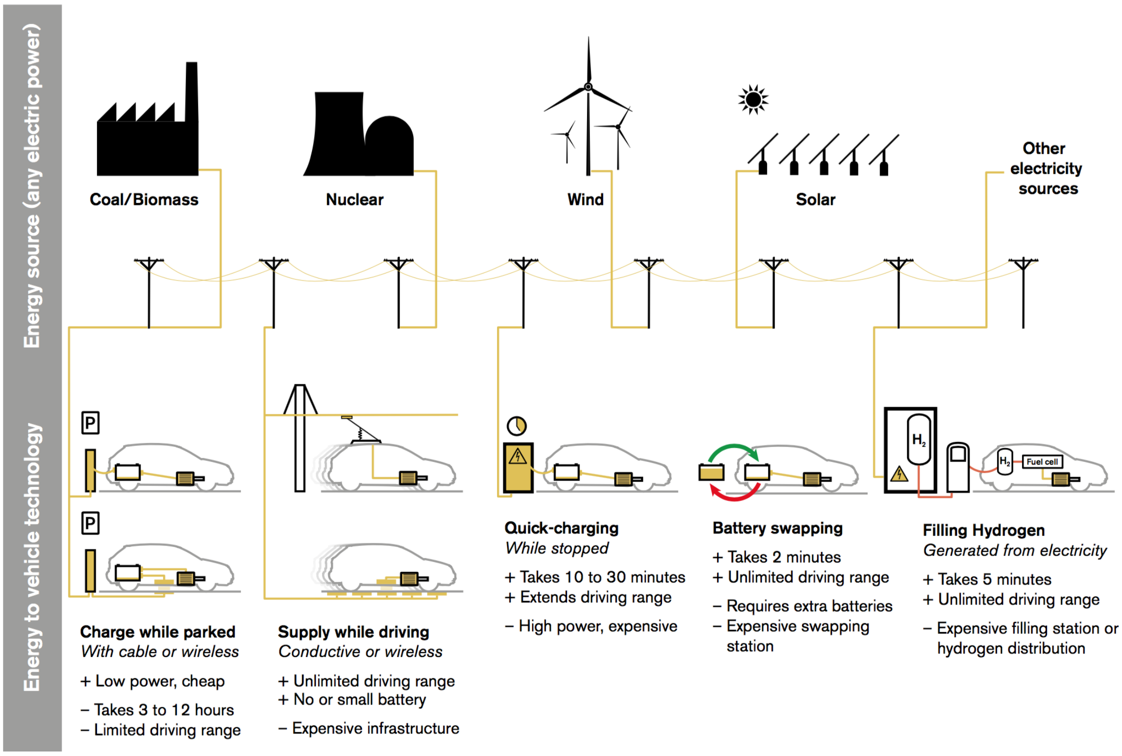

Figure 2.1: Examples of electricity sources and technologies to transfer electrical energy to vehicles (Grauers et al., 2014).

The Fuel cell Vehicle (FCV) carries the energy in the form of liquid hydrogen which may be generated from electricity and transform it into electricity on board using fuel cells (Grauers et al., 2014). FCVs have a comparable driving range to ICEVs and allow for refuelling times below five minutes, however, require a very expensive hydrogen-refuelling infrastructure which is currently not yet in place (Grauers et al., 2014).

Finally, there is the option of vehicles with continuous power supply drawing energy from the electricity grid whilst in motion and therefore do not require energy storage in the form of batteries on board (Grauers et al., 2014). However, this configuration requires large investments for conductive power lines or inductive rails and the system is vulnerable to fluctuations in power supply (Grauers et al., 2014) which is becoming an obvious challenge with an increasing share of renewable energy sources.

In this thesis, primarily the challenges around the introduction of BEVs are investigated.

2.2 Inside-out Perspective

An inside-out perspective as described by Holmberg (2014) focuses on the inner strengths and capabilities as well as the knowledge and motivation of an individual or an organisation to solve problems in the outer system. In the following both the concept of *self-leadership*, involving personal inner values and core capabilities, as well as *stakeholder engagement* and *dialogue*, focusing on principles that allow for an effective and well-balanced collaboration and communication in a diverse group of stakeholders, are introduced.

2.2.1 Self-Leadership

Being a self-leader requires an understanding of one's personal strengths and weaknesses as well as the awareness about one's core capabilities and inner values to not only embody a true leader but also stay true to one's inner self. As mentioned by Senge et al. (2015) to lead system transitions one should have profound commitment to the health of the whole, build relationships based on deep listening, encourage learning by doing, see the larger system and be open to cooperate with other leaders while staying honest. In addition to that Ryan and Deci (2000) point out the importance of being intrinsically motivated and self-determined when engaging oneself with challenging and complex issues because *'motivation produces'*. According to them, three innate psychological needs have to be satisfied: *Competence*, *autonomy* and *relatedness*. When these are met the chances for enhanced self-motivation and mental health are largely increased. Further important aspects showing the relevance of self-leadership are given by Stewart et al. (2011), such as *team composition*, *collective cognition* and *conflict management*. He claims that a high level of *self-leadership* from every group individual leads to improved team building, more effective task distribution and collective processing of information as well as improved conflict management which ultimately leads to higher satisfaction and performance of every individual.

2.2.2 Stakeholder Engagement

In this section an overview on the concept of *stakeholder engagement* (s. section 2.2.2.1) is given including its benefits (s. section 2.2.2.2 on page 11) if performed according to existing standards as well as practical tools (s. section 2.2.2.3 on page 12) aiming to facilitate the overall *stakeholder engagement* process.

2.2.2.1 The Concept of Stakeholder Engagement

'Inclusivity is the participation of stakeholders in developing and achieving an accountable and strategic response to sustainability. Stakeholder engagement is a tool that organisations use to help them achieve inclusivity.' (Accountability, 2008)

Stakeholder engagement as a concept has been discussed for many years already and, with the publication of the 2^{nd} edition of the *AA1000 Stakeholder Engagement Standard* in 2008, been accepted as *'crucial to an organisation's sustainability and success'* (Accountability, 2008). It has also been recognised as a *'fundamental accountability mechanism, since it obliges an organisation to involve stakeholders in identifying, understanding and responding to sustainability issues and concerns, and*

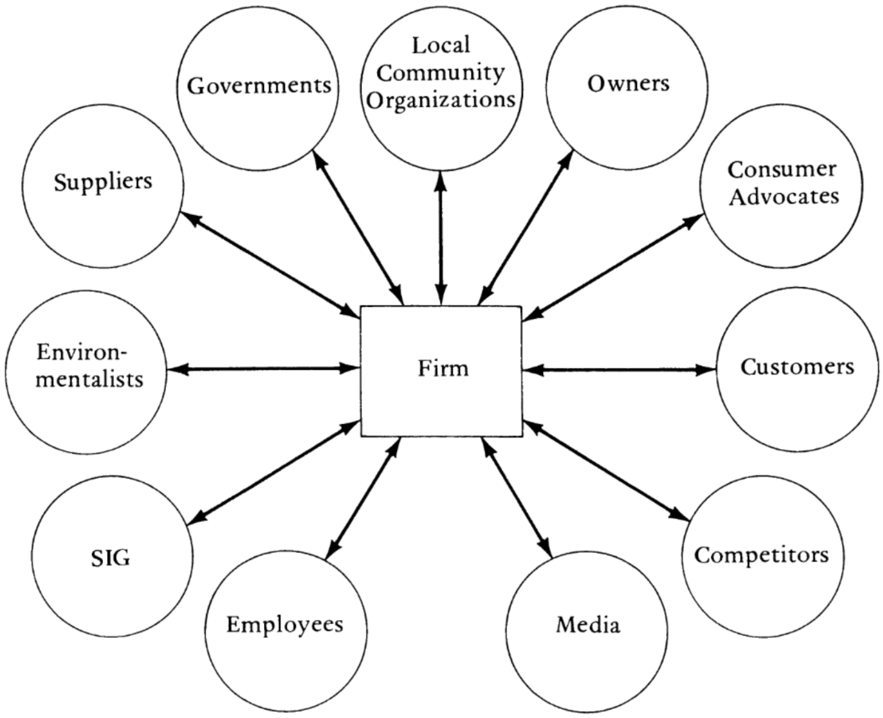

Figure 2.2: Categories of Stakeholder groups (Freeman, 1984).

to report, explain and be answerable to stakeholders for decisions, actions and performance' (Accountability, 2008). Jeffrey (2009) argues that *stakeholder engagement* is *'relevant to any type of organisation: business, public and civil society'* and that it must not be confused with *stakeholder management*, as *stakeholder engagement* is based on the mutual willingness to listen between stakeholders and organisation as well as openness to change the organisation's operation structure and objectives which ultimately leads to a win-win for both business and society.

The term 'Stakeholder' originates from the concept of the 'Shareholder' who represents the owner of a company and can either positively or negatively be affected by the achievements of an organisation's objectives (Freeman, 1984). As illustrated in figure 2.2, various categories of stakeholders, such as the owners, employees, customers, suppliers, competitors and others, have to be considered during the engagement process. Van de Kerkhof and Wieczorek (2005) emphasise the importance of broad stakeholder participation and multi-disciplinary learning, especially when facing global environmental challenges, such as climate change.

As illustrated in figure 2.3 (left) on page 11 the purpose (**Why**) behind the *stakeholder engagement* and its scope (**What**) has to be understood as well as all relevant stakeholders (**Who**) have to be determined (Accountability, 2008). These three aspects must to be clearly identified beforehand in order to initiate the *AA1000SES stakeholder engagement process*, including four stages: *Plan*, *Prepare*, *Implement* and *Act, Review, and Improve* (s. figure 2.3 (right)).

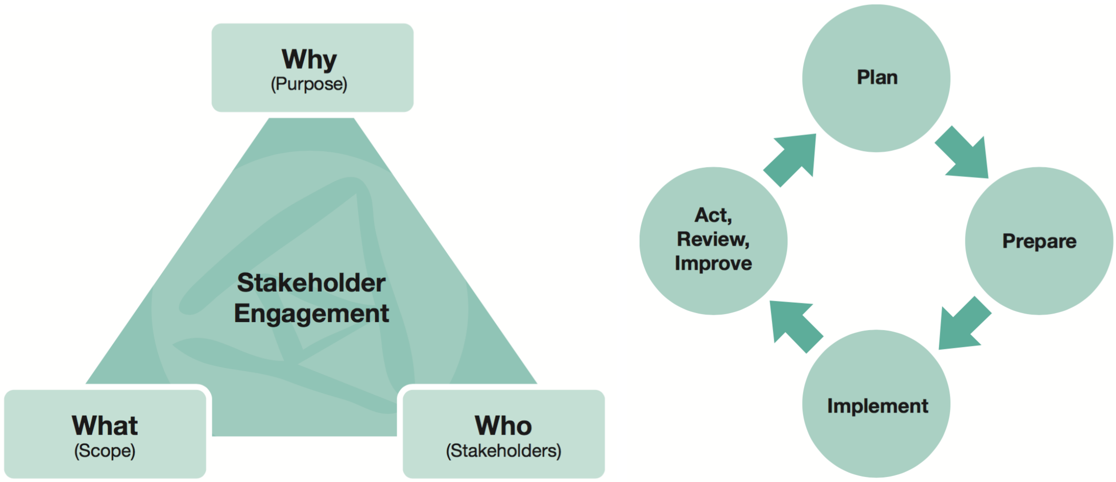

Figure 2.3: Purpose (Why), scope (What) and stakeholders (Who) (left) and the *AA1000SES stakeholder engagement process* (right) (Accountability, 2008).

2.2.2.2 The Benefits of Stakeholder Engagement

Following the approach for the so called *Quality Stakeholder Engagement* according to the *AA1000 Stakeholder Engagement Standard 2011* (Accountability, 2008) it will benefit both the organisation and included Stakeholders.

On the basis of that *Quality Stakeholder Engagement* can (Accountability, 2008):

- *'Lead to more equitable and sustainable social development by giving those who have the right to be heard the opportunity to be considered in decision making processes'*;
- *'Enable better management of risk and reputation'*;
- *'Allow for the pooling of resources (knowledge, people, money and technology) to solve problems and reach objectives that cannot be reached by single organisations'*;
- *'Enable understanding of the complex operating environments, including market developments and cultural dynamics'*;
- *'Enable learning from stakeholders, resulting in product and process improvements'*;
- *'Inform, educate and influence stakeholders to improve their decisions and actions that will have an impact on the organisation and on society'*; and
- *'Contribute to the development of trust-based and transparent stakeholder relationships.'*

Furthermore, Van de Kerkhof and Wieczorek (2005) argue that *stakeholder engagement* may foster *commitment* by incentivising active contribution to the discussion, *fairness* by including minority viewpoints into the discussion, *transparency* by creating clarity about procedures, tasks and responsibilities and *competence* by improving the knowledge around highly complex issues.

2.2.2.3 Tools for Stakeholder Engagement

In this section tools for *stakeholder engagement*, such as interviews, dialogue & facilitation as well as the *fishbowl* set-up are presented and described. These tools were selected in accordance to the methodology applied in this thesis. Further approaches and tools for *stakeholder engagement* may be used for different purposes, such as organisational planning (Accountability, 2008).

Stakeholder Interviews

When it comes to interviews as a tool for qualitative research as well as *stakeholder engagement* one has to distinguish between *structured*, *semi-structured* and *unstructured* interviews (Van Teijlingen, 2014).

Structured interviews include predetermined questions with fixed wording and a pre-set order are posed to the interviewee. This type of interview is similar to a survey whereas open-response questions may be included to allow for more elaborate answers (Van Teijlingen, 2014).

Semi-structured interviews also include predetermined questions, however, the order may be adjusted for the sake of maintaining the flow of the discussion. Additionally the formulation of certain questions can be changed and further explanations may be given. If regarded as appropriate from the interviewer certain questions may also be omitted or added for particular interviewees (Van Teijlingen, 2014).

Unstructured interviews are rather informal and only consist of a rough framework for a discussion around a certain area of interest (Van Teijlingen, 2014).

For the interviews conducted in this thesis the *semi-structured* approach was chosen. A more detailed description of the applied methodology is given in section 5.4.1 on page 45.

Stakeholder Dialogue & Facilitation

To effectively engage with stakeholders dialogues can be used as a powerful tool which, however, if aiming for its effective application, requires a considerable amount of knowledge, preparation and practise regarding the skill of facilitation. Isaacs (1993) provides a set of guidelines to facilitate a dialogue:

- *'Suspend assumptions and certainties*
- *Observe the observer*
- *Listen to your listening*
- *Slow down the enquiry*
- *Be aware of thought*
- *Befriend polarisation'*

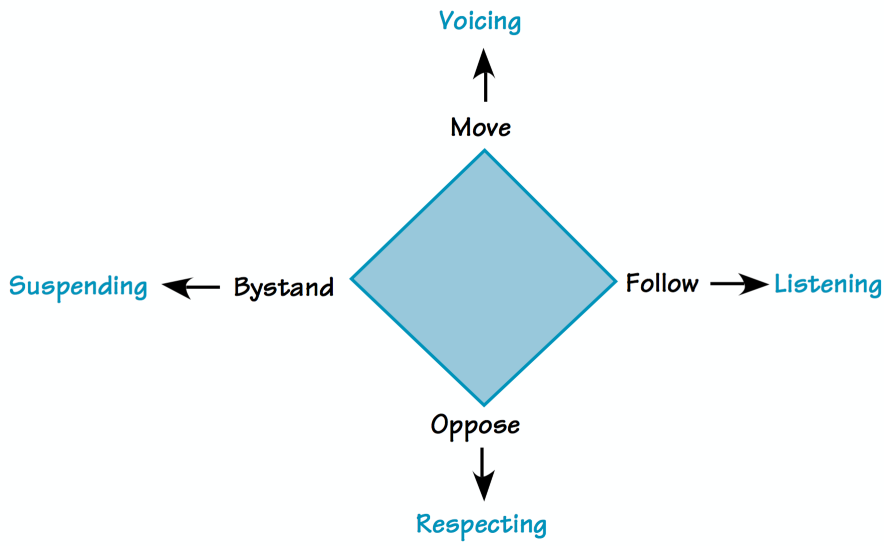

Figure 2.4: Four practices for Dialogic Leadership (Isaacs, 1999).

Furthermore, *dialogic leadership* as a concrete tool for leading dialogues effectively is described by Isaacs (1999) (s. figure 2.4). A dialogic leader has to internalise all of the following four practises to guide and facilitate a dialogue effectively and to *balance action*:

- **Listening** (Follow): *'To listen together is to learn to be part of a larger whole - the voice and meaning emerging not only from me, but from all of us.'*
- **Respecting** (Oppose): *'To respect is to listen for the coherence in people's views, even if you find what they are saying unacceptable.'*
- **Suspending** (Bystand): *'To suspend is to bystand with awareness, which makes it possible for us to see what is happening more objectively.'*
- **Voicing** (Move): *'To speak our voice has to do with revealing what is true for each of us, regardless of all the influences that might be brought to bear on us.'*

Lastly, Sandow and Allen (2005) explain the importance of social collaboration and what is needed to get work really done. Besides supporting the relevance of listening to each other as well as oneself and understanding others views and opinions they also depict the significance of trusting each other by being open and collaborating by sharing knowledge.

The Fishbowl set-up

There are various settings in which dialogue facilitation can be applied, such as the *fishbowl* set-up as illustrated in figure 2.5 on page 14. In this set-up the actual dialogue is conducted in the inner circle, the *fishbowl*, in which experts from different fields are sharing their knowledge about a common subject, whereas the outer circle is solely listening and taking notes of what is spoken. This set-up may be used *'as an alternative to traditional debates, as a substitute for panel discussions,*

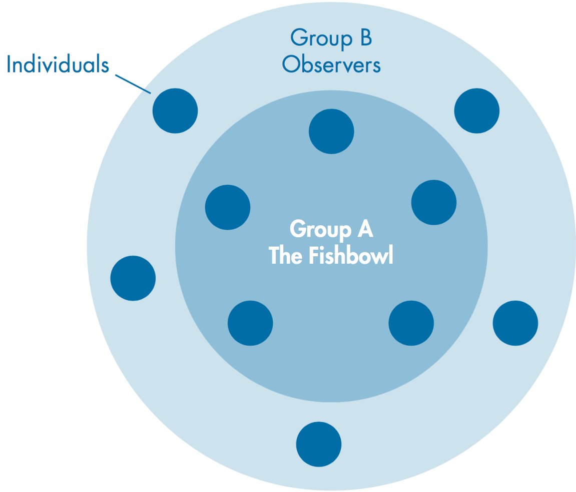

Figure 2.5: The fishbowl set-up (Office of the Commissioner, 2016).

to foster dynamic participation, to address controversial topics or to avoid lengthy presentations.' (Office of the Commissioner, 2016).

Generally, in addition to the experts, three different roles should be represented in and around the *fishbowl*: The *facilitator*, the *questioner* and the *observer.* The *facilitator*, sitting in the inner circle, is supposed to guide (open, close and summarise) the dialogue and ensure an equal participation of all members inside the inner circle. The *questioner*, also sitting in the inner circle, is supposed to ask previously defined questions and challenge the experts. Lastly the *observer*, sitting in the outer circle, is supposed to listen actively, take notes, come up with further questions and reflect upon what is spoken (Office of the Commissioner, 2016).

There are two different types of the *fishbowl* set-up, open and closed. The open *fishbowl* allows the *observer* to to join the inner circle at any given time by replacing one of the *questioners* creating a highly dynamic dialogue, whereas in the closed *fishbowl* the participants are split into two groups representing the inner and the outer circle. In this case it is up to the *facilitator* to decide whether or when the groups are switching sides. *'The closed fishbowl approach is only appropriate if all participants have at least some level of knowledge about the subject'* (Office of the Commissioner, 2016).

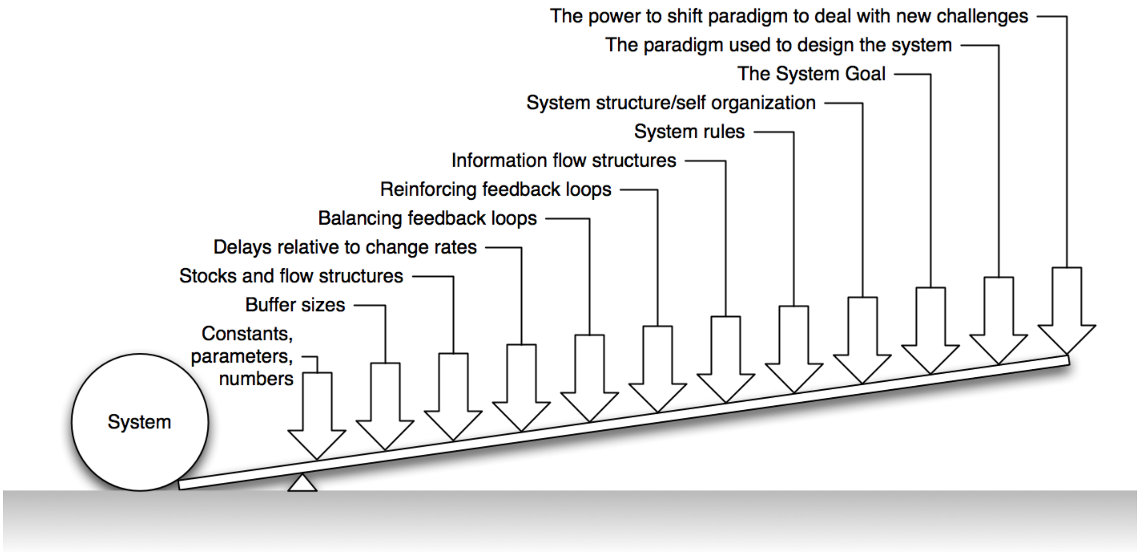

Figure 2.6: The 12 leverage points by (Meadows, 2009) visualised (source: (Composite Creative, 2014)).

2.3 Outside-in Perspective

As mentioned in section 1.1 on page 1 in order to take on sustainability transitions, apart from realising one's inner value system (s. section 2.2 on page 8), one must also *'understand and deal with the requirements global sustainability will put on the system'* (Holmberg, 2014). By placing oneself outside the system one gains the systemic perspective of an observer. In this section the concepts *systems thinking* along with the Multi-Level Perspective (MLP) as an approach for *systems analysis* are presented. These concepts compliment each other by providing an outside-in perspective of the system at hand.

2.3.1 Systems Thinking

Sustainability transitions are a highly complex challenge with many uncertainties. *Systems thinking* provides a framework of thinking aiming to reduce these complexities and uncertainties. Even though there is no commonly accepted definition of this term, in this thesis *systems thinking* is considered a perspective, a language and a set of tools as perceived by Monat and Gannon (2015) review study. According to Meadows (2009) a system is defined as a set of elements or parts that is coherently organised and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its 'function' or 'purpose'. Hence, systems thinking is the consideration of any given challenge or problem as a system with its characteristics. *Systems thinking* provides a holistic and integrative approach as opposed to the traditional linear thinking for analysing complex socio-economic or socio-technical problems (Monat and Gannon, 2015; Meadows, 2009). Typical examples of nonlinear complex problems are the predator-prey relationships and irrational behaviours of individuals, social groups or countries (Monat and Gannon, 2015).

Traditionally there are two types of *systems thinking*:

- **Systems Analysis** which identifies the structure of a system, its components and the relations among them (e.g. MLP (Geels, 2002))
- **Systems Dynamics** which deals with how the systems behave (e.g. positive feedbacks (Arthur, 1990), economies of scale and scope (Azar and Sandén, 2005) or rebound effects (Berkhout et al., 2000))

Apart from analysing and understanding a system and applying systemic approaches, it is highly relevant to understand how systems change and how one can steer a change. In order to induce sustainability transitions *systemic thinking* can also be applied effectively when so-called *leverage points* were identified in advance. Meadows (2009) has been one of the pioneers in *systems thinking* as Monat and Gannon (2015) point out in their review study. More specifically, she has highlighted 12 *leverage points* which are *'[...] places in the system where a small change could lead to a large shift in behaviour'* (Meadows, 2009) (s. figure 2.6 on page 15). Here the *leverage points* are presented in a list of increasing leverage:

1. Numbers - Constants and parameters such as subsidies, taxes, standards.
2. Buffers - The size of stabilising stocks relative to their flows.
3. Stock and flow structures — Physical systems and their nodes of intersection.
4. Delays - The lengths of time relative to the rates of system changes.
5. Balancing feedback loops - The strength of the feedbacks relative to the impacts they are trying to correct.
6. Reinforcing feedback loops - The strength of the gain of driving loops.
7. Information flows - The structure of who does and does not have access to information.
8. The rules of the system - Incentives, punishment, constraints.
9. Self-organisation - The power to add, change, or evolve system structure.
10. The goals of the system - The purpose or function of the system.
11. Paradigms - The mindset out of which the system - its goals, structure, rules, delays and parameters - arise.
12. Transcending paradigms.

2.3.2 Systems Analysis: A Multi-Level Perspective

Transition theories provide the intellectual tools to carry out a socio-technical analysis of technological transitions minding social factors and conditions that exist around technologies (Geels, 2002; Geels, 2005). According to Geels (2002) these may be considered as a result of evolutionary processes. Darwinian evolutionary

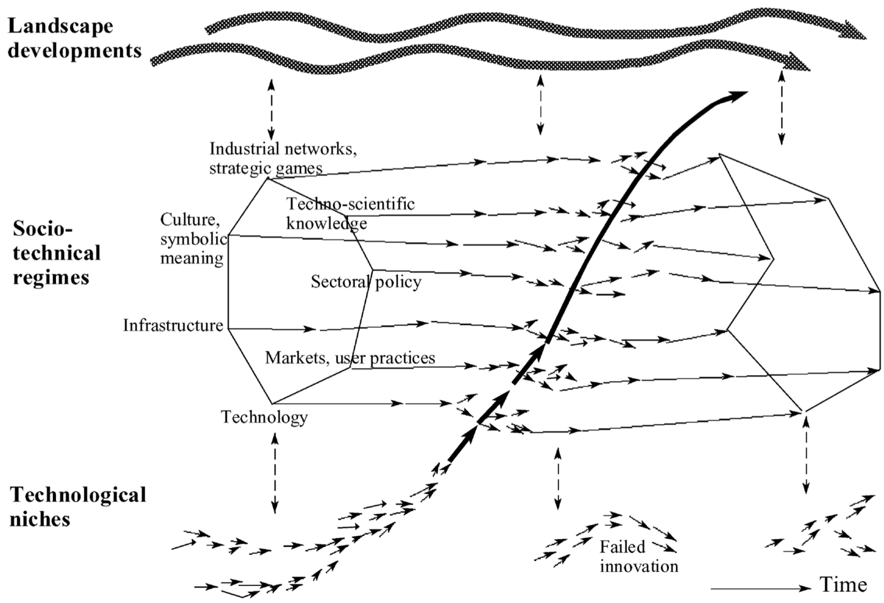

Figure 2.7: A dynamic Multi-Level Perspective (MLP) including *macro-* (Landscape development), *meso-* (Socio-technical regime) and *micro-level* (Technological niches) (Geels, 2002).

theory, characterised by variation, selection and retention, finds an analogy in socio-technical transition theories through processes of incremental improvements and reconfigurations. In addition, Geels (2002) states: *'Technological transitions are [...] major, long-term technological changes in the way societal functions [...] are fulfilled'.* Societal functions include transportation, communication, housing and other similar aspects that serve as infrastructure in a broader sense.

The transition theory, as described by Geels (2002), was developed based on the dynamic multi-level analytical framework on technological transitions. The different levels are not ontological descriptions of reality, but analytical and heuristic concepts to understand the complex dynamics of socio-technical changes. As shown in figure 2.7, there are three levels with which technological transitions can be analysed, the *meso-*, *micro-* and *macro-level.*

On the **meso-level** socio-technical regimes drive innovative activities towards incremental improvements based on a set of rules including a number of social groups, besides engineers, that are connected with rather innovative activities as part of technological niches (s. *micro-level*). Geels (2002) divides a socio-technical regime into the following seven dimensions: *'Industrial networks, techno-scientific knowledge, sectoral policy, markets & user practises, technology, infrastructure and culture & norms'.* However, different sets of dimensions can be chosen depending on the socio-technical regime that is analysed (Geels, 2005; Geels, 2012). It can also be argued that regimes are responsible for the stability of existing technology development and the occurrence of the technological trajectory - from the technological niche (micro level) to the regime (meso level) and ultimately to the landscape (macro level) as it is shown in figure 2.7.

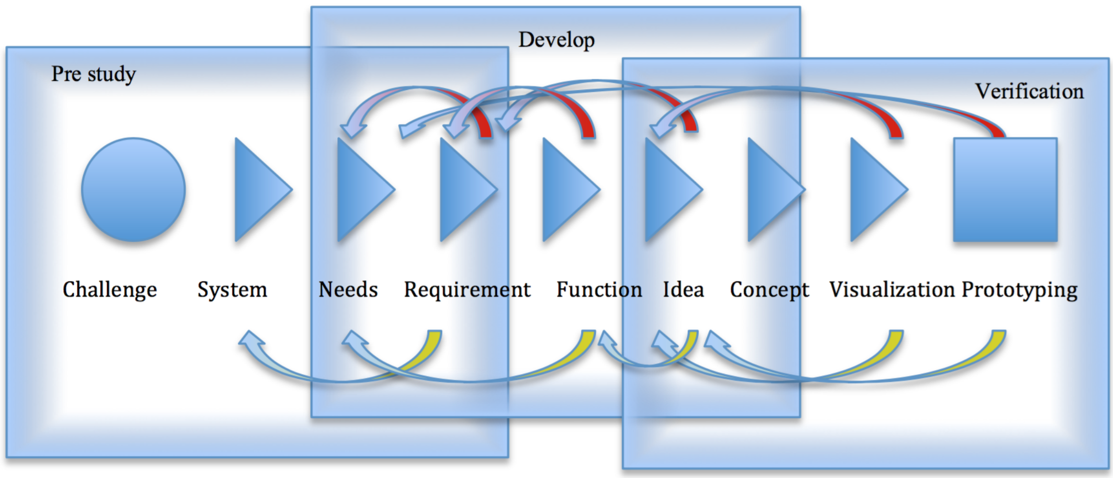

Figure 2.8: The iterative process of *design thinking* (Söderberg, 2014).

On the **micro-level** one can recognise the technological niches. These serve as *'[...] incubation rooms for radical novelties [...]'* (Geels, 2002) which means that niches are responsible for the generation and development of radical innovations. The importance about niches is that they *'provide locations for learning processes'* (Geels, 2005), which may occur in different dimensions of the socio-technical regime at the *meso-level*.

On the **macro-level** landscape developments slowly change external factors (demographic trends, political changes) providing gradients for trajectories. Innovation breakthroughs depend on processes on the level of regimes and landscapes and they are context-dependent.

The state of a technology that is still at the stage of niche development, not able yet to break through into the socio-technical regime, can be characterised by three types of phases: (1) *niche-cumulation*, (2) *technological add-on* and (3) *hybridisation*. It means that new technologies in their early phase physically link up with established technologies, often to solve particular bottlenecks (socio-technical issues). Old and new technologies do not immediately compete head on, but form a sort of symbiosis (Geels, 2002).

2.4 Design Thinking

'Remember that design thinking is a personal journey and will be different for each person and project.' (Söderberg, 2014)

Design thinking is an approach to generate ideas and solutions for given challenges and is applicable on different levels depending on how and where in the system the challenge is encountered (Söderberg, 2014). The levels of intervention for design modeling are the societal, socio-technical, product-service and product-technology system as their mutual relationship is brilliantly visualised with the Multilevel Design Model (MDM) created by Joore (2010) and Joore and Brezet (2014) (s. figure 2.9 on page 21).

The sequence of steps from the initial *'challenge'*, as Söderberg (2014) calls it, or *'starting position or functional problem'* according to Joore and Brezet (2014) until the solution (*'Prototyping'* (Söderberg, 2014) or *'Experience'* (Joore and Brezet, 2014)) is depicted in two different ways, each of them from the aforementioned researchers. Both of them give a seemingly linear visualisation of steps even though they highlight that *design thinking* is a highly iterative process (Söderberg, 2014; Joore and Brezet, 2014):

Söderberg (2014) depicts *design thinking* as it is shown in figure 2.8 on page 18 including many *'re-takes'* as an essential part of it:

1. **Challenge**: A challenge or a problem regarding a situation is identified.
2. **System**: An envisioned system state is described and its boundaries are drawn.
3. **Needs**: The difference between the present state and the desired state of the system.
4. **Requirement**: Identified and analysed requirements, wishes or regulations set from the characteristics of the desired system.
5. **Function**: Functions are the different abstract ways to meet the needs (requirements, wishes etc) from stakeholders.
6. **Idea**: More specific ways on how to deliver the functions.
7. **Concept**: Various ways that can realise the ideas.
8. **Visualisation**: A quick and easy way to communicate (an) idea(s) or (a) concept(s).
9. **Prototyping**: Here the concepts or ideas are tested and feedback results are acquired. The prototype is the closest to the concept can get to the 'real world'.

Joore and Brezet (2014) depict *design thinking* as it is shown in figure 2.10 on page 22:

1. **Reflection**: Starting position for a design process or a problem solving process is the result of a reflection of the current existing situation that can be a description of a 'problem' or even the identification of an 'opportunity' for a potential future situation.
2. **Analysis**: The problem is interpreted and a new desired situation is envisioned in an abstract manner providing the requirements without concrete solutions or concepts.
3. **Synthesis**: Concrete idea generation and development takes place resulting in a described new possible solution.

4. **Experience**: The new concept or solution is realised and a new situation with new characteristics is experienced. This could be based through a model, a prototype or a final product.

Both methods can be recognised in many processes that use similar phases, though may use different names (Joore, 2010; Joore and Brezet, 2014).

These closely related ways of the *design thinking* process were taken into consideration for this thesis. However, the main theoretical methodological steps followed were taken from Söderberg (2014). In the following a more thorough description of his work is given.

In general, this approach embodies the reflection of both inside-out and outside-in perspectives and aims at discovering one's personal way of thinking while acquiring a variety of tools to understand and be able to handle the iterative character of designing solutions. More specifically, the process *design thinking* consists of three overarching phases: The *pre-study*, *development* and *verification phase* (s. figure 2.8 on page 18). During the *pre-study phase* one focuses primarily on the co-creation of a requirement or demand list serving as a template for work or decisions (Söderberg, 2014). The *development phase* is characterised by discussions and brainstorming sessions while staying open-minded to finally create a first set of *ideas* and *concepts* for future *solutions*. Finally, these *concepts* have to be verified by visualisation (e.g. text, matrices, pictures, scenarios, etc.) and prototyping to pave the way for further discussion with team members and stakeholders. As mentioned by Söderberg (2014), when communicating these prototypes of solutions one has to be aware of the difference between people's desires and their actual needs due to unawareness. This implies that *semi-structured* interviews (s. section 2.2.2.3[1] on page 12) could allow for asking questions and receiving answers which have not been considered beforehand. As indicated by the arrows in figure 2.8 several iterations are a natural part of the process. Hereby, it must be noted that the upper, red-blue arrows indicate the retakes one should do expected from the stakeholder and the lower, yellow-blue arrows indicate the retakes one should be prepared to do oneself in any case. A major difference here is that the stakeholder most likely expects a re-conceptualisation of the first few results of a prototype which has to be taken into account during the planning phase of a project.

For the present thesis we primarily focus on steps 3 (*needs*) to 7 (*concept*) based on the *design thinking* approach from Söderberg (2014). When designing *solutions*, in order to reach the final *concepts* from *functions*, according to Söderberg (2014), a general simplistic rule to understand is that the sequence of steps follows a continuum from the most abstract (*function*) to the most specific (*concept*) (s. figure 2.8 on page 18). Hence, if one follows the 'course' from abstractions to specific *concepts*, the key question to ask is 'how', whereas when in the opposite direction one should ask the question 'why' (Söderberg, 2014).

[1]Stakeholder Interviews

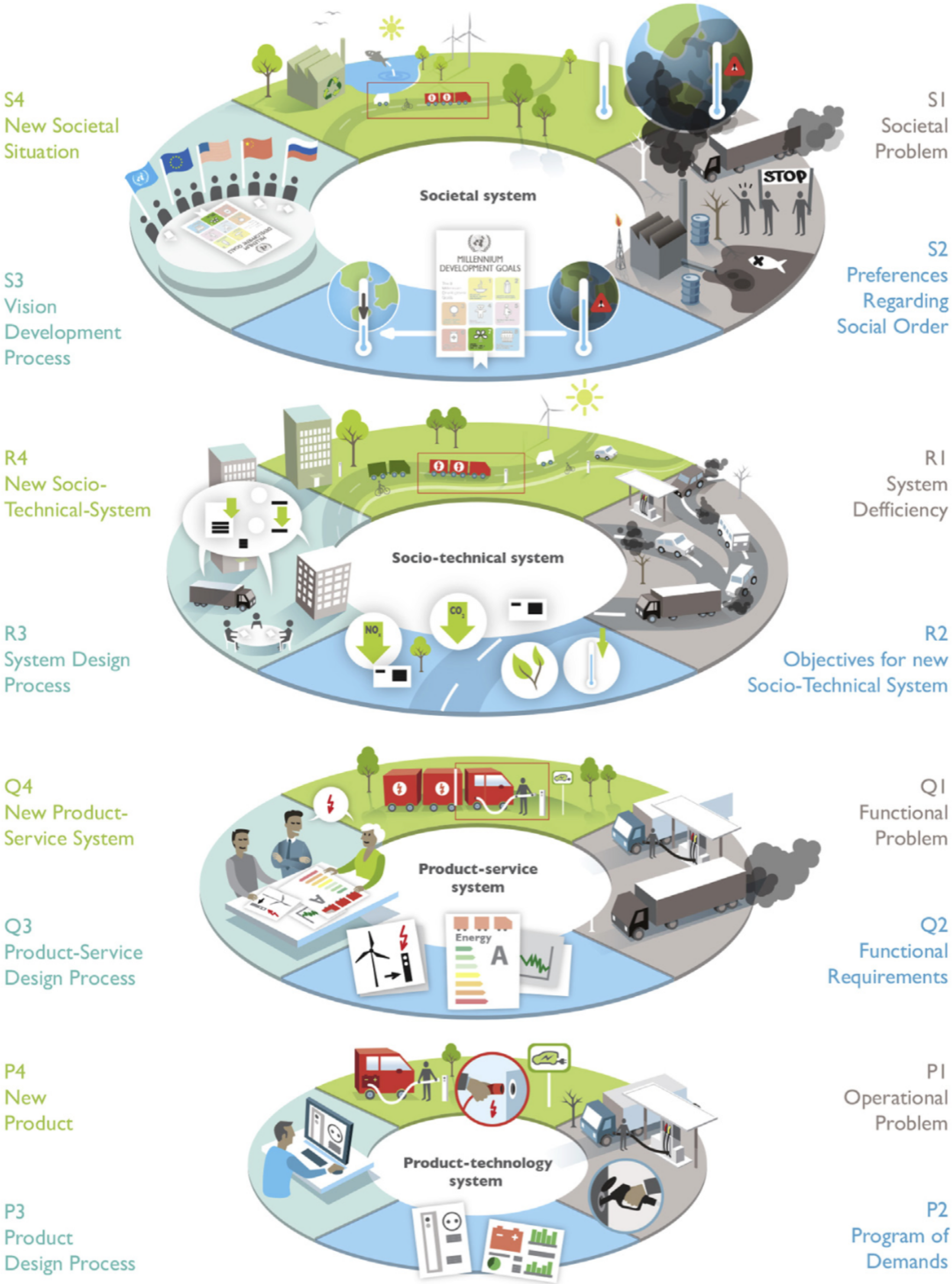

Figure 2.9: MDM cyclic visualisation - sustainable transport (Joore and Brezet, 2014).

Figure 2.10: MDM linear visualisation - sustainable transport (Joore and Brezet, 2014).

2.4.1 Scenario Design

Reviewing literature and dictionaries on *scenario* as a term, there is no commonly adopted definition. In in most dictionaries, including Oxford English Dictionary, a *scenario* is defined as *'A sketch or outline of the plot of a play, ballet, novel, opera, story, etc., giving particulars of the scenes, situations, etc.'* or *'A film script with all the details of scenes, appearances of characters, stage-directions, etc.'*. In scenario planning, scenarios set the *scenery* against which they frame strategic conversations. This thesis is focusing on strategic planning for the future towards sustainability (s. section 2.5[2] on page 24) and it can potentially be used as an input for decision making. Hence, scenario design here is more associated with reducing future uncertainties and explore future possibilities. Stewart et al. (2013) characterise scenarios as *'internally consistent representations of possible futures'*. The main goal for scenario planning is to stimulate the creativity to see and explore contingencies so as to 'strategise' decision making accordingly (French et al. (2009) and Stewart et al. (2013)).

In this thesis, the approach for *scenario design* for a sustainable future is used as it is described by Lundqvist et al. (2006). Their study was carried out on case studies based on companies aiming to integrate *scenario design* and strategic planning towards sustainability on which there is not much previous experience in general.

[2]The Backcasting Methodology

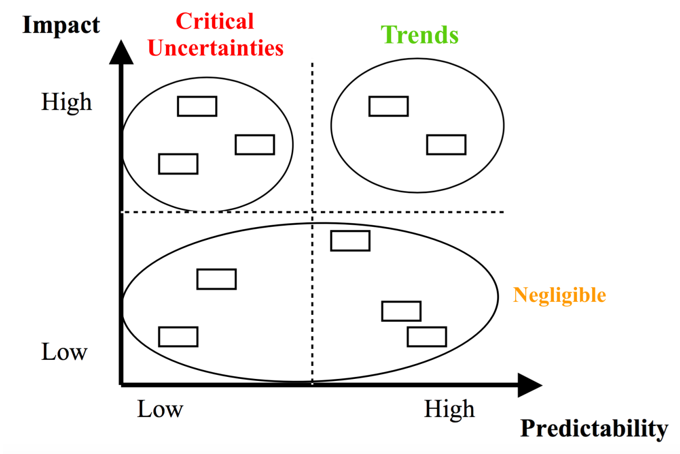

Figure 2.11: The small squares represent different external factors. Critical factors are the ones with high impact and only those are taken into consideration for the scenario development (Lundqvist et al., 2006).

2.4.1.1 Development of Scenarios

The methodology for development of the scenarios followed here is carried out in six steps as described by Lundqvist et al. (2006):

1. **Identify external factors:** Any given socio-technical system (e.g. a company, a network, an institution, a transportation system) (s. section 2.3.2[3] on page 16) under examination may be affected by external changes that might happen in its direct or indirect surroundings (for example political conditions, environment, economy, market, technology, society, customers, suppliers, users etc.). In this step one is called to identify and list these factors that, depending on the type of examined entity, can vary from customer's behaviour to new regulations. Usually these factors are identified in brainstorming sessions.

2. **Sort external factors:** The second step is to sort the external factors on a diagram based on their impact and predictability, as it is shown in figure 2.11.

3. **Classification of critical factors:** Once the factors are placed on the impact-predictability diagram, they are classified into *critical* and *non-critical* factors (negligible): The *critical* factors are the ones that exert relatively high impact and the rest are considered negligible since on the scenario development only the critical factors are taken into consideration. The critical factors that have high predictability are classified as *trends* whereas the critical factors with low predictability are classified as *critical uncertainties*. The trends are factors that are part of all scenarios, have clear development and are easily projected in the future such as population growth. *Critical uncertainties*, which are also characterized by Lundqvist et al. (2006) as *'potential discontinuities'*, exert a great influence on the focal question, are highly uncertain as they can have multiple possible outcomes and might either pose a threat or provide

[3] Systems Analysis: A Multi-Level Perspective

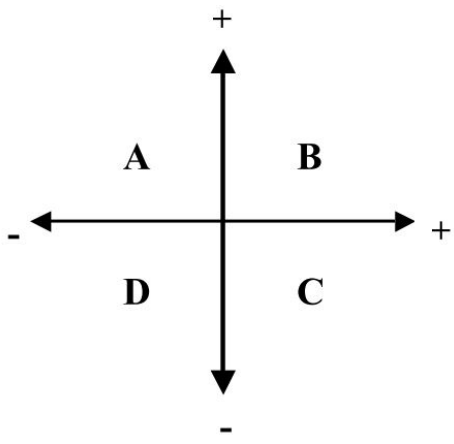

Figure 2.12: The extreme values of two critical uncertainties are used to form four scenarios (Lundqvist et al., 2006).

opportunities for the investigated system. Examples of *critical uncertainties* could be user behaviour or future technological innovations.

4. **Selection of critical uncertainties:** The *critical uncertainties* form the major differences between the future scenarios. After the brainstorming one selects two uncertainties that are unrelated and highly relevant and defines and describes the two extreme values of these uncertainties.
5. **Generation of possible scenarios:** In the fifth step, the extreme values of the uncertainties created in the previous step are used to form two crossing axes in a diagram, which gives four different areas (quadrants), each representing a scenario: A, B, C, and D (s. figure 2.12). The extreme values, and consequently the scenarios, should be equally probable.
6. **Name and describe the generated scenarios:** In the sixth and final step, the four generated scenarios are labelled and described in some detail based on their characteristics such as values for *trends* and *critical uncertainties*.

According to Lundqvist et al. (2006), experiences and conclusions on this methodology have shown that the methodology may be highly iterative and intuitive, especially in the steps of the identification of the external factors and their sorting as well as during the selection of the 'appropriate' critical uncertainties that are independent on each other and provide equally probable scenarios.

2.5 The Backcasting Methodology

This section gives an overview of the methodological framework of using the backcasting methodology for strategic planning towards sustainability.

The backcasting approach was first adopted in the 1970's for energy studies on electricity supply and demand by Lovins (1976) as a planning methodology (Robinson, 1982a; Robinson, 1982b). However, the term was given by Robinson (1982b) as

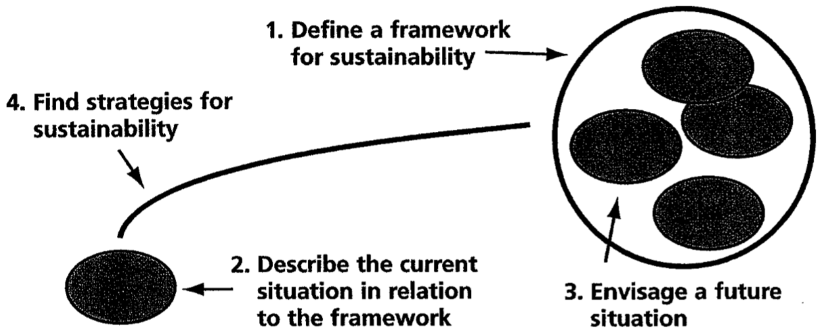

Figure 2.13: The steps in strategic planning for sustainability (Holmberg, 1998).

a future method to develop normative scenarios and explore their feasibility and implications.

Furthermore, Robinson (1990) initiated the application of backcasting for sustainability with a study supported by the Swedish Energy Research Council. Generally, according to Dreborg (1996), in order to achieve long-term sustainability, integrated multidisciplinary efforts and studies with systemic perspectives that offer a holistic view are needed. However, that alone is not enough. Thus, Dreborg (1996) claims that an approach such as backcasting with the ability to provide a solution that could potentially disrupt current trends would be an attractive approach compared to the dominating traditional forecasting approaches in the field of future studies. In addition, Holmberg and Robèrt (2000) argue that backcasting is a planning methodology that is particularly helpful when the problems at hand are highly complex and highly complicated and present trends are part of the problems, namely 'wicked' problems, such as challenges related to sustainability.

In the context of sustainable development backcasting means to start planning from a description of the requirements that have to be met when society has successfully become sustainable; then the planning process continues by linking today with tomorrow in a strategic way (Holmberg and Robèrt, 2000). As defined by Holmberg and Robèrt (2000), '*Backcasting is a method in which the future desired conditions are envisioned and steps are then defined to attain those conditions, rather than to take steps that are merely a continuum of present methods extrapolated into the future*'.

The backcasting approach used in the present thesis is participatory as it uses broad stakeholder involvement. This particular backcasting process was characterised by Robinson (2003) as the *'second generation'* of backcasting. In such an approach, the private sector and other organisations of civil society participate in, apart from scientific experts, practitioners and professionals from governments. More specifically, a wider involvement of diverse actors *'[...] add meaningful information, new insights and a less narrow and less technocratic view on causes and solutions'* (Tuinstra, 2002). In fact, Tuinstra (2002) speaks in favour of this approach as such:

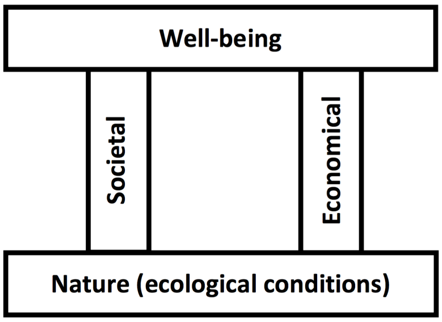

Figure 2.14: Principles for sustainability (Holmberg, 2015).

- *'It helps to bridge the gap between a scientifically defined environmental problem and the experiences, values and practises of actors who are at the root of both cause and solution of such problems;*
- *Participation helps in clarifying different, often opposite, views and interests on a problem, making problem definitions more adequate and broadly supported;*
- *Participation in the scientific assessment may improve the quality of decision making, not by taking over the role of scientific expertise but by adding and complementing it with other dimensions. As such it increases feasibility, prevents implementation problems, reinforces the commitment of stakeholders, increases the democratic content, etc.'*

The methodology consists of 4 steps and is described in the following subsections as defined by The Natural Step Organisation and Holmberg (1998):

Step 1 - Define a framework and criteria for sustainability

Step 2 - Describe the current situation in relation to the criteria for sustainability

Step 3 - Envisage future sustainable solutions

Step 4 - Find strategies for sustainability

2.5.1 Step 1 - Define a Framework and Criteria for Sustainability

During the first step of the backcasting process a future state detached from the present situation is envisioned and criteria for sustainability are defined. This step requires a considerable amount of imagination and creativity since most of our ideas of the future stem from current trends and developments. When envisioning a desirable future state it is necessary to think as freely as possible and try not to relate to the boundaries of the present situation. The future state vision is based on criteria for sustainability in four dimensions: Economical, ecological, societal and well-being (s. figure 2.14). These four pillars must be understood in such a way that the economical, ecological and societal sustainability criteria must be fulfilled to ensure human well-being in the present as well as for future generations (Holmberg, 2015). To fit the methodology of backcasting, the criteria should be *'principles of the outcome (sustainability), not the transition (sustainable development)'* (Holmberg and Robèrt, 2000). As defined by Holmberg and Robèrt (2000) the following system conditions must not be violated to avoid further deterioration of our planet:

1. Substances extracted from the earth's crust must not be accumulated in the lithosphere.
2. Substances produced by society must not be accumulated in the lithosphere.
3. The life processes on earth must not be degraded by the exploitation of energy sources and further materials.
4. Resources required for human needs must not run out.

These system conditions must always be considered when defining criteria around ideas or concepts of possible future states.

2.5.2 Step 2 - Describe the current Situation in Relation to the Criteria for Sustainability

In step 2 of the backcasting process a thorough analysis of the current state of the system under examination is conducted in relation to the sustainability criteria set in step 1. An 'inventory' of all the systemic attributes and conditions, such as competences, activities, behaviours, trends, is compiled. The analysis is carried out in respect to the four sustainability pillars or dimensions of step 1 that cover all the relevant aspects of sustainability through answering relevant questions to these non overlapping principles (Holmberg, 1998). Subsequently, one is in the position to know and be able to describe the gaps between the current and the envisioned future situation. Then, with the acquired knowledge of the complexity of the system along with the existing gaps, one is able to recognise the *leverage points* in the system where an intervention can be carried out (Meadows, 1997).

There are several tools to acquire a comprehensive analysis of the current state of a given system:

- **Stakeholder engagement** (s. section 2.2.2 on page 9)
- **System analysis tools such as the MLP** (s. section 2.3.2 on page 16)
- **Identification of leverage points** (s. section 2.3.1 on page 15)

2.5.3 Step 3 - Envision Future Sustainable Solutions

With the awareness about existing gaps between the present situation (step 2) and a desirable future state (step 1) the third step of the backcasting methodology deals with the design of future solutions within the principles defined in step 1 (Holmberg, 1998). There is generally a variety of possible future solutions as illustrated in figure 2.13 on page 25. However, none of these solutions should be described in too much depth but should rather aim towards opening people's mind for new options without being limited by the restrictions of the present system (Holmberg, 1998). Although this step seems rather natural to most of us as we intend to easily think about solutions when defining criteria for a sustainable future or describing the present situation it is usually very challenging to design a set of possible future solutions which promise a systemic transition into a more sustainable state. To facilitate this process the concept of *design thinking* (Söderberg, 2014) can be applied as described in section 2.4 on page 18. The goal is to find solutions that allow for ongoing sustainable development compared to traditional static views on activities or products. As Holmberg (1998) puts it, this can be done by *'[...] companies that sell 'preservation of food at home' rather than refrigerators; 'fast food nutrition at low price' rather than hamburgers; or 'light and indoor climate' rather than energy'*.

2.5.4 Step 4 - Find Strategies for Sustainability

In step 4 of the backcasting methodology strategies that eventually link the present situation with the future sustainable one are identified and a development path is drawn. These strategies compile the key strategic steps that have to be taken to accommodate for the solutions generated in step 3 to happen. Here, time is taken into consideration for the required steps on the way to reach the envisioned state. These steps interact directly with the set of solutions in the sense that they enable them but also are enabled by them in a future-based perspective.

One common way to draw each of these steps is to place oneself into the future state and go backwards in time constantly asking the question: 'What policies, entities, strategic concepts, etc., have to be in place in order for the vision to be achieved?' Ultimately, following this backcasting process a desirable strategy is drawn beginning planning directly from the future in a step-by-step manner.

In general, when drawing strategies in step 4, it is important to consider the following points (Holmberg, 1998):

- *'Will each measure (products, services, investments) bring us closer to sustainability?'*
- *'Is each measure a flexible platform for the next step towards sustainability?'*
- *'Will each measure pay off soon enough?'*
- *'Will the measures taken together help society to make changes at a sufficient speed and scale to achieve sustainability without too many losses for humans and other species during the transition?'*

According to Holmberg (1998) strategies that succeed in combining these points can accommodate for the paths towards sustainability because *'in the same time as each measure is designed to fit a path towards sustainability, the measures must also pay off soon enough. In this way, chances of optimizing future progress get fueled by a relatively stronger economy in a positive spiral'*. If the points are not fulfilled the actors might run out of resources or loose their competitive leverage.

3

Methodology Phase I

In the following chapter the methodology of Phase I is described representing the workshops, group tasks and thought processes during the first four weeks inside the C-Lab which finally led to the formulation of the research question of this thesis. The results acquired by conducting the following steps of the backcasting methodology are presented in chapter 4 'Results Phase I' on page 35.

3.1 Formulating a Research Question

In this section it is described how the participants employed some of the theories presented in section 2. Thereby, tools, concepts and perspectives are acquired and applied under an overarching backcasting process and offer an overview of the methodologies that were followed throughout Phase I at the C-Lab. Steps 1 to 3 of the backcasting process were performed as a set of workshops and group tasks by investigating various sustainability challenges whereas step 4 was performed rather individually by finding the final group constellation and research question.

3.1.1 Step 1 - Define a Framework and Criteria for Sustainability

The first week of Phase I focused on investigating one's personal strengths and weaknesses in a *self-leadership* workshop (inside-out perspective) as described in section 2.2.1 on page 9 and the definition of criteria for sustainable urban development as the overarching thematic area by envisioning a desirable future state (outside-in perspective) as described in section 2.5.1[1] on page 26. The final vision and sustainability criteria formulated by all the C-Lab students as a result of the following methodology are presented in section 4.1.1[2] on page 35.

Inside-out perspective

The participants of the C-Lab were introduced to a 'Self-Leadership' workshop given by a consultancy firm specialised on leadership consulting. In this session activities

[1] Step 1 - Define a Framework and Criteria for Sustainability (Theory)
[2] Step 1 - Define a Framework and Criteria for Sustainability (Results)

of self-reflection as well as team building activities, such as story telling and sharing of value related experiences, took place helping the participants to realise and reflect on their values and strengths on an individual level but also as a group. These activities were supposed to facilitate the group discussions and team-formation for the thesis projects in the later stages of Phase I. During the workshops theories behind *self-leadership* as described in section 2.2.1 on page 9 were acquired, discussed and applied.

Outside-in perspective

To develop sustainability principles for a desirable future state various workshops were carried out with assistance of the C-Lab team to understand the backcasting process (Holmberg, 1998), future-state visioning (Stewart, 1993) and the four dimensions of sustainability (Holmberg, 2015) (s. figure 2.14 on page 26). During this process each dimension (economical, ecological, societal and well-being) was allocated to one of four teams the group was divided into with the purpose of formulating specific criteria based on group discussions and literature research. In order for each participant to get an insight into all dimensions while maintaining a smaller group size the 'World Café' method was applied. This is a simple and effective way of leading separate collective dialogues based on group rotations. In each of the small groups there is a facilitator taking notes of the conversation which takes approximately 20 minutes. After each round all participants except for the facilitators move to the next group. There, the facilitator briefly describes what was discussed during the previous round and afterwards reopens the discussion. After four rounds every participant had equally contributed to the definition of the principles and acquired roughly the same knowledge about the four dimensions. With this knowledge the participants returned to their original groups and continued with the definition of the criteria.

3.1.2 Step 2 - Describe the Current Situation in Relation to the Criteria for Sustainability

During step 2 again an outside-in and inside-out perspective was taken to acquire a comprehensive *systems analysis*, as described in section 2.3.1[3] on page 15, of the current state of the Gothenburg region and its sustainability challenges (Holmberg, 2014). The results of the following methodology are presented in section 4.1.2[4] on page 37.

Outside-in perspective

The 'motto' that followed us along step 2 of the backcasting process was: '*Think big, start small, act now'* (The Challenge Lab, 2016). After having acquired an

[3]Systems Thinking

[4]Step 2 - Describe the Current Situation in Relation to the Criteria for Sustainability (Results)

understanding on the global challenges our task was to look examine how they are projected to the local context.

In regards to the local context, we organised the set-up of four stakeholder dialogues that took place at the C-Lab premises after being introduced to the concept of dialogue (Isaacs, 1999) through literature and lectures as well as highly participatory processes amongst us and the C-Lab team. After having practised the 'virtue' of *dialogue facilitation* (s. section 2.2.2.3 on page 12) and connecting ourselves with our inner values and strengths (s. section 2.2.1 on page 9) we came to a consensus concerning the role allocation during the dialogues (*facilitator*, *questioner* and *observer*) through an open democratic session.

The dialogues were conducted in an open *fishbowl* set-up as described in section 2.2.2.3 on page 13. In this set-up stakeholders from the Gothenburg region were invited as experts to interact with the *facilitators* and *questioners* in the inner circle. The outer circle consisted of the C-Lab team, other stakeholders and participants who took the role of the *observer* by listening actively and taking notes. The outer circle was given the possibility to interact with the inner circle at specific points providing the 'outside-in' perspective to the dialogic value.

The four stakeholder dialogues took place with different configuration of approximately 5 stakeholders.

After every dialogue the group would come together and self-reflect on the facilitation of the dialogue, the learning outcomes and the key takeaways. Also a useful general feedback on the sessions would be given by the C-Lab team.

Inside-out perspective

By applying *systems analysis* tools, such as the Multi-Level Perspective (MLP) by Geels (2005) (s. section 2.3.2 on page 16) the system of the Gothenburg region was analysed in three levels:

- The landscape level (*macro-level*): National, global and EU legislation and trends.
- The socio-technical regime level (*meso-level*): Depending on the thematics the following components of the local regime of the Gothenburg region were identified: local market, infrastructure, industries, technologies, knowledge capacities and actors, culture and norms.
- The technological niche level (*micro-level*): Innovative hubs, processes and projects taking place locally were listed and researched.

In dependence on the 12 *leverage points* identified by Meadows (2009) (s. section 2.3.1 on page 15) places to intervene in the system were identified. More specifically, places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift can produce big changes in the system as a whole were identified. These points can be related to the discovered innovative projects in the Västra Götaland region of which their further development could shift the

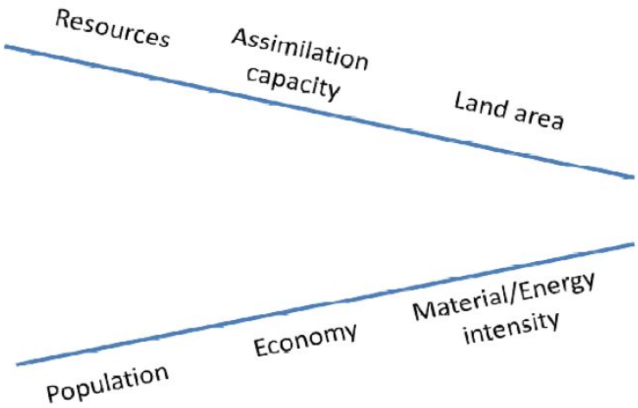

Figure 3.1: The funnel method introduced by Holmberg (1998) and presented during his lectures

whole system towards a more sustainable state. The leverage that can be created with these identified points led us to step 3 of the backcasting process.

The current trends were described through the funnel method introduced by Holmberg (1998) as shown in figure 3.1. The funnel method identifies six global trends that put pressure on the current system nowadays. These are scarcity of resources, assimilation capacity, decreasing land area from one side and the increasing population, economic growth and the increasing material or energy intensity. Through individual research and continuous group discussions and exchange of information in a collaborative open environment we gradually gained a holistic understanding of the trends and started looking at how these affect the region, the city and the institution (university). This was facilitated by continuous team presentations in which we were rotating regardless our areas of interest in order to *'stay in the question'* and investigate thoroughly as objectively as possible. As a result overarching thematics were identified to be investigated further.

3.1.3 Step 3 - Envision Future Sustainable Solutions

From step 3 on primarily an outside-in perspective was taken to align potential future solutions (hot topics) with the boundaries set by the previously defined sustainability principles of the outer system. The hot topics as well as different perspectives that may be taken are presented in section 4.1.3[5] on page 39.

Outside-in perspective

During the last week of Phase I we focused on finalising the identified regional hot topics around sustainable urban development. As described in 2.5.3[6] on page 27 these hot topics or possible future solutions were not described in much detail but provided opportunity for discussion and personal engagement as they were supposed

[5]Step 3 - Envision Future Sustainable Solutions (Results)
[6]Step 3 - Envision Future Sustainable Solutions (Theory)

to enable intervention into the system with high leverage. To narrow down the large list of hot topics first similar topics were clustered and a few were discarded. With a condensed list of three critical areas an evaluation of the following aspects was performed:

- Stakeholders interest
  - Are there many stakeholders working with this topic?
- Dimensions of sustainable development
  - Can this topic cover all dimensions of sustainable development (economical, ecological, societal and well-being)?
- Transformative character
  - Has this topic the potential to transform the current system?
- Integrative character
  - Does this topic integrate multiple aspects and stakeholders?
- Socio-technical aspects
  - In which way are the aspects of the socio-technical regime (policy & legislation, industrial networks, market & user practises, technology, infrastructure, knowledge, culture & norms) covered with this topic?
- Scale
  - To which extend can this topic be scaled up?
- Value chain
  - Where in the value chain can be intervened with this topic?

Various tools, such as the MLP (Geels, 2002) (s. section 2.3.2 on page 16) or *design thinking* (Söderberg, 2014) (s. section 2.4 on page 18), were further applied during the evaluation process while making use *self-leadership* competencies (s. section 2.2.1 on page 9) acquired during the first step of the backcasting process. For the identification of possible research projects the group came up with topics and perspectives within each of the major hot areas (s. section 4.1.3 on page 39). More specifically, this process was again supposed to broaden the perspectives by investigating correlations between critical challenges and looking for possible leverage points for intervention. Afterwards, the whole group performed a rating procedure of the existing topics and perspectives mainly focusing on personal interests. By doing so, a first draft of possible group constellations around similar areas of interest could be established. Further discussions amongst the students and the C-Lab team as well as personal reflections finally led to a compilation of hot-topics or *solutions* for possible thesis projects

Step 3 of Phase I can be characterised by continuous broadening out and narrowing down on possible hot topics to develop an advanced understanding of their interrelatedness and importance. From here primary focus was put on defining the actual research question.

3.1.4 Step 4 - Find Strategies for Sustainability

Step 4 of Phase I generated the final configuration of the group constellations as well as the individual research questions on the selected hot topics. The final research question of this thesis and some background thoughts on its formulation process are presented in section 4.1.4[7] on page 41.

The final research question could be identified through matching personal interests in hot topics with perspectives. We investigated various possibilities of combinations of hot topics and perspectives through discussions and presentations of other C-Lab students' perception of projects and perspectives. Once we chose topics and perspectives, we started to form groups based on the criterion of sharing the same interests and energy for specific projects. Then, through brainstorming sessions and discussions the groups merged their strengths, study backgrounds and interests and formulated a research question that could bring the system to a more sustainable state.

[7]Step 4 - Find Strategies for Sustainability (Results)

4

Results Phase I

In the following chapter the results from Phase I are presented as the outcome of the methodology described in chapter 3 ‘Methodology Phase I’ on page 29, finalised with the research topic and research question of this thesis.

4.1 Formulating a Research Question

In dependence on the previous chapter the results are divided into step 1 to 4 of the backcasting process.

4.1.1 Step 1 - Define a Framework and Criteria for Sustainability

The results of step 1 in Phase I are again distinguished between the inside-out and outside-in perspectives as described in sections 2.2 on page 8 and 2.3 on page 15. The process that was followed to come up with the subsequent results on backcasting step 1 is described in section 3.1.1[1] on page 29.

Inside-out perspective

By conducting a *self-leadership* workshop every group member was able to reflect on personal strengths and weaknesses and those of others to better understand group dynamics and improve team-work in general. However, the most immediate result of this workshop was a map of personal values one could objectively compare amongst group members to facilitate finding a suitable thesis partner during the later stages of Phase I.

Outside-in perspective

‘We envision a sustainable future where we, approximately 10 billion people, are able to meet our own needs within the planetary boundaries without compromising the ability of our future generations to meet theirs.’ (C-Lab 2015)

[1] Step 1 - Define a Framework and Criteria for Sustainability (Methodology)

This vision was adopted from last year's C-Lab team in order to put more efforts into defining criteria for a sustainable future state covering all of the four dimensions (ecological, economical, societal and well-being) required for sustainable development. These criteria, as listed below, were meant to be further used during the course and therefore must be non-overlapping and universally applicable to any future scenario or solution.

Ecological criteria

Human activities affecting nature's function and diversity are done in such a way that:

- They do not increase the concentration of substances from the lithosphere in the ecosphere;
- They do not increase concentration of human made substances in the ecosphere;
- They do not systematically deteriorate the resource base; such as fresh water, fertile land, and biodiversity through manipulation, mismanagement, or overexploitation.

Adopted and inspired by Holmberg et al. (1996), Holmberg and Robèrt (2000), Larsson (2016) and the Criteria of C-Lab 2015.

Economic criteria

The economic system is an instrument that enables individuals to meet the other criteria (society, well-being, nature) efficiently and effectively in such a way that:

- The function of the economic system is driven by the other criteria and not the other way around;
- It enables further use of resources and avoids dissipative use of materials;
- It ensures an equitable distribution of resources;
- It has an inherent mechanism of maintaining and serving societal infrastructure and institutions that permits human well-being to be met over time;
- It has the ability to change and to adapt when facing shocks and disturbances.

Adopted and inspired by Sen (1999), Anand and Sen (2000), Simmie and Martins (2010), Larsson (2016) and the Criteria of C-Lab 2015.

Societal criteria

The societal system is an instrument for individuals to live together within the other criteria with respect to the following conditions:

- It enables the well-being, empowerment and productiveness of every individual while adhering to the ecological principles by:

  - Equitable accessibility to education and health care;
  - Gender and social equity;
  - Equal human rights;
- Its governing mechanisms (and societal institutions) are built on transparency, accountability, mutual trust, adaptability and recognition of diversity.

Adopted and inspired by Raworth (2012), Pisano (2012), Larsson (2016) and the Criteria of C-Lab 2015.

Well-being criteria

First we present the basics for survival and continue with components supporting self-fulfilment and self-realisation.

The goal of the society and economy, relying on nature as the fundament, is to serve the human well-being where:

- Everyone has the right to human basic needs; health, security, future security, food, water, sanitation, recreation, shelter, energy;
- Human life includes: subsistence, protection, affection, understanding, participation, idleness, creation, identity, freedom;
- Everyone should have access to the same opportunity and the freedom to build a meaningful life;
- Everyone should have access to the same opportunity and freedom to explore and express one's ”inner self” and to life according to one's values without limiting others' freedom or harming others;
- Social and economic inequalities are not justified unless they are to the greatest benefit to the least-advantaged members of society.

Adopted and inspired by Rawls (1972), International Wellbeing Group (2013), Cruz (2009), Larsson (2016) and the Criteria of C-Lab 2015.

4.1.2 Step 2 - Describe the Current Situation in Relation to the Criteria for Sustainability

Similar to step 1, the results of step 2 in Phase I are again distinguished between the inside-out and outside-in perspectives as described in sections 2.2 on page 8 and 2.3 on page 15. The process that was followed to come up with the subsequent results on backcasting step 2 is described in section 3.1.2[2] on page 30.

[2]Step 2 - Describe the Current Situation in Relation to the Criteria for Sustainability (Methodology)

Inside-out

By analysing the current system of the Gothenburg region we acquired an understanding of the global contemporary sustainability challenges, as well as the local ones. We got ourselves familiar with looking at challenges in the MLP allowing us to finally acquire a holistic picture of the present state. For this the research was focused on two 'domains': Firstly, literature on universal contemporary complex sustainability issues (Rockström, 2009; Unknown, 2015; Cruz, 2009) was researched in depth and secondly studying of literature, local news items and relevant meetings gave us the picture of the present state of the local surrounding system in Gothenburg Region. The result from this process was the selection of overarching thematics for structuring the further investigation. The selection was based mainly on our personal interests and supposed to allow for alignment with our inner values and strengths. The following thematic areas were co-decided with the C-Lab team:

- *Mobility and Urban Development*
- *Sustainability Driven Innovation for Urban Development*
- *Integration and Social Innovation*
- *Energy and Mobility*

Outside-in

The outside-in perspective has to be given by actors that come outside the C-Lab. Hence, dialogues were organised per thematic area as presented above. By conducting stakeholder dialogues the necessary understanding of the perspectives, the components and the structure of the complex current system as well as on ongoing projects in the region, city or university was achieved. We were trained how to participate in, facilitate, observe and reflect on a real-time dialogue following the methods and roles (respecting, suspending, voicing and listening) as defined by Isaacs (1999) (s. section 2.2.2.3, paragraph 'Stakeholder Dialogue & Facilitation' on page 12). After each dialogue, important insights on the local state were acquired broadening our understanding of how great sustainability challenges are 'projected' in the local context. These provided the 'gaps' and later the existing leverage points as Meadows (1997) calls them, for a possible change in the system. More specifically, the challenges for each of the dialogues and the respective thematic were the following:

- Dialogue on *Mobility and Urban Development*:
  - Social integration in the city of Gothenburg;
  - Locked-in behaviour of people;
  - Zero-emission mobility;
  - Accessibility and availability of transportation network;
  - Conflict between currently existing policies;

  - Balancing competing priorities and across boundaries collaboration between stakeholders.
- Dialogue on *Sustainability Driven Innovation for Urban Development*:
  - Sustainable (alternative) materials for construction;
  - Sustainability criteria for construction;
  - Sharing economy initiatives concerning urban development;
  - Implementation of new innovations in society;
  - Efficiency of existing structures (energy usage/supply, renovating old buildings);
  - Sustainability in the supply chain (product accountability over life cycle);
  - Social integration driven urban development (community building , collective living).
- Dialogue on *Integration and Social Innovation*:
  - Urban agriculture;
  - Social entrepreneurship and integration;
  - Local markets for products.
- Dialogue with *Chalmers Areas of Advance - Energy*[3]:
  - Energy solutions for a new mobility project in the Frihamnen area;
  - Scaling up electromobility in the Gothenburg region;
  - Scaling up innovative collective living such as HSB Living Lab (HSB Living Lab, 2016);
  - Car-free cities;
  - A future without a private car;
  - Batteries - Key elements for vehicles but also for other aspects (houses).

4.1.3 Step 3 - Envision Future Sustainable Solutions

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Outside-in perspective

According to the methodology described in section 3.1.3[4] on page 32 the results of step 3 in Phase I were primarily generated from an outside-in perspective. This led to an enhanced understanding of regional hot topics and their interrelatedness. During the first part of step 3 the following hot topics and perspectives were identified:

[3] Cross functional teams consisted of researchers and employees from Chalmers University of Technology

[4] Step 3 - Envision Future Sustainable Solutions (Methodology)

Hot topics

1. Scaling up Electromobility
2. City Vision
3. Traffic reduction
4. Traffic strategy
5. Fossil free strategy
6. DenCity (Project for sustainable development in Gothenburg City)
7. Logistics
8. Value chain of material use
9. Sustainable criteria for housing
10. Inclusive Communities
11. Smart grid

Perspectives

1. Policies and Regulations
2. Markets
3. Technology
4. Infrastructure and Logistics
5. Knowledge
6. Culture and Norms
7. Behaviour
8. Product Development
9. Procurement

After identifying overlaps and focusing more on interests of the stakeholders as well as the group members these hot topics were clustered into the following three areas which were meant to be the overarching themes for all master thesis projects of this year's C-Lab:

1. Transport strategy
2. DenCity
3. Value chain and materials

This was followed by rating a procedure of the whole group as described previously in section 3.1.3 on page 32. The end result was the regional hot topic for this thesis: 'Scaling up electromobility'. Important to note is that 'electromobility' was suggested as a hot topic much earlier in the process, however, only after an iterative process of broadening up and narrowing down to investigate further correlations to contemporary challenges the criticality of this topic could be fully understood and was therefore accepted as the most sustainable alternative to fossil fuel based transportation.

4.1.4 Step 4 - Find Strategies for Sustainability

Phase I ends either on this step or on step 3 for most of the participants as the final research question was formulated in different time-frames for each group of the participants. After the funnel process that concluded step 3 a lot of discussion processes took place mostly because participants wanted to reassure that they are placed on the right constellation concerning their interests in perspectives and hot topics (s. section 4.1.3). More specifically, the research question for the present thesis was a result of matching electromobility as a hot topic with the perspective of policies and regulations.

We selected Electromobility as a solution for bringing the current system in the Gothenburg region closer to a future where sustainable transportation is in place. In this context, step 4 of Phase I ends with formulating a research question on how to strategise a path towards sustainable transportation through the implementation of electromobility as a solution. After applying a necessary contextualisation based on location the research question was narrowed down to the city level and crystallised into: *'How to develop a strategy for scaling up electromobility in the city of Gothenburg by applying the backcasting methodology'.* In the following chapters an attempt is made to investigate and answer this research question amongst others as presented in section 1.3[5] on page 3.

[5]Purpose and Research Questions

5

Methodology Phase II

This chapter describes the methodology followed during Phase II of the thesis project. Firstly, a brief introduction of the 'Organisation of the Work' (s. section 5.1) and the chosen approaches for 'Data Collection' (s. section 5.2) is given. This is followed by the description of specific methodologies applied for the realisation of the backcasting process (s. section 5.3 'backcasting step 1' on page 44, section 5.4 'backcasting step 2' on page 45, section 5.5 'Backcasting step 3' on page 48 and section 5.6 'Backcasting step 4' on page 54).

5.1 Organisation of the Work

In order to continuously maintain focus and facilitate data exchange continuous efforts were put into how to organise the upcoming work at the beginning of Phase II.

Initially a roadmap was created including key tasks to follow, such as documentation of Phase I and II, *organisation of stakeholder interviews* or *design of future scenarios*, serving as an orientation for the chronological execution of all the tasks. Also, important deadlines and events were added to the roadmap. For more specific tasks a weekly agenda was set up in advance of every week including upcoming meetings or interviews and weekly goals to be achieved. For the documentation of research data and brainstorming session separate files were created on *Google-Drive* allowing for simultaneous editing and reviewing. The documentation of the final report was realised with *ShareLaTeX* to allow for real-time editing of the common document. The work behind this thesis was largely carried out in co-creation since most of the tasks required joint efforts to be realised. When it came to the documentation of the final report responsibilities for the different sections were split equally.

5.2 Data Collection

As a basis for all the steps of the backcasting methodology data was collected in various ways. Extensive research on literature, such as scientific publications and papers, official web-pages and various project summaries, was conducted, especially for backcasting step 2 (s. section 6.2.1[1] on page 64). In addition to literature research, qualitative research was performed by organising *semi-structured* interviews with local stakeholders from the public, private and academic sector (s. section 5.4.1 on page 45) and finally holding a stakeholder dialogue for a final input of data (s. section 5.6.1 on page 54).

The results and analysis of the acquired data is presented in chapter 6 'Analysis & Results Phase II' from page 59.

5.3 Backcasting step 1 - Envisioning a Sustainable Transportation System

This section describes the methodology followed to conduct backcasting step 1. This included the formulation of both a vision for the transportation of 2050 (s. section 5.3.1) and sustainability criteria on electromobility (s. section 5.3.2).

5.3.1 Formulation of a Vision for the Transportation System of 2050

The Formulation of a vision for the transportation system of 2050 was a highly iterative process. The first draft of the vision, at the very beginning of the process, was a co-creative result of several extensive brainstorming sessions and based on a preliminary understanding of the transportation system in the city of Gothenburg which was partly acquired already during Phase I. The methodology for the formulation of the vision was mainly based on our academic knowledge and our understanding of sustainability as well as future requirements (criteria) as we have acquired them throughout Phase I and the C-Lab experience (s. section 3.1 on page 29). Hence, to generate the final result, extensive discussions were carried out upon the topic of sustainable transportation and its relation to electromobility. During the following backcasting steps adjustments were made according to the feedback from stakeholders, our supervisor and the C-Lab team to create a challenging but also feasible and desirable vision for the future.

The final result of the vision is presented and analysed in section 6.1.1[2] on page 59.

5.3.2 Formulation of Sustainability Criteria on Electromobility

The methodology behind the formulation of sustainability criteria on electromobility was, similarly to the formulation of a vision, based on several brainstorming sessions. Hereby, principles for the ecological, economical, social and well-being dimension of sustainability were discussed and analysed. A good starting point for the formulation

[1] A Multi-Level Perspective on the Transportation System in Gothenburg City

[2] A Vision for the Transportation System of 2050

of specific criteria related to electromobility was provided by the set of sustainability principles co-created by all the C-Lab students during Phase I (s. section 4.1.1 on page 35). During the creation process of the criteria the following aspects had to be met:

- The criteria must be non-overlapping (Holmberg and Robèrt, 2000);
- The criteria must ensure a sustainable state;
- The criteria must promote electromobility as a solution for a sustainable transportation system;
- The criteria must be descriptive and preferably short.

After verifying the criteria against the aforementioned aspects the first draft of principles was generated. Again, similar to the formulation of the vision, the final set criteria was a result of an iterative process as adjustments were made during the following steps of the backcasting methodology.

The results of the final set of sustainability criteria and their analysis is presented in section 6.1.2[3] on page 61.

5.4 Backcasting Step 2 - Describing the Current Transportation System in the City of Gothenburg

This section describes the applied methodology to investigate the current transportation system in the city of Gothenburg. In addition to an extensive literature research, stakeholders were engaged into the process by applying *semi-structured* interviews in order to describe each of the seven dimensions of the current socio-technical regime (inspired by Geels (2002)), namely sectoral policy & legislation, markets & user practises, stakeholder networks, knowledge, technology, infrastructure and culture & norms, as described in section 2.3.2[4] on page 16. With Step 2 of the backcasting process the purpose (**Why**) of the project and the *stakeholder engagement*, the final scope (**What**) and the mix of relevant stakeholders (**Who**) was identified (s. section 2.2.2.1[5] on page 9).

5.4.1 Semi-structured Stakeholder Interviews

This section describes the four steps of the methodology followed for the realisation of *semi-structured* stakeholder interviews, the *planning*, *doing*, *analysing* and *reflecting phase*. Despite the seemingly chronological order of these steps the interviews were a highly *'[...] iterative process in which data collection, on-going data-analysis, reflections and generating new questions are part of a continuous comparative effort'*

[3]Sustainability Criteria on Electromobility
[4]Systems Analysis: A Multi-Level Perspective
[5]The Concept of Stakeholder Engagement

(Van Teijlingen, 2014). Before being able to initiate the *planning phase* of our interviews we were mostly relying on referrals from the C-Lab team to identify possibly important stakeholders for our project that could be interviewed. The time scope taken for the execution of all the interviews was roughly two months, from the end of February to the end of April. During that time 15 face-to-face interviews with different stakeholders from the public, private and academic sector in the city of Gothenburg were organised and undertaken (s. table B.1 in Appendix B.1 on page V for the list of conducted stakeholder interviews). In addition to the 15 *semi-structured* interviews, several unstructured, informal interviews were conducted as well. The following steps, inspired by Van Teijlingen (2014), were performed for each of the *semi-structured* interviews.

5.4.1.1 Planning Phase of the Interviews

During the *planning phase* the schedule and the overall structure of the interviews was set up. Before the first interview a short presentation of our thesis project with comprehensive visualisations, such as the applied backcasting methodology, the four pillars of sustainability, the triple-helix, the current network of stakeholders and others, was set up to facilitate the interaction with the interviewees. The last slides of the presentation contained a predefined set of questions which were designed to be answered in non-chronological order dependent on the flow of the conversation. A set of core questions was kept and only slightly adjusted for all interviews and a few individual questions were formulated to extract very specific information from each of the interviewees. Generally, the questionnaire was supposed to motivate the interviewee to respond but also challenge their way of thinking about themselves as individuals, their organisation and the current system. A condensed sample of the questionnaire can be found in Appendix B.3 on page VII.

5.4.1.2 Doing Phase of the Interviews

The *doing phase* is represented by the execution of the interview itself. Most of the meetings took place in the facilities of the interviewees and only a few at the C-Lab. Before presenting the background and current status of our research topic focus was put on creating a pleasant atmosphere by briefly introducing ourselves as well as giving the interviewee the chance to do so. Also the interviewee was kindly asked for permission to take extensive notes during the meeting for our research purposes, which was generally accepted. Compared to audio or video recording, this method was chosen to allow for the possibility of taking side-notes and creating a preliminary structure around the data as well as increasing the overall efficiency during the *analysing phase*. Amongst the two of us the tasks of presenting, interviewing and taking notes were switched regularly. During the presentation the interviewee was generally given the chance to ask for clarifications if needed. After familiarising the interviewee with our research topic all predefined questions in addition to others, coming up during the interview, were posed in the appropriate order to maintain the flow of the conversation. Hereby attention to certain key aspects, as mentioned by Van Teijlingen (2014), was payed, such as actively listening to the interviewee, observing the interviewee's non-verbal behaviour and evaluating the response.

5.4.1.3 Analysing Phase of the Interviews

After each interview, firstly, one's own behaviour was analysed to identify possible mistakes and allow for further improvements during the following interviews. Throughout all 15 interviews various adjustments were made, such as adding a brief introduction of the C-Lab, allowing more time for clarification and feedback for both of us and the interviewee or including an informal invitation to our stakeholder dialogue to increase the chances of the particular interviewee's participation. Secondly, the interviewee's behaviour was analysed to understand her or his attitude towards our project and to approach them accordingly in future conversations. Lastly, the notes were archived and analysed by extracting relevant information for the description of the socio-technical regime of the current transportation system in the city of Gothenburg (s. section 6.2.1[6] on page 64) as well as potential drivers and barriers for scaling up Electromobility in Gothenburg City (s. section 6.2.2[7] on page 90).

5.4.1.4 Reflecting Phase of the Interviews

During the *reflecting phase* the main conclusions from the *analysing phase* were drawn and yet existing information gaps were identified. With each interview the amount of information to reflect upon increased gradually since acquired data and knowledge from previous meetings generally had to be taken into account. Of major importance during the *reflecting phase* was the appropriate preparation of the next interview according to the accumulated take-aways from previous meetings.

5.4.2 Adjustment of the Scope

The research for carrying out the second step of the backcasting methodology started with an investigation of the whole transportation system, including both the public and private transportation in the city of Gothenburg. Stakeholders from both public (bus, tram, etc.) and private transportation (car, bicycle, etc.) were mapped (s. section 6.2.1.2[8] on page 77) and a part of them was interviewed. Early on in that process the scope of this thesis was narrowed down solely to the challenges around the electrification of private transportation, more specifically, the car, and the required infrastructure in order to compile the MLP of the transport system (s. section 6.2.1 on page 64). The adjustment of the scope was applied for three reasons:

- Firstly, during the interviews, the majority of stakeholders pointed out that the electrification of public transport as it is more easily controllable from a 'top-down' approach and it has already started, is not as challenging as the

[6] A Multi-Level Perspective on the Transportation System in the City of Gothenburg
[7] Local Drivers and Barriers for Electromobility
[8] The Socio-technical Regime Level, paragraph 'Stakeholder Networks'

electrification of private transportation. According to them, more complex issues arise in private transportation, for instance, related to user behaviour and infrastructure involving a great range of stakeholders demanding a more integrative transformation.

- Secondly, our main stakeholder, the Urban Transport Administration (Trafikkontoret) of the City of Gothenburg, considers the investigation of challenges, drivers and opportunities to scale up the electrification of the car in the city as a need of high importance.
- Thirdly, a more practical reason was the realisation that investigating both public and private transportation is too broad given the combination of the time constraints and the research tools that are employed in the thesis. Also, since our ambition was to engage a focused group of stakeholders and carry out an open interactive workshop as part of the methodology tools applied here, focusing a small specialised group of participants was vital.

However, aspects from the public transport are included in the MLP analysis since there is an interrelatedness between the two types of transportation that cannot be disregarded, mainly in terms of common stakeholders and innovative niche projects (s. section 6.2.1.3[9] on page 87 and section 6.2.1.2, paragraph 'Stakeholder Networks' on page 77).

5.5 Backcasting Step 3 - Designing Solutions and Scenarios around Electromobility

Step 3 of the backcasting methodology is divided into four parts. The first part focuses on development of future solutions and concepts (s. section 5.5.1 on page 49) that can potentially solve the challenges identified in step 2 following the *design thinking* methodology as described in section 2.4 on page 18. The second part focuses on scenario development (s. section 5.5.2 on page 50) with a view to reducing uncertainties of the possible futures according to section 2.4.1 on page 22. Subsequently, the third part presents the methodology on why the chosen scenario is the most sustainable one (s. section 5.5.3 on page 51). The fourth part of backcasting step 3 consists of a quantitative evaluation method of potential future *concepts* designed in part 1 aiming to investigate their level of sustainability, their potential in overcoming the identified barriers and their robustness in the proposed scenario (s. section 5.5.4 on page 52).

The method for carrying out backcasting step 3 was inspired by Lundqvist et al. (2006) along with material taken from an academic summer-school given by Ulrika Lundqvist, that one of the authors of the report attended. However, the end result was adjusted to the needs and the scope to this thesis due to its participatory character but also to time constraints. Moreover, throughout step 3 we conducted highly

[9] The Technological Niche Level

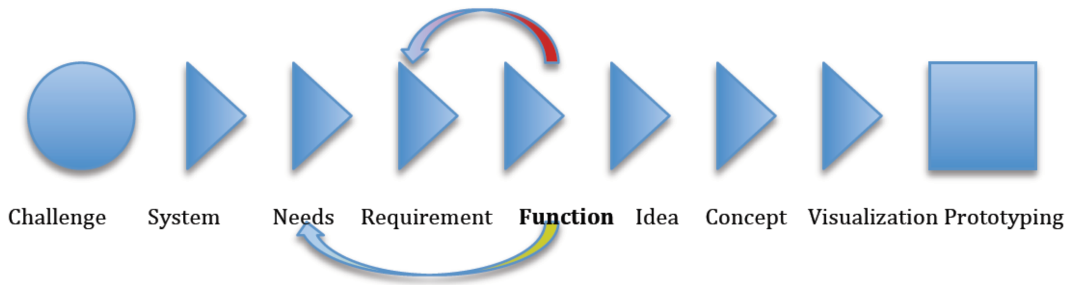

Figure 5.1: The iterative process behind designing solutions (Söderberg, 2014)

creative brainstorming sessions to fully understand the barriers and its potential future *solutions* as well as to construct the possible future scenarios.

5.5.1 Development of potential Future Solutions and Concepts

After having identified the drivers and barriers for achieving the vision for the transportation system in 2050 and meeting the sustainability criteria set on step 1 (s. section 6.1[10] on page 59), we initiated a series of brainstorming sessions to develop *ideas* and *concepts* to alleviate the barriers and bridge the existing gaps. The design of these ideas for potential future *solutions* and *concepts*, followed steps 3 to step 7 of the *design thinking* methodology by Söderberg (2014) as described in section 2.4 on page 18. Figure 5.1 depicts the logical sequence we used to get from the identified *challenges* to specific *solutions*. The process followed in this thesis, started from the identification of *functions* as they are rising up from the *needs* of the transportation system to reach a more sustainable state in which electromobility has the greatest share of the available technologies. In line with the theory articulated by Söderberg (2014), several analogies were made in relation to our topic and *needs*. More specifically, the *needs* represent the tension between the sustainability principles (*requirements*) and the vision set in backcasting step 1 as well as the barriers identified in backcasting step 2. Subsequently, *functions* were identified according to these *needs* and *ideas* were generated which were formulated into specific future *solutions* and *concepts* later on.

The *requirements* were identified as a combination of the sustainability principles and the desires and possibilities from the stakeholders' side. Hence, we carried out highly creative brainstorming sessions in a context where the *requirements* and stakeholders' desires represented the limitations for the designs of *ideas*. In more concrete terms, we listed abstract *functions* that could bridge the gaps or *needs* by asking the question 'why'. After having identified the major *needs* we continued by asking the question 'how' yielding more specific statements to generate unique future *solutions* and *concepts*. After successive intensive brainstorming, we connected the *functions* and *solutions* through several strings of logic, continuously asking the key

[10]Backcasting Step 1 - Envisioning a Sustainable Transportation System (Results)

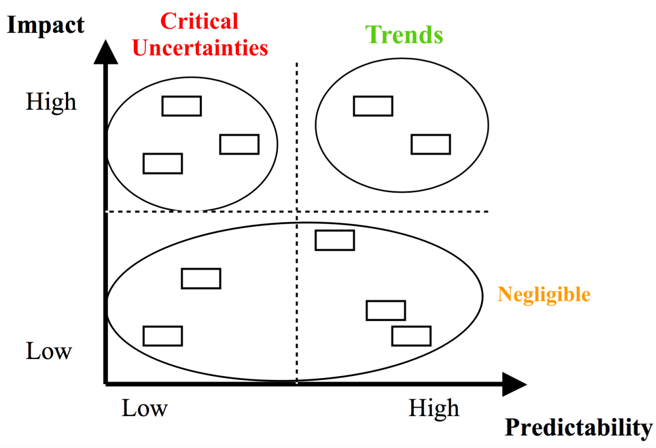

Figure 5.2: The small squares represent different external factors. Critical factors are the ones with high impact and only them are taken into consideration for the scenario development (Lundqvist et al., 2006).

questions 'why' and 'how'. This process allowed for the generation of specific future *concepts* was facilitated.

Following the MLP for the transportation system in the city of Gothenburg (s. section 2.3.2 on page 16), the *solutions* were focused mainly on the dimensions technology, knowledge, culture and policy of the socio-technical regime.

The final set of proposed *solutions* and *concepts* proposed had to fulfil the following three requirements:

1. Fulfilling the sustainability criteria.
2. Bridging the gaps between the present state and the envisioned future (overcoming the barriers).
3. Being robust (can exist) in the proposed desirable scenario.

The final set of potential future *solutions* and *concepts* including a brief analysis is presented in section 6.3.1 on page 98.

5.5.2 Development of Future Scenarios

The development of scenarios was carried out following the methodological steps as presented in theory section in 2.4.1 on page 22. More specifically:

1. **Identify external factors**: With the knowledge already acquired by the results of backcasting step 2 (s. section 6.2 on page 64) along with relevant specific insights from the discussions taking place during the interviews, we managed to compile a list of external factors that influence the transition from the current unsustainable transportation system of the city to a sustainable one based on electromobility. In order to identify the factors, we followed a structured investigation seeking for factors mainly at the socio-technical regime

as well as the landscape level as defined by Geels (2002) (s. section 2.3.2[11] on page 16).

2. **Sort external factors:** The second step was to sort the external factors based on their predictability and impact and place them on the diagram with the respective axes. This was a challenging process with high intuition as many assumptions had to be made, especially for abstract, not easily definable or measurable factors, such as environmental awareness or sustainable behaviour. Hence, this step was characterised by many iterations as well as intensive debates and argumentation between us before the final decision on the allocation of the factors in the respective axes (s. figure 5.2 on page 50).

3. **Classification of critical factors:** The third step sorted out the critical factors from the negligible ones that do not have considerably high impact on the transportation system.

4. **Selection of critical uncertainties:** Another iterative process was step 4 when selecting the two *'highly relevant but unrelated'* (Lundqvist et al., 2006) critical uncertainties for the construction of the scenarios in the next step. The biggest challenge was to identify the pair of critical uncertainties that would not overlap with each other in the sense that they are related or interdependent. Another criterion on the selection of the uncertainties was that the chosen uncertainties had to be relevant with the purpose and the characteristics of the thesis. This means that they should touch upon issues that are neither too technical nor too specific, rather refer to *macro-level* challenges and are equally probable. The overall process until the final selection took longer than expected to learn, but the guidance from our supervisors was very valuable for the final result.

5. **Design of four possible future scenarios:** After the pair of uncertainties was selected their extreme values were defined generating four quadrants that represented the four possible scenarios.

6. **Name and describe the generated scenarios:** The four possible future scenarios were labelled with a short phrase and described briefly.

The intermediary results including the external factors and their classification, the determined critical uncertainties and the finally developed scenarios are presented in section 6.3.2 on page 101.

5.5.3 Identification of a desirable and sustainable Scenario

In this part the most sustainable possible future out of the four scenarios was selected. This was done through projecting the sustainability criteria developed in step 1 of the backcasting methodology in one of the scenarios. We decided to choose one scenario as the most sustainable one for two reasons. Firstly and most importantly, since our thesis was designed to allow for external participation and interaction with

[11] Systems Analysis: A Multi-Level Perspective

our stakeholders (s. section 5.6.1[12] on page 54) our intention was to make an impact during the imminent dialogue by qualifying a chosen scenario. This choice of ours was made because the focus of co-creating a strategy was higher than documenting a highly subjective and controversial discussion on the scenario selection that could be proven as unproductive. Secondly, time constraints would prevent us from analysing all four scenarios and thus completing all fours steps of the backcasting methodology.

The proposed desirable and sustainable future scenario ‘A Green New Deal’ is presented and described in section 6.3.3 on page 109.

5.5.4 Evaluation of Potential Future Concepts

Legend			
Rating	*Sustainability Score (SS)*	*Electromobility Score (ES)*	*Robustness Score (RS)*
2	Highly positive impact	Strongly decreases barrier	Very high robustness
1	Positive impact	Slightly decreases barrier	High robustness
0	No impact	No impact on the barrier	-
-1	Negative impact	Slightly decreases barrier	Low robustness
-2	Highly negative impact	Strongly increases barrier	Very low robustness

Table 5.1: Legend for the evaluation of potential future concepts.

Evaluation of Potential Future Concepts				
	Concept Score (CS)	*Concept 1*	*Concept 2*	*Concept 3*
Sustainability Criteria				
Principle 1	**1**	-2	2	1
Principle 2	**2**	1	2	-1
Principle 3	**0**	-1	0	1
Sustainability Score (SS)		**-2**	**4**	**1**
Main Barriers				
Barrier 1	**1**	2	0	-1
Barrier 2	**2**	-1	1	2
Barrier 3	**0**	2	0	-2
Electromobility Score (ES)		**3**	**1**	**-1**
Robustness for the proposed Scenario				
Dimension 1	**3**	2	-1	2
Dimension 2	**2**	-1	2	1
Robustness Score (RS)		**1**	**1**	**3**
Final Score		**2**	**6**	**3**

Table 5.2: Example for the evaluation of potential future concepts

[12] Stakeholder Dialogue

As mentioned in section 5.5.1[13] on page 49 our four requirements for the final future *concepts* were ① to fulfil the sustainability criteria, ② to overcome the identified barriers and ③ to be robust in the proposed scenario. For the qualification of the most desirable and sustainable future *concepts*, we **quantitatively** evaluated all the generated *concepts* based on these three requirements. A possible fourth requirement on the stakeholders' desirability of the concepts could have been included if more time for the evaluation was available. Due to these time constraints this requirement was not included in the final evaluation in this thesis, however we consider it of high relevance and importance when one is conducting a participatory backcasting method where the stakeholders participate in all the steps of the process.

The evaluation was made through the experience and knowledge gathered during the thesis project (literature research, interviews, dialogue, and general understanding). The final score results are highly subjective and mostly 1st order impacts. For the quantification of the evaluation a scale between -2 and 2, including zero (0), was invented as it is shown in table 5.1 on page 52. However, for the robustness the rating zero (0) was excluded as a concept could either exist (positive values) or not exist (negative values) in a scenario.

An example for the evaluation of potential future concepts is given in table 5.2. Three separate scores for each concept were generated, the Sustainability Score (SS) (What impact does the concept have on the sustainability principles?), the Electromobility Score (ES) (Does the concept increase or decrease the barrier?) and the Robustness Score (RS) (How well can the concept exist in the proposed scenario?). The Final Score for each concept was generated by summing all three scores. Also a so-called Concept Score (CS) was generated summing up all values horizontally representing how well the chosen concepts ① meet the sustainability criteria, ② overcome the barriers and ③ can exist in the dimensions of the chosen scenario.

To explain the example given in table 5.2, *concept* 2 is the most sustainable by having highly positive impact on both principle 1 and 2, *concept* 1 has the highest potential in scaling up electromobility by strongly decreasing barrier 1 and 3, and *concept* 3 has the highest robustness for the proposed scenario as it can exist in both dimensions. However, *concept* 2 has the highest Final Score which may be seen as an indicator for concepts that have the highest potential in both enhancing the sustainability of electrified transportation and contribute to scaling up electromobility by being in line with the proposed scenario. The Final Score has to be interpreted with care, since a concept may have a very high SS, but only a weak ES and a negative RS and still have a high Final Score, especially since the RS has very low influence on the Final Score. Concerning the CS, in this case, both principle 3 and barrier 3 (those with the lowest CS) have to be considered as 'critical' as the compilation of proposed *concepts* is not necessarily aiming at improving principle 3 or overcoming barrier 3.

For this methodology of evaluating potential future *concepts* to be adopted in a participatory multi-stakeholder environment we suggest an adjustment of the most

[13]Development of potential Future Solutions and Concepts

desirable *concepts* (those with a high Final Score) in order to improve the critical sustainability criteria and overcome the critical barriers. However, this iterative step was not conducted in the present thesis.

At this point, it should be noted that the generated assessment of the ideas represents a simplistic evaluation of concepts without going in depth into the reasoning behind each score. For instance, value zero (0) was given if either a direct impact could not be identified or the impact was hard to predict. Also the rating is highly influenced by our understanding of the current system and dynamics expected in the short-term rather than the long-term. The presented evaluating process is a simple representation of steps one should follow in order to complete the proposed methodology on conducting step 3 of the backcasting methodology. In a fully participatory backcasting process this evaluating step should involve all the stakeholders related to the project.

The final results of the quantitative evaluation can be found in Appendix B on page V and the analysis of the most desirable future *concepts* (high SS, ES and RS) as well as critical sustainability criteria and barriers (low CS) is given in section 6.3.4 on page 111.

5.6 Backcasting Step 4 - Finding Strategies to scale up Electromobility

This section describes the methodology followed in order to find actual strategies to scale up electromobility in the city of Gothenburg as the final step of the backcasting process. This step was initialised with a stakeholder dialogue (s. section 5.6.1) in which a large share of the interviewed representatives of the public, private and academic sector were brought together to discuss about possible next steps to take in order to scale up electromobility in the city of Gothenburg. The input acquired through this dialogue served as a basis for the design of a roadmap towards our proposed future scenario (s. section 5.6.2 on page 58) representing the final result of this thesis.

The outcome and analysis of the dialogue is presented in section 6.4.1 on page 122 and the final roadmap towards 'A Green New Deal' in section 6.4.2 on page 124.

5.6.1 Stakeholder Dialogue

This section describes the approach followed for the organisation, preparation, execution and, finally, analysis and reflection of the stakeholder dialogue which represents the most important element for the participatory character of this thesis.

5.6.1.1 Organisation of the Dialogue

The organisation of the stakeholder dialogue included the execution of the *semi-structured* interviews as described in section 5.4.1 on page 45, an ongoing communication with the stakeholders via telephone or mail, the determination of a common date and accordingly the synchronisation of all the stakeholders.

The interviews in step 2 of the backcasting process were not only conducted to improve our understanding of the current transportation system in the city of Gothenburg and to identify the current regional drivers and barriers for scaling up electromobility. As a matter of fact, during the interviews, the stakeholders were already informed about the approximate date of the stakeholder dialogue, its purpose as well as anticipated outcome.

To ensure the highest possible participation early action was taken by requesting the availability of our 'problem owners' from Trafikkontoret, the local Urban Transport Administration of the City of Gothenburg. Their response formed three possible dates for the dialogue to take place which were presented to the rest of the stakeholders. From here on track was kept of each stakeholder's availability to identify the most appropriate date as soon as possible. Finally, six weeks before the dialogue the 4^{th} of May was confirmed by majority and communicated immediately to each participant accordingly. Shortly after the official invitation, including time and location, the list of attendees and the schedule was distributed. Furthermore, a lunch for after the dialogue session was organised to allow for further exchange of ideas and knowledge amongst the stakeholders and us.

5.6.1.2 Preparation of the Dialogue

In preparation for the day of the dialogue both a presentation and a script with guidelines for the facilitation and possible questions was set up.

The presentation contained the whole backcasting process starting with our vision for the transportation system of 2050 and the sustainability criteria on electromobility (step 1), followed by the main identified barriers to scale up electromobility (step 2), the proposed most desirable and sustainable future scenario including the other possible scenarios (step 3) and a first draft of the strategy path or roadmap from 2016 until 2050 including officially announced milestones (step 4). Hereby steps 1 to 3 were considered as input for the discussion whereas step 4 was meant to be partly shaped by the stakeholders during a small workshop (a detailed description of the workshop follows in section 5.6.1.3).

Concerning the preparation of the script (s. Appendix D.1 on page XIX) the already existing schedule was filled with content in terms of detailed guidelines for the facilitation and pre-formulated questions that may be posed to start or reignite the discussion, if needed.

Some final adjustments for the facilitation of the dialogue were made after consulting Martin Sande, founder and facilitator at 'Dialogues' (Sande, 2016). Herewith, we received very valuable feedback on our planned approach and some creative suggestions for the facilitation, such as providing a 'Kinder-Egg' to all the stakeholders symbolising the applied backcasting methodology which also aims at unveiling yet unknown future solutions represented by the 'surprise' inside the wrapping of the egg.

Lastly, some final tasks amongst us and some fellow students were distributed, such as welcoming the stakeholders, introducing our project and taking notes or photos.

5.6.1.3 Execution of the Dialogue

In this section only a few key-aspects of the execution of the dialogue will be described. A detailed script of the dialogue is provided in Appendix D.1 on page XIX.

Before the official start of the dialogue the stakeholders were received in front of Johanneberg Science Park (Johanneberg Science Park (JSP)) in Gothenburg where the C-Lab is located to guide them to the correct floor and make them feel welcome. During the dialogue a version of the closed *fishbowl* set up, as described in section 2.2.2.3[14] on page 13, was applied to allow for the passive participation of observers who would only listen to the discussion or take notes.

The dialogue was divided into two sessions, whereof the first session was addressing *'A desirable Scenario for the Future of Electromobility'* (step 3) and the second one *'Next Steps towards Electromobility'* (step 4). To initiate the dialogue a 'Check-in' was performed by asking the stakeholders two questions: *'Who are you?'* and *'Why did you choose to come here?'*. The purpose behind this 'Check-in' was to, firstly, allow the stakeholders to introduce themselves to the other participants and, secondly, to get an impression on their motivation to join the dialogue and their expectations. Thereafter a short presentation of our previous work was given, including step 1 to 3 of the backcasting methodology, whereof the introduction of our future scenarios as part of step 3 was meant to be the basis for the first session of the discussion. A detailed description of our future scenarios, namely *'Scenario A - Technological and Institutional Eden', 'Scenario B - A Green New Deal', 'Scenario C - Green it ourselves'* and *'Scenario D - Green marketing'* is given in section 6.3.2[15] on page 101. At this stage of the dialogue, questions, such as *'Where do we place ourselves right now, as a system?'* or *'Where do you see yourselves, as individuals or organisations, in the future?'*, were discussed. During the first session the discussion was slightly shifted with the proposal of *'Scenario B - A Green New Deal'* as the most desirable and sustainable future scenario for 2050. The sustainability criteria presented in step 1 were placed inside scenario B, *'A Green New Deal'*, to 'prove' visually that scenario B fulfils our criteria and therefore is the most sustainable. At that stage of the dialogue, questions, such as *'Could you see yourself in that scenario?'*, *'What do we, as a system, need to push towards that direction?'* or *'How could these criteria be realised in such a scenario?'*, were discussed.

[14] Tools for Stakeholder Engagement
[15] Future Scenarios

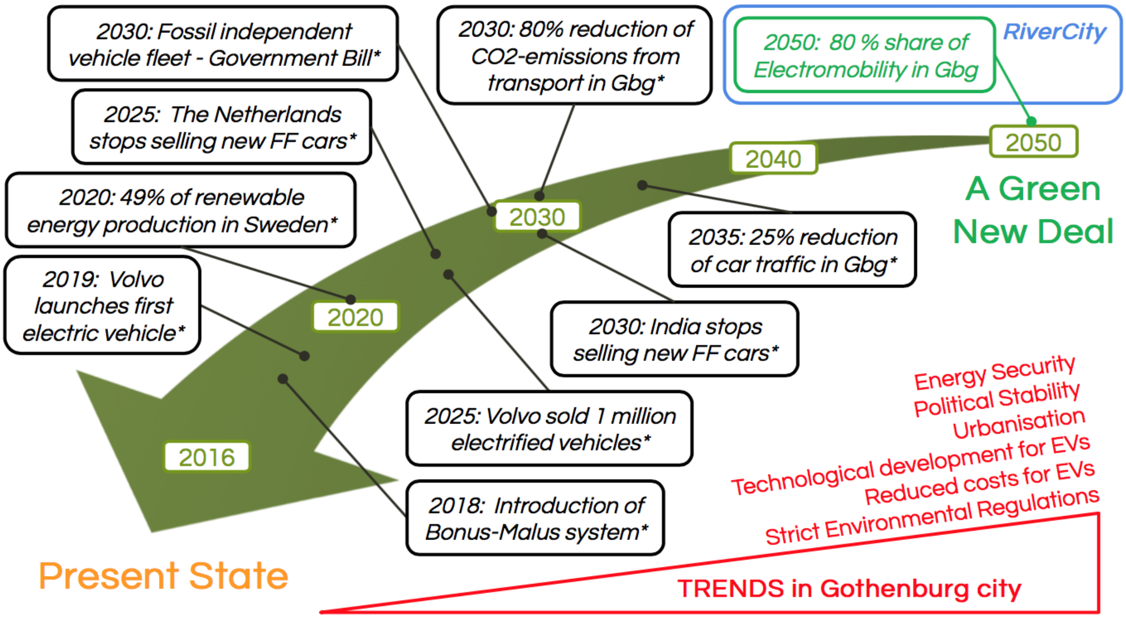

Figure 5.3: A compilation of officially announced milestones between the present state (2016) and and 'A Green New Deal' (2050) as the basis for the workshop.

After a coffee break the second session was initiated with a small workshop as the interactive part of the dialogue addressing *'Next Steps towards Electromobility'* representing step 4 of the backcasting methodology. During this workshop the stakeholders were asked to place three post-its (green, blue and orange) on a previously prepared backcasting arrow drawn on a white-board representing the future until 2050 (s. figure 5.3). The green post-it represented ① a desirable future solution that can contribute in achieving the vision in the future of 'A Green New Deal'. The blue post-it ② represented the stakeholders' contribution to realise their desired future solution and the orange post-it ③ the synergies needed amongst each other to realise their contribution. The stakeholders were motivated to think outside the box meaning to disregard the boundaries of today's system and place their contributions later than 2020 on the backcasting arrow and thereby to attempt going beyond the scope of current projects and challenge themselves with high uncertainty.

After this highly creative workshop session, the discussion was reignited by giving the stakeholders the chance to elaborate on their ideas and talk about possible next steps in the short-term future to ultimately realise their desired future solutions inside 'A Green New Deal'. At this stage of the dialogue questions, such as *'How can we take advantage of today's dialogue and possibly open up for further actions or meetings?'* or *'How can we ensure that the public, private and academic sector are working together on the very same goal?'*, were discussed.

The dialogue was concluded with a 'Check-out' by asking the participants in the inner circle of the fish bowl including us the facilitators, two last questions: *'What is your main take-away from today?'* and *'How do you feel?'*. The purpose behind this 'Check-out' was to, firstly, officially close the dialogue and, secondly, to allow the stakeholders to personally reflect upon the whole meeting.

5.6.1.4 Analysis and Reflection of the Dialogue

After the dialogue, the notes taken during the discussion as well as the stakeholders' post-its placed during the workshop session were gathered and analysed. Since the input from the stakeholders in terms of desired future solutions, contributions and synergies formed an essential part for the final step 4 of the backcasting process represented by roadmap towards 'A Green New Deal' (s. section 5.6.2) this data was chronologically sorted in a table to facilitate further analyses and reflections.

5.6.2 Design of a Roadmap

The final step of the backcasting methodology was to generate the roadmap of actions to take towards our defined vision and the future scenario 'A Green New Deal'. For that as input the *solutions* and *concepts* along with their evaluation in step 3 were considered, the insights we acquired during our interaction with the stakeholders through the interviews and the workshop as well as our intuition. While building the roadmap we came across the difficulties that policy makers encounter on the highly uncertain task of 'strategising' the way towards the future. Firstly, we placed the Urban Transport Administration (Trafikkontoret) as the focal stakeholder of our strategy path and then we divided the steps into three fields: *Technology*, *policy* and *society*. The interplay among these fields was crucial for developing the strategy. Subsequently,we identified steps and actions that must take place to accommodate for the future *concepts* to be implemented. Next step was to decide the chronological sequence for the steps to happen starting from the long term ones and going back in time. For that the strategy was divided into a short and a long term timeline. For each action and *concept* that is proposed, either a technological or a policy one, there is a direct or indirect effect on society. Therefore the outcome would be a depiction of the compilation of technology and policy steps along with their effect on the society. During the whole process of designing the roadmap in step 4, we were in close collaboration with the Urban Transportation Administration as the report would be an input for their future plans on formulating a concrete strategy for scaling up Electromobility in the city of Gothenburg.

6

Results & Analysis Phase II

In this chapter the results gathered throughout the Backcasting process in order to answer our research question on 'How to develop a strategy for scaling up electromobility in the city of Gothenburg?' are presented. An analysis of the final results is generally included in order to illustrate their close interrelation and maintain a better overview. In the following sections the results specific to each of the backcasting steps are presented[1].

6.1 Backcasting Step 1 - Envisioning a Sustainable Transportation System

In this section the results of backcasting step 1, following the methodology described in section 5.3 on page 44, are presented and analysed. Firstly, our vision of the transportation system of 2050 and the thinking process behind it is described (s. section 6.1.1), followed by the introduction of our sustainability criteria including a brief elaboration of each principle (s. section 6.1.2 on page 61)

6.1.1 A Vision for the Transportation System of 2050

'We envision an ecologically, economically and socially sustainable multi-modal transportation system of people in the city of Gothenburg for 2050 with zero emissions and an 80 % share of electromobility.'

Our vision for the transportation system of 2050 entails a shift towards a perfectly sustainable state of transportation meaning that all four dimensions of sustainability have to be taken into consideration and fulfilled. At the same time, as mentioned in section 4.1.4[2] on page 41 we promote electromobility as the solution that will bring the system closer to a sustainable state. We consider that an electrification of the transportation system highly contributes to decarbonisation of the transportation system as long as the electricity provided comes from renewable energy sources

[1]s. section 6.1 'Backcasting Step 1 - Envisioning a sustainable Transportation System' on page 59, section 6.2 'Backcasting Step 2 - Describing the current Transportation System in city of Gothenburg' on page 64, section 6.3 'Designing Solutions and Scenarios around Electromobility' on page 98 and section 6.4 'Finding Strategies to scale up Electromobility' on page 122

[2]Step 4 - Find Strategies for Sustainability (Phase I)

(Grauers et al., 2014) and offers a sustainable solution for urban mobility. It is important to note that, amongst others, the following three assumptions were made to clarify the context of the vision:

- The system boundaries are drawn on the local urban level and the focus is put solely on the transportation of people, not on the transportation of freight or goods.
- The electrified transportation system is supplied by electricity from 100% renewable energy sources.
- The implementation of electromobility by itself will not lead to sustainable transportation in a holistic way. Further multi-lateral change is required in order to solve this complex issue.

Analysis of the vision

In order to facilitate the interpretation of the vision the definitions of the two focal concepts, sustainable transportation and electromobility, have to be considered. As mentioned in section 2.1[3] Grauers et al. (2014) defines electromobility as *'[...] a road transport system based on vehicles that are propelled by electricity.'* As for sustainable transportation there is no commonly accepted definition in current bibliography. However, the definition from The Centre for Sustainable Transportation (2002) is preferred due to its simplicity and comprehensiveness. Hence, sustainable transportation is defined as a system that:

1. *'allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;*
2. *is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development;*
3. *limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes while minimising the impact on the use of land and the generation of noise.'*

The term ***'multi-modal'*** concerns a variety of modes used in combination so that the respective advantages of each mode are better exploited (Rodrigue et al., 2013; The Centre for Sustainable Transportation, 2002). In our vision it is also specified that we focus on a ***'transportation system of people'*** and not of goods or freight. Furthermore, in the vision, it is specified that the geographical boundaries are strictly set on the urban level of the city of Gothenburg . What is more, the use of a long term perspective of **2050** is used in order to challenge current short-term existing visions and strategies especially from the City of Gothenburg (s. City of Gothenburg, 2014a; City of Gothenburg, 2014b) but also because for such a systemic transition to happen a vision should be as farsighted as possible. Furthermore, the quality of ***'zero emissions'*** is specifically mentioned in the vision to highlight

[3] What is Electromobility? (Theory)

the importance of sourcing electromobility exclusively from renewable energies with neither GHG nor considerable noise emissions. Finally, an ***'80% share of electromobility'*** is provided for three reasons: ① To demonstrate the importance of electricity to have the greatest share in the transportation system amongst other secondary energy sources and secondly, ② because a quantified vision can guide any possible user to more concrete goals that are easier to visualise, and ③ 80% is preferred over utterly ambitious 100% since we want the system to allow for new innovative clean technologies that possibly break through until 2050 as well as for the technologies that can be applied in the system where electromobility technologies are not accessible. In any case, the goal of 80% share of electromobility is aligned with the national objectives (International Energy Agency, 2013) and can deliver sustainable levels of emissions and reduced environmental pressure.

6.1.2 Sustainability Criteria on Electromobility

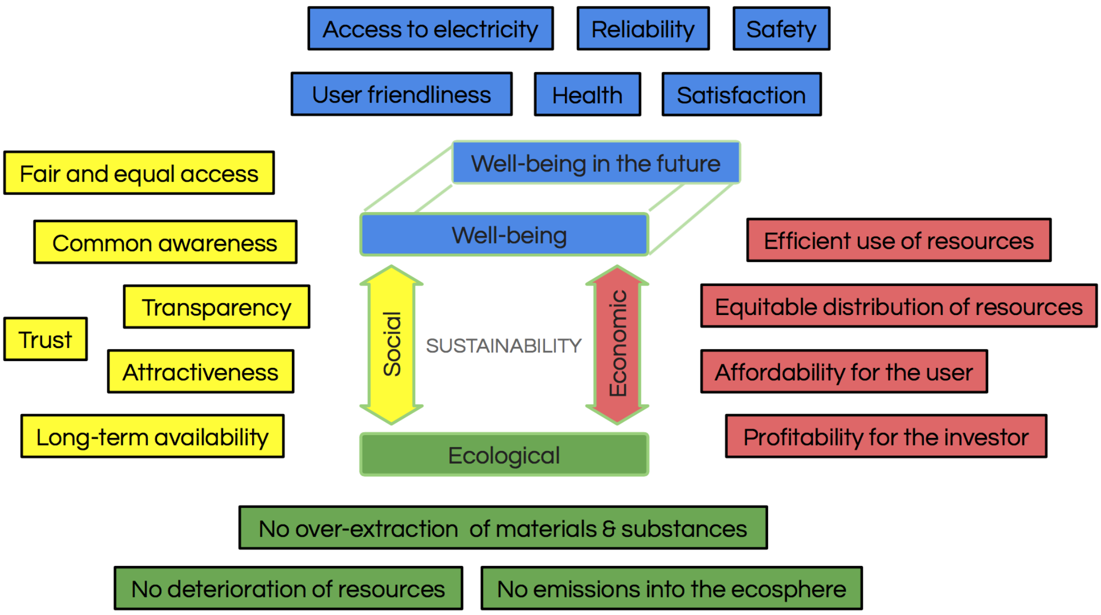

Figure 6.1: Sustainability Criteria on Electromobility.

By studying the definition of sustainable transport from (The Centre for Sustainable Transportation, 2002) presented above (s. paragraph 'Analysis of the Vision') we managed to derive sustainability criteria that fall under the aspects described in section 5.3.2[4] on page 44. An illustration of the sustainability criteria according to the four sustainability dimensions is given in figure 6.1.

[4]Formulation of Sustainability Criteria on Electromobility

Ecological criteria

The ecological criteria were adapted from the results of Phase I in section 4.1.1 on page 35 and by analysing the third item on the definition of sustainable transport from The Centre for Sustainable Transportation (2002).

No emissions into the ecosphere: No GHG emissions and minimised noise emissions to the safest possible level (as completely silent vehicles may pose a threat to pedestrians).

No over-extraction of materials and substances: The extraction of materials and substances should be kept within the planet's ability to provide for the following generations.

No deterioration of resources (air, water, land, materials): The quality of the resources should be kept intact and no mismanagement or over-exploitation should take place.

Economiccriteria

Efficient use of resources: As proposed also by the definition by The Centre for Sustainable Transportation (2002) a sustainable transport system should operate efficiently in terms of materials, financial resources and infrastructure avoiding wasteful investments and redundant operation.

Equitable distribution of resources: The resources should be equitably distributed among users, operators and investors; always adjusted to benefit the least-advantaged members of society.

Affordability for the user (of E-mobility solutions): In order for electromobility to diffuse, the conditions of acquiring e-mobility services, products and infrastructure have to be favourable for the user to be able to make use and 'enjoy' them.

Profitability for the investor (into E-mobility solutions): In order for electromobility to diffuse, investments into corresponding solutions and business models must have minimal risk for the investors to choose making the endeavour.

Societal criteria

Common awareness: Society must be equally aware of electromobility as a concept with its technological features, advantages and disadvantages. Sustainability awareness should also be shared among the users.

Attractiveness: Electromobility solutions and services including the required infrastructure have to be inviting and attractive for the users to choose them over other alternatives.

Long-term availability: It has to be ensured that technologies, designs and solutions will be available in the long-run without any limitations (set for example by nature in the form of resource limitations) for the users.

Fair and equal accessibility: There is no discrimination or exclusion of individuals from accessing electromobility operations and infrastructure.

Trust: As long as values of trust among users, investors and policy-makers exist in electromobility related operations, the development can be facilitated.

Transparency: The possibility for users to access data and review background processes behind electromobility solutions and services can highly improve mutual trust and the overall learning experience.

Well-being criteria

Health: Health must at no cost be risked when individuals experience and interact with electromobility.

Access to electricity: Every individual should have access to electricity in order to enjoy electromobility solutions.

User friendliness: Electromobility solutions and services should be easy to use and understand for any individual.

Satisfaction: Individuals should be highly satisfied with electromobility and its features and by the fact that they contribute to lower environmental impact.

Safety: Electromobility should not pose any peril for the individual.

Reliability: Electromobility solutions should be technically reliable meaning to deliver the service promised by the provider without any malfunctions and failures.

6.2 Backcasting Step 2 - Describing the current Transportation System in the City of Gothenburg

In this section the current transportation system of people in the city of Gothenburg is described and analysed. The basis for this analysis is the Multi-Level Perspective (MLP) as described in section 2.3.2[5] on page 16. The results on the MLP analysis are presented in section 6.2.1, followed by a summary of local drivers and barriers for electromobility (s. section 6.2.2 on page 90). Finally, as a result of the adjustment of the scope (s. section 5.4.2 on page 47), the final focus group of stakeholders is presented in section 6.2.3 on page 96.

6.2.1 A Multi-Level Perspective on the Transportation System in the City of Gothenburg

An analysis of the MLP is applied for the current transportation system in the city of Gothenburg. The intention of this analysis is to provide a systemic overview of the transportation system. The analysis presents ① the current landscape level (*macro-level*), which includes current conditions on the national level in Sweden but also on the global level (s. section 6.2.1.1) and its influence on the transportation system of people in the city of Gothenburg, ② the seven dimensions (sectoral policy & legislation, markets & user practises, stakeholder networks, knowledge, technology, infrastructure and culture & norms) of the current socio-technical regime (*meso-level*) of the local transportation system in city of Gothenburg (s. section 6.2.1.2 on page 71) and ③ current local developments related to electromobility and sustainable transportation on the technological niche level (*micro-level*) (s. section 6.2.1.3 on page 87).

6.2.1.1 The Landscape Level

Carbon and Nuclear Energy Tax

In the early 1990s Sweden introduced taxes on oil and natural gas to charge for carbon, sulphur dioxide and industrial nitrogen oxide emissions. These reforms were part of a broader tax-shifting operation that also strengthened the value-added taxes while reducing taxes on labour and traditional energy taxes (on motor fuels and other oil products). More specifically, the annual vehicle tax consists of a basic rate of 360 SEK plus 20 SEK for each gram of CO_2 emitted above 117 g/km. This sum is multiplied by 2.33 for diesel cars. Owners of diesel cars registered for the first time in 2008 or later have to pay an additional 250 SEK and for those registered earlier an additional 500 SEK. For alternative fuel vehicles, the tax is 10 SEK for every gram emitted above 117 g/km.

[5]Systems Analysis: A Multi-Level Perspective (Theory)

Also an increased nuclear energy tax, to accommodate for shifting the investment towards renewable energies, is implemented (Official Site of Sweden, 2016).

The Fossil Independent Sweden Initiative and the Super Green Car Premium

Sweden's emissions from transport sector make up 25% of all national emissions (Eberle et al., 2014). Despite government's policy measures aiming to reduce these emissions, the sector's contribution is such that additional effort is likely to be required. For that the Ministry of the Environment and Energy developed an initiative in which it is implicitly articulated that there must be more electrification in the transport sector. More specifically, in 2009 the Swedish Government presented the Government Bills, an integrated climate and energy policy, prop.2008/09:162 and 163 (Government proposition 2008/09:163, 2009). The bills include the goal of a fossil-fuel independent transport sector by 2030: *'The target is for Sweden to have a vehicle fleet that is independent of fossil fuels in 2030'* (International Energy Agency, 2013). The government considers the access to renewable energy (bio-fuels here are considered renewable) as a crucial factor for achieving a fossil-free transport sector. Furthermore, in this initiative, among others, energy labelling for light cars in collaboration with the Swedish Consumer Agency is mentioned, car benefit taxation, such as a five year exemption from annual circulation tax, and a premium system for purchasing new clean cars (the so-called 'Super car rebate').

The formula for petrol- and diesel Internal Combustion Engine Vehicles (ICEV) as well as Hybrid Electric Vehicles (HEV) and Plug-in Hybrid Electric Vehicles (PHEV) is as follows:

$$CO_{2,max} = 95 + 0.0457 \cdot (m - 1372) \tag{6.1}$$

$CO_{2,max}$: Maximum CO_2-emissions allowed in g_{CO_2}/km
m: Curb weight of the car in kg

Moreover, for both EVs and PHEVs the electrical energy consumption per 100 km must not exceed 37 kWh to be regarded as a green car. Namely, the 'Super green car premium' is available for the purchase of new cars with CO_2-emissions of maximum 50 g/km. The premium is applied both for the purchase by private customers and companies with 4.500 EUR for private owners and 35 percent of the cost for such a car for companies (such as car pools). A prolongation of the validity of the present 40% reduction of the fringe tax value (max. 1.800 EUR) for leased company cars is discussed (Sandén, 2014). The premium was introduced in 2011 and will continued to be paid in 2016 as long as the funds are sufficient.

Bonus-Malus System for New Light Vehicles

The Government is currently (April, 2016) discussing a 'referral' which proposes the introduction of a new 'Bonus-Malus' system by the year 2018 for passenger cars, light trucks and light buses that are registered in the vehicle registry on January

1, 2018 or later (Government referral SOU 2016:33 (2016)). ‘Bonus-Malus’ means ‘good and bad’ in Latin. The system will reward environmentally friendly vehicles with low CO_2 emissions at the time of purchase through a bonus while vehicles with high emissions of CO_2 are charged with higher taxes. Hence the taxes collected will provide the funds for the subsidies (bonuses) for the low emitting vehicles. The five-year exemption from a vehicle tax is recommended to be abolished as soon as the new system is introduced as it is thought to substitute the ‘Super green car premium’ (s. also paragraph 6.2.1.1 ‘The Fossil Free Sweden Initiative and Super green car premium’ above). It is important to note that this is a policy framework ‘on-the-making’ proposed by the Swedish government in April, 2016 and not an implemented policy yet (Government referral SOU 2016:33, 2016).

EU 2020 Goals & ‘Super Credits’

Directives from the EU 2020 strategy push for environmental reform throughout the European Union (European Commission, 2016): There are strict regulations regarding the pollution standards for transportation. The EC regulation 443/2009 (European Parliament, 2009) emission performance standards for light vehicles, imposes reductions in average emission levels for vehicle manufacturers, setting objectives of 95 g_{CO_2}/km for 2020. The European strategy promotes the use of environmentally friendly vehicles which is supposed to establish the development of EVs that are at least as safe as conventional ones, a European standard for charging points, a public charging network, a smart grid and research programmes for the safe recycling of batteries, as priorities. However, Sweden is well beyond compliance with these requirements (International Energy Agency, 2013).

Furthermore, EU gives manufacturers additional incentives to produce vehicles with low emissions (below 50 g_{CO_2}/km). These are the so-called ‘Super Credits’. More specifically, for each low-emitting car sold in 2016 the vehicle manufacturers are allowed to sell one high-emitting conventional car without affecting the overall CO_2 target for their fleet. From 2020 to 2023 each low-emitting vehicle will be counted as:

- 2 high-emitting vehicles in 2020
- 1.67 in 2021
- 1.33 in 2022
- 1 in 2023 and later

For the second phase (2020-2030) there will be a cap on the scheme’s contributions to the target of 7.5 g_{CO_2}/km per manufacturer over the three years.

Urbanisation and Demographic Change

In Sweden the population of the urban environment will increase significantly in the coming years according to UN projections, as illustrated in figure 6.2 on page 67, which will have an immediate impact on the population in the city of Gothenburg.

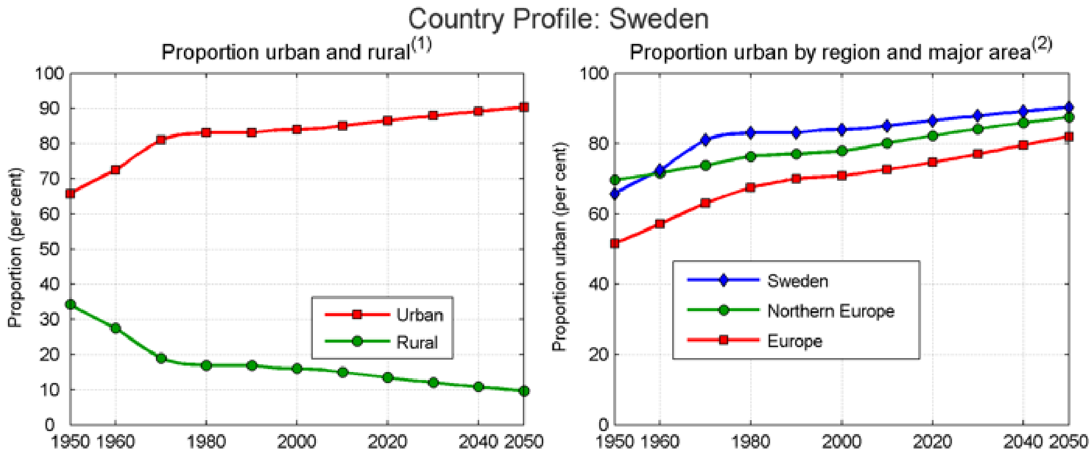

Figure 6.2: (1) Proportions of urban and rural population in Sweden in per cent of the total population, 1950 to 2050. (2) Proportions of the urban population in Sweden as compared to Northern Europe and Europe. The proportion is expressed in per cent of the population between 1950 and 2050 (Population Division, 2014).

In the meantime, there has been a record-high population growth in the past two years according to the city Annual Report because of record-breaking immigration figures for 2014 (City of Gothenburg, 2014b). As the year 2015 was marked with the so-called 'Refugee Crisis', the urban population in the metropolitan area of Gothenburg is subject to increase even more. Meanwhile, the projections from the United Nations for the global population increase, propose that in 2025 the world population will mount to slightly more than 8 billion while for 2050 all three projections suggest a figure between 9 and 10 billion people on the planet earth (UN Department of Economic and Social Affairs, 2015).

Global Contemporary Challenges

The world's biggest sustainability challenges affect the transition to a more sustainable transportation on the *macro-level* but also their indirect impact can be recognised on the regional level.

Financial and economic global crisis: The financial crisis started in the West in 2008 as a result of a collapse in the investment banking sector and it still goes on. Throughout the years we have witnessed a conflict between sustainability policies and regulations and the financial crisis and its policies (Clapp et al., 2009). More specifically, according to Geels (2013), sustainability transitions, such the one in the transportation system, seem to be slowing down because of the crisis. The effects of the crisis are negative on financial investments, governance and public attention and support (Geels, 2013).

Climate change and other environmental challenges: Climate change, biodiversity loss, ocean acidification, chemical pollution, fresh water and land use problems will be transgressing the planetary boundaries in the long-term (Rockström, 2009). All these planetary problems that we face or will be fac-

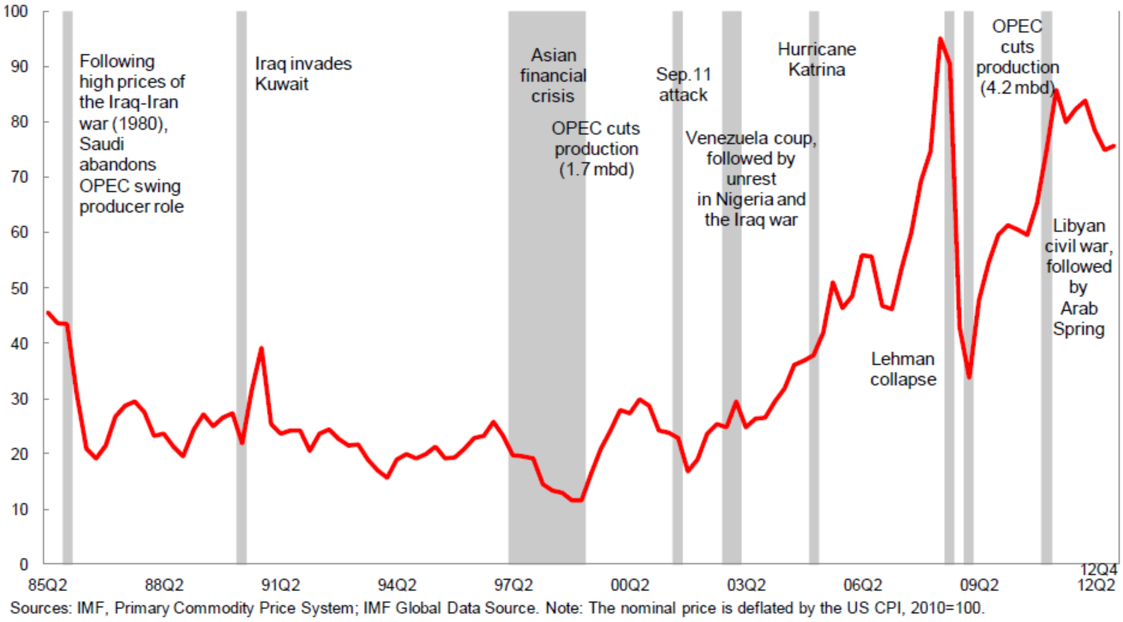

Figure 6.3: Evolution of the real oil price and political events (Beidas-Strom and Pescatori, 2014).

ing more acutely in the future come also with implications on the other sustainability dimensions often changing the institutional and societal landscape depending on the context. For instance, on the macro-level, given the 'encouraging' results from the U.N. Climate Change Conference in Paris in 2015, it can be concluded that nations seem more committed to take action and formulate stricter environmental regulations (Center for Climate and Energy Solutions, 2015; United Nations Framework Convention on Climate Change, 2015).

Geopolitics and Energy and Resource Security

Nowadays geopolitics play a significant role in energy and resource security as well as energy prices.

Geopolitics and oil dependency: In today's world the role of oil for society and the economy is massive. Since the development of air and road transportation, but also after World War II and especially after the oil crisis during the 1970's, the transfer of wealth from the consuming countries to the producing ones has created such dynamics that make oil a resource of a highly strategic character. The fossil fuel dependency of today's society is undeniable, hence the ownership over resources will continue to be an issue until we manage to decouple economic growth from fossil fuels and resources extraction and achieve low-carbon energy autonomy (UN: International Resource Panel, 2011). Furthermore, the unstable price volatility of oil is affected primarily by this complex interplay of geopolitics, economics and technological changes in a global context (Olayele, 2014). However, at the same time it affects inflation,

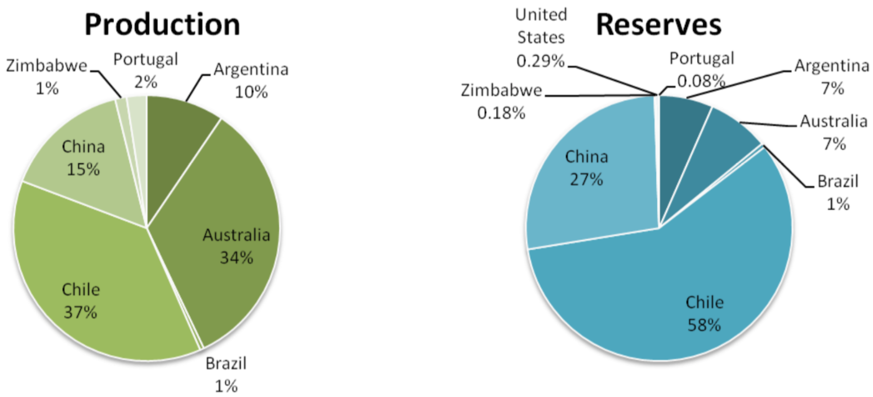

Figure 6.4: Distribution of production and reserves of rare earth oxides by country in 2011 (Speirs et al., 2013).

purchasing power and the industry's production costs in a national context (Olayele, 2014). The oil price volatility in relation to Political Events is shown in figure 6.3 on page 68.

Resource security: The resource and material intensity for a low-carbon future economy remains a highly uncertain issue in academia. More specifically, imminent scarcity of materials such as lithium (essential material for Lithium-ion (Li-ion) batteries) or the Rare Earth Element (REE) neodymium (used in magnets for electric motors and wind turbines) seem possible uncertain barriers in a transition towards an battery electrified transport system. As argued by Söderman et al. (2014) *'[...] a transition to electric vehicles based on lithium batteries is not unproblematic mainly due to concerns about limits to annual extraction and geographical concentration of reserves'*. However, the uncertainty about the scarcity of materials, such as lithium, is influenced by the performance characteristics of the vehicle, determined by the specific power and energy of batteries, and the specific power of magnets in electric motors. Also these variables are likely to change over time as technologies improve, recycling-processes become more efficient and consumer preferences change. Therefore, projections for resource sufficiency and estimations of future demand are vital for a sustainable transportation system based on electromobility. Meanwhile, REEs, raw materials used in the EV batteries (such as neodymium), Photovoltaics (PV) for solar power, hydrogen fuel cells and wind turbines, among others, are produced and distributed primarily by China as it is shown in figure 6.4. In fact, since the late 1990s, China has provided 85 to 95 percent of the world's REEs (USGS, 2014).

Current Benchmarks on Proactive Policy Initiatives for Electromobility

On the way to a low carbon economy countries and cities are making an effort to set the foundation for a sustainable future of transportation (s. figures A.1 and A.2 in Appendix A on page II). Sprei et al. (2014) have compiled an comprehensive enough review on current policies on both national and local level. Here only a summary is conducted to provide a glimpse to the reader of ongoing activity in a broader context.

The first most well-known example is Norway having achieved a global EV (including HEV, PHEV and BEV) market share of remarkable 22% but also owning the largest EV fleet and reached the highest yearly sales of EVs per capita as a country (Figenbaum et al., 2015). Also, even though it is not officially a legislation yet, Norway has announced a ban of selling new fossil-based vehicles by 2025 (Morris, 2016). In Norway the incentives from the state are still abundant as one can see in the article from Figenbaum et al. (2015):

- **Fiscal incentives for the reduction of purchase price:**
  - Exemption from registration tax
  - VAT exemption
  - Reduced annual vehicle license fee
  - Reduced imposed taxable benefit on company cars
- **Direct subsidies for users and reducing costs for investors:**
  - Free toll roads
  - Reduced rates on ferries
  - Financial support for charging stations
  - Rapid charging stations
- **Incentives for time cost reductions:**
  - Access to bus lanes
  - Free parking

The second promising and ‘bold’ example is the Netherlands. More specifically, the majority of the lower house in the Dutch parliament supported a motion to ban the sale of all new fossil-based vehicles by 2025. Also on a local level Dutch cities seem environmentally proactive since Rotterdam and Utrecht have banned the circulation of diesel cars manufactured before 2001 and petrol cars manufactured before 1992 in the city centre. Furthermore, the city of Amsterdam has announced their ambitious plan to replace their entire fleet of conventional buses with fully electric ones by 2025.

Last but not least, India’s Minister of Power, Coal, New and Renewable Energy, has also announced the government’s ambition that India will become an 100% EV nation by 2030 (Loveday, 2016).

Tesla Model 3 & Gigafactory

Tesla Motors is one of the pioneering automotive companies in accelerating the advent of sustainable transportation. As a highly innovative BEV company, recently released most affordable Model of their fleet, namely Tesla Model 3, which has been received with great enthusiasm (The Tesla Team, 2016). Meanwhile, the company

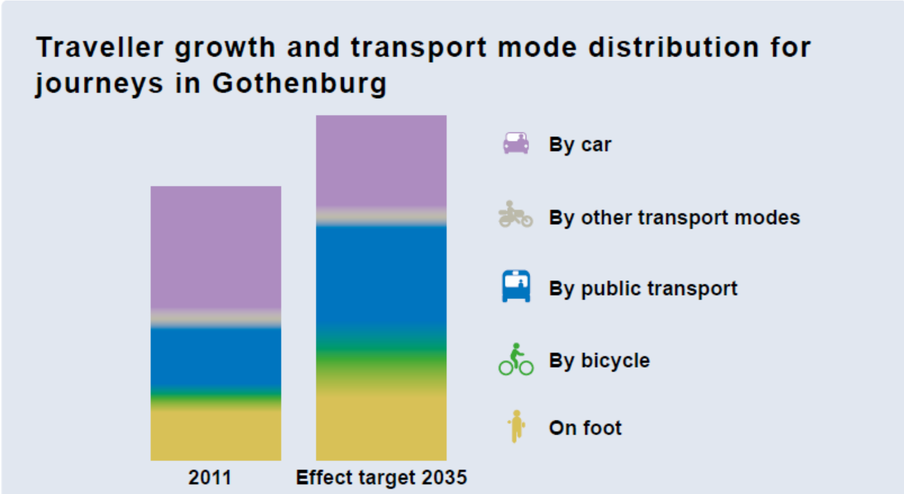

Figure 6.5: Transport mode distribution (City of Gothenburg, 2014a).

has taken on a very promising and ambitious initiative of constructing the so-called 'Gigafactory' for producing Li-ion battery packs in a strategic partnership with Panasonic. By 2020 Tesla Motors are expected to boost the battery production worldwide and thereby most likely reduce the production costs for Li-ion batteries and consequently the investment costs for EVs in general (Truett, 2015).

6.2.1.2 The Socio-technical Regime Level

Sectoral Policy and Legislation

In this paragraph, the policy directives and conditions are analysed. The part of legislation is mainly analysed on the landscape as influence from the national level.

City objectives

However, in 2015, 46% of all trips were performed by car and only 27% by public transportation whereas 20% were made by foot and 7% by bicycle (Trafikkontoret, 2015). Compared to 2014 travel by car increased by 2.3%, travel by public transportation increased by only 1.3% and travel by bicycle even dropped by 3% (Trafikkontoret, 2015).

The City of Gothenburg along with Trafikkontoret, the Urban Transport Administration, have developed several ambitious objectives for the transportation system in the city to achieve a doubling of journeys performed by foot or bicycle and public transportation as well as a reduction of journeys performed by car of 25 % during the coming decades:

- **Reduction of car traffic:** The Urban Transport Administration has articulated the goal that *'by 2035 at least 35 per cent of journeys in Gothenburg will be taken on foot or by bicycle'* (City of Gothenburg, 2014a). The national prognosis predicts that the number of journeys by private car will increase

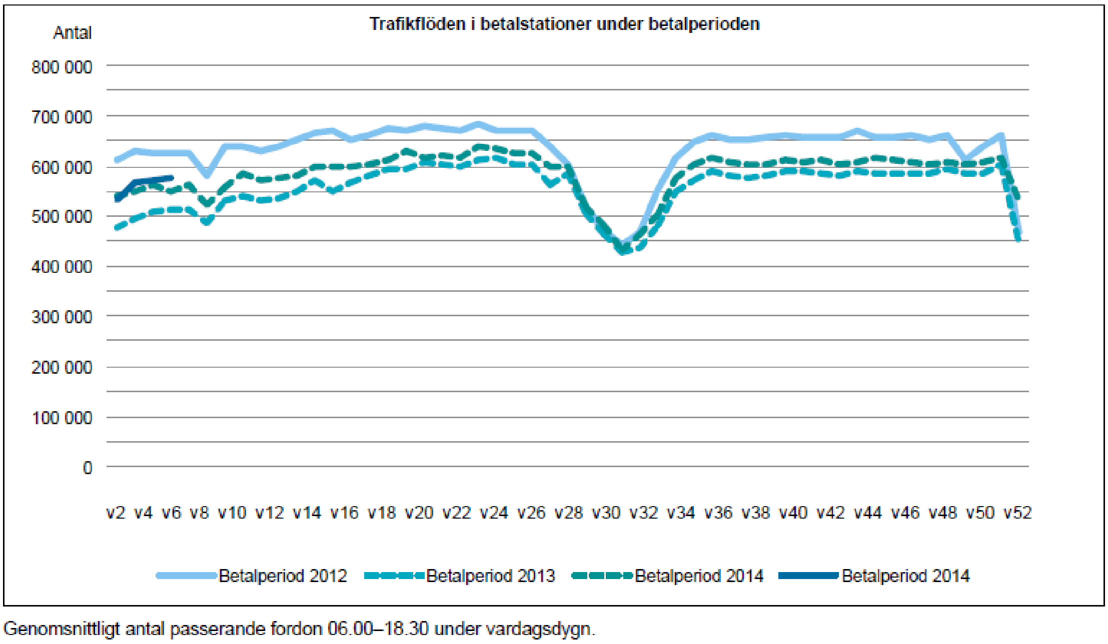

Figure 6.6: Data of passages collected from all check-points during charging hours (06:00-18:30) for the period 2012-2014 for the corresponding weeks (M.O. Larsson, Trafikkontoret, Personal Communication, March 18, 2016).

by approximately 35 % to 2030, while climate objectives indicate that this number needs to be reduced (City of Gothenburg, 2014a). The transport strategy's targets for transport mode distribution corresponds to a reduction in the number of car journeys by 25% on the 2011 number (s. figure 6.5 on page 71). If the effect targets above are met and technological development leads to considerably more environmentally friendly vehicles the targets for climate gas emissions by passenger transports can also be met.

- **Promote Public transport:** In 2011 the share was approximately 34% (City of Gothenburg, 2014a). The target includes journeys to, from and within the Gothenburg region.
- **De-carbonisation of the local transport system:** CO_2-emissions from road transport within the Gothenburg geographical area have to be decreased by at least 80% by 2030 compared to 2011. This objective is equivalent to the projected reduction of car traffic of 25% by 2035.
- **Environmental targets:** *'Emissions per capita in Gothenburg 2050 shall not exceed the globally sustainable levels'*. For this target EU directives are followed for air quality and noise levels are monitored (City of Gothenburg, 2014c).

In the documents of city, (City of Gothenburg, 2014a; City of Gothenburg, 2014b; City of Gothenburg, 2014c) it is not completely and explicitly described how these objectives are to be achieved, however, policy instruments are developed in order to:

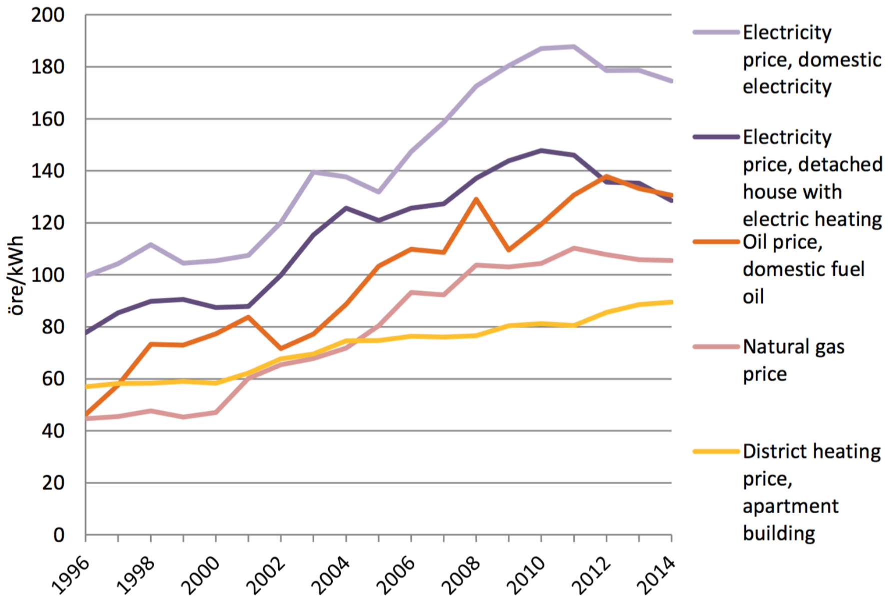

Figure 6.7: Energy prices for the residential and services sector, 1996–2013, real (2014) öre/kWh (Swedish Energy Agency, 2015).

- **Raise awareness:** The city of Gothenburg aims to develop education initiatives and communicate climate information on sustainable transportation on an 'ongoing' basis but also from an early stage (City of Gothenburg, 2014c).
- **Prioritise walking, cycling and public transport:** The city of Gothenburg has already applied a series of measures, such as congestion charges, pedestrian speed allowances for vehicles and an allowance for only stopping and not parking on the side of the streets (City of Gothenburg, 2014a).
- **Showcase a low impact vehicle fleet:** By the end of 2015, Gatubolaget (the owner of the city's vehicle fleet) owned 187 BEVs. Approximately 5000 BEVs run in Sweden in total. That means that the city of Gothenburg owns 4 % of all BEVs in Sweden and 43% of the BEVs registered in Gothenburg (A. Sjöberg, Trafikkontoret, Personal Communication, April 21, 2016). The intention from the city of Gothenburg is also to reinforce the local second hand automotive market with BEVs by providing a part of their fleet (A. Sjöberg, Trafikkontoret, Personal Communication, April 21, 2016).

Congestion charges

After an initiative from the Swedish Traffic Agency in collaboration with the city and the Urban Transport Administration in 2013 congestion taxes have been introduced in the city of Gothenburg. The main goals are the reduction of traffic especially during rush hours, the increase of accessibility to the city centre, increase of the use of public transport and lastly the reduction of GHG-emissions and noise. The charges are automatically applied to the owners of the vehicles entering the city as special sensors are placed in designated check-points around the city centre keeping

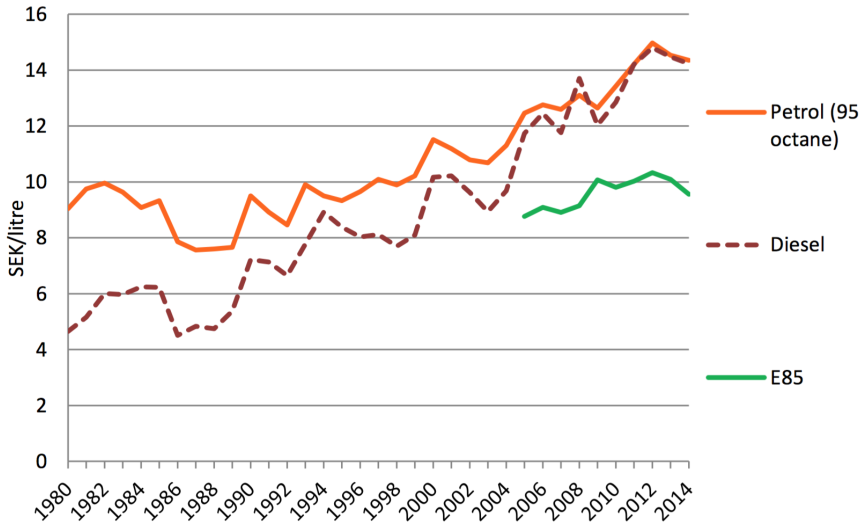

Figure 6.8: Road transport fuel prices 1980–2014, real (2014) SEK/litre (Swedish Energy Agency, 2015).

track of the passing license plates. The Urban Transport Administration considers the measure successful as the the car traffic has been decreasing steadily since their introduction as shown in figure 6.6 on page 72 provided by the Urban Transport Administration.

Market & User Practises

In this paragraph market conditions of the transportation system in Gothenburg are analysed, namely the price of commodities around transport and personal vehicles, existing business models and automobiles.

Market prices

Current fuel price levels	
Type	*Fuel Price [€/litre]*
Unleaded	1.344
Diesel	1.447
LPG	0.965

Table 6.1: Today's fuel prices levels on May 15th, 2016 (Matvoz, 2016).

The average fuel prices in Sweden today are shown in table 6.1. Figure 6.8 shows the increasing tendency road transport fuel prices are showing in Sweden according to the Swedish Energy Agency (2015). At the same time, the electricity price is decreasing, especially in comparison to the price of fuel, such as petrol, as it is depicted in figure A.3 in Appendix A or in comparison to other energy prices in

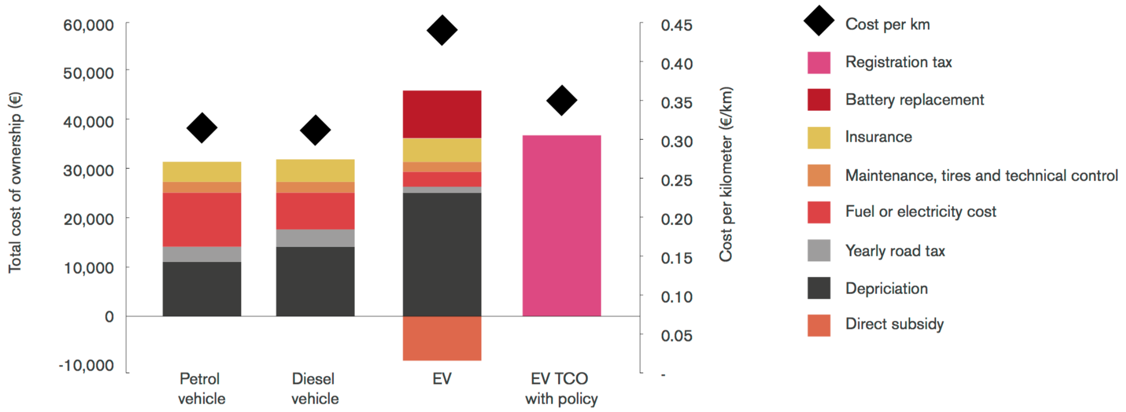

Figure 6.9: TCO and cost per km of petrol, diesel and EV, with and without policy (Sprei et al., 2014)

figure 6.7 on page 73. Right now in the European automotive market, there are 12 BEVs available for the consumers. A rough price list of these BEVs, updated in February 2016 along with their range, can be found at EV Obsession (2016). Meanwhile, Volvo Cars, which is considered as an important factor for the local economy and the city as a whole, has announced the launch of their first BEV in the market in 2019 (Volvo Car Group, 2015). Their ambition, as stated in Volvo Car Group (2015), is to have sold 1 million BEVs by 2025.

On the public transportation side, apart from commercially available hybrid buses, an unique fully electric type of bus from Volvo Buses is in test operation in a niche project called ElectriCity (s. section 6.2.1.3[6] on page 87) in Gothenburg but not commercially available yet. When it comes to electrified transport, the price of Li-ion battery packs is a critical factor. Currently the battery pack costs are the main reason why EVs in general, and especially BEVs with a considerably larger battery, have such a high TCO. A comparison of TCO between EVs and conventional car is shown in figure 6.9.

Consumer preferences and market segments

In a transportation system of people the users possess characteristics of a customer when choosing a personal vehicle. Even though there is no scientific standardised set for these attributes, here we were inspired by various literature, news items and personal experience for listing the attributes that a costumer seeks for when choosing a personal vehicle are the following (as adopted from Carello (2016)):

- **Safety:** Safety features, vehicle safety;
- **Comfort:** Interior space, cargo volume, number of passengers;
- **Brand:** Image, fashion;
- **High-tech:** Innovative devices, inter-connectivity;

[6]The Technological Niche Level, paragraph 'Initiatives in Cooperation with Chalmers University of Technology'

- **Eco-friendly:** Emissions, efficiency;
- **TCO:** Fuel, maintenance, second hand selling value;
- **Quality:** Quality of materials, reliability, durability, design;
- **Performance:** Handling, response, weight.

As far as the market is concerned, there are two types of segmentation: ① segmentation based on the **product type** and ② segmentation based on **costumer profile**. The categorisation can be found in Appendix A on page I.

Consumer behaviour and EVs

Research on early adopters of all kinds of EVs around the world has demonstrated that this group is composed of mainly higher-income consumers with a distinct set of attitudes and behaviours: higher education, concerns about the environment and/or cost-efficiency and the TCO (McKinsey and Amsterdam Roundtables Foundation, 2014; Figenbaum et al., 2015). When it comes to consumer behaviour customers demonstrate three key motives for early EV adoption apart from other factors such as brand or performance (McKinsey and Amsterdam Roundtables Foundation, 2014):

- **Environmental factors:** The main driver for the early adopters-customers is to reduce the carbon footprint and are willing to pay a premium for zero or low emission alternatives to ICEVs.
- **Driving and usage benefits:** Additional benefits, such as direct incentives for use by governments or cities (s. section 6.2.1.1 'The Landscape Level' on page 64)
- **Cost savings:** Without subsidies EVs are significantly more expensive than ICEVs. More specifically, the price of an BEV for example is higher than an ICEV by 50% to 100% (Williander, 2013; Williander and Stalstad, 2013) (s. section 6.2.1.1 'The Landscape Level' on page 64).

According to McKinsey and Amsterdam Roundtables Foundation (2014) and Figenbaum et al. (2015) the price, or more importantly, the TCO, seems to be a key driver for the decision of a purchase before the environmental one. In fact, according to McKinsey and Amsterdam Roundtables Foundation (2014), the concern about the price is predicted to be even higher among the general population compared to early BEV adopters. Thereby, one can conclude that, so far, the consumers' choice of purchasing an BEV over other alternatives seems to be dependent on governmental or regional support.

Business models and market value

Meanwhile, in the local market, when it comes to electromobility solutions and the business case around them, there is always a hesitant approach from investors and entrepreneurs. That demonstrates a need for successful proven business models that could motivate the local market to be the incubator for business innovation and development. Many of the interviewees (s. table B.1 in Appendix B on page

V) address the issue of insufficient time for business cases to be proven but also the issue of general immaturity and the risk that comes along with this new technology.

Last but not least, there is currently high uncertainty right now on what the second hand selling market value of an EV will be (Williander, 2013; McKinsey and Amsterdam Roundtables Foundation, 2014).

Stakeholder Networks

This paragraph gives an overview on the network of stakeholders working with different aspects of electromobility for both private and public transportation inside the city of Gothenburg. It is important to note that all these stakeholders were mapped before the scope was narrowed down as described in section 5.4.2[7] on page 47. Also additional stakeholders may be added to the following compilation, however, in this section focus in put on the most relevant stakeholders that must be involved when solving today's challenges around electromobility and sustainable transportation.

According to the concept of the triple-helix the stakeholders were categorised in the **public**, **private** and **academic sector**. A map of the following stakeholder network can be found in Appendix B in figure B.1 on page VI.

The **public sector** is represented by organisations owned by the city of Gothenburg or the Swedish government. The following stakeholders were identified:

- Västra Götalandsregionen (VGR): Devolved County Council of Västra Götaland County in Sweden that is responsible for public transport throughout Västra Götaland owning Västtrafik.
- Västtrafik: Public agency responsible for public transport services involving buses, ferries, trains, and the Gothenburg tramway in the county of Västra Götaland.
- Trafikverket: Swedish Transport Administration, responsible for long-term infrastructure planning for all kinds of transport on a national level.
- The city of Gothenburg.
- Trafikkontoret: Urban Transport Administration, responsible for management of the road, track and tram infrastructure for the city of Gothenburg.
- Älvstranden Utveckling: Organisation focusing on the realisation of the 'RiverCity' vision in Älvstaden (Gothenburg City Council, 2012) creating an inclusive, green and dynamic city centre around the river.
- Swedish Energy Administration: Responsible for research and development on energy systems and security of supply.
- Swedish Transport Agency: Legal responsibility for delivering regulations for all kinds of transport.
- Business Region Göteborg (BRG): Non-profit company that strives to contribute to sustainable growth in the Gothenburg region.

[7] Adjustment of the Scope

- Göteborg Energi: Partly State owned, Energy Company responsible for providing energy provision, heat and power along with the electricity supply network.
- Gatubolaget: City owned company responsible for Gothenburg's Vehicle fleet and transport solutions.
- Parkeringsbolaget: City owned company responsible for Management of Parking spaces in Gothenburg.
- Vinnova: Swedish government agency responsible for funding for research and development.
- Environmental Protection Agency: Responsible for development of tools and support for the implementation of environmental protection activities.
- Familjebostäder: State owned Housing Management Company.

The **private sector** is represented by companies which is not controlled by the state. The following stakeholders were identified:

- Volvo Group: Global actor manufacturing trucks, buses, engines, providing services and being active in local development in the Gothenburg Region.
- Volvo Cars: Global actor manufacturing personal vehicles and being active in local development in the Gothenburg Region.
- Keolis: One of the world's largest operators of public transportation.
- Move About: EV sharing company active in Scandinavia.
- Sunfleet: Car-Sharing company owned by Volvo Cars.
- Clean Motion: Company that develops clean efficient vehicles.
- Ubigo: Company that offers integrated mobility solution service.
- Hedin Bil: Company offering electric services and repairs for Vehicles in Gothenburg.
- Chalmersfastigheter: Chalmers' own property company working towards the shared vision of a sustainable future.

The **academic sector** is represented by public or private higher education establishments and non-profit research organisations whose primary mission is to pursue research. The following stakeholders were identified:

- Chalmers University of Technology: Including AoA Energy and research departments 'Energy & Environment' and 'Signals & Systems'.
- Johanneberg Science Park (JSP): Collaborative environment located on the campus of Chalmers University of Technology that promotes the exchange of ideas and knowledge between academia, industry and society focusing on Urban Development and Energy amongst other fields.
- Lindholmen Science Park: Organisation dedicated to research and development in mobile communication, intelligent vehicles and transports systems amongst other fields.

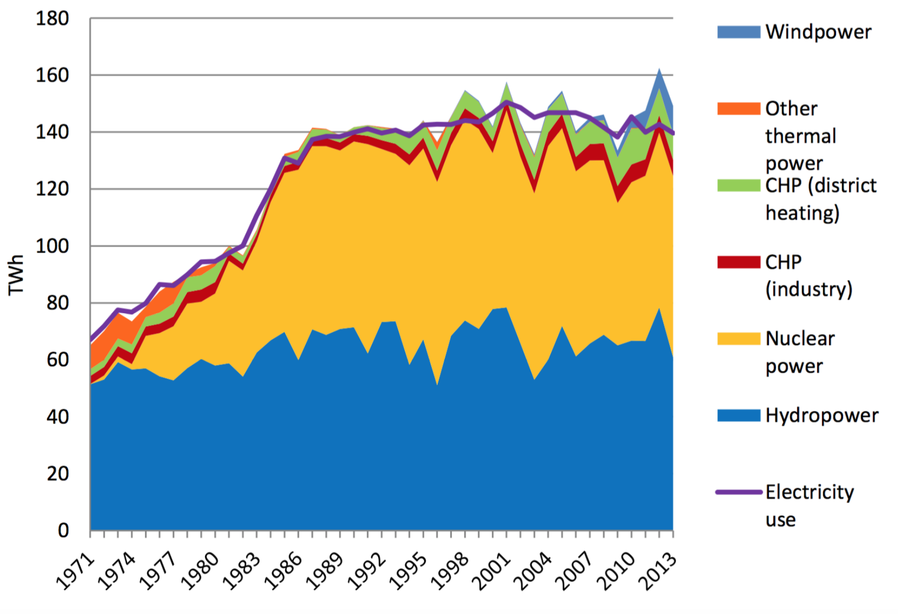

Figure 6.10: Net electricity production, 1971 – 2013, TWh (Swedish Energy Agency, 2015).

- Swedish Hybrid Vehicle Centre: National centre of excellence for the development of electric and hybrid vehicles.
- IVL: Swedish Environmental Research Institute.
- Viktoria Swedish ICT: Swedish Research Institute on research and development in applied information technology.
- GMV: Research Institute on environment and sustainability.

In addition to these stakeholders one must consider the user as another key stakeholder in regard to electromobility and transportation in general.

Technology

In the current transportation system of Gothenburg, with respect to a higher share of electromobility in the future, one has to consider the current mix of **electricity production technologies** and **transportation technologies** that are in use as well as available **charging technologies**.

Regarding its **electricity production technologies**, Sweden is taking a lead compared to other countries when it comes to low emissions. *'According to the latest statistics from the International Energy Agency (IEA), the average Swede releases 4.25 tonnes of carbon dioxide (CO_2) per year into the atmosphere, compared with the EU average of 6.91 tonnes and the US average of 16.15 tonnes.'* (Energy use in Sweden, 2016). This is due to the dominating role of nuclear and hydro power. In 2013, 149 TWh of electricity was produced of which 43% (64 TWh) came from nuclear and 41% (61 TWh) from hydro power (s. figure 6.10). During the recent years wind power emerged as the third largest zero-emission technology with a share of

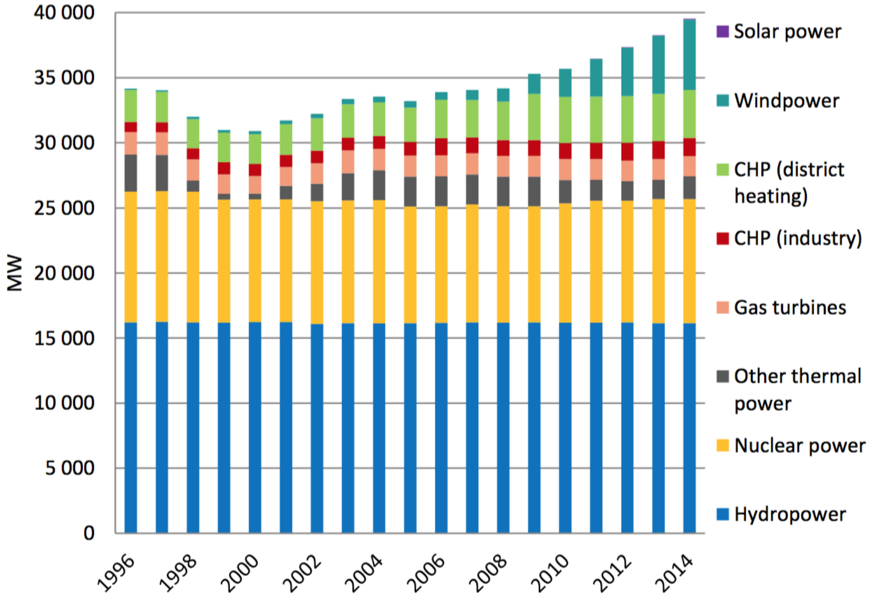

Figure 6.11: Electricity production capacity, 1996 – 2014, MW (Swedish Energy Agency, 2015).

7% (10.4 TWh) in 2013 tending to increase rapidly (Swedish Energy Agency, 2015). As can be seen in figure 6.11 the overall increase of installed electricity production capacity is primarily due to the growing amount of operating wind power turbines in Sweden. Important to note is that solar power still accounts for less than 1% in installed capacity and can therefore not yet be considered to be part of the socio-technical regime around electromobility in Sweden or the city of Gothenburg (s. section 6.2.1.3[8] on page 87. For the coming decades one can expect a rather drastic increase of installed capacity of renewable energy technologies, such as wind and solar power. These new technologies will gradually replace the electricity generated by nuclear power plants since Vattenfall, a government-owner power company, decided to shut down two nuclear power reactors within the next three to five years (Energy use in Sweden, 2016). Although the future for nuclear power cannot be clearly extrapolated yet it seems rather clear that Sweden aims at closing down further reactors in the near future (s. section 6.2.1.1[9] on page 64). However, with an increasing share of wind and solar power which are not considered as base load technologies and are highly dependent on weather conditions, the electricity grid will face more fluctuating loads which raises the demand for increased flexibility and balance regulations (Swedish Energy Agency, 2015). At the moment pumped hydro power plants can be used to balance such load variation in the electricity grid while maintaining high conversion efficiencies of greater than 80% in one round-trip (Energy Storage Association, 2016).

[8] The Technological Niche Level, paragraph ‘Initiatives in Cooperation with Chalmers University of Technology’

[9] The Landscape Level, paragraph ‘Carbon and Nuclear Energy Tax’

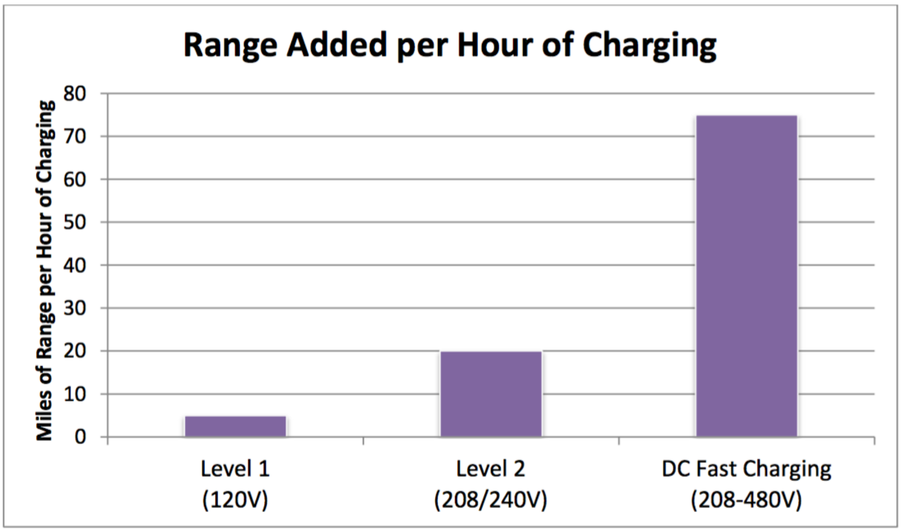

Figure 6.12: Range added per hour of charging (Vermont Energy Investment Coporation, 2014).

Looking at the Gothenburg region, in regard to available **transportation technologies**, ICEVs are currently still dominating with a share of 97.9% of all vehicles registered in the municipality. About 1.6% are HEVs which are propelled by both an internal combustion and a small electric engine to reduce fuel consumption and CO_2 emissions. Lastly only 0.26% of all registered vehicles in Gothenburg city are PHEVs which are equipped with a considerably larger battery and can be charged similarly to a BEV which currently has a share of only 0,24% (M.O. Larsson, Trafikkontoret, Personal Communication, March 21, 2016). However, these small shares are not very surprising considering that Volvo just started to put their first HEVs into commercial operation, starting with Hamburg in December 2014 followed by Stockholm in 2015. In June 2015, the first fully electric bus route 55 was launched in Gothenburg as a showcase of the ElectriCity project (ElectriCity, 2016) (s. section 6.2.1.3[10] on page 87.

Concerning currently available **charging technologies** one can differentiate between three basic types of charging configurations: ① Normal- or slow-charging (**Level 1**), ② destination- or fast-charging (**Level 2**) and ③ rapid- or Direct Current (DC)-fast-charging (often referred to as **Level 3**) (Vermont Energy Investment Coporation, 2014; Wiederer and Philip, 2010). In addition to these, one should mention bus-charging as a separate option in relation to bus line 55 (ElectriCity, 2016), as it is considered by Göteborg Energi, Western Sweden's leading energy company, providing most of the charging stations in the city of Gothenburg (Göteborg Energi, 2016). However, this option is not further investigated in this section.

Level 1, normal- or slow-charging, is the simplest form of charging using a standard electrical outlet at residential buildings with usually 120 V and 15 - 20 A of Alternating Current (AC) current resulting in a power draw of around 1.4 kW. This

[10] The Technological Niche Level, paragraph 'Initiatives in Cooperation with Chalmers University of Technology'

configuration leads to very low installation costs while maintaining a low impact on the electric utility peak demand whereas the charging rate is very slow compared to Level 2 and 3 with only 5 - 7 km of range added per hour of charging (Vermont Energy Investment Coporation, 2014) (s. figure 6.12 on page 81). This type of configuration is commonly used for charging at home since it is usually performed over several hours over night and does not require high power draws from the grid.

Level 2, destination- or fast-charging, is characterised by single-phase 240 V or three-phase 208 V AC with up to 80 A which results in a power draw between 3 to 20 kW, depending on the vehicle and plug type. This increases the charging time significantly and allows for up to 30 km added range per hour of charge, however, is more expensive to install and possibly increases the impact on the electric utility peak demand (Vermont Energy Investment Coporation, 2014). This configuration is often used for charging at supermarkets or other facilities around the city centre (Wiederer and Philip, 2010). For both Level 1 and Level 2 charging different connector types may be used, namely Type 1 (e.g. J1772 standard connector), for only single-phase and up to 7.4 kW and therefore rather irrelevant for European three-phase outlets, and Type 2 or so-called ‘Mennekes’ for both single-phase and three-phase current and up to 43.5 kW as the most common plug in Europe and thereby Sweden (Mennekes, 2016).

Lastly, **Level 3**, the rapid-charging configuration, can almost be compared to a conventional gas-station with currently up to 500 V and 200 A of DC allowing for power draws of around 100 kW. This type of configuration allows for long distance travel as roughly 80% of charge can be provided in 30 minutes (Vermont Energy Investment Coporation, 2014). Currently the following three connectors for fast-charging from different manufacturers are available (Vermont Energy Investment Coporation, 2014; McKinsey and Amsterdam Roundtables Foundation, 2014):

- *CHAdeMO* used by Nissan, Mitsubishi and Kia;
- *CCS Combo* used by American and European brands, such as Chevrolet, BMW and Mercedes-Benz;
- *Tesla’s Supercharger* used exclusively on Tesla Model S and later versions.

This brief introduction of currently used charging configurations and connector types shows the large variety of standards and equipment a potential user has to consider before making the conscious choice of purchasing a BEV. This leads to the overarching issue of limited accessibility and flexibility for the user. Therefore, in order to solve this issue, European Union has proposed as standards the Type 2 ‘Mennekes’ for home and destination charging and CCS Combo for rapid charging, through the Clean Fuel Directive (European Parliament, 2014).

Overall one can say that the transportation system in the city of Gothenburg is still completely dominated by the ICEV, however, the considerable share of hydro power and the expected growth of wind and solar power in Sweden allow for a large scale introduction of BEVs in the future. Also, there is a large variety of charging standards and equipment which may be used for different purposes, such as home-charging, destination-charging or rapid-charging.

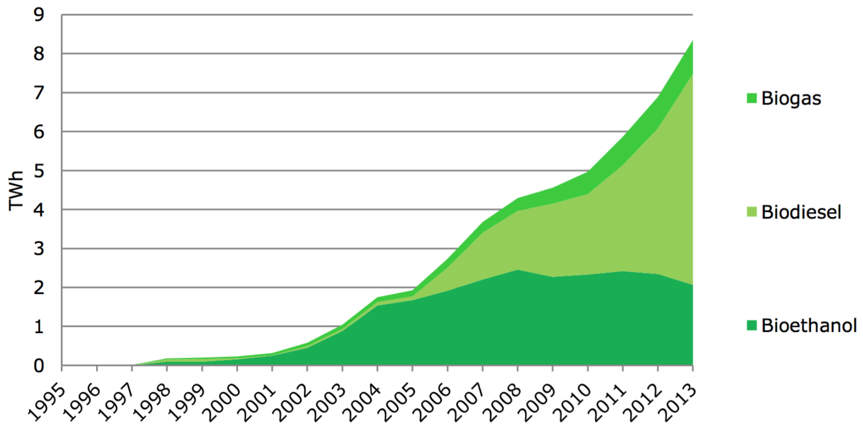

Figure 6.13: Biofuels in the transport sector (domestic), by fuel, 1995 – 2013, TWh (Swedish Energy Agency, 2015).

Infrastructure

The infrastructure of a transportation system traditionally included aspects such as the **road-** and **traffic-infrastructure** of different transportation modes as well as the **parking-** and **fuel-infrastructure** for cars (Geels, 2005). However, new aspects related to electromobility, such as different types of charging configurations, as presented in paragraph 'Technology' on the previous page, start to break into the socio-technical regime of the city of Gothenburg and influence the characteristics of the infrastructure.

Concerning the **road- and traffic-infrastructure** in the city of Gothenburg all transportation modes are well represented. However, as described in paragraph 'Sectoral Policy and Legislation' on page 71, car traffic has been increasing over the recent years and therefore the city of Gothenburg (Göteborgs Stad, 2016) is making strong efforts to increase the attractiveness of public transportation by improving the overall accessibility and introducing showcases, such as the electric bus line 55 connecting JSP with Lindholmen Science Park (ElectriCity, 2016) (s. section 6.2.1.3[11], on page 87), and the attractiveness of bicycle-travel by providing safe bicycle-lanes, bicycle-sharing services and initiating a free electric bicycle project in 2016 for people commuting between their workplace and home for more than three days a week. As discussed in paragraph 'Sectoral Policy & Legislation' on page 71 the city is aiming to reduce travel by car drastically in the coming years.

However, the infrastructure around the city of Gothenburg, including the **parking-infrastructure**, is still built around the car and individual transportation. During the day idle cars occupy a large amount of space in centralised parking areas and during rush-hours are rather simultaneously released leading to congestion inside and around the city putting the already dominating road-infrastructure to its limits.

[11]The technological Niche-Level', paragraph 'Initiatives in cooperation with Chalmers University o Technology

Further investigating the **fuel- and charging-infrastructure** around the car, there are currently 194 petrol stations (Hitta, 2016) and 70 charging station (Göteborg Energi, 2016) registered in the city of Gothenburg mostly concentrated in the city centre, along the river Göta Älv and Frölunda. This simple comparison already shows the dominance of conventional petrol stations around Gothenburg. Generally, when it comes to fuels used for transportation one has to differentiate between fossil fuels, such as gasoline and diesel, and bio fuels, such as ethanol, biogas and biodiesel. As can be seen in figure 6.13 on page 83 the use of biofuels in the transport sector of Sweden has increased drastically during the recent years. This is primarily due to the growing popularity of biodiesel which accounted for 64% amongst biofuels in 2013 (s. figure 6.13). Gasoline and diesel is provided at all the 194 petrol stations of which 64 also offer Ethanol E85 as a biofuel option (Miljofordon, 2016), such as INGO (Ingo, 2016), Statoil (Statoil, 2016) and St1 (St1, 2016) with 13 stations each, Shell with 11 stations (Shell, 2016), Preem with 9 stations (Preem, 2016), and OKQ8 with 5 stations (OKQ8, 2016). Consequently, in terms of availability around Gothenburg, both biofuel outlets and charging stations are equally represented, however, the large variety of different charging configurations and standards, as described in paragraph 'Technology', make them currently even less competitive to the biofuel option. Furthermore, not all existing charging stations are available to the public (only 18 out of 70 charging stations according to Göteborg Energi (2016)). The other 52 charging stations belong to various businesses and organisations and may only be used by owners, members or customers. Lastly, currently only a few BEVs have the capacity to use the Level 3 rapid-charging configuration and therefore accessibility is limited even further.

Overall, one can conclude that the infrastructure of the city of Gothenburg is still largely built around the car, for the future, however, has not only to accommodate for both public and private electrified transportation but also ensure for sustainable transportation by, for instance, reducing car-traffic in the city centre.

Knowledge

The knowledge dimension in the current transportation system is related to the current structure of how the knowledge is created, diffused, employed and further developed within the boundaries of the current regime. More specifically, knowledge is mainly created, managed and diffused in three ways according to the knowledge triangle (s. figure 6.14 on page 85):

- **Research:** In Gothenburg region as well as on the national level in Sweden there are relevant research and educational institutes that influence the knowledge around the transportation system, its functions and its development. More specifically, educational institutes and research institutes create and diffuse knowledge through research projects (research programmes on a national level, thesis projects or individual initiatives) undertaken either individually or in partnership with other institutes or actors from the public or private sector (s. paragraph 'Stakeholder Networks' on page 77). The research undergone is this field can be related to transport user behaviour analysis and experience

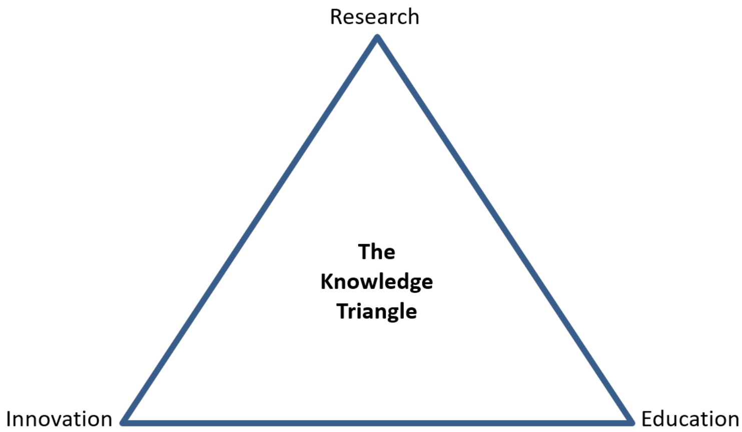

Figure 6.14: The knowledge triangle (research, innovation and education).

(SEVS et al., 2014) (F. Sprei, Chalmers University, Personal Communication, March 8, 2016), technological innovation and cross-boundary collaborations in transport (s. section 6.2.1.3[12] on page 87), on sustainable mobility as well as on transportation design. Research can also be undergone by actors in the private sector in R&D departments and in transport public actors on how to improve their product and/or services.

- **Innovation:** Innovation brings on awareness and knowledge as it is an excellent showcase of applied knowledge. Innovation in transport can be generated by individual private initiatives (car-sharing initiatives such as Move About and Sunfleet), triple-helix collaborative projects (ElectriCity, projects on mobility by Viktoria Swedish ICT) or small scale projects that spin off from research or educational institutes.

- **Education:** Education can be generated in many ways and from every actor from the triple-helix. Education is about knowledge transfer on transportation regulations, technological innovations, different transportation modes and solutions as well as sustainable lifestyle. Education can be facilitated through awareness campaigns, showcases, regulations, role models and educational programmes or courses at school and University. The receiver is any user that experiences transportation in any form and context.

All in all, knowledge generation, diffusion and application in a transportation system is vital. That is because it helps the actors to better understand the system in a holistic way along with the behaviour and choices of users and by testing innovations the characteristics of the system, such as efficiency and quality, is improved and the all actors (policy makers, researchers, users, etc.) become more knowledgeable and educated.

[12]The Technological Niche-Level

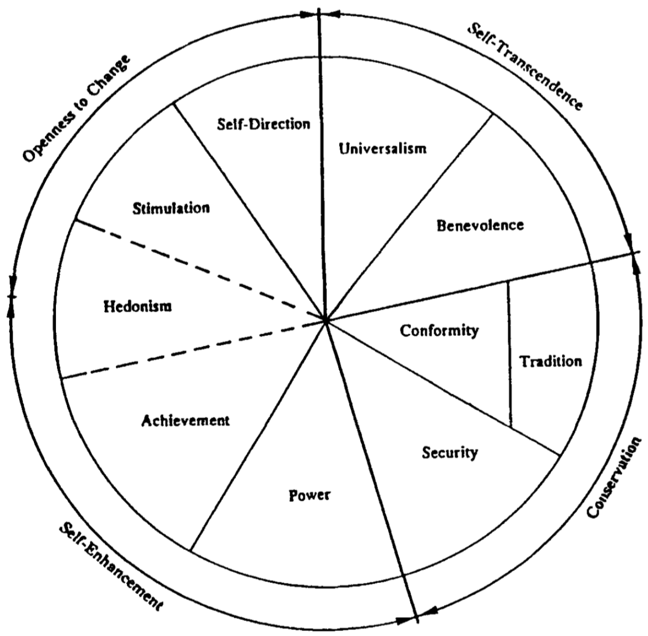

Figure 6.15: The circumplex structure of value priorities (Schwartz, 1992).

Culture & Norms

When investigating Gothenburg's culture and societal norms in relation to transportation in general it essentially comes down to the basic human need for mobility (Sandén, 2014) leading to individual satisfaction and well-being when met (Bergstad et al., 2011). This effect closely relates to the inner value system of people creating *'guiding principles'* which have motivational impact on attitudes and behaviours (Schwartz, 1992). Various cultural norms are affected by these *'guiding principles'*, such as the travel patterns of the user, the symbolic meaning of the car or the public awareness on sustainability issues.

Generally, there are different approaches to identify the mode choice and travel decision of people, *'activity-based-, attitudinal- and market/consumer-approaches'* (SEVS et al., 2014), (A. Grauers, Personal Communication, March 3, 2016). Different user groups are affected in different ways when it comes to their choice of transport. Most *'people usually favour sustainability measures which do not affect their activity patterns in major ways'* (SEVS et al., 2014). Concerning the attitudes of users the majority is rather *'conservative'* being governed by values, such as security, tradition and conformity (s. figure 6.15). Robinson (2009) describes these user groups as *'late majority'* or *'laggards'* who tend to see the risk rather than the benefits of *'adopting a particular product or behaviour.'* Sustainable transport choices are preferred by those user groups who keep hold of values, such as universalism and benevolence living the virtue of *'Self-Transcendence'*.

Social norms are the result of the value system the majority believes in and what is considered to be *'morally correct'* (SEVS et al., 2014). However, personal norms are values and principles internalised by individuals which are not necessarily in compliance with the majority. In Gothenburg one can argue that 'Sustainability &

Environmental Awareness' as a once rather personal norm amongst environmentalists is growing in popularity, since the city of Gothenburg is pushing for sustainable urban development and influential organisations, such as Volvo, are setting aggressive sustainability goals (s. paragraph 'Sectoral Policy & Legislation' on page 71). It seems that Gothenburg's culture is on the verge of transitioning into a more sustainable future, most certainly in regard to transportation. However, for this transition to happen one central conflict has to be solved, the one between self-interest and collective interest which is also studied within the *'Social dilemma paradigm'* (SEVS et al., 2014). As argued by Ostrom (1998) the *'Green Travel Option'*, meaning to collaborate, has to become to most attractive alternative by building trust and reciprocity amongst citizens.

A large hinder for such a normative change to happen is created by the symbolic meaning of the car as it evolved over the last century. For most user groups the car represents freedom and individuality (Geels, 2005). Nowadays, the car is still by far the most flexible and often times the fastest mode of transportation (SEVS et al., 2014), especially for users that live outside the city have to commute between their workplace and home. And finally, many users simply enjoy the experience of driving a car. However, one can argue that the dominating share of car-travel (s. paragraph 'Infrastructure' on page 83) is partly due to habits build around daily travel patterns (SEVS et al., 2014) meaning that users are simply not aware of possible travel alternatives that may be much more sustainable, also in economic terms.

In summary, societal norms inside the culture of Gothenburg are the backbone of the impending transition into a sustainable and electrified transport system. It is indispensable to realise the value systems of different user groups regarding their travel patterns and to provide appropriate alternatives to allow a gradual shift towards more sustainable transport solutions.

6.2.1.3 The Technological Niche Level

As described in section 2.3.2[13] on page 16 technological niches serve as *'[...] incubation rooms for radical novelties [...]'* (Geels, 2002) and may lead to *'learning processes'* in any of the dimensions described in section 6.2.1.2[14] on page 71. In this section various radical innovations, especially in terms of technological development and new business models, evolving inside the socio-technical regime of Gothenburg, are presented and briefly discussed.

'For a Sustainable Future' - Initiatives in Cooperation with Chalmers University of Technology

There are various initiatives taken by Chalmers University of Technology in fields of urban sustainable development, namely the 'Areas of Advance (AoA) joint ini-

[13] Systems Analysis: A Multi-Level Perspective (Theory)
[14] The Socio-technical Regime Level

Figure 6.16: The electric bus from the ElectriCity project (left) (ElectriCity, 2016) and Wireless Charging of Electric Vehicles (right) (WiCh, 2016).

tatives', such as 'Energy on Campus' including the 'Solar Initiative' and the 'ElectriCity' project (Areas of Advance, 2016). In Gothenburg Solar PV can still be considered to be on the verge of breaking through to the mainstream and therefore still requires niches or so-called *'incubation rooms'* to mature. These are provided with the Campus of Chalmers where solar panels are tested under real conditions as part of the 'Solar Initiative'. Furthermore, research for sustainable public transportation is conducted with the 'ElectriCity' project and the new electric bus line 55 (s. figure 6.16 (left) on page 88) as a showcase which was launched in June 2015 as a highly collaborative project including various stakeholders, such as the Volvo Group, Västra Götalandsregionen (VGR), Västtrafik, the city of Gothenburg, Chalmers University and many more (ElectriCity, 2016). This highly collaborative project between the academic, the public and the private sector is aiming for the development, demonstration and evaluation of new sustainable public transport solutions. Bus route 55 currently includes three fully electric buses operated by 100 % renewable energy sources and seven hybrid electric buses (Volvo Group, 2015). This initiative can be seen as very good example for a radical technological innovation implemented in Gothenburg, in this case acting as a test bed or niche itself, by collaboration and a high level of trust amongst the stakeholders (L. Göthe, Personal Communication, March 10, 2016).

Alternative and Sustainable Business Models

Interesting alternative and environmentally sustainable business models are realised by young organisations, such as Move About providing an BEV-sharing service (Move About, 2016), Clean Motion developing small personal BEVs called *'Zbee'* (Clean Motion, 2016) and the non-profit research institute Viktoria Swedish ICT dedicating themselves to *'enable sustainable mobility by the use of Information and Communications Technology (ICT)'* having initiated projects, such as *'ELMOB'* (ELMOB, 2016) or *'Mobility as a Service (MaaS)'* (Viktoria Swedish ICT, 2016) and doing research on alternative business models for EVs (Williander, 2013).

Move About, launched in Sweden in 2009, is providing a truly sustainable business model combining car-sharing with personal transportation by emission-free BEVs, such as Nissan Leaf, Renault Zoe or Tesla Model S 70D (Move About, 2016). However, inside the city of Gothenburg they are still finding themselves at the niche level by providing their services around the city centre (U. Jakobsson, Personal Communication, March 21, 2016) yet unable to penetrate the socio-technical regime of Gothenburg.

Williander and Stalstad (2013) are proposing four alternative business models in the scope of the *'BeliEVe'* project (Williander, 2013) that may facilitate the introduction of BEVs depending on factors, such as the price difference between BEVs and ICEVs, battery warranty limitations of the EV or the technology improvement speed:

- *'All-electric car leasing chain, where the operational lease company keeps ownership of the car through a sequence of lease cycles until its end-of-life;*
- *All-electric car subscription, where the car-sharing company uses suburban commuters to extend their car-sharing market by moving vehicles to where people are;*
- *Free floating all-electric city cars which can be picked up at one place and left at another without requiring booking in advance;*
- *Fringe benefit plug-in cars which utilizes that the lower fringe benefit tax on cars with low CO_2 tailpipe emissions makes the plug-in car economically competitive as fringe benefit car.'*

Furthermore, there is plenty of research going on in finding new attractive business models for sustainable transportation by combining green technologies, leading to the potential of *'Solar Powered Bike Sharing with Electric Bikes'* (Fogelberg, 2014) or using the batteries of idle BEVs to balance the loads in the electricity grid assuming a large share of renewable power production (A. Edh, Volvo Cars, Personal Communication, April 25, 2016) as feasible options for the future inner city travel and energy management.

Overall, alternative and ecologically sustainable business models in relation to EVs are available for a variety of configurations, however, most of them are still on the drawing board. For an effective implementation of these ideas not only ecological and social sustainability aspects have to be met, but also, and most importantly for their success, economicaspects, meaning to provide revenues to the investor.

Battery and Charging Technology

Nowadays, BEV technology in general finds itself still in the technological niche level, especially in Gothenburg since the market is, so far, almost nonexistent (s. section 6.2.1.2[15]). The fact that BEV technology has not yet reached the main market is mainly due to the immaturity of battery and charging technology and therefore high costs compared to ICEV technology (Grauers et al., 2014). New attractive solutions, such as inductive charging (Wedlin and Pettersson, 2016) or coordinated charging (Clement-Nyns et al., 2010) could contribute to the break-through of BEVs into the regime of Gothenburg.

[15]The Socio-technical Regime Level, paragraphs 'Market & User Practises' on page 74 and 'Technology' on page 79

Inductive charging was realised with the Wireless Charging of Electric Vehicles (WiCh) demonstration project (s. figure 6.16 (right) on page 88) in cooperation with the research institute Viktoria Swedish ICT (Wedlin and Pettersson, 2016) and is supposed to facilitate the charging procedure of an EV considerably while being much less affected by weather conditions, such as rain and ice, and therefore improves the convenience for the user.

Coordinated charging is a concept investigated by many researchers (Clement-Nyns et al., 2010; Saunders et al., 2014) which will become highly relevant when facing a large-scale introduction of BEVs as well as power production by renewable energy technologies and a possible lack of base-load technologies, such as nuclear. It is aiming at reducing the intermittency, peak loads and voltage deviations in the electricity grid by charging any type of EV (also PHEVs) during night or, generally, when the load-demand and therefore electricity price is low. Furthermore, BEVs may act as energy storage during cloudy days or when no wind is blowing leading to reduced energy supply.

Autonomous Driving and Artificial Intelligence (AI)

Lastly, autonomous driving and AI are most certainly still in the conceptual phase, however, various car companies, such as Volvo Cars (Volvo Car Group, 2015) with *'Drive Me'* and *'Concept 26'* or Tesla (Tesla Motors, 2016) with their autopilot feature are putting a lot of efforts into making self-driving cars a reality.

In 2017 Volvo Cars will initiate the *'Drive Me'* trial with 100 customers on public roads in Gothenburg (Volvo Car Group, 2015). The *'Concept 26'* is *'intended to demonstrate how the cabin of an autonomous Volvo will allow the average commute of 26 minutes per day to be spent in a more meaningful way and how autonomous technology will create a new type of luxury driving experience'* (Volvo Car Group, 2015).

In general, however, one has to make a clear distinction between semi-autonomous technology, such as Tesla's autopilot which is already part of today's market, and full-autonomous technology, such as completely self-driving cars. Although self-driving cars seem to be the logical next step to driver assistance systems they pose a completely separate challenge to overcome, related to other various dimensions of the socio-technical regime, such as new policies and safety regulations as well as culture and norms by challenging moral acceptance.

6.2.2 Local Drivers and Barriers for Electromobility

The MLP in the previous section has provided a holistic overview of the current transportation system which electromobility as a socio-technological innovation system (Geels, 2012; Geels, 2002) will have to break through. At the same time this overview, along with the knowledge derived through the interviews (s. section 5.4.1 on page 45), have demonstrated a certain ongoing 'tension' between the desired state, as articulated in our vision in step 1 (s. in section 6.1 on page 59), and the state as described in the MLP analysis (s. section 6.2.1 on page 64). From this tension certain barriers (referred to as 'gaps' in section 2.5.2 on page 27) and drivers emerge in relation to the challenge of scaling up electromobility in the city of Gothenburg. These are categorised in general drivers and barriers (s. section 6.2.2.1) as well as specific ones for private transportation (s. section 6.2.2.2 on page 94).

6.2.2.1 General Drivers and Barriers

In the following paragraph general local drivers and barriers to scale up electromobility in comparison to fossil fuel based transportation are presented.

General Drivers for Electromobility

- **Pressure from the landscape level:** Initiatives from the Swedish government, such as 'The Fossil Independent Sweden Initiative' from the Ministry of the Environment or the EU 2020 goals (s. section 6.2.1.1 on page 64).
- **Decreasing emission standards and increasing fuel prices:** The fact that oil is a limited resource and, mostly importantly, emissions become more and more expensive due to lower allowances for emissions (s. section 6.2.1.1[16] on page 64) as well as fuel prices are increasing rapidly (s. section 6.2.1.2[17] on page 74) fossil based transportation is becoming less competitive to fossil free transportation technologies based on biofuels or electrification in the future.
- **Common commitment on reducing climate impact:** Most of the local Stakeholders (s. section 6.2.1.2[18] on page 77) have the ambition to create a fossil free system in the future by focusing on climate change (S. Pettersson, Viktoria Swedish ICT, Personal Communication, April 7, 2016)
- **Rapid technological development:** History has shown how quickly technology is improving and decreasing in costs once commercialised due to economy of scale. The economic break even point is considered to be quite close (F. Sprei, Chalmers University, Personal Communication, March 8, 2016). Therefore, to make the transition into an electrified transportation system, is not primarily a technological issue (S. Pettersson, Viktoria Swedish ICT, Personal Communication, April 7, 2016; A. Grauers, Chalmers University, Personal Communication, May 4, 2016).
- **Increasing sustainability awareness:** Inside the culture of Gothenburg one can most certainly notice an increasing awareness on sustainability issues (s. section 6.2.1.2[19] on page 86) (U. Jakobsson, Move About, Personal Communication, March 21, 2016) making electrified transportation an attractive new option for an increasing number of people.

[16] The Landscape Level, paragraph 'EU 2020 Goals & 'Super Credits'
[17] The Socio-technical Regime Level, paragraph 'Market & User Practises'
[18] The Socio-technical Regime Level, paragraph 'Stakeholder Networks'
[19] The Socio-technical Regime Level, paragraph 'Culture & Norms'

- **Future generations with a new mindset:** Coming generations will grow up with a different mindset and a higher sustainability awareness without being mentally locked into using conventional fossil based technologies and therefore choose the ‘green’ option right from the beginning (S. Pettersson, Viktoria Swedish ICT, Personal Communication, April 7, 2016).
- **Higher comfort and satisfaction levels:** Due to lower noise emissions of an electric engine higher comfort and satisfaction levels for both passengers of electrified transportation modes (buses, cars) and pedestrians are reached (F. Sprei, Chalmers University, Personal Communication, March 8, 2016).

General Barriers for Electromobility

- **Need for a common vision and strategy:** Even though city’s policy documents (s. section 6.2.1.2[20] on page 71) have articulated many visions and goals towards a more sustainable transportation system in the city of Gothenburg, and the need for more sustainable mobility solutions there is no clear strategy specifically for developing electromobility. Furthermore, the majority of the interviewees as well as our own understanding and experience demonstrates that the city’s vision looks upon the short term and should be extended. *‘When an overarching vision exists even when working individually not being able to see others’ progress, you have the confidence that you all work for the same purpose* (A. Grauers, Chalmers University, Personal Communication, May 4, 2016)
- **Need for cross boundary collaborative projects:** While investigating the issue of scaling up electromobility and throughout the interviews with the stakeholders approached for this report, the overarching understanding is that even though there are many actors from the triple-helix working on electromobility projects (s. section 6.2.1.3[21] on page 87), they are doing so either individually or in small groups detached from broad collaborations as realised for example with the ElectriCity project (ElectriCity, 2016) (s. section 6.2.1.3 on page 87). This barrier is also related to the absence yet of a broad enough common vision and strategy.
- **Need for financially sustainable business models:** When interviewing private actors (s. section 6.2.1.2[22] on page 74) a widely acclaimed barrier that emerges is the high risk of conducting successful secure business around electromobility solutions. That is mainly because electromobility as a concept apart from the technology per se is still ‘young’ since adequate time but also safety have to be given to the market and private sector for the innovative business models to be proven.
- **Rigidity in the current regime:** The current transportation system either in local or global context is designed and operated from and for traditional

[20] The Socio-technical Regime Level, paragraph ‘Sectoral Policy & Legislation’

[21] The Technological Niche Level, paragraph ‘Initiatives in Cooperation with Chalmers University of Technology’

[22] The Socio-technical Regime Level, paragraph ‘Market & User Practises’

fossil fuel based actors. There is rigidity for newcomers in the market for innovative electromobility solutions to diffuse (U. Jakobsson, Personal Communication, March 21, 2016).

- **Immaturity of Electromobility:** The immaturity of electromobility is apparent in three ways. ① It is encountered in the service side as there are not many actors in the field of EV repairing for electromobility both in numbers but also in certification for all the range of BEVs (F. Sprei, Chalmers University, Personal Communication, March 8, 2016; P. Aldby, Move About, Personal Communication, April 27, 2016). This issue crosses the geographical boundaries of Gothenburg city as it definitely affects users' experience and their choices and could be proven a detracting factor for possible BEV buyers be that individuals or private companies. ② The costs of Li-ion battery packs are still too high to allow for economies of scale to take place (s. section 6.2.1.2[23] on page 74). ③ There is low perceived reliability on the maturity of electromobility from the side of the potential users that hinders consumers from chosing electromobility solutions.

- **Need for visible showcases:** Showcases related to electromobility solutions have to be more visible to the public. A first-class example of this issue is that the city of Gothenburg owns around the 43% of the registered BEVs in the city but that is neither communicated nor shown to the public (A. Sjöberg, Trafikkontoret, Personal Communication, April 21, 2016).

- **High risk for policy makers:** The risk as perceived from the city is high. That is because if they take policy action towards electromobility they might run the risk of sacrificing the funding for other needs (e.g. health care) while the transition to electrification can happen organically in a 'laisser-faire' fashion. On the national level there is the impending risk of sacrificing economic-competitiveness to other countries if investments into electromobility (e.g. via subsidies) are not paying off soon enough.

- **High risk for large companies:** There is a high risk in shifting to electromobility from the large automotive companies such as Volvo Cars as they will have to change their whole production lines, way of conducting business and their business models. Large companies have highly rigid structures in the sense that they are most often locked-in in their path-dependency of how they have been offering their value to the society that any change is perceived as a high risk that may lead into bankruptcy.

- **Need for sustainability awareness of the users:** As A. Roth very aptly describes it during our interview, *'If people were environmentally aware they wouldn't drive ICEVs'* (A. Roth, IVL, Personal Communication, March 3, 2016). There is a need for us, the public, to shift our behaviour to a more sustainable lifestyle and start making more sustainable choices such as using sustainable transport solutions.

[23]The Landscape Level, paragraph 'Market & User Practices'

6.2.2.2 Specific Drivers and Barriers

In the following paragraph, local drivers and barriers for private electrified transportation are presented. Hereby, a comparison to fossil fuel based private transportation as well as public transportation in general is drawn.

Specific Drivers for Private Electrified Transportation

- **Pressure from the landscape level:** Various countries, such as Norway and the Netherlands, and recently also India, have announced to ban selling of fossil fuel based vehicles in the near future (s. section 6.2.1.1[24] on page 69). This creates incentives for Sweden and consequently the City of Gothenburg to act accordingly and provide solutions for electromobility to stay competitive in the long-run.
- **Attractive and sustainable new business models from start-up companies:** With the imminent shift towards a more sustainable transportation system in Gothenburg city new Alternative and Sustainable Business Models, such as BEV-sharing from Move About or the Zbee cars from Clean Motion, are evolving in different niches (s. section 6.2.1.3[25] on page 88). These small start-up companies have an advantage to large companies, such as Volvo, to apply new sustainable business models from the beginning without taking high monetary risks (U. Jakobsson, Move About, Personal Communication, March 21, 2016).
- **Initiatives for charging infrastructure:** Local projects were initialised by Göteborg Energi to install 15 rapid-charging stations (up to 50 kW) and 10 fast-charging stations with 200 poles around the city (F. Persson, Göteborg Energi, Personal Communication, March 7, 2016) (for information on different charging configurations s. section 6.2.1.2[26] on page 83).
- **High level of flexibility:** Compared to public transportation private transportation in general is more flexible for the user and mostly requires a shorter travel time (A. Roth, IVL, Personal Communication, March 14, 2016).
- **Mindset of innovative car owners:** There is an increasing number of users who are willing to participate in driving BEVs and car-sharing to become more sustainable (U. Jakobsson, Move About, Personal Communication, March 21, 2016). BEV-users usually adapt their driving patterns and have no issues with lower travel range and longer 'refuelling' times (F. Sprei, Chalmers University, Personal Communication, March 8, 2016).
- **Attractive driving experience of EVs:** There is no doubt about the attractive driving experience of a BEV as it is silent and highly responsive. Most people who lived with a BEV do not want to shift back to conventional fossil

[24] The Landscape Level, paragraph 'Current benchmarks regarding proactive policy initiatives for electromobility'

[25] The Technological Niche Level, paragraph 'Alternative and Sustainable Business Models'

[26] The Socio-technical Regime Level, paragraph 'Infrastructure'

fuel based cars (F. Sprei, Chalmers University, Personal Communication, May 4, 2016; J. Konnberg, Volvo Cars, Personal Communication, May 4, 2016).

- **Capacity and Knowledge of large companies:** Regarding Tesla as the benchmark of today's BEV-market one can argue that large companies, such as Volvo, have the capacity and knowledge that is required to build a 'Tesla-like' car themselves (S. Pettersson, Viktoria Swedish ICT, April 7, 2016).
- **Local projects and collaborations:** Various stakeholders are involved in many ongoing projects around Gothenburg city, such as *'Drive Me'*, *'BeliEVe'* or *'ELMOB'* (s. section 6.2.1.3[27] on page 88), pursuing the same goal of sustainable transportation based on electromobility (S. Hellberg, Parkeringsbolaget, March 23, 2016). Such collaborative projects are highly important as they create possible solutions and increase knowledge and experience around possible ways of implementing BEVs into the transportation system of Gothenburg city.

Specific Barriers for Private Electrified Transportation

- **Need for standardised charging infrastructure:** Currently, there are multiple connectors in the charging system for EVs, especially for the rapid-charging configuration (s. section 6.2.1.2[28] on page 83). The issue with a non-standardised charging infrastructure is the lack of inter-compatibility for BEV-users of different car brands as well as the lack of inter-operability regarding common identification and communication systems (e.g. payment systems). For that a common system of standardised charging would be vital (A. Edh, Volvo Cars, Personal Communication, April 25, 2016; J. Konnberg, Volvo Cars, Personal Communication, April 13, 2016; D. Bergman, Göteborg Energi, Personal Communication, April 28, 2016)
- **Need for incentives for users and investors:** Reviewing case studies of scaling up electromobility so far worldwide there is the need for both local and national financial or policy incentives (McKinsey and Amsterdam Roundtables Foundation, 2014; Perdiguero and Jimenez, 2012) (s. section 6.2.1.2[29] on page 74). For that, the city , according to the interviewees, has a lot more to do (J. Konnberg, Volvo Cars, Personal Communication, April 13, 2016).
- **Reducing traffic vs. Introduction of BEVs:** By reading the policy objectives from the city (s. section 6.2.1.2[30] on page 71), one can understand that the main goal for the City of Gothenburg is to decrease the usage of vehicles around the city and promote walking, cycling and public transport solutions. At the same time the city's intention is to find ways to promote the scale-up of electromobility solutions, especially when it comes to the private transportation as they want to promote it as the technological solution for a

[27] The Technological Niche Level, paragraph 'Alternative and Sustainable Business Models'
[28] The Socio-technical Regime Level, paragraph 'Infrastructure'
[29] The Socio-technical Regime Level, paragraph 'Market & User Practises'
[30] The Socio-technical Regime Level, paragraph 'Sectoral Policy & Legislation'

cleaner transport system. However, there is a conflict between promoting the usage of vehicles on one hand and intending to reduce their circulation in the city centre on the other.

- **Need for designated parking spaces:** The housing agencies are not yet involved, and right now in the city there is the issue that not all of the parking lots available for residents are equipped with charging infrastructure. That is a serious barrier for possible EV and PHEV users since they are not able to charge their vehicle in their homes (F. Sprei, Chalmers University, Personal Communication, March 8, 2016, S. Hellberg, Parkeringsbolaget, Personal Communication, March 23, 2016; A. Sjöberg, Trafikkontoret, Personal Communication, April 19, 2016)
- **High investment costs for the user:** Nowadays, especially without subsidies, customers perceive the investment on an BEV highly costly which is mainly due to the most expensive part of a BEV, the Li-ion-battery (s. section 6.2.1.2[31] on 74).

6.2.3 Focus Group of Stakeholders

As described in section 5.4.2[32] on page 47, after a holistic investigation of the current transportation system in the city of Gothenburg the scope was narrowed down to private transportation for further in-depth analyses when conducting steps 3 and 4 of the backcasting methodology.

In accordance to the new scope the following stakeholders were focused on as all of them were interviewed and invited to the stakeholder dialogue. A map of the focus group of stakeholders can be found in Appendix B in figure B.2 on page VI.

Stakeholders from the **public sector**:

- Trafikkontoret
  - Malin Andersson: *Head of Department Development and International Affairs*
  - Alexander Sjöberg: *Project Leader - Traffic and Sustainable Transport*
  - Mats-Ola Larsson: *Environmental Advisor Travel and Transport*
- Göteborg Energi
  - Dan Bergman: *Business Developer for EVs and infrastructure charging*
  - Fredrik Persson: *Technical Project Manager in infrastructure for renewable electricity*
- Parkeringsbolaget
  - Stefan Hellberg: *Strategic Business Development - Sustainable Transportation*

[31]The Socio-technical Regime Level, paragraph 'Market & User Practises'
[32]Adjustment of the Scope

    - Anna Wideman: *Strategic Business Development - Car-sharing and parking infrastructure*

Stakeholders from the **private sector**:

- Volvo Cars
    - Johan Konnberg: *Senior Project Manager - Electric Propulsion Systems*
    - Axel Edh: *Senior Strategic Advisor - Environment*
- Move About
    - Ulf Jakobsson: *Marketing Director*
    - Peter Aldby: *After Sales Manager*

Stakeholders from the **academic sector**:

- Chalmers University of Technology
    - Frances Sprei: *Assistant Professor at Energy and Environment - Sustainable Transportation*
    - Anders Grauers: *Associate Professor at Signals and Systems - Automatic control research group*
- Johanneberg Science Park
    - Ulf Östermark: *Director Open Arena - Energy*
- Viktoria Swedish ICT
    - Stefan Pettersson: *Research Manager Electromobility*
- IVL - Swedish Evironmental Research Institute
    - Anders Roth: *Director Business Development*

6.3 Backcasting Step 3 - Designing Solutions and Scenarios around Electromobility

In this section the results from backcasting step 1 and 2, the sustainability criteria (s. section 6.1.2 on page 61) and identified barriers (s. sections 6.2.2 on page 90), are addressed here for the generation of the *functions*, *solutions* and final *concepts* that may contribute to a transition of the current transportation system to reach our vision (s. section 6.1.1 on page 59). The methodology followed in order to acquire the following results on backcasting step 3 are described in section 5.5 on page 48.

Firstly, the generated potential future *solutions* and *concepts* are shown (s. section 6.3.1) and, subsequently, the results from the scenario development method with four possible future scenarios (s. section 6.3.2 on page 101). This is followed by the proposal of the most desirable future scenario 'A Green New Deal' and a brief analysis behind its proposal (s. section 6.3.3 on page 109). Lastly, the results from the quantitative evaluation of potential future *concepts* are presented and selectively motivated (s. section 6.3.4 on page 111).

6.3.1 Potential Future Solutions and Concepts

As described in section 5.5[33] on page 48 based on (Söderberg, 2014), the problematic in this section is to develop potential solutions that are:

1. Fulfilling the sustainability criteria;
2. Bridging the gaps between the present state and the envisioned future (overcoming the barriers);
3. Being robust (can exist) in the proposed desirable scenario.

Firstly, the task was to generate a list of *functions* that describe in an abstract manner the ways to meet the barriers and the *requirements* (sustainability criteria). That 'tension' between the identified barriers in step 2 (s. section 6.2.2 on page 90) was the basis for the formulation of abstract *functions*. The relation between the compiled *functions* and *solutions* is mainly an abstract causality. It is important to note that the proposed *solutions* may fulfil multiple *functions* and that the same *function* may apply for different *solutions*. An overview of these causalities can be found in tables C.1, C.2 and C.3 in the Appendix C on page IX.

'Sharing Models': Here, different aspects of sharing models are proposed in order to achieve higher efficiency of resources, allocation of the environmental burden and introduction of sharing in a social context bringing societal actors closer.

'Changing the Game with strong Policies': The need to achieve a sustainable transportation in the future comes with the functions of having access to cleaner cities and to do so with the obligation to promote cleaner transport through strong policies.

[33] Backcasting Step 3 - Designing Solutions and Scenarios around Electromobility (Theory)

'The Power of Vision': The barriers demonstrated a need for collaborative strategies and for broader synergies. In order to achieve that, actions related to an overarching vision for electromobility have to be in place.

'Convenient Charging': In order for electromobility to diffuse, solutions have to be flexible, accessible and convenient for the users to choose them over other alternatives. To make the charging experience more convenient for the user is one solution to make EV in general more attractive.

'Try it and you will like it': In order to enhance and prove the reliability of electromobility, the possibility to test and experience electromobility services, technologies and features has to be given to the user.

'Education for Sustainability': On the way to a sustainable electrified transportation system where sustainable choices are made intuitively, different ways of education for sustainability have to be offered. Education can also bring to light yet unknown electromobility cases and accelerate their diffusion.

'Rapid Technology Development': The support for rapid technology development solutions can offer technological reliability since the technology is improved and access to clean city is granted through cleaner technological innovations. In addition, 'Rapid Technology Development' provides higher efficiency of resources and potentially higher convenience for the user.

'Doing well by doing good' Providing the means to potentially have win-win functions of contributing to the common good while improving oneself, the attractiveness for electromobility rises while social capital value is added.

By listing *solutions* from the identified *functions*, a broad range of options and possibilities is presented for bringing the system closer to a sustainable state. The next task to be accomplished was to create more concrete and specific *concepts* on how to provide the future *solutions*. Hence, for every *solution* 'package' a set of different *concepts* was created. These *concepts* are described very shortly and simplistically without examining their technological, institutional or regulatory specifications, as Dreborg (1996) quotes that *'[...] the merits of backcasting should be judged in the context of discovery rather than in the context of justification.'*

'Sharing Models'

Shared autonomous BEVs with Decentralised Parking: Shared autonomous BEVs are constantly circulating around the city, serving users as the *Uber* (Uber, 2016) of the future and only park in parking areas outside the city centre when to be recharged or not summoned by a user.

Share-the-Ride Platform: A platform on which users can communicate and arrange to share a part of or the whole car trip, be that a commuting trip or a leisure one. Users share any type of car (both conventional ICEVs and any type of EV).

Shared Parking Space: The parking space for residents is no longer strictly owned by one user or apartment owner. The parking lots are flexible by allowing for residents to share the parking space, providing rotational sharing patterns for EV services, such as charging.

'Changing the Game with Strong Policies'

Zero Emission Zones: Gradual implementation of zones in the city where only vehicles of zero emissions are allowed to enter, starting from the core city centre.

Banning to sell new Fossil-based Cars: The new fossil fuel based cars are forbidden to be sold, to steer people to choose cleaner alternatives, such as electromobility.

Strong increase of CO_2 taxes: The carbon tax gradually will be increased significantly for the people to turn to electromobility solutions.

Bonus-Malus System: The Bonus-Malus system will favour users of clean light vehicles with direct subsidies that will be accommodated by the financial contributions made from the owners of high emitting fossil fuel based vehicles.

'The Power of Vision'

A common Vision and Strategy: A common overarching vision and strategy with main purpose the development of electromobility as a means to achieve sustainable transportation in the future will be created and communicated to all the city and the local stakeholders.

Cross-boundary Collaborations (Triple-Helix): Cross-boundary collaborations of the triple-helix develop under the set vision, focusing on electromobility.

Multi-Stakeholder Dialogues: Local interdisciplinary dialogues are organised, where local stakeholders exchange views and knowledge on electromobility and make potential commitments on further joint actions.

'Convenient Charging'

Inductive Charging: Wireless charging technology via induction taking away the necessity of charging equipment.

Smart payment systems: User-friendly payment systems where the operators of charging points provide EV charging services to customers on a contractual but also on an ad-hoc basis.

Standardised charging: Common charging infrastructure for both fast- and rapid-charging accessible for any type of EV regardless of the brand.

Ultra-rapid charging: Charging stations that allow for recharging at the same or competitive time of refuelling a conventional ICEV at a petrol station.

Coordinated Charging: A smart charging system connected to the local electricity grid allowing for coordinated charging of EVs by distributing the load over a whole day depending on both supply and demand to maintain grid-stability.

'Try it and you will like it'

Trialability Programmes: Any type of showcase-event, campaign or service that can allow potential users to test and experience electromobility solutions and services.

'Education for Sustainability'

Sustainability Workshops: Workshops on sustainable transportation and people's behaviour and choices, organised by local authorities with the participation of users, car dealers and other local stakeholders.

Innovation Contests: Monthly competitions organised by private and/or public actors seeking for innovations on the field of sustainable transportation.

Awareness Campaigns: Campaigns organised by the City of Gothenburg supported by the media with a focus on raising awareness on sustainable choices in transportation.

Peer-to-peer Platforms: Platforms where EV owners share opinions, knowledge and experiences with other owners and potential electromobility users.

'Rapid Technology Development'

Investment in R&D for Green Technology: Considerable investments from public authorities into research programmes for electromobility, renewable energy systems, battery technologies and recycling processes.

Local Renewable Power Production and Energy Storage: Continuous installation of advanced technologies for local power production technologies from renewable energy sources and local energy storage for users and residents.

Advanced ICT solutions: Highly advanced and digitalised technologies for a high level of interconnectedness among electric devices, houses and vehicles (Internet of Things[34]).

'Doing Well by Doing Good'

Generation of Research Projects for sustainable Business Models: Include Academia in seeking for sustainable models for successful entrepreneurship.

6.3.2 Future Scenarios

In this section, the intermediary results acquired throughout the methodology of developing future scenarios, as described in section 5.5.2[35] on page 50, are presented

[34]Internet of Things is defined as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ITU, 2012)

[35]Development of Future Scenarios

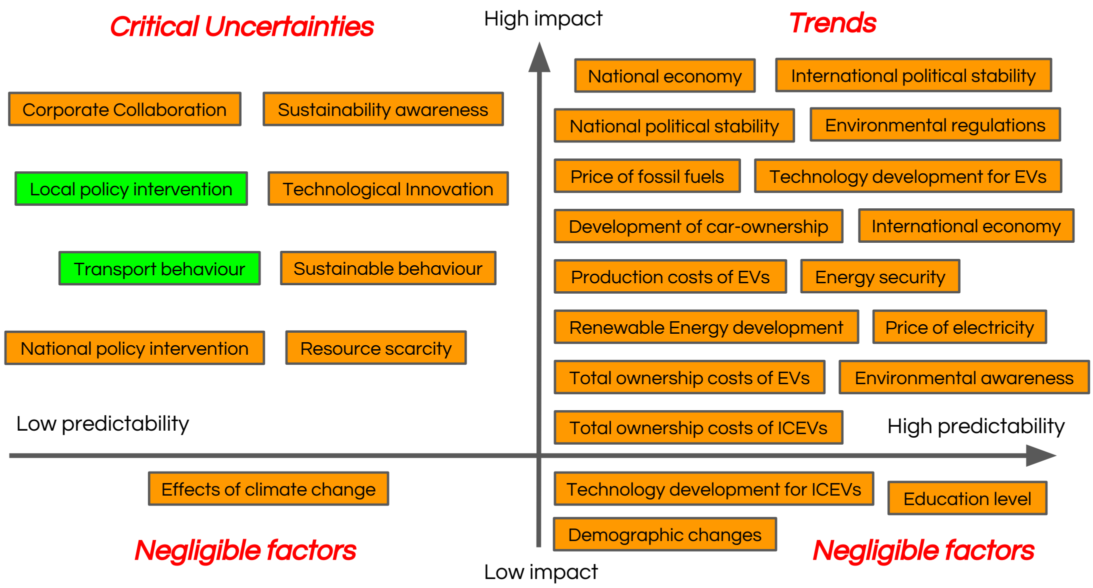

Figure 6.17: Sorting of external factors based on predictability and impact.

in a step-by-step fashion. The sorting (step 2) and classification (step 3) of the identified external factors (step 1) including a brief elaboration on each of the factors is presented in section 6.3.2.1. This is followed by the selection of critical uncertainties as the basis for the future scenarios (step 4) including an elaboration on their extreme values in section 6.3.2.2 on page 107. Lastly, in section 6.3.2.3 on page 109, the final four future scenarios are presented (step 5) including a label and a brief description.

6.3.2.1 Sorting and Classification of External Factors

Through our experience with the analysis undergone in backcasting step 2 (s. section 6.2 on page 64) we were able to identify external factors that influence the socio-technical innovation system of electromobility in the city of Gothenburg. After the identification (step 1), the sorting (step 2) based on the predictability and impact followed as shown in figure 6.17. The classification (step 3) of the critical external factors[36] as well as negligible or non-critical external factors[37], as illustrated in figure 6.17, is a result of literature review and assumptions based on our critical thinking and intuition. In the following section a short analysis of the allocated external factors is given.

The critical factors are distinguished between 'Critical Uncertainties (U)' with high impact and low predictability and 'Trends (T)' with high impact and high predictability in relation to scaling up electromobility in Gothenburg city. The negligible factors (N) are characterised by their generally low impact.

[36]s. paragraphs 'Critical Uncertainties' on page 103 and 'Trends' on page 104
[37]s. paragraph 'Negligible Factors' on page 107

Critical Uncertainties (U)

Local Policy Intervention (U)

So far, the local policy makers in Gothenburg city, even though they have been active in providing an adequate visionary background for a sustainable transportation (City of Gothenburg, 2014a; City of Gothenburg, 2014b) (s. section 6.2.1.2[38] on page 71), they have not practically initiated strong policies to favour the diffusion of electromobility, especially when it comes to personal transport (also in comparison with other benchmark initiatives (s. section 6.2.1.1[39] on page 69). Keeping that in mind, it seems uncertain in the future how much local policy makers are willing to intervene or not in the city of Gothenburg.

National Policy Intervention (U)

In comparison to other nations, Sweden is considered modest in regards to electromobility without explicitly choosing vehicle technology (Sprei et al., 2014). However, intentions for sustainable transportation, such as the national government bill (Government Offices of Sweden, 2016), are apparent. Hence, it remains uncertain how strong the intervention policy will be on a national level in Sweden.

Corporate Collaboration (U)

There is the uncertainty for the future whether or not corporate actors around electromobility will engage in more symbiotic relationships and schemes (e.g. sharing resources, participating in broad collaborative endeavours) or will move towards individualistic operation. In this uncertainty, it is unknown how the future development of electromobility would be affected.

Transport Behaviour (U)

By describing the development of transport behaviour as a critical uncertainty in the future is meant whether future transport choices from users will shift towards more collective or individualistic transport solutions. This behavioural variation would also determine the technologies and services developed around electromobility to a great extent.

Sustainable Behaviour (U)

This identified uncertainty is directly related to the users' choices and lifestyle. It is uncertain even when people will be sustainably aware whether we will turn to more sustainable choices of transport or not (A. Roth, IVL, Personal Communication,

[38]The Socio-technical Regime Level, paragraph 'Policy & Legislation'

[39]The Landscape Level, paragraph 'Current Benchmarks on Proactive Policy Initiatives for Electromobility'

March 3, 2016). When talking about scaling up electromobility, as long as the reliability of the technology is proven enough, the users' behaviour and choices consist a vital factor for the diffusion.

Resource Scarcity (U)

Material security is extremely important to be there for the sustainable development of electromobility. As described in backcasting step 2 (s. section 6.2.1.1[40] on page 68), there are too many parameters and variables to provide us with safe conclusions on whether or not material and resource scarcity pose or not a threat to the future development of electromobility. .

Technological Innovation (U)

Technological innovations are bound to happen in the future since we go through a highly innovative era. However, the uncertainty lies upon the time-frame as well as the relevance of the technological innovation with electromobility solutions.

Sustainability Awareness (U)

There is the uncertainty lies upon three factors: ① Whether in the future people will be aware of the concept of sustainability, ② whether that will affect their actions and behaviour towards electromobility and ③ how fast this awareness will grow.

International Economy (U)

Following the recent financial crisis of 2008, the geopolitical instability and conflicts in regions such as Middle East and other global imbalances, the future of the global economy is highly uncertain. In a globalised economy that might affect issues related to the diffusion of electromobility, such as technological development, allocation of funds for research or policies or availability and accessibility of resources.

Trends (T)

Political Stability (T)

Here it is assumed that the political stability will continue to prevail on national as well as on a local level. Political stability is important to be in place for such a systemic transition as the shift from fossil fuel based to electrified transportation to happen.

[40] The Landscape Level, paragraph 'Geopolitics and Energy and Resource Security'

Technology Development of EVs (T)

Electromobility can be considered as a growing 'hype' among scientists and corporate actors leading to more and more scientific publications and investments on electromobility. Thus, it is considered that technology development of EVs will grow and advance in the future.

Environmental Regulations (T)

As mentioned in step 2 (s. section 6.2.1.1[41] on page 67), it is thought that environmental regulations will increase and intensify in the future. As a result, stricter environmental regulations will favour cleaner technologies, such as electromobility.

Electricity Price (T)

Taking into consideration the analysis conducted in backcasting step 2 (s. section 6.2.1.2[42] on page 74, the electricity price will most probably drop in the long run as it is assumed that more and more renewable energy solutions will enter the electricity mix with very low variable costs in comparison with conventional fossil fuel based solutions.

Price of Fossil Fuels (T)

In the same line of argumentation for the electricity price, taking into consideration the electricity price trends (s. section 6.2.1.2[43] on page 74 where a clearly increasing Fossil Fuels price is depicted, we assume that continuous introduction of renewable energies and stricter environmental regulations will drive the fossil fuel price to even higher levels (s. also section 6.2.1.1[44] on page 67). High levels of pricing for fossil fuels will promote cleaner technologies that are propelled with inexpensive renewable energy systems.

National Economy (T)

Swedish Economy is characterised stable and secure. In fact looking at the country's Gross Domestic Product (GDP), one can see that it has been growing steadily for the past years even during the financial crisis of 2008 and the stagnation of the EUR currency. As we saw in backcasting step 2, political support both on national and local level is needed for the user to choose electrified solutions over alternatives. Thus, national economy is highly crucial for the future of electromobility.

[41] The Landscape Level, paragraph 'Global Contemporary Challenges'
[42] The Socio-technical Regime Level, paragraph 'Market and User Practises'
[43] The Socio-technical Regime Level, paragraph 'Market and User Practises'
[44] The Landscape Level, paragraph 'Global Contemporary Challenges'

Production Costs of EVs (T)

The production cost for EVs is still high mainly due to the high price of battery packs. However, it is declining slowly and a long-term drop is expected through a technological evolution in the future (McKinsey and Amsterdam Roundtables Foundation, 2014) (s. also section 6.2.1.2[45] on page 74).

Total Ownership Costs of EVs (T)

Similarly to the production costs above, the Total Costs of Ownership (TCO) will drop as the battery costs will decrease.

Total Ownership Costs of ICEVs (T)

The Total Costs of Ownership (TCO) of ICEVs is expected to grow as fossil fuel price is expected to grow and stricter environmental regulations will be in place in the future. This increase will most likely promote EV diffusion as the price gap between them and the conventional vehicles will be decreasing.

Renewable Energy Development (T)

The development of renewable energy systems is expected to grow considerably in the future accompanied by a gradual phase-out of nuclear energy (Energy use in Sweden, 2016; Swedish Energy Agency, 2015). A more sustainable electricity mix renders electromobility solutions even cleaner.

Energy Security (T)

The steady and reliable energy supply is vital for the diffusion of electrified transport.GHG-free energy supply is considered secure in Sweden and will remain as such for the years to come (Swedish Energy Agency, 2015).

Development of Car-Ownership (T)

With more and more innovative models that suggest an alternative in car-ownership mainly when it comes to urban mobility (s. section 6.2.1.3[46], on page 87) one could expect further development of such models in the future. Electromobility is already promoted as a solution for urban mobility and is closely connected with such models.

[45]The Socio-technical Regime Level, paragraph ‘Market and User Practises’
[46]The Technological Niche Level

Negligible Factors (N)

Effects of Climate Change (N)

The effects from climate change are highly unpredictable. However, since the phenomenon is so chaotic (wicked), in the way it impacts the globe and its subsystems, we consider that it does not cause any first-order effects on our local system in focus. It causes indirect ones, such as stricter environmental regulations, that are already taken into account as separate entity in the trends.

Education Level (N)

Education level is highly predictable that will rise in the future in Sweden. However, the first-order effect is considered rather low.

Technology Development for ICEVs (N)

Technological evolution for ICEVs is expected to grow in the coming years as environmental regulations will drive fuel efficiency advancement. However, the technology improvement will not make such a first-order effect on the willingness to choose an EV over an ICEV from the user.

Demographic Changes (N)

As described in step 2 (s. section 6.2.1.1[47] on page 66), the urban population of Gothenburg city is thought to grow noticeably in the future. Higher population figures in the cities, potentially affect the future of electromobility in various ways both negative and positive (e.g. more consumers, more congestion in the cities, etc.) but the impact is indirect, and considered low.

6.3.2.2 Critical Uncertainties and Extreme Values

The two critical uncertainties that were chosen for the scenario design are meeting the two criteria, as described in section 5.5.2[48] on page 50), of being highly relevant but at the same time unrelated. Meanwhile, considering the highly participatory character and the purpose of this thesis, the uncertainties should be broad and general enough, but also relevant to the intentions of our closest stakeholder, the Urban Transport Administration (Trafikkontoret) as the results would be potentially used as input for their future strategies towards electromobility. At the same time, throughout the interviews one of the factors that the stakeholders would keep addressing was the user perspective and the need for including the user behaviour in our attempts to ‘predict’ the future. Hence, the uncertainties we chose,

[47]The Landscape Level, paragraph ‘Urbanisation and Demographic Change’
[48]Development of Future Scenarios

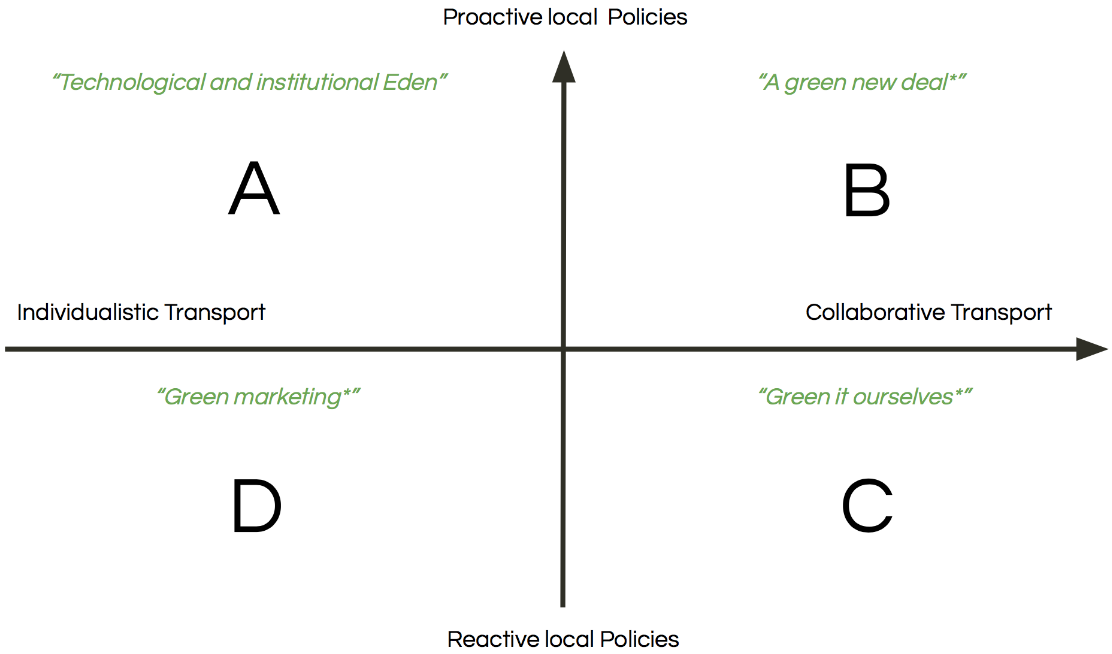

Figure 6.18: The four generated scenarios and their labels (labels with * inspired by Bontoux and Bengtsson (2015).

were ① **local policy intervention** reflecting the intervention form Urban Transport Administration and other local public administrative actors and ② **transport behaviour** reflecting the user's intentions.

For the generation of the two extreme values for the critical uncertainty of **local policy intervention**, the term was specified as **'local policy intervention for sustainable transportation'**. The two potential extreme values that are uncertain for the future is whether the local policy will be *proactive*, promoting sustainable transportation solutions, or *reactive*, meaning that the market will be left to self-regulate itself and the promotion of sustainable transport will only happen passively after stimuli from the market and the users. As can be seen in figure 6.18 the extreme value of proactive policies is placed on the positive part of y-axis and the reactive ones the negative one.

For the generation of the two extremes for the critical uncertainty of **transport behaviour**, two trends of user behaviour were selected: A future extreme in which users tend to choose collaborative means of transport and an other extreme in which users tend to choose more individualistic ones. More specifically, the *individualistic transport* describes a future in which modes, means, patterns, habits and business models are done privately and in an individualistic fashion. On the other hand, *collaborative transport* proposes a future where public transport is primary option and ownership of means of transport is challenged, being more 'fluid' than in present. As can be seen in figure 6.18 on page 108 the extreme value of collaborative transport is placed on the positive part of x-axis and the individualistic on the negative one.

6.3.2.3 A proposal of Future Scenarios

The following four equally probable scenarios stem from the crossing of the uncertainties axes and can be seen in figure 6.18 on page 108. They may be described as follows:

- **Scenario A: *'Technological and Institutional Eden'***
  - Strong local policies and regulations proactively guide towards a more sustainable mobility system while users tend to choose individualistic transport solutions.
- **Scenario B: *'A Green New Deal'***
  - Strong local policies and regulations proactively guide towards a more sustainable mobility system while users tend to choose collaborative transport solutions.
- **Scenario C: *'Green It Ourselves'***
  - No early political action on the local level towards a more sustainable mobility system is taken and the market is self-regulated while users tend to choose collaborative transport solutions.
- **Scenario D: *'Green Marketing'***
  - No early political action on the local level towards a more sustainable mobility system is taken and the market is self-regulated while users tend to choose individualistic transport solutions.

6.3.3 'A Green New Deal' - A desirable and sustainable Future Scenario

In this section, the reasoning for proposing Scenario B - 'A Green New Deal' - for the transportation system of Gothenburg city in 2050 is presented and some key aspects are highlighted. As briefly described in section 6.3.2[49] on page 101, 'A Green New Deal' is characterised by a system in which:

'Strong local policies and regulations proactively guide towards a more sustainable mobility system while users tend to choose collaborative transport solutions.'

In order to effectively implement electromobility as a technical solution into the transportation system of the future and at the same time provide sustainable transportation, two transitions have to be brought about:

1. The transition from a fossil fuel based to an electrified transport system.
2. The transition from an unsustainable to an ecologically, economically and socially sustainable transportation system ensuring well-being in the present and the future.

[49] Future Scenarios

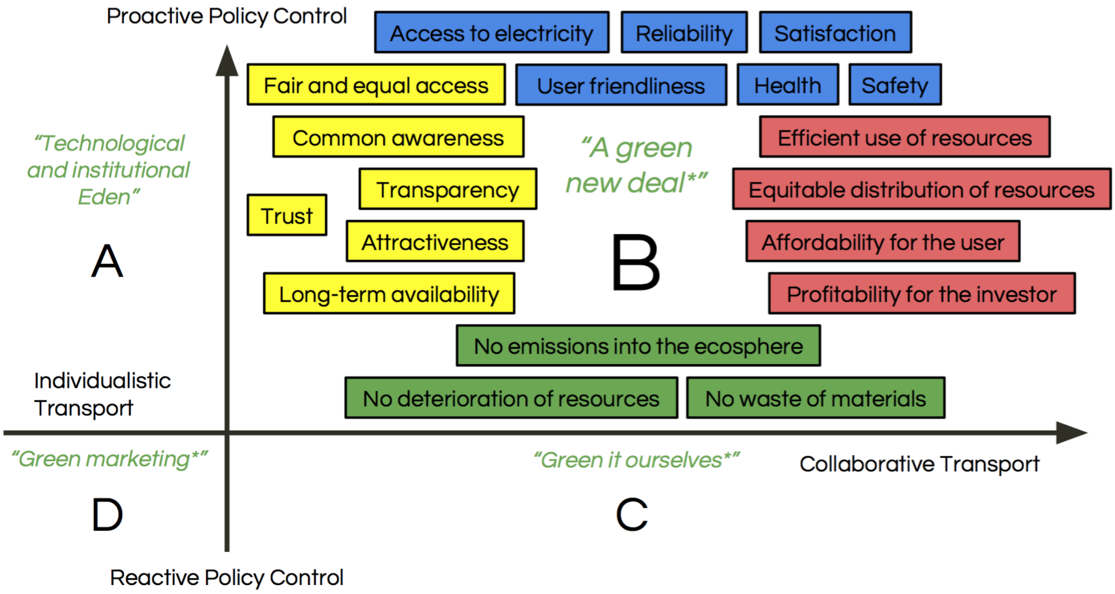

Figure 6.19: The Sustainability Criteria within Scenario B 'A Green New Deal'.

For both of these transitions to be realised, we propose scenario B - 'A Green New Deal' - which involves proactive policies for an effective transition into electromobility (dimension 1) and collaborative transport solutions for a truly sustainable transportation system (dimension 2). This framework allows the sustainability criteria to be placed inside the two dimensions (s. figure 6.19 on page 110) and for them to be met by different combinations of the proposed *concepts* generated at the beginning of backcasting step 3 as presented in section 6.3.1[50] on page 98. Finally, it is important to note that the proposal of Scenario B is supposed to create an inspirational framework or 'playground' for stakeholders engaging themselves with the challenge of scaling up electromobility in the city of Gothenburg to do so by respecting the sustainability criteria. A detailed description of 'A Green New Deal' is not intended as this could lead to limited imagination for ways to procure both of the aforementioned transitions.

Proactive Policies for an Effective Transition into Electromobility

Strong local policies that proactively guide towards a more sustainable mobility system were chosen over reactive policies to allow for an effective transition into electromobility. The perception from the interviewed local stakeholders but also the 'landscape pressure' renders the transition to a clean electrified transport an urgent matter. Hence, we believe that strong proactive policies are required in order to make this transition happen in a coordinated and thus more efficient way in terms of time, financial and physical resources. In addition, a guidance from local authorities can lead by example by providing incentives for stakeholders to invest in and for making electromobility solutions more affordable for potential users. Furthermore,

[50] Potential Future Solutions and Concepts

proactive action from local authorities can promote common awareness and aim for fair and equal access from every citizen. Finally, by investigating the culture and norms in Gothenburg (s. section 6.2.1.2[51] on page 86) it became apparent that the transition from fossil fuel based to electrified transportation will not be induced by the users themselves (reactive) but rather the local policy-makers as the common environmental and sustainability awareness is still too low.

Collaborative Transport Solutions for Sustainable Transportation

Collaborative transport solutions were chosen over individualistic transport solutions to allow for truly sustainable transportation, based on electromobility as a solution, to be realised. We believe that collaboration amongst users and sharing of transport solutions or services instead of individualism and private ownership is highly required in order to shift the transportation system into a ecologically, economically and socially more sustainable state: ① *Ecologically* because by sharing means of transport the environmental footprint is shared. Thus the emissions, materials and the deterioration of resources if any are allocated and the total environmental pressured is mitigated. ② *Economically* because with sharing models, resources are used more efficiently and distributed equitably. ③ *Socially* because sharing models facilitate the development of trust and transparency among the users and have the potential to become attractive if designed properly.

6.3.4 A Proposal of Future Concepts

This section presents the results of the quantitative evaluation of potential future *concepts* following the methodology described in section 5.5.4[52] on page 52. Hereby, focus is put on *concepts* with a very high Sustainability Score (SS) (s. section 6.3.4.1[53]) and a very high Electromobility Score (ES) (s. section 6.3.4.2[54] on page 116) as well as sustainability criteria and barriers with a very low concept Score CS (s. sections 6.3.4.3[55] on page 118 and 6.3.4.4[56] on page 120). The circled numbers in the following sections correspond to the numbers given to the sustainability criteria as well as the main identified barriers to facilitate their classification. The final results of the quantitative evaluation of all the future *concepts* are given in Appendix C.2 on page XII.

As already mentioned in section 5.5.4 on page 52 it is important to note that the results of this evaluation are highly dependent on the character of all the proposed *concepts* and our personal understanding of their interrelation to the sustainability criteria and the identified barriers to scale up electromobility. Generally one can say that all of the evaluated future *concepts* have a positive Robustness Score (RS) and

[51]The Technological Regime Level, paragraph ‘Culture & Norms’
[52]Evaluation of Potential Future Concepts (Methodology)
[53]Concepts for Sustainability
[54]Concepts for scaling up Electromobility
[55]Critical Sustainability Criteria
[56]Critical Barriers

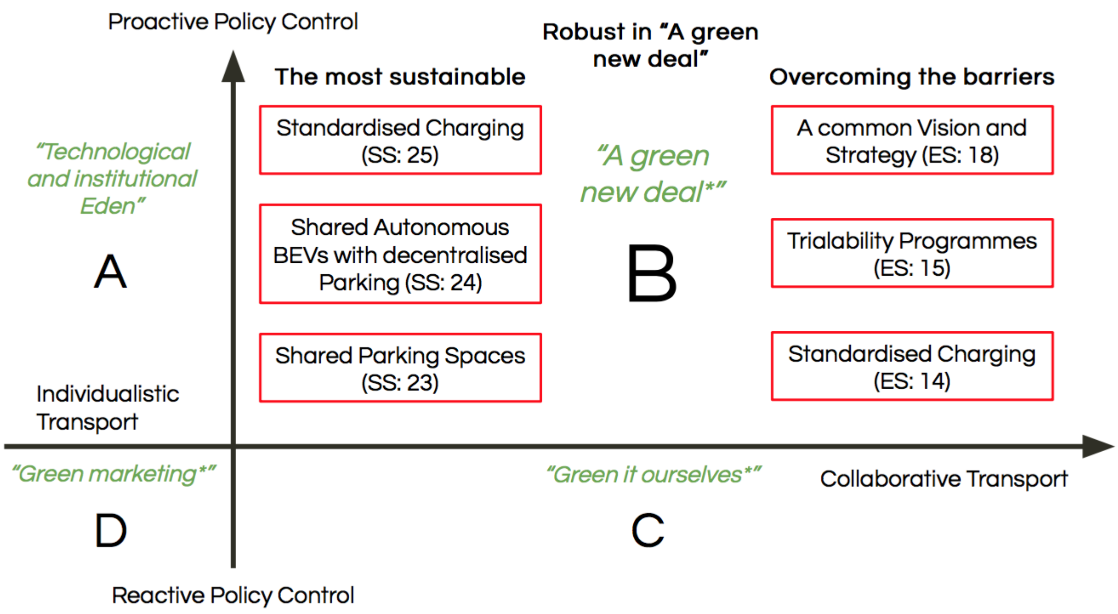

Figure 6.20: A proposal of three concepts each with the highest SS (the most sustainable) and ES (overcoming the main barriers) as well as a positive RS (robust in 'A Green New Deal').

therefore can exist in scenario B 'A Green New Deal', meaning they can exist in a future with both local proactive policies and users preferring collaborative transport solutions. However, some of the *concepts* are even promoting proactive policies, such all *concepts* of the *solution 'Changing the Game with strong Policies'* or *'The Power of Vision'*, and collaborative transport solutions, such as the *solution 'Sharing Models'* or the *concept 'Zero Emission Zones'*. Overall, 67% of the *concepts* are promoting proactive policies and only 17% are promoting collaborative transport solutions.

6.3.4.1 Concepts for Sustainability

The following three *concepts*, *'Standardised Charging'*, *'Shared Parking Spaces'* and *'Shared Autonomous EVs with Decentralised Parking'*, can be considered to meet most of the sustainability criteria and therefore highly contribute to the development into a more sustainable transportation system built around electromobility in Gothenburg city.

Standardised Charging (SS: 25)

The *concept 'Standardised Charging'* has the highest SS with 25 out of a possible maximum of 38. This is due to its overall positive impact on all of the four sustainability dimensions as it meets or improves 89% (17 out of 19) of the sustainability criteria.

The **Ecological Sustainability** benefits as *'Standardised Charging'* ① highly reduces emissions into the ecosphere by replacing conventional gas-stations and allowing for increased usage of EVs as a zero-emission technology, ② less materials and substances are extracted by allowing for a higher usage rate of existing charging stations and consequently leading to less charging stations needed overall and ③ is not deteriorating any resources, such as water, air or land, again for the same reason as mentioned in ①.

The **EconomicSustainability** benefits as *'Standardised Charging'* ④ uses resources more efficiently for the same reason as mentioned in ②, ⑤ allows for an equitable distribution of resources or in this case the charging stations themselves since every EV regardless of the car brand has access to the existing charging infrastructure, ⑥ can be affordable for the EV user since regulations (e.g. subsidies for EVs) and overall production, distribution and installation processes will be optimised for a single unified charging configuration which lowers the overall investment costs for the investor and ultimately the costs for the user (e.g. for charging equipment), and is thereby ⑦ profitable for the investor as is also allows for a higher usage rate of each installed charging station and thereby leads to a higher revenue for the investor or owner.

The **Societal Sustainability** benefits as *'Standardised Charging'* ⑧ raises common awareness by convincing more users to shift towards electromobility solutions and thereby implementing the importance of sustainable development into their mindset, ⑨ is more attractive for any EV user by being more convenient, ⑩ ensures a long-term availability of the technology and consequently the user as there is usually no incentive to choose a non-standardised solution over a standardised one, ⑪ allows for fair and equal accessibility amongst every EV user, ⑫ increases trust between user and provider and ⑬ possibly enhances transparency since simultaneous efforts for making the standardised charging stations more visible and accessible (e.g. via smart-phone app) can be expected.

The **Well-being** of the user benefits as *'Standardised Charging'* ⑮ creates the demand for access to electricity by strengthening the charging-infrastructure simultaneously, ⑯ improves user-friendliness by being more convenient, ⑰ increases satisfaction while ⑱ enhancing the reliability of electromobility by ensuring the user of any EV, be it a Tesla, a Nissan or a Mercedes, to charge at any charging station.

The only sustainability criteria that are not necessarily improved by *'Standardised Charging'* are ⑭ Health and ⑱ Safety making it the most desirable concept in regard to the four sustainability dimensions.

Shared Autonomous BEVs with Decentralised Parking (SS: 24)

The *concept 'Shared Autonomous BEVs with Decentralised Parking'* scores 24 of 38 points making it, along with *'Shared Parking Spaces'*, the second most sustainable *concept*. This is mainly due to its excellent SS in the well-being and societal dimension. However, it meets or improves only 79% (15 out of 19) of the sustainability criteria.

The **Ecological Sustainability** benefits as *'Shared Autonomous BEVs with Decentralised Parking'* ① avoids emissions into the ecosphere by replacing conventional fossil fuel based vehicles with BEVs, ② ensures no over-extraction of materials or substances as less vehicles are needed for the same amount of people transported over a day by constantly circulating in traffic which finally leads to a lower total number of vehicles in the city and therefore a lower consumption of materials used for the production of vehicles, ③ is not deteoriating resources, such as air, water and land, for the same reason as mentioned in ①.

The **EconomicSustainability** benefits as *'Shared Autonomous BEVs with Decentralised Parking'* ④ uses resources more efficiently as the vehicles are in use most of the time and only parked during charging periods when their batteries may also serve as energy storage, increasing their economic value even further.

The **Societal Sustainability** benefits as *'Shared Autonomous BEVs with Decentralised Parking'* ⑧ raises common awareness by being a very visible and ⑨ attractive showcase, ⑩ ensures long-term availability as a technology if the materials of all components, especially the batteries which use REEs, are recycled, ⑪ improves fair and equal accessibility, especially for older people or people with special needs allowing them to be picked up and dropped anywhere around the city without further assistance, ⑫ enhances trust amongst users as a fundamental principle when it comes to *'Sharing Models'* and ⑬ allows for transparency by allowing users to have insights, for instance via smart-phone app, into where available vehicles are located, who is or will be using them, to which level their batteries are charged and how long it will take them to get to their destination.

The **Well-being** benefits as *'Shared Autonomous BEVs with Decentralised Parking'* ⑭ contributes to cleaner cities due to zero local emissions (e.g. carbon monoxides, nitrogen oxides) and thereby ensures higher health levels and also offers almost noiseless trips reducing overall stress levels, ⑯ is highly user-friendly as it picks up and drops off the user anywhere around the city, ⑰ most likely leads to a higher satisfaction of the user because of ⑯, ⑱ highly increases the safety during inner city travels since self-driving vehicles have to follow strict safety regulations (Ni and Leung, 2015) and ⑲ can be considered to be very reliable once fully implemented into the transportation system as they can predict traffic and driving patterns more accurately.

The only sustainability criteria that are not necessarily improved by *'Shared Autonomous BEVs with Decentralised Parking'* are mostly related to the economic criteria as it is highly uncertain whether ⑤ resources, meaning the vehicles themselves, are distributed equitably and ⑥ affordability for the user as well as ⑦ profitability for the investor can be ensured. Finally ⑮ access to electricity is not necessarily granted for every user as vehicles are charged autonomously in decentralised parking areas compared to personal EVs that allow for charging at home.

Shared Parking Spaces (SS: 23)

The *concept 'Shared Parking Spaces'* scores 23 out of 38 points making it, along with *'Shared Autonomous BEVs with Decentralised Parking'*, the second most sustainable *concept*. This is due to its mostly positive impact on all of the four sustainability dimensions. It meets or improves 84% (16 out of 19) of the sustainability criteria.

The **Ecological Sustainability** benefits as *'Shared Parking Spaces'* (1) potentially decrease the overall emissions into the ecosphere as shared parking spaces may reduce inner city traffic by limiting the total amount of parking spaces, assuming still a considerable share of fossil fuel based vehicles, (2) ensure no over-extraction of materials and substances as no excessive use of materials is required and (3) do not deteriorate any resources, such as water and land, as, due to less traffic and efficient use of space; the air quality may be considerably improved.

The **Economic Sustainability** benefits as *'Shared Parking Spaces'* (4) use available resources, namely the parking spaces, more efficiently ensuring a high usage and rotation rate and thereby increase their economic value, (5) allow for an equitable distribution of resources by aiming at meeting any user's (EV or ICEV user) actual need for parking, especially in parking areas connected to apartments, by granting common accessibility across different apartment blocks and encouraging the users to avoid long occupancy times of the parking spots, (6) is most likely affordable for the user and (7) profitable for the owner or investor since both the usage and rotation rate is high opening up for new business models in which parking fees for the user may be dropped by still ensuring a good revenue for the owner.

The **Societal Sustainability** benefits as *'Shared Parking Spaces'* (8) require common awareness amongst all the users to be realised which therefore might be increased by a demand-pull effect, (10) ensures long-term availability for every user as there is no ownership over the parking spaces, (11) are supposed to guarantee fair and equal accessibility for every user as nobody is privileged, (12) strongly requires and therefore enhances trust amongst users by fostering collaboration rather than individualism and (13) allows for increased transparency if insights into the availability and usage patterns of parking spaces, for instance via smart-phone app, are given to the user.

The **Well-being** benefits as *'Shared Parking Spaces'* (14) increase the overall health level of the citizens due to lower local emissions (e.g. carbon monoxides, nitrogen oxides) as a result of reduced traffic in the city, (15) highly require access to electricity on enough parking spaces, depending on the demand, to attract EV users, (16) highly improves user-friendliness and therefore (17) satisfaction as every user should be guaranteed to have a parking space when truly needed, for instance when charging is required, which can be further improved by *'Smart Payment Systems'* as another *concept*.

The only sustainability criteria that are not necessarily improved by *'Shared Parking Spaces'* are (9) attractiveness and (18) safety. Furthermore, (19) the reliability of such a service might be decreased for a large share of users if, during the transition phase into less inner city traffic, the demand for parking spaces is higher than its supply in which case *'Shared Parking Spaces'* would not help to improve the situation immediately. However, over time, it is expected that users will shift towards more collaborative transportation modes, such as public transportation or car- and ride-sharing.

6.3.4.2 Concepts for scaling-up Electromobility

The following three *concepts* are considered to overcome most of the identified local barriers around the city of Gothenburg that hinder electromobility as a solution from diffusing into society.

A common Vision and Strategy (ES: 18)

The *concept 'A common Vision and Strategy'* scores 18 out of 28 points while reducing 86% (12 out of 14) of the identified barriers making it the most attractive *concept* to induce a process of scaling up electromobility.

The barriers towards electromobility are overcome by *'A common Vision and Strategy'* as ① the need for a common vision and strategy is satisfied by the *concept* itself, ② the conflicting endeavours of reducing traffic in the city centre and simultaneously introducing the BEV, as a private transportation mode in the first place, may be aligned, ③ the creation of cross-boundary collaborative projects are facilitated since a common goal and pathway for all involved stakeholders is provided and synergies are more easily identified, ⑤ the rigidity in the current regime may be decreased by making the stakeholders more clearly see their responsibilities in the challenge of scaling up electromobility in the city of Gothenburg as well as the synergies they are dependent on resulting in a higher willingness for collaboration, ⑥ electromobility will mature rapidly since, with an officially announced vision and strategy path, it is accepted as a solution for the future of a sustainable transport system, ⑧ investment costs for the user will drop over time as the price reducing effect of economy of scale will have a large impact on the production costs of batteries, ⑨ the framework for more visible showcases is provided which may be seen as a practical next step on the strategy path when aiming at the realisation of a vision, ⑩ incentives for both users of and investors into electromobility solutions, are given as a clear picture of and towards the future is provided to the public which will reduce uncertainty and thereby ⑪ the risk for policy makers to introduce further transition policies (e.g. the *'Bonus-Malus System'*) is reduced as well as ⑫ the risk for large companies to invest into research and development of EVs and their commercialisation, ⑬ the sustainability awareness of the users is growing as the need for the transition into a more sustainable transportation system will create new norms in the culture of Gothenburg's society, and ⑭ the decision-making for a standardised charging infrastructure may be facilitated considerably.

The only barriers that may not necessarily be reduced by *'A common Vision and Strategy'* are ④ the need for financially sustainable business models and ⑦ the need for designated parking spaces for EVs and as these required additional efforts and *concepts* to be truly overcome.

Trialability Programmes (ES: 15)

The *concept 'Trialability Programmes'* scores 15 out of 28 points while reducing 76% (11 out of 14) of the identified barriers.

The barriers towards electromobility are overcome by *'Trialability Programmes'* as ① it is closely linked to the existence of *'A common Vision and Strategy'* towards electromobility that provides the framework for a successful introduction of trials and showcases (e.g. test-drives) around the city, ③ it will foster cross-boundary collaborations since the realisation of such programmes depend on more than one stakeholder and could open up for further collaborative projects, ④ financially sustainable business models might be created by receiving large amounts of feedback from participating users and stakeholders, ⑤ the rigidity in the current system will most likely be reduced by inviting new stakeholders to join the mix and old stakeholders opening up for new pathways, ⑥ the currently perceived immaturity of electromobility will be decreased drastically by providing potential users the opportunity to experience BEVs including attractive services and convince themselves about their superb functionality and comfort, ⑧ the investment costs for the user may drop in the long-term as such programmes help electromobility to gradually leave the technological-niche level (s. section 6.2.1.3 on page 87) and enter the socio-technical regime (s. section 6.2.1.2 on page 71) making it an affordable mainstream technology, ⑨ it naturally overcomes the need for visible showcases around the city, ⑩ it creates incentives, especially for local users by increasing the likelihood of them converting from conventional ICEVs to BEVs for inner-city travel, ⑪ it decreases the risk for policy makers to change legislation as realised *'Trialability Programmes'* already pave the way towards a more sustainable transportation system by increasing user acceptance and their willingness to buy, ⑫ it highly decreases the risk for large companies to further invest into electromobility-solutions, and ⑬ raises sustainability awareness of users by making electromobility more visible which can be complemented by the concept *'Awareness Campaigns'* to further increase this effect.

The only barriers that may not necessarily be reduced by *'Trialability Programmes'* are ② the conflict between reducing traffic and introducing BEVs simultaneously as it additionally measures are needed to reduce traffic, ⑦ the need for designated parking spaces for EVs and ⑧ the need for a standardised charging infrastructure.

Standardised Charging (ES: 14)

The *concept 'Standardised Charging'* scores 14 out of 28 points while reducing 76% (11 out of 14) of the identified barriers.

The barriers towards electromobility are overcome by *'Standardised Charging'* as ① it requires and therefore promotes the formulation of a clear vision and strategy towards electromobility, ③ cross-boundary collaborations will become more attractive for relevant stakeholders as they are highly important in order to find agreements on a common standard, ④ financially sustainable business models might be designed more easily by attracting a higher number of users due to an overall higher convenience, 6 electromobility will mature drastically in terms of user-acceptance and flexibility, 7 designated parking spaces for EVs will be created in order to spread the common standard more rapidly, 8 the investment costs for the user might drop since all EVs will have the same charging standard which will most likely be sold by a few large external suppliers who are able to mass-produce the required equipment lowering its price, 9 it allows for a higher amount of visible showcases around the city in the form of standardised charging poles that can be accessed by any EV, 10 incentives to use or invest into EV-technology or -services will be created, 11 the risk for both local and national policy makers to stand behind electromobility will be decreased once a common standard is implemented, 12 the risk for large companies to invest into electromobility will decrease drastically since there is no concern anymore about the user-acceptance of in-house charging solutions and the overall investment costs can be considered to drop as described in 8, and lastly 14 it naturally overcomes the identified barrier of a currently non-standardised charging-infrastructure.

The only barriers that may not necessarily be reduced by *'Standardised Charging'* are 2 the conflict between reducing traffic while introducing BEVs simultaneously, 5 the rigidity in the current regime amongst certain stakeholders when it comes to conventional technology and 13 the need for sustainability awareness as a new mindset of the users.

6.3.4.3 Critical Sustainability Criteria

On the basis of our quantitative evaluation the following sustainability criteria are considered to be either negatively or not at all affected by the proposed compilation of *concepts*.Therefore they should be further studied when it comes to the realisation of sustainable transportation based on electromobility in the city of Gothenburg. Hence in the following paragraphs sustainability criteria with a CS of 10 or lower are briefly discussed.

Safety (CS: 6)

The sustainability criterion 'Safety' scores only 6 points out of a possible CS of 48 making it the most disregarded principle as only 21% (5 out of 24) of the proposed Concepts considerably aim at improving it.

The analysis of this result shows that mainly technical *concepts*, such as *'Shared Autonomous BEVs with Decentralised Parking'* or *'Inductive Charging'* have a positive impact on safety regulations and the overall safety level when it comes to inner city travel. The 'raison d'être' of the *concepts*, primarily focusing on how to scale up electromobility and how to promote collaborative transport solutions to ensure sustainable transportation. Thus, the principle 'Safety', as a fundamental requirement for the well-being of people, might be easily overlooked.

Equitable distribution of resources (CS: 7)

The sustainability criterion *'Equitable Distribution of Resources'* scores only 7 points out of possible CS of 48 making it the second weakest principle as only 25% (6 out of 24) of the proposed *concepts* directly aim at improving it. Additionally, the *concept 'Banning to sell new Fossil Fuel based Cars'* has a negative impact on an equitable distribution of resources.

The analysis of this result shows that only the *concepts 'Shared Parking Spaces'* and *'Advanced ICT Solutions'* have the potential of highly improving today's inequalities when it comes to the distribution of resources. However, in order to maintain and improve the economic productivity of society, the introduction of electromobility has to aim at achieving a state of social equality in which people have the same access to transportation in general or, in this case, parking spaces if using a personal vehicle.

No over-extraction of materials and substances (CS: 9)

The sustainability criterion *'No over-extraction of materials and substances'* scores only 9 points out of possible CS of 48 and only 33% (8 out of 24) of the proposed Concepts considerably aim at improving it.

The analysis of this result shows that mainly the *solution 'Sharing Models'* and especially the *concept 'Local Renewable Power Production & Energy Storage'* and possibly also '*Standardised Charging'* may limit an excessive use of materials and substances as there will be a more efficient use of resources compared to individualistic models and no waste products compared to fossil based technologies. However, without highly efficient recycling procedures a large scale diffusion of EVs, solar PV and additional batteries for local energy storage the resource scarcity of REEs, especially lithium, could be a possible showstopper for scaling up electromobility (Söderman et al., 2014).

Fair and equal accessibility (CS: 10)

The sustainability criterion *'Fair and equal accessibility'* scores only 10 points out of possible CS of 48 and only 37.5 % (9 out of 24) of the proposed *concepts* considerably aim at improving it. Additionally, the *concept 'Zero Emission Zones'* has a highly negative impact on fair and equal accessibility lowering the overall score by -2.

The analysis of this result shows that especially concepts, such as *'Advanced ICT Solutions'* or a *'Share-the-Ride Platform'* can ensure a fair and equal accessibility of electromobility solutions and services across different user groups and social classes. Also *'Sustainability Workshops'* that are open for anyone to learn more about EVs and the urgency to live a more sustainable live-style. To make electromobility a truly sustainable solution of the future more concepts that ensure fair and equal accessibility to both technologies and knowledge have to be designed and implemented.

6.3.4.4 Critical Barriers

The following barriers are considered to be slightly or not at all mitigated by the majority of the proposed *concepts* and therefore should be mainly focused on when redesigning the *concepts* in order to effectively scale up electromobility in the city Gothenburg. In the following paragraphs barriers with a CS of 10 of lower are briefly discussed.

Need for standardised charging infrastructure (CS: 7)

The barrier *'Need for standardised charging infrastructure'* scores only 7 points out of a possible CS of 48 making it the most critical barrier to overcome in order to scale up electromobility in the city of Gothenburg. Only an alarming 21% (5 out of 24) of the proposed *concepts* induces a shift towards a standardised charging infrastructure.

The analysis of this result shows that only the *concept 'Standardised Charging'* as the inversion of the barrier and possibly *'Inductive Charging'* or *'Coordinated Charging'* along with *'A common Vision and Strategy'* have the potential to incentivise the establishment of a standardised charging infrastructure in Sweden and most likely all over Europe. The fact that a standardised charging infrastructure is the most sustainable *concept* (s. section 6.3.4.1[57] on page 112) and simultaneously reduces a large number of identified barriers (s. section 6.3.4.2[58] on page 116) enhances the importance of overcoming this particular barrier in the short-term and possibly ahead of or simultaneously with others.

Reducing traffic vs. introduction of BEVs (CS: 9)

The barrier 'Reducing traffic vs. introduction of BEVs' scored only 9 points out of a possible CS of 48 and only 33% (8 out of 24) of the proposed *concepts* are aiming to solve this issue making it the second most critical barrier to overcome when aiming at scaling up electromobility in a sustainable way.

The analysis of this result shows that only *'Sharing Models'*, especially *'Shared Autonomous BEVs with Decentralised Parking'* and *'Zero Emission Zones'*, amongst a few other *concepts*, have the potential to introduce BEVs while reducing traffic at the same time. However, *'Ultra Rapid Charging'* might increase the attractiveness of BEVs to such an extent that the overall traffic in and around the city of Gothenburg will increase drastically.

[57]Concepts for Sustainability

[58]Concepts to scale up Electromobility

Need for financially sustainable business models (CS: 10)

The barrier 'Need for financially sustainable business models' scored only 10 points out of a possible CS of 48 and only 33% (8 out of 24) of the proposed *concepts* are aiming to solve this issue.

The analysis of this result shows that only *concepts*, such as *'Smart Payment Systems for Charging'* and the *'Generation of Research Projects for Sustainable Business Models'*, are satisfying the need for financially sustainable business models regarding electromobility. However, this issue remains as long as there are no further *concepts* that are primarily aiming at creating business models that can sustain themselves over time without external support. Tesla may be taken as a suitable example for applying a financially unsustainable yet business model as more investments than revenues were made to commercialise their vehicles. However, for electromobility to 'survive' in the long-run sustainable business models are indispensable, for both investors and customers.

High investment costs for the user (CS: 10)

The barrier 'High investment costs for the user' scored only 10 points out of a possible CS of 48 and only 37.5% (9 out of 24) of the proposed *concepts* are aiming to solve this issue. Also the *concept 'Shared Autonomous BEVs with Decentralised Parking'* may increase the investment costs for the users as long as there are no financially sustainable business models for users in place. Without reducing the investment costs for the user an EV will always be a product for the rich which will not represent the sustainable state we are striving for.

6.4 Backcasting Step 4 - Finding Strategies to scale up Electromobility

In this section, the results from the methodology followed for conducting backcasting step 4 (s. section 5.6[59] on page 54) are presented and analysed. This last step of the backcasting methodology takes into account the results of all the previous steps in order to describe a strategy path towards a 'A Green New Deal' based on our vision of a sustainable transportation system dominated by electromobility from step 1 that overcomes the identified barriers from step 2 by incorporating a compilation of our proposed *concepts* from step 3. More specifically, the results from the stakeholder dialogue are described and briefly analysed (s. section 6.4.1) which provide the basis for the following proposal of a roadmap towards a sustainable and electrified transportation system in the city of Gothenburg (s. section 6.4.2[60] on page 124).

6.4.1 The Outcome of the Stakeholder Dialogue

With the successful realisation of the stakeholder dialogue the final and most anticipated part of this participatory thesis was reached. In this section, firstly, a brief reflection upon how well the methodology, described in sections 5.6.1.3[61] on page 56 and 5.6.1.4[62] on page 58, could be realised from an inside-out perspective is presented, followed by an outside-in analysis of the actual outcome, the response from the stakeholders and the overall impact of the event.

Since a lot of effort was put into the preparation of the event the schedule could be followed with only minor delays. Also an atmosphere of openness and mutual trust amongst the stakeholders could be created by making the participants feel comfortable and welcome. The discussion during the first dialogue session about *'A desirable scenario for the future of electromobility'* required only little guidance from us as facilitators as the purpose of the conducted backcasting process during the dialogue could be conveyed enabling the stakeholders to detach themselves from the present and envision possible future scenarios. Curiously, by asking the question *'Where do we place ourselves right now as a system?'* different opinions were voiced, ranging from scenario A, C and D, except scenario B 'A Green New Deal' (s. section 6.3.2.3[63] on page 109) as our proposed scenario for a sustainable transportation system of 2050. Therefore, once scenario B was unveiled, we could create the anticipated tension between the present state and a desirable future state. By providing this framework of thinking about the future, local proactive policies and collaborative transport solutions, in relation to the previously presented sustainability criteria (backcasting step 1) and the identified barriers to scale up electromobility (backcasting step 2) we allowed the stakeholders to think more freely about possi-

[59] Backcasting Step 4 - Finding Strategies toscale up Electromobility (Methodology)
[60] A Roadmap towards 'A Green New Deal'
[61] Execution of the Dialogue
[62] Analysis and Reflection of the Dialogue
[63] A Proposal of Future Scenarios

ble future *solutions* and *concepts* (backcasting step 3) that could be placed into 'A Green New Deal'.

Although the anticipated outcome of the second dialogue session about *'Next steps towards electromobility'* was very ambitious the small workshop and the following discussion worked out surprisingly well. By asking the stakeholders to post ① a desirable future *solution*, ② their contribution to realise this *solution* and ③ the needed synergies to make their contribution happen on the white-board, a large compilation of ideas was generated in roughly 30 minutes. However, these ideas were rather taken as an inspirational source for our final proposal of strategy path towards 'A Green New Deal' (s. section 6.4.2[64] on page 124) than being analysed thoroughly due to the varying quality of the responses as a result of the highly spontaneous character of the workshop. Also the chronological allocation of the post-its on the backcasting arrow was not based on a thorough reflection from the stakeholders and therefore could not be taken as a valid input for further analysis. During the final part of the dialogue after the workshop the discussion narrowed down to possible next steps and projects that could be initialised in the city of Gothenburg.

The following topics relevant for the transition into electromobility in the short-term were discussed:

Trialability programmes: It is recognised that *'Trialibility is very important'* (F. Sprei, Chalmers University, Personal Communication, May 4, 2016) and that *'Visibility is one of the key ingredients in what the city needs to focus on for the next few years'* by possibly implementing a *'[...] trialability programme with loads of stakeholders [...]'* (M. Andersson, Personal Communication, May 4, 2016) participating to make electromobility accessible to the users.

Implementation of innovations: Although trialability is relevant it is even more important to find ways of implementing the solutions and innovations. Currently there is the problem that *'We try things out but never implement them'* (M. Andersson, Trafikkontoret, Personal Communication, May 4, 2016). *'Innovation means that something is actually used and not only invented'* (U. Östermark, JSP, Personal Communication, May 4, 2016). This aspect has to be included when discussing about how to effectively scale up electromobility.

Visibility of the charging infrastructure: Similar to the realised need for trialability programmes the *'Visibility of charging stations is very important'* (F. Sprei, Chalmers University, May 4, 2016). Currently it is still difficult to find public charging stations and *'We have to find them via app'* (F. Sprei, Chalmers University, May 4, 2016). However, this issue should be solved soon as charging stations *'[...] will not be hidden anymore very shortly'* (M.O. Larsson, Trafikkontoret, Personal Communication, May 4, 2016) as there will be *'15 rapid charging stations up and running this summer'* (F. Persson, Göteborg Energi, Personal Communication, March 7, 2016). There is clearly a hot debate around charging infrastructure and it seems like consent is by far not yet reached, especially when it comes to the standardisation.

[64] A Roadmap towards 'A Green New Deal'

User convenience and acceptance: There is a common opinion amongst all the stakeholders that user convenience and acceptance are key aspects to focus on in the short-term. The mindset that *'You do not stop an EV to charge it, you charge it when you stop'* (J. Konnberg, Volvo Cars, Personal Communication, May 4, 2016) which tries to say that owning an EV instead of an ICEV facilitates the 'refuelling' procedure to be carried out in private spaces and parking lots since there is no need to take a trip to the petrol station anymore. However, this is closely related to the imminent challenge around the visibility and therefore availability of charging stations around the city of Gothenburg. This issue must be solved in order to enhance user convenience and thereby achieve the highly required user acceptance for the diffusion of electromobility in the short-term.

A common vision: The city of Gothenburg has a clear vision: *'It should be an arena for innovation'* (M. Andersson, Trafikkontoret, Personal Communication, May 4, 2016) in which electromobility as a solution for a sustainable transportation system should be implemented.

Overall, the stakeholder dialogue was very well received by all the participants and the event itself created some momentum by bringing together knowledgeable local experts from the public, private and academic sector and making them realise that every participant is pursuing the same objective: Replacing fossil fuel based with electrified transportation. However, in order to effectively make this transition happen, the need for a common vision and strategy became very apparent for all the stakeholders and especially the local Urban Transport Administration (Trafikkontoret). For that a continuation of participatory processes such as stakeholder dialogues would be vital.

6.4.2 A Roadmap towards 'A Green New Deal'

The backcasting methodology is concluded with step 4 and the suggestion of key policy steps that path the way towards 'A Green New Deal' aligned with our vision of a sustainable and electrified transportation system in 2050. In this step, a proposed path of a strategy is elaborated including various steps for different groups of stakeholders and a follow-up agenda to be pursued. For the proposed strategy path towards 2050 we distinguish between short-term (2016-2025) and long-term (2025-2050) developments. The steps to be initialised in each timeline are categorised under technological, regulatory (policy and legislation) and societal level. Also, in order to contextualise each timeline, a set of planned milestones, that directly affect our proposed path, are presented. The listed milestones are taken from the system analysis in step 2 (s. section 6.2.1 'A Multi-Level Perspective on the Transportation System in city of Gothenburg' on page 64). Also it is important to note that, when it comes the need of referring to national policies, basic proposals on how local policy makers can influence the national level will be given.

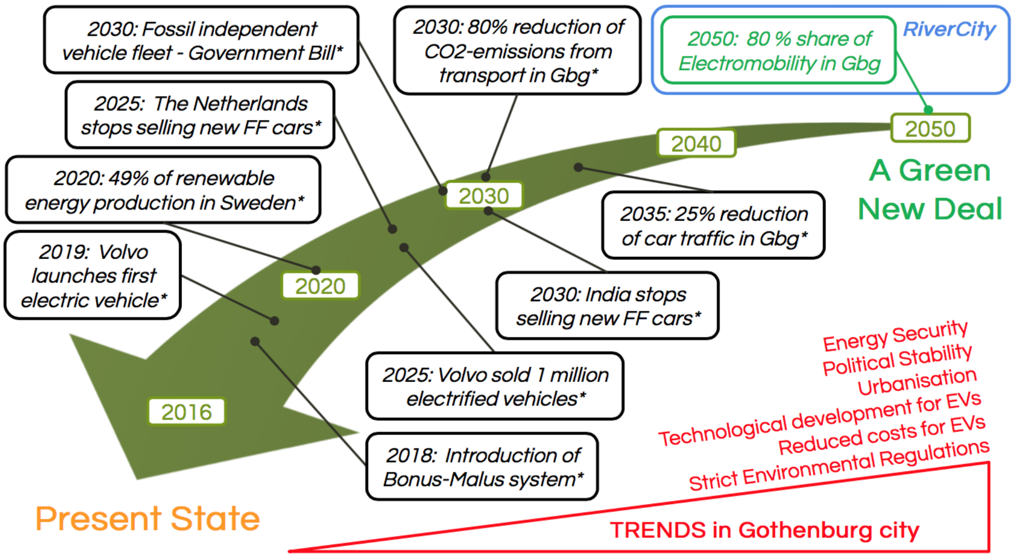

Figure 6.21: A compilation of officially announced milestones between the present state (2016) and and 'A Green New Deal' (2050).

6.4.2.1 Short Term: 2016-2025

In the short term local and national level governments are the main actors to stimulate the transition, seeking to establish an initial trend of sustainable transportation facilitated with electromobility solutions. The local transportation system has a long way until it can be characterised as truly sustainable but both local actors from the triple-helix and civilians are working hard in order for the trend to become dominant.

Officially announced milestones until 2025

- 2018
  - The Swedish government introduces the 'Bonus-Malus System' for lighter vehicles (Government referral SOU 2016:33, 2016) (s. section 6.2.1.1[65] on page 65).
- 2019
  - Volvo releases the first BEV in the market (Volvo Car Group, 2015) (s. section 6.2.1.2[66] on page 74).
- 2020
  - The EU regulations addressed to car manufacturers become stricter for high-emitting vehicles while more incentives are given for low emitting vehicles (s. section 6.2.1.1[67] on page 66).

[65]The Landscape Level, paragraph 'Bonus-Malus System for New Light Vehicles'
[66]The Socio-technical Regime Level, paragraph 'Market & User Practises'
[67]The Landscape Level, paragraph 'EU 2020 Goals & 'Super Credits''

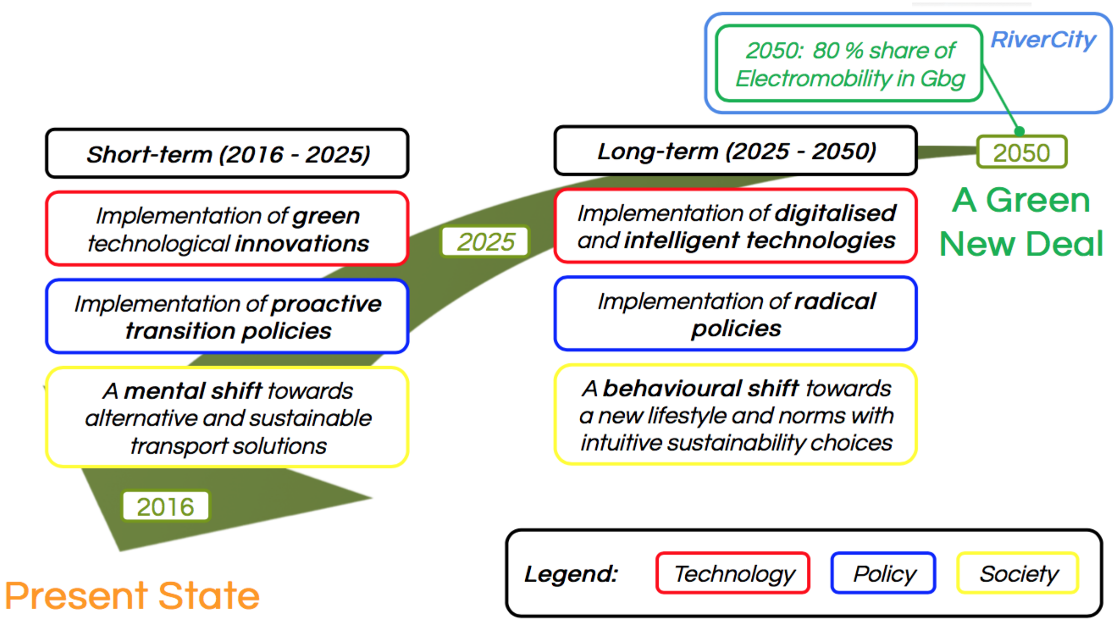

Figure 6.22: Projected developments in the areas technology (red), policy (blue) and society (yellow) in the short-term (2016-2025) and the long-term (2025-2050).

- 2025
  - The Netherlands ban the sales of new fossil fuel based vehicles (s. section 6.2.1.1[68] on page 69).
  - Volvo will have sold cumulatively 1 million BEVs (Volvo Car Group, 2015) (s. section 6.2.1.2[69] on page 74).
  - The world population will mount to approximately 8 billion people (UN Department of Economic and Social Affairs, 2015) (s. section 6.2.1.1[70] on page 66).
  - Göteborg Energi projects that there will be 30.000 - 40.000 BEVs on the streets of Gothenburg (s. section 6.2.1.2[71] on page 83).

Technologies - *'Green technological innovations to envision the future'*

Towards the vision electromobility technologies are continuously improving mainly due to *'Investments into R&D for Green Technology'* from public authorities. More specifically, private actors, such as Volvo or Move About, as well as research institutes with proven merit, such as Viktoria Swedish ICT and IVL, related to electromobility, infrastructure solutions, battery technology and recycling processes, are receiving increased support and therefore are taking lower risks when focusing on

[68] The Landscape Level, paragraph 'Current Benchmarks on Proactive Policy Initiatives for Electromobility'
[69] The Socio-technical Regime Level, paragraph 'Market and User Practises'
[70] The Landscape Level, paragraph 'Urbanisation and Demographic Change'
[71] The Socio-technical Regime Level, paragraph 'Infrastructure'

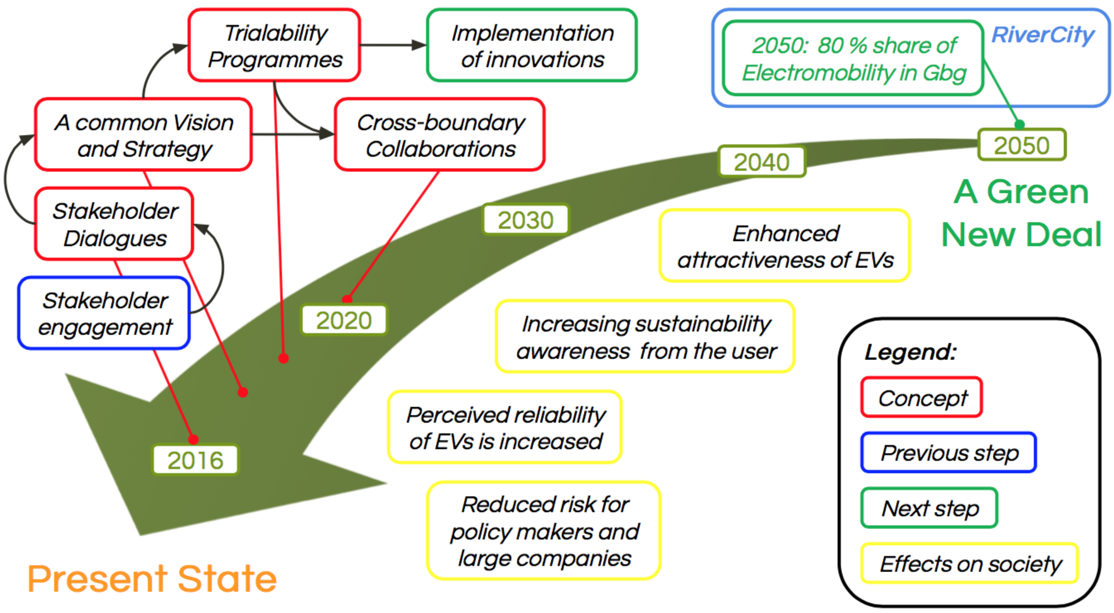

Figure 6.23: Strategic steps for the implementation of the *concepts* *'Multi-Stakeholder Dialogues'*, *'A common Vision and Strategy'*, *'Trialability Programmes'* and *'Cross-boundary Collaborations'* (Further proposals for the implementation of future *concepts* can be found in Appendix D.2 on page XXI).

the development of electromobility solutions and services. Technological improvement and diffusion is also achieved by further scaling up already existing research programmes such as *ELMOB*, *ElectriCity*, *WiCh* and similar initiatives.

Regarding the charging infrastructure, *'Inductive Charging'* solutions keep evolving enabling *'Convenient Charging'* as a substitute on the way to *'Standardised Charging'*. The latter seems more likely than ever as synchronised initiatives from the private sector and EU national governments on 'lobbying' for a common standardisation as mandated by the EU Directive after a phase-out period. Meanwhile, technologies for smart *'Coordinated Charging'* are developed to gradually equip parking lots for EVs, especially local parking areas where a large amount of connected EVs may increase the load on the local grid. This is done to prepare the users for the need of adjusting their charging-behaviour and allow for continuous grid-stability despite the increasing share of *'Local Renewable Power Production'* while maintaining or even enhancing the user's convenience and parking experience.

At the same time, *'Sharing Models'*, such as *'Share-the-Ride Platforms'* via phone or web applications and car-sharing services, especially by using EVs, are implemented in order to enhance fair and equal accessibility and trust amongst users and as a result handle available resources more efficiently.

Policies - *'Igniting the transition with proactive measures'*

On the policy side, policy-makers take on the demanding task to deliver *'A common Vision and Strategy'* that can accommodate for the two transitions to happen in order to reach the desirable future scenario 'A Green New Deal' (s. section 6.3.3[72] on page 109): *'A technological transition into electromobility and a holistic transition into a more sustainable transportation system'.* For that policies on the local, national and European level have to be proactive focusing on these transitions. Local policy-makers can both work locally but also make substantial efforts to influence the regulations and policies on the national level. The City of Gothenburg and the Urban Transport Administration (Trafikkontoret) initiate the process by engaging with stakeholders and systematically organising *'Multi-Stakeholder Dialogues'* to co-create a strong long-term vision for a sustainable future of an electrified transport system that could complement the ambitious RiverCity vision of 2050 (Gothenburg City Council, 2012) (s. figure 6.23 on page 127). Once *'A common Vision and Strategy'* is in place a set of *'Trialability Programmes'* with a clearly communicated purpose and a high participation of relevant stakeholders showcasing their products and services can be realised in a very effective way. Simultaneously, the Urban Transport Administration initiates a highly inclusive backcasting process to ignite *'Cross-boundary Collaborations'* which are facilitating the task of implementing successful innovative products, services or business models after their trialability phase.

As far as the *'Standardised Charging'* infrastructure is concerned, in the beginning of the short-term, local policy makers lobby to the national government to take a proactive approach and implement the EU standardised technology. More specifically, since in Sweden the state owned companies are responsible for delivering the infrastructure (such as Göteborg Energi), then the national and local authorities take action and obtain the first-mover advantage adopting the EU standardised module and initiate a phase-out plan for other technologies until 2018. As proposed by the Swedish government, a *'Bonus-Malus System'* for low emission vehicles is introduced in 2018. This means that, beginning from 2018, an influx of BEV adoption will happen. Hence, the state and the local authorities act proactively establishing the EU standardised module avoiding redundancy, determining the technology in an independent fashion letting the industry abide to standardised technology and the market to self-regulate around that measure.

In the meantime, Urban Transport Administration (Trafikkontoret) in collaboration with the city of Gothenburg initiates long-term *'Trialability Programmes'* that strongly promote electromobility solutions and innovations, engaging local stakeholders, such as Volvo Cars (first BEV by Volvo is released in 2019), Viktoria Swedish ICT (innovative projects on electromobility), Move About (successful business model in BEV-sharing) and Gatubolaget (owns a BEV fleet) to showcase their innovative technologies, projects, and fleets to users and other local actors. After the trialability period, an implementation plan is conducted for the most promising and impactful showcased innovations on the prototype stage. The implementation plan is led by the City of Gothenburg and is realised mainly with the engagement of local entrepreneurs as well as researchers from the academia, and thereby local economy actors are supported. The plan is also complemented with *'Innovation Contests'* and *'Research Projects for Sustainable Business Models'.* Hence, the city of Gothenburg

[72]'A Green New Deal' - A desirable and sustainable Future Scenario

promotes and works together with local sustainable businesses offering a 'platform for innovation'.

Furthermore, *'Sustainability Workshops'* are organised by the Urban Transport Administration (Trafikkontoret) and the City of Gothenburg on sustainable mobility solutions and sustainability awareness for users, car-dealers and service providers. For that informative *'Awareness Campaigns'* take off along with the growing support from local media. The intention for taking on more 'bold' policies is demonstrated when the Urban Transport Administration forms a project group focusing on investigating on applying *'Zero Emission Zones'* in the city of Gothenburg that can potentially be implemented in the long-term to ensure that the goals for traffic reduction goals will be achieved along with a cleaner urban environment. Last but not least, the ownership over parking spaces, especially in parking lots for residents in block of apartments, is challenged. A new system of *'Shared Parking Spaces'* is in place where EV chargers are more accessible for owners and potential users.

Society - *'A mental shift towards alternative and sustainable transport solutions'*

Private actors around the city lead the transition by example towards the envisioned future of 'A Green New Deal', by either participating in BEV and PHEV *'Sharing Models'* or by building their own low-emitting fleet with BEVs and PHEVs. At the same time users show an increasing inclination towards the *'Sharing Models'* such as car-sharing and shared parking-spaces. This change in both ends, happens mainly due to economic benefits provided by the transition policies but also from *'Awareness Campaigns'* leading to *'Education for Sustainability'*. The transition policies, such as the *'Bonus-Malus System'* made the BEV more affordable. The standardisation rendered the charging infrastructure more reliable and convenient for the users. As a result an influx of BEV users has been observed and gradually the noise in the city continuously decreasing. This rise of awareness gradually creates new trends and norms among the citizens urging them to be more eager to try and change behaviour. For the latter, *'Trialability Programmes'* have brought about awareness through practical experience and *'Peer-to-Peer Platforms'* where users can exchange experiences and early adopters can shift late adopters to test electromobility solutions and services. As a result, people begin to realise the superiority of BEVs and slowly demand more zero-emission technologies in general.

Lastly, the superior convenience of the charging infrastructure over conventional ICEVs has begun to show in the most charging points where *'Smart Payment Systems'* are installed. This adds to the reliability of electromobility infrastructure influencing more and more people on making the shift towards clean alternatives.

6.4.2.2 Long-term: 2025-2050

Already at the beginning of the long-term time-line the number of registered BEVs and PHEVs together is already higher than the number of ICEVs registered in the city of Gothenburg. Throughout the policy measures taken and technological improvements made in the short-term until 2025 the electromobility transition was established as a popular trend and is slowly sustaining itself by increasing positive feedbacks in the system, meaning that the diffusion process of electromobility, once considered as only an accumulation of technological niches, has begun. This state can allow for the introduction of stronger policy measures and regulations in order to transform the urban environment of Gothenburg into a holistically sustainable transportation system based on electromobility, not only ecologically, but also economically and socially, ultimately leading to a higher level of well-being of the citizens of Gothenburg.

Officially announced milestones until 2050

- 2030
  - India becomes a world leader when it comes to BEVs (s. section 6.2.1.1[73] on page 69).
  - The vehicle fleet in Sweden becomes fossil fuel independent (s. section 6.2.1.1[74] on page 65).
  - 80% reduction of CO_2-emissions in the transport sector in the Gothenburg region compared to 2010 (s. section 6.2.1.2[75] on page 71).
  - Car traffic is reduced by 25% in the city of Gothenburg (s. section 6.2.1.2 on page 71).
- 2050
  - The world population will mount to approximately 10 Billion people (UN Department of Economic and Social Affairs, 2015) (s. section 6.2.1.1[76] on page 66).

Technologies - *‘The era of highly digitalised and intelligent technologies’*

On the technology side, in the urban environment more and more highly efficient local autonomous energy systems for *‘Local Renewable Power Production and Energy Storage’* are installed. That is driven by the continuous R&D undergone by projects emerging through *‘Cross-boundary Collaborations’* among actors of the triple-helix focusing on battery technologies, renewable energies and electromobility solutions. The energy autonomy is also accompanied by *‘Advanced ICT Solutions’* providing enhanced interconnectedness of electronic devices and vehicles. In the meantime, *‘Shared autonomous EVs with decentralised Parking’* have established themselves as

[73] The Landscape Level, paragraph ‘Current Benchmarks on Proactive Policy Initiatives for Electromobility’

[74] The Landscape Level, paragraph ‘The Fossil Independent Sweden Initiative and the Super Green Car Premium’

[75] The Socio-technical Regime Level, paragraph ‘Sectoral Policy and Legislation’

[76] The Landscape Level, paragraph ‘Urbanisation and Demographic Change’

an proven and accepted technology and the urban landscape begins to shift accommodate for the safe symbiosis of pedestrians, autonomous and man-driven vehicles.

Regarding the charging infrastructure *'Coordinated Charging'*, which was introduced in the short-term time-line, now it becomes a necessity because of the continuous increasing influx of BEVs and *'Local Renewable Power Production'*. In addition, *'Inductive Charging'* technologies are in place to allow for exclusive home-charging. Finally, the latest version of *'Ultra-Rapid Charging'* allows for charging times of BEVs comparable to refuelling times of ICEVs which makes the BEV by far the most attractive and convenient mode of private transportation while maintaining a high level of sustainability, especially when combined with *'Sharing Models'*.

Policies - *'Round off the transition with radical measures'*

After phasing out the *'Bonus Malus System'* in 2025, as it was only considered as a transition policy measure to accelerate the selection of electrified transportation solutions, local authorities are introducing a series of radical policies that directly affect the urban mobility and urban life in general without direct subsidies. A *'Strong Increase of CO_2-Taxes'*, as already indicated by a gradual increase during the short-term, will be introduced in the beginning of the long-term time-line to accelerate the phase-out of fossil-dependent technologies, such as conventional ICEVs. Simultaneously the Urban Transport Administration (Trafikkontoret) announces the strategy plan for gradual implementation of *'Zero Emission Zones'* around the city, starting from the city centre. The long-term goal of the zero emissions scheme, is to ultimately ban the circulation of cars (both EVs and ICEVs) in the core of the city centre to primarily allow for a higher well-being of the citizens, however, this is done in a step-wise process. This implementation of the policies is facilitated through the trust developed between the citizens and local authorities. That is because in the long term timeline awareness has risen and a behavioral shift has already begun to show from the citizens' side. Also local policymakers prepare a proposal to the national government for a national plan of *'Banning to sell new Fossil Fuel based Cars'*. At the same time, after the successful Drive-Me project (s. section 6.2.1.3 'The technological Niche Level' , paragraph 'Alternative and Sustainable Business Models' on page 88) the Urban Transport Administration and the city of Gothenburg in collaboration with Volvo Cars and Viktoria Swedish ICT, have taken all the appropriate legal and organisational actions for the safe co-existence of completely autonomous cars with man-driven ones allowing for the realisation of *'Shared Autonomous EVs with Decentralised Parking'*. Lastly, local authorities in close collaboration with Göteborg Energi, local private energy companies, housing agencies and citizens have been financially incentivising the installation of 'Local Renewable Power Production and Energy Storage' to accommodate for nuclear power which will be phased out between 2025 and 2035.

Society - *'A new lifestyle in which sustainable transport choices are intuitive'*

On the society level, there are signs already of an ongoing shift in the mindset of users and citizens regarding sustainable choices over urban mobility and their lifestyle general. More specifically, *'Sharing Models'* have started challenging the car ownership. Especially ownership of new ICEVs has dropped considerably while more and more citizens choose more collaborative modes of transport and they only use their own vehicles for long intercity trips outside the urban centre and 'ride-sharing' over already well established and popular *'Share-the-Ride Platforms'*. This shift enhances the trust needed between the local authorities and the citizens for the newly introduced radical policies. Additionally, the shared mobility with autonomous vehicles is perceived safe and reliable by the users. Meanwhile, the costs and market prices related to electromobility along with a *'Rapid Technology Development'* have rendered electromobility as the most affordable and sustainable solution. The aforementioned *'Rapid Technology Development'* in collaboration with strong incentives on further installation of highly reliable technologies for *'Local Renewable Power Production and Energy Storage'*, have started turning neighbourhoods into energy autonomous clusters where people feel empowered as they can become 'energy generators' and thus freely manage clean electricity production and storage for their interconnected electric devices, homes and vehicles.

7
Discussion

In this chapter the C-Lab as alternative learning environment is discussed (s. section 7.1) as well as the process of determining a scope (s. section 7.2 on page 135), the backcasting methodology based on its application in Phase II (s. section 7.3 on page 136) and finally the validity of the results (s. section 7.4 on page 137).

7.1 The Challenge Lab

Participating in the C-Lab to write a master thesis may be considered as a very unique learning experience. The major difference to conventional theses is the fact that we define our research question independently after having investigated our own values, interests and strengths by taking an inside-out perspective throughout a self-leadership workshop as well as the current system around Gothenburg city by taking an outside-in perspective to identify highly relevant sustainability challenges that are to be solved. The C-Lab includes these four weeks of Phase I for this personal investigation process to happen and simultaneously provides us with a large set of theoretical concepts and tools, such as backcasting or *design thinking*, that may be applied in practice during Phase II of the thesis project when focusing on our individual research questions.

The fact of including Phase I (4 weeks) into the thesis project obviously affects the available time to conduct Phase II (18 weeks). This limited time enhances the demand for a highly structured and well organised schedule to successfully reach the expected outcome. However, preset deadlines that are known from the beginning of Phase II allowed for a better design of the roadmap (s. Appendix E, figure E.1, on page XXIV).

Being responsible for content and extent of a thesis project without having anyone telling you exactly what to investigate and which results to deliver shaped up as a considerably challenging task. As E. Roosevelt said: *'With freedom comes responsibility'*. In the C-Lab we were given a large amount of freedom accompanied with some initial guidance and basically no control. Consequently many possibilities for potential research topics and perspectives emerged after the investigation of the present system of the city of Gothenburg during Phase I. However, provided with this amount of freedom we felt a great amount of responsibility to deliver a highly valuable end-result not only for research purposes but also for the public and thereby to have an actual impact on the sustainable development of the city of Gothenburg to such an extent that stakeholders we were engaging with will remember us as 'change agents' (s. section 7.1.2 on page 134).

7.1.1 Formulating a Research Question

Finding and formulating a personal research question is easier said than done. During the last week of Phase I we were supposed to start thinking about our actual research question and possible team-constellations for the realisation of Phase II. This research question was solely based upon our personal interests and a rough idea about the local stakeholders' interests. Fortunately, both of our interests, concerning methodological approach and thematic area, which were strongly influenced by our study backgrounds could be combined forming the research question of this thesis on *'How to develop a strategy for scaling up electromobility in the city of Gothenburg'*. This formulation was kept throughout the whole thesis project. The formulation and adjustment of further, secondary research questions, as described in section 1.3[1] on page 3, during Phase II enriched the extent of the main research question. These questions evolved during the process along with a gradually improving understanding of the transportation system in Gothenburg city and the mapping of relevant local stakeholders (s. Appendix B, figures B.1 and B.2, on page VI).

7.1.2 Master Students as 'Change Agents'

As described by Holmberg (2014) one of the missions of the C-Lab is to *'Build trust within the clusters through students. A defining feature of students is that they are simultaneously non-threatening and challenging, a feature crucial to the kind of change society greatly needs, positioning the students to be powerful change agents.'* But could this mission actually be achieved throughout the realisation of the thesis project in Phase II?

With this thesis project we were testing our role as 'change agents' by involving stakeholders from the triple-helix (public, private and academic sector) right from the beginning in our process. This was done by realising a large amount of *semi-structured* interviews (s. Appendix B, table B.1, on page V) and finally conducting a stakeholder dialogue to which most of the interviewees were invited. Early in the process, after a first set of interviews, we already noticed our neutral 'non-threatening' role as 'change agents'. Most of the stakeholders were very open and talkative as they had a lot of trust in us and the work we do even during the early stages of the process when we developed our understanding for Electromobility in relation to the boundaries of the current transportation system in the city of Gothenburg. With a growing competence about the challenges of scaling up Electromobility in this region an interesting shift concerning our interaction with the stakeholders could be observed. The initial perception of *'We need them'* in order to realise our thesis project turned into *'They need us'* in order to accelerate the transition from fossil

[1] Purpose and Research Questions

fuel based transportation to electrified transportation. Openness, trust and cross-boundary collaborations crystallised themselves as some of the key requirements for such a complex transition to happen. This is where we, as ‘change agents’, came into play as our mission was to connect relevant stakeholders, each of them with a unique set of skills and knowledge, from different sectors by inviting them to participate in our journey of backcasting without posing any threat. We soon understood that our intention was in line with most of the stakeholders’ interests and that our framework created an inspiring learning experience for all of them.

Finally, being a ‘change agent’ as a representative of the C-Lab allowed us to approach almost any stakeholder, be it a researcher, a project manager or the head of an organisation, that was considered relevant for the realisation of our thesis project and thereby confront them with critical questions that could not be asked in a typical business environment. The fact that all the findings acquired throughout the interviews and the dialogue were solely used as an input for this thesis which, after all, must be considered as a proposal, gave us access to the stakeholders’ personal opinions and desires in relation to their organisation.

7.2 Determination of the Scope

Along with the formulation of the research question comes the task of defining the scope of this thesis. Although there was a preliminary understanding of the system boundaries at the beginning of the thesis project further adjustments had to be made during the whole process of Phase II.

Starting with a holistic system perspective of the transportation system of people including both public (buses, trams, etc.) and private transportation modes (cars, bicycles, etc.) soon turned out to be too complex for a thorough investigation with the goal of developing a strategy path based on a proposal of *solutions* and *concepts*. Therefore only the first two steps of the backcasting process were consciously carried out with a rather holistic perspective to understand the challenges of the whole transportation system before the scope got narrowed down to the finding a strategy on how to gradually introduce the BEV into today’s society as the green alternative of the conventional ICEV and simultaneously ensure sustainable transportation in the ecological, economical and societal dimension. However, by analysing external factors that may influence such a highly complex transition on the system level we realised the difficulty in maintaining a narrow scope, both thematically and geographically.

Thematically, there is always a clear linkage to public transportation or other means of private transportation, such as bicycles or walking, since these have to be considered in comparison to the car when envisioning the future of a truly sustainable transportation system in which Electromobility has a share of 80% (s. section 6.1.1[2] on page 59). Investigating only the issue of replacing the ICEV with an EV without realising the need for collaboration (e.g. via ‘Sharing Models’) would most likely

[2]A Vision for the Transportation System of 2050

lead us to a future in which resources become a limiting factor for the process of scaling up Electromobility.

Geographically, the development of the transportation system in the city of Gothenburg is always influenced by decisions made on the national or EU level (s. section 6.2.1.1[3] on page 64). Only regarding the processes inside the geographical boundaries of the city of Gothenburg would simply display a falsified picture of the real system and its dynamics.

All in all, the systemic perspective taken in this thesis allowed for a better understanding of critical external factors that must be considered when developing a strategy for scaling up electromobility in the city of Gothenburg, however, reduced the level of depth when analysing specific dynamics on the technological, political or societal level.

7.3 The Backcasting Methodology in Phase II

The methodology provided by this thesis is based on both theoretical concepts from acknowledged authors, such as backcasting by Robinson (1982b), and independently developed approaches, such as the evaluation of potential future concepts, to finally design a unique framework that is the most suitable for answering our research question(s). Thus, it is not possible to put every part of our methodological approach into context, however, a discussion of its usefulness the achieve the expected outcome may be performed.

The backcasting methodology has been applied in various fields to tackle a variety of complex and complicated challenges, such as *'problem analysing and designing of investment strategies'* or *'dialogue as a shared mental model for community building'* (Holmberg and Robèrt, 2000). Therefore backcasting evolved as a highly effective tool to trigger disruptive change in comparison to conventional forecasting (Dreborg, 1996), especially when combined with stakeholder engagement (Robinson, 2003) and applied on sustainability challenges (Holmberg and Robèrt, 2000). In this thesis backcasting is applied in a highly participatory manner and serves as the overarching methodological framework to induce a systemic change in the transportation sector of Gothenburg city. More specifically, the backcasting approach was used a guiding tool in which further theoretical tools were implemented, such as *semi-structured* interviews (Van Teijlingen, 2014) and the Multi-Level Perspective MLP (Geels, 2002) in step 2 or *design thinking* (Söderberg, 2014) and *scenario design* (Lundqvist et al., 2006) in step 3. By applying the backcasting approach in a local multi-stakeholder environment we realised that it is easy to convey and makes people think more freely about the future without being influenced by the boundaries of the present state and thereby function as an effective tool to foster creativity and inspiration. All of his showed that backcasting is easy to understand, highly flexible and may be served as a guiding tool when developing a strategy for scaling up electromobility in the city of Gothenburg.

[3] The Landscape Level

7.4 Validity of the Results

By conducting all four steps of the backcasting methodology as described by Holmberg (1998) in only 18 weeks time and to do so in a highly participatory manner certainly influenced the depth of the acquired results as only a limited amount of iterations could be performed. Although most of the results are based on literature-reviews, interviews and official announcements some had to be based on general assumptions and subjective intuition as comparable data was not available. This may be explained by the fact that our approach entered unknown terrain in which certain questions have not necessarily been investigated before, such as *'which sustainability criteria have to be fulfilled by electrified transportation?'* or *'which future concepts are most likely to scale up electromobility and how sustainable are they?'*.

Overall, the results discussed in the following sections have to be handled with care as they are by no means final. They should be rather considered as a first generation prototype developed throughout the backcasting approach.

7.4.1 The Vision and Sustainability Criteria

As a result of conducting backcasting step 1 a vision for the transportation system of 2050 and sustainability criteria on electromobility were created. The different aspects of the vision are meant to define a desirable future state that challenges today's situation by reaching outside the current technological, political and societal boundaries. It is difficult to validate our vision since there are only a few comparable visions available, such as the RiverCity vision (Gothenburg City Council, 2012). One may argue that reaching for an 80% share of electromobility and zero emissions over the whole value chain (from electricity production to consumption) is a very ambitious goals that might be unrealistic to achieve by 2050. However, our overall vision was very well received by all the stakeholders that were confronted with it. It allowed them to think more clearly about a possible future state and be more courageous to break today's limitations and barriers. This effect was further increased by providing them with the complementary results on the formulated sustainability criteria as they helped to distinguish between ecological, economical and societal sustainability as well as principles required for individual well-being. Since only a few iterations were performed to come up with the final set of sustainability criteria they can only be considered as a first compilation of possibly relevant criteria one should be aware of when scaling up electromobility in a sustainable way. However, as they are partly inspired by the criteria defined by the C-Lab during Phase I, which were inspired by authors, such as Holmberg and Robèrt (2000), Larsson (2016), Sen (1999) or Rawls (1972), they are most certainly valid results.

7.4.2 The Main Drivers and Barriers

The main drivers and barriers for scaling up electromobility were identified mainly by interviewing local stakeholders from the public, private and academic sector and partly through additional literature review. Thus, a somewhat both static and dynamic picture of the present situation is given. On the one hand, the barriers may represent the static aspects as they give an impression on the obstacles and gaps that must be overcome to reach the previously defined future vision of 2050. On the other hand, the drivers represent the the dynamic part of the picture as they illustrate the system's potential to change and thereby overcome the barriers.

The present compilation of barriers is of such nature that, if all of them are overcome, electromobility will be in place, at least in the city of Gothenburg. However, this does not guarantee that the presented barriers represent a complete picture of the present state as possibly important requirements for the transition into an electrified transportation system, primarily focused on cars, might have not been taken into account. Furthermore, some of the barriers include the need for a transition into a more sustainable transportation system in general (e.g. *'Reducing traffic vs. introduction of BEVs'* or *'Need for sustainability awareness of the users'*), which might be considered as even more relevant than replacing fossil based ICEVs with BEVs.

Overall the presented compilation of drivers and barriers should be seen as a good starting point for the strategic planning of political actions to induce a transition into a more sustainable and electrified transportation system based on the car.

7.4.3 'A Green New Deal' & Future Concepts

As formulated by Dreborg (1996) *'One conclusion is that the merits of backcasting should be judged in the context of discovery rather than in the context of justification.'* This could be observed when potential future *concepts* were designed and subsequently evaluated against the sustainability criteria (backcasting step 1) and the main identified barriers (backcasting step 2). Firstly, the design of future scenarios and the following proposal of 'A Green New Deal' as the most desirable future scenario, was supposed to provide a framework for the discovery of potential future *solutions* and *concepts* that could be aligned with such a future, rather than justifying why they were chosen. It is important to note that the design of the future *concepts* was strongly influenced by the identified drivers and barriers and partly represent a simple inversion of the barrier: Out of the identified barrier *'Need for a common vision and strategy'* evolved the *concept 'A common vision and strategy'* or our of the barrier *'Need for standardised charging infrastructure'* evolved the *concept 'Standardised Charging'*.

Furthermore, the quantitative evaluation allowed for the discovery of specific *concepts* one should focus on when developing a strategy for scaling up Electromobility as well as creating a holistically sustainable transportation system. Since this evaluation was highly subjective it was not about justifying and backing up every single rating but much more about discovering interesting constellations of future *concepts* that are more or less sustainable and have a higher of lower potential of overcoming the identified barriers. The conclusion drawn from this evaluation is aiming to highlight preferable concepts as well as critical sustainability criteria and barriers that are less tackled with the proposed set of *concepts*. Based on these conclusions one may improve any of the *concepts* or design additional ones that aim to overcome critical barriers or improve critical sustainability criteria. As this is only the first and very basic approach of combining the backcasting approach with an evaluation of potential future *concepts* its practical usefulness remains to be seen. However, we believe that this approach can facilitate the choice as well as design of highly effective *concepts* that are supposed to propel the transition into a more sustainable and electrified transportation system.

7.4.4 The Proposal of a Strategy

The proposed strategy path may be seen as a result of all the previous steps of the backcasting methodology. For the design of the strategy the potential future *concepts* (backcasting step 3), which preferably overcome the main barriers (backcasting step 2) and are sustainable in the ecological, economical, societal and well-being dimension (backcasting step 1), are put into temporal context on the timeline between 2016 and 2050. However, since the *concepts* were originally not designed to depict a complete strategy path towards 2050 when put into chronological order the allocation could only be performed within their limitations. As a result all the *concepts* were categorised in short-term (2016-2025) and long-term (2025-2050) as well as distinguished between technologies (e.g. *'Inductive Charging'* or *'Shared Autonomous EVs with decentralised Parking'*), policies (e.g. *'Bonus-Malus System'* or *'Zero Emission Zones'*) and society (e.g. *'Awareness Campaigns'* or *'Share-the-Ride Platforms'*).

Regarding the validity of the proposed strategy it is important to note that it is mostly based on our personal understanding of how the system should be changed over time. However, the chosen time frame for the approximate implementation of the concepts is partly oriented by officially announced milestones. For example, *'A common Vision and Strategy'* has to be in place before effective *'Trialability Programmes'* can be launched in order to increase the perceived reliability of BEVs to prepare Gothenburg's society for the launch of Volvo's first BEV in 2019. These short-term dynamics, amongst others, are in accordance with the ambitions of local stakeholders as could be observed during the stakeholder dialogue held at the end of this thesis project, which makes the proposed strategy for the following years even more viable.

Lastly, the long-term strategy path (2025-2050) is by far less specific than the short-term strategy path (2016-2025) since most of the future *concepts* (e.g. *'Cross-boundary collaborations'*, *'Standardised Charging'* or *'Innovation Contests'*) are influenced by the current needs of the system to get the transition started. Additionally, the further we reach into the future the more uncertainties we face which makes a distinct proposal of a valid strategy almost impossible. Therefore, the whole strategy path must be seen as logical framework that allows for a scaling up process of electromobility in the city of Gothenburg and a guideline, mainly for local policy makers, for the next steps to take, especially in the short-term.

8
Conclusion

Applying sustainable development in the urban landscape demands a transformative and integrative intervention in many different areas. The transportation system is one of these areas. In this thesis, in order to investigate opportunities for sustainable development in the transport system, two successive processes, Phase I and Phase II, were conducted. During Phase I the research question of this thesis was formulated and during Phase II it was investigated and answered. The initial process in the C-Lab started with Phase I during which the group of the master thesis students defined sustainability criteria to provide solutions in order to solve challenges related to sustainable development. Then, systems thinking was applied to analyse the current situation in the Gothenburg region regarding challenges around sustainability. Subsequently, potential solutions to tackle these challenges in terms of master thesis projects were generated.

Hence, sustainable transportation based on electromobility arose as a result of Phase I to be further investigated during Phase II. More specifically, the main purpose of Phase II was to demonstrate a way of co-creating a strategy for scaling up electromobility in the city of Gothenburg by implementing the backcasting methodology in a participatory multi-stakeholder environment. For that a methodological framework that follows the backcasting methodology was structured and its results are presented for the case of Gothenburg. The sequence of steps of this framework can also be seen as a proposal of an approach when future strategy studies are required for solving complex challenges. Therefore, it can be adopted and adjusted to tackle similarly complex challenges as the electrification of the transport system.

Consequently, the two-folded purpose of this thesis must be supported with conclusions on both of the methodology that was applied (s. section 8.1) as well as the results that were acquired including their analysis (s. section 8.2).

8.1 Conclusion on the Methodology

The methodology followed in the thesis used backcasting as the overarching guideline complemented with theoretical concepts and tools, such as *systems thinking*, *design thinking* or *stakeholder engagement*. When combined with these complementary tools the backcasting methodology is ideal for dealing with such a complex environmental and societal challenge as the transition into a more sustainable and electrified transportation system. Firstly, formulating our vision and sustainability criteria (backcasting step 1) from the beginning provided a clearly defined end-state in which a sustainable transportation system with an 80% share of electromobility can exist. This picture of the future provides a first step to steer the system towards a defined desirable state with clear boundaries. Secondly, investigating the present situation and identifying drivers and barriers for scaling up electromobility breaks down and simplifies the system with all of its components (backcasting step 2). Hence, the gaps that must be overcome to reach the desirable future state become apparent. Thirdly, *solutions* and specific *concepts* can be designed to bridge the gaps (backcasting step 3). Lastly, a strategy path can be created by contextualising the previously designed *concepts* in terms of a logical sequence on the timeline towards the desirable future state (backcasting step 4).

Throughout our experience with this methodology complementary tools were used, such as *semi-structured interviews*, *scenario design* and *stakeholder dialogue*. They can effectively be combined with the backcasting methodology enhancing the value of the results. More specifically, the participatory tools used in this thesis project, such as interviewing highly relevant stakeholders or realising the stakeholder dialogue, offered a 'lively' first-hand representation of the current situation and thereby enhanced our understanding of the local stakeholders' intentions and desires. The employment of such tools also showed their potential in accelerating the creation of synergies and common strategies to overcome today's unsustainable state including the barriers for the diffusion of electromobility to ultimately reach sustainable transportation. For instance, without conducting the interviews and only studying official literature we would have not considered the rigidity in the current regime as an existing barrier for new actors related to electromobility to enter the market. Also the dialogue revealed different perspectives and understandings from the participants, which cannot be found in any literature. For example, it was very insightful to observe that actors from different sectors (private, public and academia) have a different perception of the policy intervention that takes place by the city. More specifically, private sector actors expressed the opinion that the city should take more action whereas public actors were of the opinion that they are already doing enough.

In addition, the *scenario design* provided a glance into the future of uncertainties enriching a better planning when designing strategies for a future sustainable transportation system. More specifically, analysing the uncertainties of *travel behaviour* and *local policy intervention* by building scenarios around their extreme values shaped three useful conclusions. Firstly, it made us reflect, especially during the stakeholder dialogue, upon where we place our system right now regarding the uncertainties and upon the need to guide the system towards a future of more collaborative transport and more proactive policies. Secondly, the design of equally probable scenarios of the future gave an insight into how the system *could* change and by promoting 'A Green New Deal', as the most desirable and sustainable future scenario, how the system *should* change. Thereby, the framework for *concepts* that promote a transition towards such a future is given and their design facilitated. And thirdly, the generation of scenarios, along with the dialogue, contributed in crystallising our realisation for the necessity of two transitions: ① The technological transition from fossil fuel based into electrified transport solutions, and ② a holistic transition into a an ecologically, economically and socially sustainable transportation system in which proactive policies and collaborative transport solutions are in place. For instance, an isolated investigation of only the first transition would have neglected the goals from the City of Gothenburg, such as a car traffic reduction in the city centre of 25% by 2035 compared to 2011.

Furthermore, since we were two authors compiling this report, there was a high need for co-creation between each other. A general empirical conclusion is that the backcasting methodology is very well suited for such a highly co-creative process throughout all the steps. Also, since the methodology itself is open and convenient for combining it with further methodological tools, it allows but also challenges the users to be highly creative and *'think out of the box'*, especially when designing and planning for the future. Our experience with conducting a participatory backcasting workshop with local key stakeholders, demonstrated that the methodology and its components are highly comprehensible and thus very much inviting to stakeholders to get engaged and participate.

On one hand, one can argue that backcasting and some complementary tools, such as *scenario design*, can be highly intuitive because of their high need of creativity and dealing with a lot of uncertainties because of trying to 'strategise' a path towards uncertain futures. While conducting the backcasting method one 'keeps learning by doing' throughout the four steps as knowledge from a later step can induce changes in previous ones. This happens because the uncertainties are high and subjectivity during the brainstorming sessions plays an important role as abstract *concepts* have often different interpretations. That said, one may claim that the method is iterative. For example, while one evaluates the generated *concepts* against the sustainability criteria, there might come up a need for improved formulation or even rethinking some criteria because of possible overlaps or because a quantitative evaluation is not possible. Despite this iteration to acquire useful results, the method is flexible enough to easily move between each of the backcasting steps and apply alterations once the previous step(s) is (are) completed.

Last but not least, this project could only be realised in close collaboration with the stakeholders, especially concerning the realisation of the stakeholder dialogue and the interviews conducted beforehand. Also, the need for a large amount of brainstorming sessions required the participation of at least two people to obtain the results presented in this thesis. Many of the ideas and tools used here, such as sustainability principles, scenarios and its methodological components along with all the future *concepts* and the proposed strategy path are created from scratch. Hence, the amount of quality communication, active listening, patience and teamwork are indispensable 'ingredients' for such an endeavour.

8.2 Conclusion on the Results

Conclusions regarding the results of applying the methodologies and tools on the case of the electrification of private transportation in city of Gothenburg are multilateral. First of all, a general conclusion is that we need a *systemic holistic change* when attempting to scale up electromobility to reach a sustainable transportation system in the future. Transport is a complex sector with many different stakeholders, both in the private and public sector, such as infrastructure and services providers across different modes, producers of vehicles, regulators and, finally, users and their behavioural choices. Their actions are interconnected, but many stakeholders have only a partial perspective of the system they play a part in. The main obstacle lies on the fact that a fragmented, isolated approach is unlikely to be efficient or to guarantee the necessary consistency to address long-term challenges. Moving from isolated and spontaneous adaptation to integrated, complementary and mutually supportive action from the different stakeholders such as *cross-boundary collaborations* and working under the same *common vision* can enable a more effective and efficient transition into a more sustainable state.

As a first step to initiate the transformation of the transport system the local Urban Transport Administration (Trafikkontoret) of the City of Gothenburg ought to develop a more concrete and elaborate inclusive strategy to scale up electromobility. It is supposed to take action through inclusive processes, such as backcasting campaigns, and thereby co-create an overarching vision for an electrified sustainable transportation system of the future. The first step of approaching significant local stakeholders was made at the C-Lab with this thesis project. By being impartial students we, as ‘change agents’, managed to invite local stakeholders to a neutral arena where all the participants opened up, shared their views, were called to co-create a path and felt as part of a group with the common goal of diffusing electromobility in the city of Gothenburg. At the end the participants were able to realise the need for a holistic change and were admittedly motivated to keep the energy high by engaging in initiatives, projects and joint strategies for the future development of electromobility. A great challenge for that is the alignment of the stakeholders under a common vision, which can be overcome through participatory processes and dialogues. The stakeholders co-creating the vision and strategy, should come from the triple-helix without excluding the often neglected the side of the user. In this transition the users are focal, since they are the ones that will be called to change their mental and behavioural habits.

Another critical barrier to overcome in the short-term is the lack of a standardised charging infrastructure in the city of Gothenburg but also on a national level in Sweden as only a few *concepts* considered in this thesis are tackling this issue. The evaluation of the generated *concepts* demonstrates that *standardised charging* is the most sustainable of them (s. figure 8.1 on page 145), as for its realisation, coordinated action from the stakeholders as part of the triple-helix has to be taken. At the same time, a central initiative from either national or local authorities must be taken on installing the standardised rapid-charging configuration proposed by the EU directive for clean alternative fuels. This will strengthen the reliability and

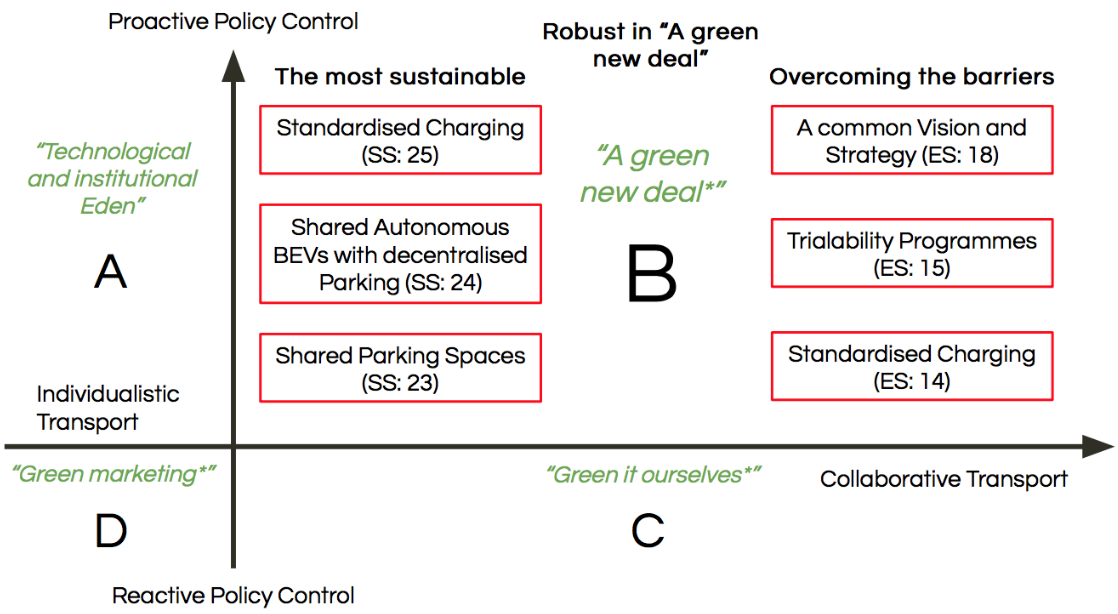

Figure 8.1: A proposal of three *concepts* each with the highest Sustainability Score (SS) (the most sustainable) and Electromobility Score (ES) (overcoming the main barriers) as well as a positive Robustness Score (RS) (can exist in the future scenario 'A Green New Deal').

accessibility of the infrastructure and thereby drastically enhance user-convenience and attractiveness of electromobility. At the same time, higher direct subsidies should come from the national government potentially from the introduction of a Bonus-Malus system currently in consideration. The combination of these two *concepts* will ultimately lead to an influx of BEV users since the vehicle becomes more affordable but also to less noisy cities.

Moreover, in the short-term highest priority should be given to measures that aim for mental and behavioural shift for citizens. Hence, *trialability programmes* and visible showcases on electromobility solutions and services around the city of Gothenburg should be implemented as they highly increase the awareness and perceived reliability of potential users on electromobility solutions. Such *trialability programmes* should be initiated from the local Urban Transport Administration (Trafikkontoret) as soon as possible. As it was observed during the dialogue, most of the involved stakeholders were positive in contributing and supporting such an endeavour as all of them will benefit from it.

On the way to a more sustainable transport, the implementation of *sharing models* that can be combined with electromobility solutions is highly effective because they allow for a reduced number of cars for the same of amount of users in addition to their reduced environmental impact by being electric. More specifically, *shared autonomous BEVs with decentralised parking* is one of the most sustainable evaluated *concepts* that provides a more efficient use of resources, reduced controllable traffic, reduction of environmental pressure and promotes values of sharing building social capital. Also, it enhances the well-being of the user by being highly user-friendly, safe, reliable and by lowering the stress-level while travelling. The timeframe of implementation is placed in the long-term and it requires both a mental and behavioural shift from the side of the users and regulations and infrastructure for self-driven vehicles to be in place.

The qualitative evaluation of the proposed future concepts also indicates that some criteria that allow for a holistically (ecologically, economically and socially) sustainable state are slightly disregarded, such as 'safety', 'equitable distribution of resources' and 'no over-extraction of materials and substances'. Overall, one can conclude that explicit emphasise should be put on these sustainability criteria when designing further future *concepts* that are aiming to scale up electromobility.

A common conclusion from the literature for systemic and behavioural changes, is that it takes time for such a change to happen in people's mindset and lifestyle. A similar conclusion was drawn in our case as well. When developing a strategy for scaling up electromobility, one should make sure that transition policies are preceding a set of more radical policies since there has to be given reasonable time to the users to adjust to new trends. This will also create mutual trust between the policymakers and users in a bilateral fashion when more radical policies are implemented. Hence, this trust will enable people to be more amenable to necessary changes in their mobility behaviour, thus the policies have more chances to be successful. What is more, when developing a strategy for systemic transitions one should always take into consideration the 'interplay' between technology, policy and society. In concrete terms, every technological or political action has an direct or indirect effect that is followed by a response by the society. By understanding this interrelation and trying to identify how society reacts and self regulates around it, adds legitimacy and robustness to a strategy.

During the phase of the interviewing, one useful conclusion that was acquired is that the electrification of public transportation modes, such as buses, is 'on the way' and less complex to achieve than the electrification of private transportation modes, such as the car. This is mainly because a shift in a cleaner public transport network can be established through a 'top-down' approach depending on political initiatives rather than depending on a change in people's behaviour and every day choices. Also, the electrification of public transportation modes requires less efforts for the planning and construction of charging infrastructure because charging is only needed at predefined destination points which ultimately reduces the number of charging stations required. Furthermore, the batteries can be perfectly sized for the travel distance of the bus before it will be recharged since there are clearly defined routes compared to the variation of travel patterns when it comes to the car.

9 Recommendations for Future Studies

In this thesis the ambitious task undertaken to carry out all four steps of the backcasting methodology, generated possibilities for further investigation in parts that were not thoroughly touched upon. First of all, there is a considerable room for a more thorough investigation of the stakeholder networks related to electromobility, both for public and private transportation. More specifically, we recommend a more in-depth analysis of the identified stakeholder networks and a possible mapping of existing and potential synergies for the future. These constellations can be based on an investigation of the actors' value systems, intentions and objectives relevant to the development of an electrified and sustainable transportation system of the future. In addition, possible 'tensions' among the relevant stakeholders could be identified and ways of effective collaborations could be proposed.

What is more, the quantitative evaluation of potential future *concepts* presented here, was only conducted with a limited amount of iterations and not validated extensively. Therefore, we recommend a participatory evaluation of the existing or more future *concepts* involving the stakeholders. This may be done with a quantitative approach which helps for the validation of the acquired *Sustainability Scores*, *Electromobility Scores* and *Robustness Scores* in this thesis.

The 8 future *solutions* and 24 future *concepts* described in this thesis evolved out of a rather unstructured set of brainstorming session without attempting to cover all the necessary dimensions of technology, policy and society. Therefore we recommend a more structured design of further complementary future *solutions* and *concepts* with the focus on innovative products and services. We believe that there is a higher demand for smart, green and innovative concepts of products and services than there is for policies since a shift towards electromobility can be most likely achieved with the proposed set of policy measures, such as the *Bonus Malus System* in the short-term or a *strong increase of* CO_2*-taxes* in the long-term. However, for these measures to be effective there is a need for new and attractive alternatives, both in the short- and the long-term, to allow the users to shift towards electrified transportation instead of fossil fuel based transportation.

Although we say the electrification of public transportation, namely buses, is 'on the way' there is still the need to develop a clear strategy path to make this transition happen as soon as possible. Since this transition is supposedly easier to realise it may path the way for the electrification of private transportation and is therefore highly relevant to focus in simultaneous fashion.

Finally, we would like to recommend the initiation of a participatory process by the City of Gothenburg with the guidance of the C-Lab methods, such as backcasting and dialogue facilitation. This task may be taken on by future generations of C-Lab master thesis students in close collaboration with the local Urban Transport Administration (Trafikkontoret) or even other actors, such as Volvo Cars. More specifically, the mediation between identified stakeholders could be continued in future master thesis projects by organising further dialogue and workshop sessions in neutral 'arenas'.

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A

Appendix 1

A.1 Backup for the MLP Analysis

Automotive market segmentation based on the **product type** (EU Commision of the European communities, 1999):

- Mini cars
- Small cars
- Large cars
- Executive cars
- Luxury cars
- Sport coupes
- Multi-purpose cars
- Sport utility cars (off-road included)

Automotive market segmentation based on **consumer profile** (Market segmentation study guide, 2016):

- **'Just getting around':** Consumers consider a car as a transportation device that simply takes them from point A to B.
- **'Family needs':** The consumers' purchase of a car is defined on its capability to move their family.
- **'I've made it':** The consumers are mostly interested in the social status benefits of a car brand.
- **'Environmentally aware':** Consumers take environmental factors into account when purchasing a vehicle. This is considered as an emerging market segment.
- **'Second family car':** The consumers are part of families in which both parents work or the children start to drive a car themselves. This segment may be considered as a subset of the 'family needs'.

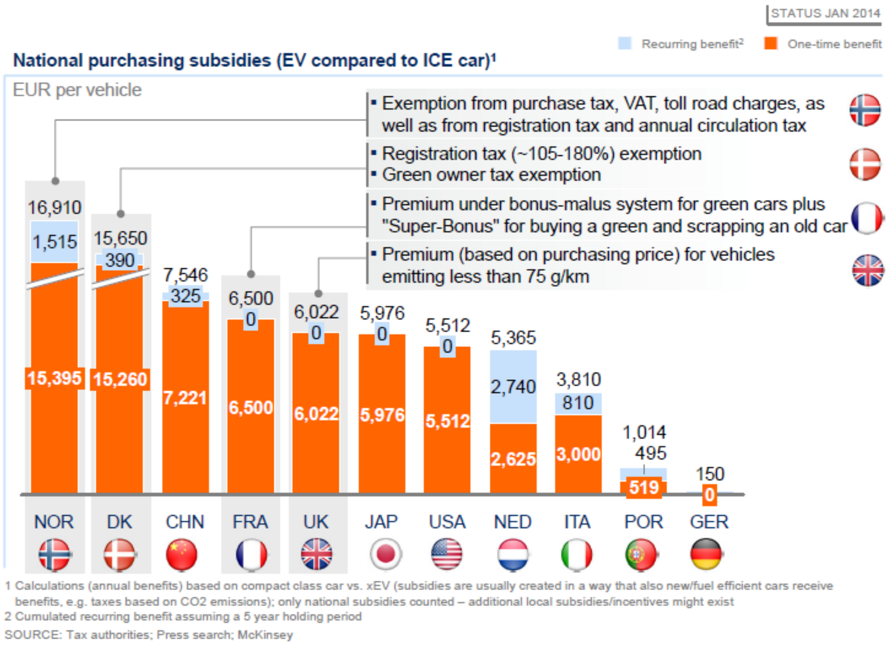
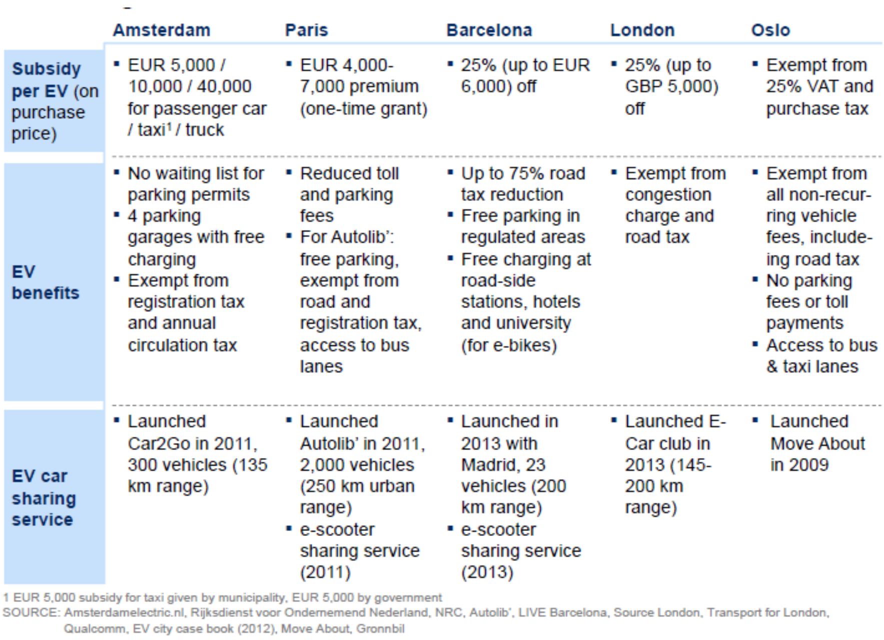


Figure A.1: National Governments stimulating EV demand (McKinsey and Amsterdam Roundtables Foundation, 2014)



	Amsterdam	Paris	Barcelona	London	Oslo
Subsidy per EV (on purchase price)	▪ EUR 5,000 / 10,000 / 40,000 for passenger car / taxi[1] / truck	▪ EUR 4,000-7,000 premium (one-time grant)	▪ 25% (up to EUR 6,000) off	▪ 25% (up to GBP 5,000) off	▪ Exempt from 25% VAT and purchase tax
EV benefits	▪ No waiting list for parking permits ▪ 4 parking garages with free charging ▪ Exempt from registration tax and annual circulation tax	▪ Reduced toll and parking fees ▪ For Autolib': free parking, exempt from road and registration tax, access to bus lanes	▪ Up to 75% road tax reduction ▪ Free parking in regulated areas ▪ Free charging at road-side stations, hotels and university (for e-bikes)	▪ Exempt from congestion charge and road tax	▪ Exempt from all non-recurring vehicle fees, including road tax ▪ No parking fees or toll payments ▪ Access to bus & taxi lanes
EV car sharing service	▪ Launched Car2Go in 2011, 300 vehicles (135 km range)	▪ Launched Autolib' in 2011, 2,000 vehicles (250 km urban range) ▪ e-scooter sharing service (2011)	▪ Launched in 2013 with Madrid, 23 vehicles (200 km range) ▪ e-scooter sharing service (2013)	▪ Launched E-Car club in 2013 (145-200 km range)	▪ Launched Move About in 2009

1 EUR 5,000 subsidy for taxi given by municipality, EUR 5,000 by government
SOURCE: Amsterdamelectric.nl, Rijksdienst voor Ondernemend Nederland, NRC, Autolib', LIVE Barcelona, Source London, Transport for London, Qualcomm, EV city case book (2012), Move About, Gronnbil

Figure A.2: Cities stimulating EV demand (McKinsey and Amsterdam Roundtables Foundation, 2014)

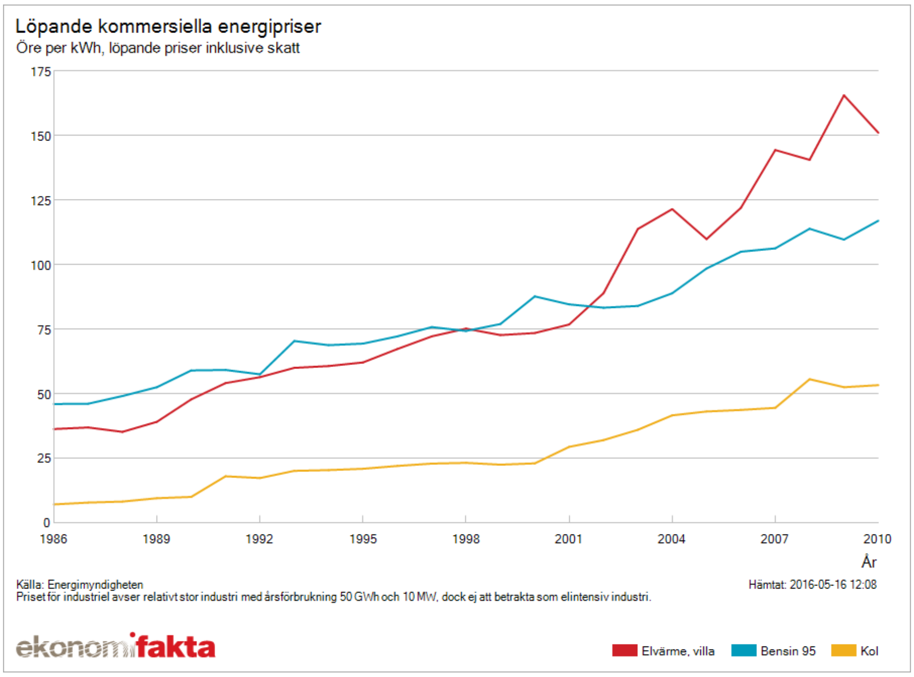


Figure A.3: Commercial Energy price development (The price for industry concerns relatively large industry with annual consumption of 50 GWh and 10 MW) (Ekonomifakta, 2013).

B

Appendix 2

B.1 List of Stakeholder Interviews

List of conducted Stakeholder interviews		
Interviewee(s)	*Organisation*	*Date*
Ulf Östermark	Johanneberg Science Park	February 22, 2016
Thomas Nyström	Viktoria Swedish ICT	February 23, 2016
Fredrik Persson	Göteborg Energi	March 3, 2016
Frances Sprei	Chalmers University of Technology	March 8, 2016
Malin Andersson & Alexander Sjöberg	Trafikkontoret	March 9, 2016
Lotta Göthe	Ecoplan	March 10, 2016
Fredrik Cederstav & Lina Olsson	Volvo Cars	March 10, 2016
Jörn Engström	Västra Götalandsregionen	March 11, 2016
Anders Roth	IVL	March 14, 2016
Niklas Gustafsson	Volvo Group	March 15, 2016
Ulf Jakobsson	Move About	March 21, 2016
Stefan Hellberg & Anna Wideman	Parkeringsbolaget	March 23, 2016
Stefan Pettersson	Viktoria Swedish ICT	April 7, 2016
Dan Bergman	Göteborg Energi	April 18, 2016
Axel Edh	Volvo Cars	April 25, 2016

Table B.1: List of conducted Stakeholder interviews

B.2 The Stakeholder Network

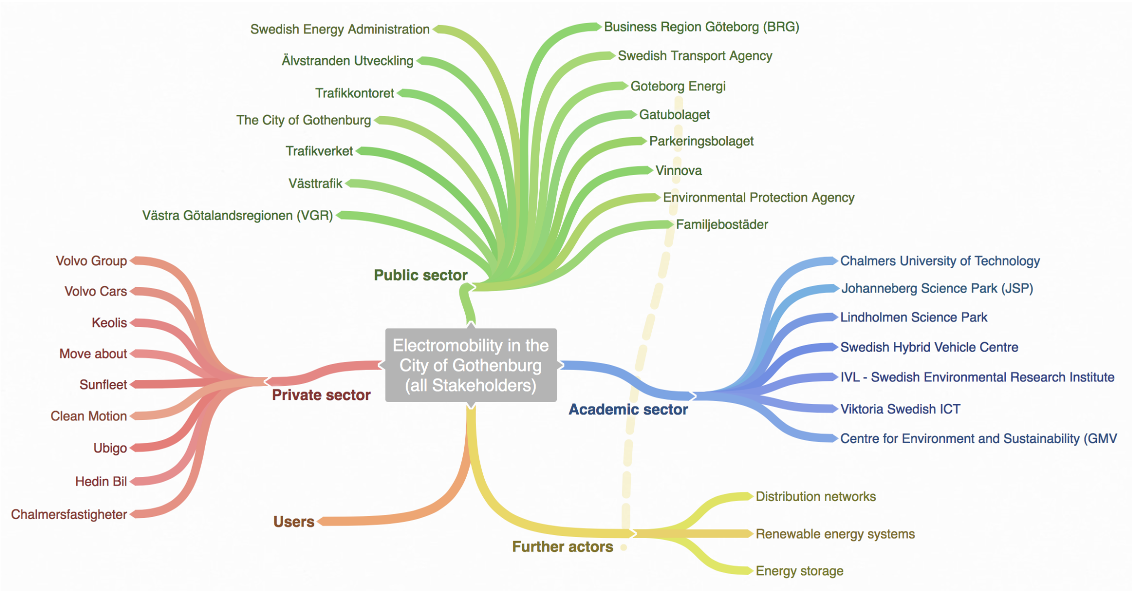


Figure B.1: Relevant Stakeholders from the public, private and academic sector in relation to Electromobility in the City of Gothenburg.

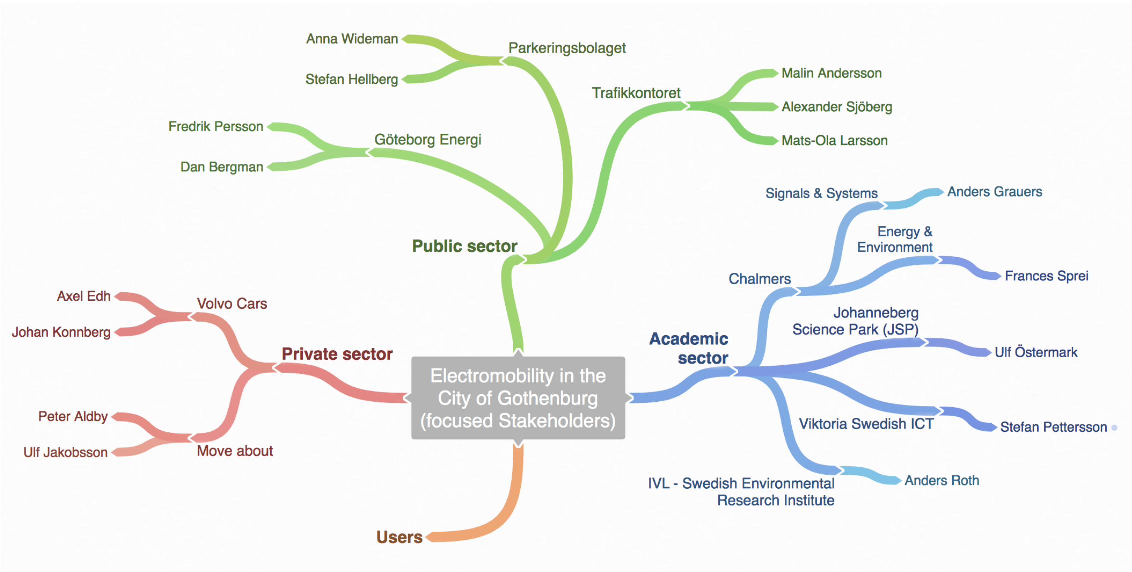


Figure B.2: Focus group of Stakeholders around private transportation from the public, private and academic sector in relation to Electromobility in the City of Gothenburg.

B.3 Questionnaire for the Stakeholder Interviews

General Questions

- How does your organisation envision a sustainable and electrified transport system of the future in the city of Gothenburg?
- What are the main drivers and barriers for diffusing EVs in the city of Gothenburg?
- What initiatives or partnerships related to electromobility does your organisation have at the moment?
- What could be critical uncertainties when thinking about future scenarios around electromobility?
- Nowadays many researchers and analysts on future transportation trends challenge car ownership. What relevant plans does your organisations have for such a future?
- What are your plans (projects, initiatives, goals, etc.) for the short-term (2016-2025) and the long-term (2025-2050) concerning electromobility and its diffusion into society?
- How can your organisation still make profits if regulations to reduce car traffic in the city centre will be introduced and collaborative transport becomes more attractive?
- How could we benefit from each other?
- Would you be interested in participating in our dialogue?

Specific Questions

- More and more battery producers claim that electricity storage is close to a break even point. Do you share that view? (Volvo Cars, Viktoria Swedish ICT)
- Are you considering ‘battery swapping’ as a valid option for the future? (Volvo Cars, Göteborg Energi, Viktoria Swedish ICT)
- How flexible is the existing system when it comes to building a charging infrastructure for EVs (Göteborg Energi, Move About, Parkeringsbolaget)
- What are the specifications of your rapid chargers? (Volvo Cars, Göteborg Energi)
- Parking lots occupy a lot of space. Are there any plans exploiting this space for other purposes as well (e.g. renewable energy systems)? (Parkeringsbolaget)

C

Appendix 3

C.1 Design Process for Potential Future Concepts

Generation process of concepts			
Functions (Why)	*Solutions (How)*	*Concepts*	*Relevant Stakeholders*
Reliability	Rapid Technology Development	Investment in R&D for 'Green' Technology	Viktoria, Chalmers University, Volvo Cars, National actors
Access to clean citiy	Rapid Technology Development	Local Renewable Power Production and Energy Storage	Göteborg Energi, Private energy companies, Municipality, users
Efficiency and convenience	Rapid Technology Development	Advanced ICT-Solutions	Viktoria, Volvo, Ericsson
Attractiveness and common good	Doing well by doing good	Generation of Research Projects for sustainable Business Models	IVL, Viktoria, Chalmers University, Gothenburg University, local entrepreneurs

Table C.1: From Functions (Why) over Solutions (How) to specific Concepts including relevant Stakeholders (Part 3).

Generation process of concepts			
Functions (Why)	*Solutions (How)*	*Concepts*	*Relevant Stakeholders*
Efficiency of resources	Sharing Models	Shared autonomous EVs with decentralised Parking	Move About, Sunfleet, Gatubolaget
Reduction of environmental pressure	Sharing Models	Share-the-Ride Platform	Viktoria, Gothenburg Municipality, Local Entrepreneurs
Social values of sharing	Sharing Models	Shared Parking Spaces	Parkeringsbolaget, Familjebostäder and other Housing companies
Access to a clean city	Changing the Game with Strong Policies	Zero Emission Zones	Urban Transport Administration
Access to a clean city	Changing the Game with Strong Policies	Banning to sell new Fossil-based Cars	National actors
Access to a clean city	Changing the Game with Strong Policies	Strong increase of CO_2 taxes	National actors
Access to a clean city	Changing the Game with Strong Policies	Bonus-Malus System	National actors
Participatory strategy and integrative synergies	The Power of Vision	A common Vision and Strategy	Gothenburg Municipality, Urban Transport Administration, local stakeholders
Participatory strategy and integrative synergies	The Power of Vision	Cross-boundary Collaborations (Triple-Helix)	Local stakeholders
Participatory strategy and integrative synergies	The Power of Vision	Multi-Stakeholder Dialogues	Local stakeholders

Table C.2: From Functions (Why) over Solutions (How) to specific Concepts including relevant Stakeholders (Part 1).

Generation process of concepts			
Functions (Why)	*Solutions (How)*	*Concepts*	*Relevant Stakeholders*
Flexibility and Convenience for the user	Convenient Charging	Inductive Charging	Göteborg Energi, Viktoria
Flexibility and Convenience for the user	Convenient Charging	Smart Payment Systems for Charging	Parkeringsbolaget, Göteborg Energi
Accessiblity and Convenience for the user	Convenient Charging	Standardised Charging	Parkeringsbolaget, Göteborg Energi, Urban Transport Administration, National actors
Flexibility and Convenience for the user	Convenient Charging	Ultra-rapid Charging	Parkeringsbolaget, Göteborg Energi
Flexibility and Convenience for the user	Convenient Charging	Coordinated Charging	Parkeringsbolaget, Göteborg Energi
Reliability	Try it and you will like it	Trialability Programmes	All local stakeholders, car dealers
Sustainability awareness	Education for Sustainability	Sustainability Workshops	Urban Transport Administration All local stakeholders, car dealers
Sustainability awareness	Education for Sustainability	Innovation Contests	Urban Transport Administration Chalmers University, Handels Business School, Vinnova
Visibility	Education for Sustainability	Awareness Campaigns	Local media, users, Viktoria
Visibility	Education for Sustainability	Peer-to-Peer Platforms	Urban Transport Administration, Viktoria, Users

Table C.3: From Functions (Why) over Solutions (How) to specific Concepts including relevant Stakeholders (Part 2).

C.2 Results from the Quantitative Evaluation of Future Concepts

		Solutions	*"Sharing models"*			*"Changing the game with strong policies"*			
		Concept No.	1	2	3	4	5	6	7
		Concepts	Shared Autonomous BEVs with Decentralised Parking	Share-the-Ride Platform	Shared Parking Spaces	Zero Emission Zones	Banning to sell new Fossil Fuel based Cars	Strong Increase of CO2 Taxes	Bonus-Malus System
	Sustainability criteria on E-mobility	**Concept Score**							
Ecological	(1) No emissions into the ecosphere	24	2	1	1	2	2	2	2
	(2) No over-extraction of materials and substances	9	1	1	1	0	1	0	0
	(3) No deterioration of resources	24	1	1	2	2	2	2	2
Economical	(4) Efficient use of resources	20	2	2	2	0	1	1	0
	(5) Equitable distribution of resources	7	0	1	2	0	-1	0	0
	(6) Affordability for the user (of E-mobility solutions)	11	0	2	1	1	0	2	1
	(7) Profitability for the investor (into E-mobility solutions)	12	0	0	1	1	0	2	1
Societal	(8) Common awareness	36	1	1	1	2	2	2	2
	(9) Attractiveness	30	2	1	0	2	2	2	2
	(10) Long-term availability	29	2	2	1	2	2	1	0
	(11) Fair and equal accessibility	10	1	2	1	-2	0	0	1
	(12) Trust	25	2	2	2	0	-1	0	0
	(13) Transparency	24	1	2	2	0	-1	0	0
Well-being	(14) Health	16	2	2	1	2	2	2	2
	(15) Access to electricity	12	0	0	2	0	1	0	0
	(16) User friendliness	19	2	1	2	2	0	2	0
	(17) Satisfaction	24	1	1	2	2	0	2	0
	(18) Safety	6	2	0	0	0	0	0	0
	(19) Reliability	18	2	0	-1	0	0	0	0
	Sustainability score (max. 38)		24	22	23	16	12	20	13

Figure C.1: Evaluation of the future *solutions ‘Sharing Models’* and *‘Changing the Game with Strong Policies’* against the sustainability criteria.

		Solutions	"The power of vision"			"Convenient charging"				
		Concept No.	8	9	10	11	12	13	14	15
		Concepts	Cross-Boundary Collaborations (triple-helix)	A common Vision and Strategy	Multi-Stakeholder Dialogues	Inductive Charging	Smart Payment Systems for Charging	Standardised Charging	Ultra-rapid Charging	Coordinated Charging
	Sustainability criteria on E-mobility	Concept Score								
Ecological	(1) No emissions into the ecosphere	24	0	0	0	2	0	2	2	2
	(2) No over-extraction of materials and substances	9	0	0	0	0	0	1	0	0
	(3) No deterioration of resources	24	0	0	0	2	0	2	2	2
Economical	(4) Efficient use of resources	20	1	1	0	0	1	2	0	2
	(5) Equitable distribution of resources	7	0	0	0	0	1	1	0	1
	(6) Affordability for the user (of E-mobility solutions)	11	0	0	0	0	0	1	0	2
	(7) Profitability for the investor (into E-mobility solutions)	12	0	0	0	0	0	1	0	1
Societal	(8) Common awareness	36	2	2	2	1	1	1	0	1
	(9) Attractiveness	30	0	1	0	2	1	2	2	-1
	(10) Long-term availability	29	0	2	0	1	1	2	1	2
	(11) Fair and equal accessibility	9	0	0	0	0	0	1	0	0
	(12) Trust	25	2	2	2	1	1	1	0	1
	(13) Transparency	24	2	2	2	1	1	1	0	2
Well-being	(14) Health	16	0	0	0	0	0	0	0	0
	(15) Access to electricity	12	0	0	0	1	0	1	1	2
	(16) User friendliness	19	0	0	0	1	2	2	2	-1
	(17) Satisfaction	24	0	1	0	2	2	2	2	-1
	(18) Safety	6	0	0	0	1	0	0	0	0
	(19) Reliability	18	0	0	0	2	2	2	1	-1
	Sustainability score (max. 38)		7	11	6	17	13	25	13	14

Figure C.2: Evaluation of the *solutions 'The Power of Vision'* and *'Convenient Charging'* against the sustainability criteria.

		Solutions	"Try it and you will like it"	"Education for sustainability"				"Rapid technology development"			"Doing well by doing good"
		Concept No.	16	17	18	19	20	21	22	23	24
		Concepts	Trialability Programmes	Sustainability Workshops	Innovation Contests	Awareness Campaigns	Peer-to-Peer Platforms	Investment into R&D for "Green Technology'	Local Renewable Power Production & Energy Storage	Advanced ICT-Solutions	Generation of Research Projects for Sustainable Business Models
	Sustainability criteria on E-mobility	Concept Score									
Ecological	(1) No emissions into the ecosphere	24	0	0	0	0	0	1	2	0	1
	(2) No over-extraction of materials and substances	9	0	0	0	0	0	1	2	0	1
	(3) No deterioration of resources	24	0	0	0	0	0	1	2	0	1
Economical	(4) Efficient use of resources	20	0	0	0	0	0	2	2	1	0
	(5) Equitable distribution of resources	7	0	0	0	0	0	0	0	2	0
	(6) Affordability for the user (of E-mobility solutions)	11	0	0	0	0	0	0	0	1	0
	(7) Profitability for the investor (into E-mobility solutions)	12	0	1	1	0	0	1	0	1	1
Societal	(8) Common awareness	36	2	2	2	2	2	1	2	0	2
	(9) Attractiveness	30	1	2	1	1	1	1	2	2	1
	(10) Long-term availability	29	1	1	1	1	0	2	2	0	2
	(11) Fair and equal accessibility	9	1	2	0	1	0	0	0	2	0
	(12) Trust	25	2	2	2	1	2	0	0	1	0
	(13) Transparency	24	2	2	1	1	2	0	0	1	0
Well-being	(14) Health	16	0	0	0	0	0	1	2	0	0
	(15) Access to electricity	12	0	0	0	0	0	1	2	1	0
	(16) User friendliness	19	2	0	0	0	0	0	0	2	0
	(17) Satisfaction	24	1	0	1	1	1	1	1	2	0
	(18) Safety	6	0	0	0	0	0	1	1	1	0
	(19) Reliability	18	2	2	2	1	1	1	1	1	0
	Sustainability score (max. 38)		14	14	11	9	9	15	21	18	9

Figure C.3: Evaluation of the *solutions 'Try it and you will like it'*, *'Education for Sustainability'*, *'Rapid Technology Development'* and *'Doing well by doing good'* against the sustainability criteria.

	Solutions	"Sharing models"			"Changing the game with strong policies"			
	Concept No.	1	2	3	4	5	6	7
	Concepts	Shared Autonomous BEVs with Decentralised Parking	Share-the-Ride Platform	Shared Parking Spaces	Zero Emission Zones	Banning to sell new Fossil Fuel based Cars	Strong Increase of CO2 Taxes	Bonus-Malus System
Main barriers	**Concept Score**							
(1) Need for a common vision and strategy	21	0	0	0	1	2	2	2
(2) Reducing traffic vs. Introduction of BEVs	9	2	1	1	2	0	0	0
(3) Need for cross boundary collaborative projects	19	1	0	1	1	1	1	1
(4) Need for financially sustainable business models	10	1	0	0	0	0	0	0
(5) Rigidity in the current regime	14	0	0	0	1	1	1	1
(6) Immaturity of Electromobility	37	1	1	1	2	2	1	1
(7) Need for designated parking spaces	11	1	1	2	1	2	0	0
(8) High investment costs for the user	10	-1	2	0	0	0	1	0
(9) Need for visible showcases	20	1	1	0	2	0	0	0
(10) Need for incentives for users and investors	23	0	0	1	2	1	2	1
(11) High risk for policy makers	14	-1	0	-1	-2	-2	-1	1
(12) High risk for large companies	16	-1	0	0	-2	-2	-1	-1
(13) Need for sustainability awareness of the users	30	2	1	1	2	2	2	1
(14) Need for standardised charging infrastructure	7	0	0	0	0	0	0	0
E-mobility score (max. 28) (push potential to scale up E-mobility)		6	7	6	10	7	8	7
Robustness in Scenario B	**Concept Score**							
Existance in local proactive policies	40	2	1	2	2	2	2	2
Existance in collaborative transport solutions	28	2	2	2	2	1	1	1
Robustness score (max. 4)		4	3	4	4	3	3	3
Total score (max. 68)		34	32	33	30	22	31	23

Figure C.4: Evaluation of the *solutions 'Sharing Models'* and *'Changing the Game with Strong Policies'* against the main barriers and robustness in scenario B.

	Solutions	"The power of vision"			"Convenient charging"				
	Concept No.	8	9	10	11	12	13	14	15
	Concepts	Cross-Boundary Collaborations (triple-helix)	A common Vision and Strategy	Multi-Stakeholder Dialogues	Inductive Charging	Smart Payment Systems for Charging	Standardised Charging	Ultra-rapid Charging	Coordinated Charging
Main barriers	**Concept Score**								
(1) Need for a common vision and strategy	21	1	2	1	1	0	1	1	1
(2) Reducing traffic vs. Introduction of BEVs	9	0	1	1	0	0	0	-1	0
(3) Need for cross boundary collaborative projects	19	2	1	2	0	0	1	0	0
(4) Need for financially sustainable business models	10	0	0	0	0	2	1	0	0
(5) Rigidity in the current regime	14	1	1	2	0	1	0	0	0
(6) Immaturity of Electromobility	37	1	2	1	2	2	2	2	2
(7) Need for designated parking spaces	11	0	0	0	1	1	1	0	1
(8) High investment costs for the user	10	0	1	0	1	0	1	2	1
(9) Need for visible showcases	20	0	1	0	1	0	1	2	1
(10) Need for incentives for users and investors	23	0	2	0	1	1	1	2	1
(11) High risk for policy makers	14	2	2	1	1	1	1	2	1
(12) High risk for large companies	16	2	2	1	2	1	2	2	2
(13) Need for sustainability awareness of the users	30	1	2	1	0	1	0	0	2
(14) Need for standardised charging infrastructure	7	0	1	0	2	1	2	0	1
E-mobility score (max. 28) (push potential to scale up E-mobility)		10	18	10	12	11	14	12	13
Robustness in Scenario B	**Concept Score**								
Existance in local proactive policies	40	2	2	2	1	1	2	2	2
Existance in collaborative transport solutions	28	1	1	1	1	1	1	1	1
Robustness score (max. 4)		3	3	3	2	2	3	3	3
Total score (max. 68)		20	32	19	31	26	42	28	30

Figure C.5: Evaluation of the *solutions ‘The Power of Vision’* and *‘Convenient Charging’* against the main barriers and robustness in scenario B.

	Solutions	"Try it and you will like it"	"Education for sustainability"				"Rapid technology development"			"Doing well by doing good"
	Concept No.	16	17	18	19	20	21	22	23	24
	Concepts	Trialability Programmes	Sustainability Workshops	Innovation Contests	Awareness Campaigns	Peer-to-Peer Platforms	Investment into R&D for "Green Technology'	Local Renewable Power Production & Energy Storage	Advanced ICT-Solutions	Generation of Research Projects for Sustainable Business Models
Main barriers	**Concept Score**									
(1) Need for a common vision and strategy	21	1	1	0	1	0	1	1	0	1
(2) Reducing traffic vs. Introduction of BEVs	9	0	0	1	0	0	0	0	0	1
(3) Need for cross boundary collaborative projects	19	1	1	0	0	1	1	2	0	1
(4) Need for financially sustainable business models	10	1	1	1	0	0	0	0	1	2
(5) Rigidity in the current regime	14	1	1	1	0	1	0	0	0	1
(6) Immaturity of Electromobility	37	2	2	2	1	2	2	2	0	1
(7) Need for designated parking spaces	11	0	0	0	0	0	0	0	0	0
(8) High investment costs for the user	10	1	0	1	0	0	0	0	0	0
(9) Need for visible showcases	20	2	1	2	1	1	0	1	1	1
(10) Need for incentives for users and investors	23	1	1	2	0	1	0	1	0	2
(11) High risk for policy makers	14	1	2	0	0	0	2	2	1	1
(12) High risk for large companies	16	2	1	0	0	0	2	1	1	2
(13) Need for sustainability awareness of the users	30	2	2	1	2	1	1	2	0	1
(14) Need for standardised charging infrastructure	7	0	0	0	0	0	0	0	0	0
E-mobility score (max. 28) (push potential to scale up E-mobility)		15	13	11	5	7	9	12	4	14
Robustness in Scenario B	**Concept Score**									
Existance in local proactive policies	40	2	2	1	1	1	2	2	1	1
Existance in collaborative transport solutions	28	1	1	1	1	1	1	1	1	1
Robustness score (max. 4)		3	3	2	2	2	3	3	2	2
Total score (max. 68)		32	30	24	16	18	27	36	24	25

Figure C.6: Evaluation of the *solutions 'Try it and you will like it'*, *'Education for Sustainability'*, *'Rapid Technology Development'* and *'Doing well by doing good'* against the main barriers and robustness in scenario B.

D

Appendix 4

D.1 Outline of the Stakeholder Dialogue

- 8:40: Reception of stakeholders in front of the building
- 8:45 - 8:55: Reception of the stakeholders at the C-Lab
- 8:55 - 9:00: Guide the stakeholders to the labelled chairs (post-its)
- 9:00 - 9:30: Welcome & Check-in
  - *'Who are you?'*
  - *'Why did you choose to come here?'*
- 9:30 - 9:40: Introduction into the topic of the dialogue (short presentation)
- 9:40 - 10:30: 1st dialogue session (A desirable scenario for the future of electromobility)
  - 9:40 - 10:00: Discussion about all scenarios
    - *'Where do we place ourselves right now as a whole system?'*
    - *'Where do you see yourselves, as individuals or representatives of an organisation, in the future?'*
  - 10:00 - 10:30: Discussion about the proposed scenario B 'A Green New Deal'
    - *'Could you see yourself in this scenario?'*
    - *'What do we, as a system, need to push towards that direction?'*
    - *'How could the sustainability principles be realised in such a scenario?'*
  - 10:30: Closing the 1st dialogue session
    - *'Imagine you are in scenario 'A Green New Deal' in 2050. How would you go from here to your next meeting?'*
- 10:30 - 11:00: Coffee break
- 10:55: Guide stakeholders back into the circle
- 11:00 - 12:00: 2nd dialogue session (Next steps towards electromobility)
  - 11:00 - 11:30: Conduction of the workshop

1. Green post-it: A desirable future solution
2. Blue post-it: The stakeholder's contribution to realise the future solution
3. Orange post-it: Required synergies amongst the stakeholders to realise the contribution

– 11:30 - 12:00: Final discussion

∗ *'How can we take advantage of this dialogue today and possibly open up for further actions, meetings, etc. since the City of Gothenburg is very eager to accelerate the transition into a more sustainable electrified transport system?'*

∗ *'How can we ensure that the public, private and academic sector are working together on the very same goal?'*

∗ *'What is needed to allow for a highly collaborative future amongst all stakeholders involved?'*

∗ *'What are the next steps we have to take in order to effectively scale up Electromobility?'*

- 12:00 - 13:00: Check-out & lunch
  - *'What is your main takeaway from today?'*
  - *'How do you feel?'*

D.2 A Proposal for the Implementation of Concepts

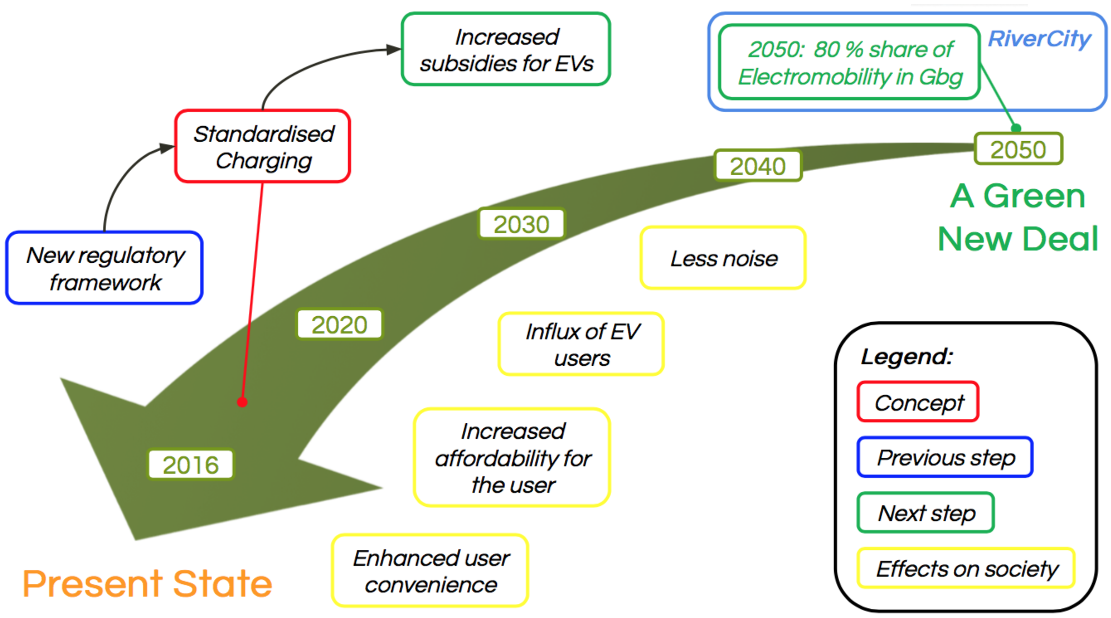


Figure D.1: Strategic steps for the implementation of the *concept 'Standardised Charging'*.

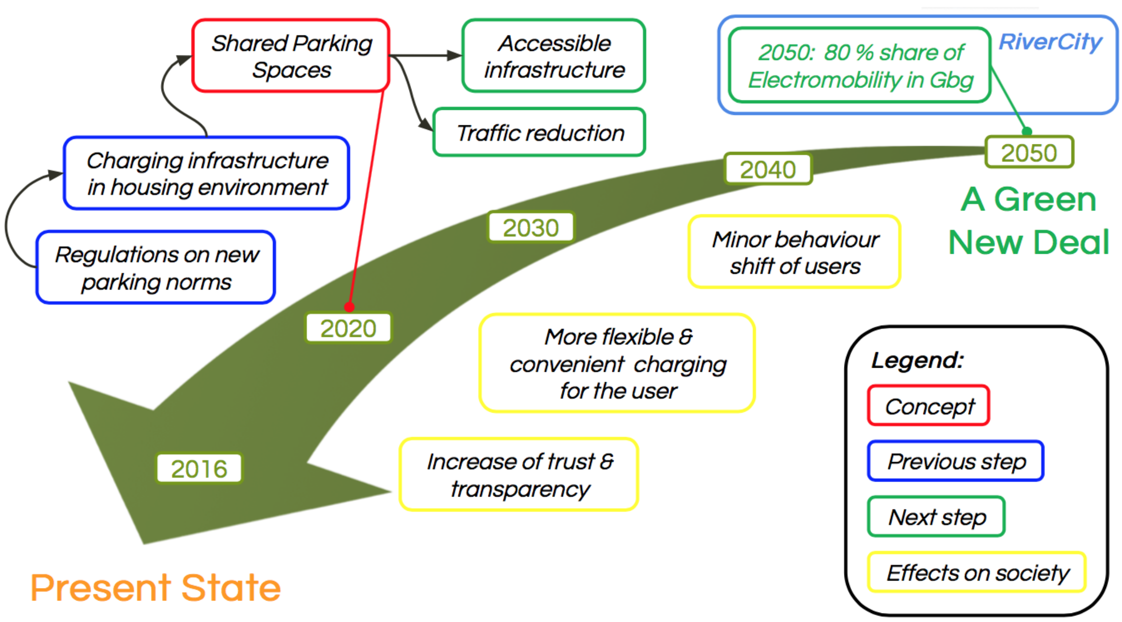


Figure D.2: Strategic steps for the implementation of the *concept 'Shared Parking Spaces'*.

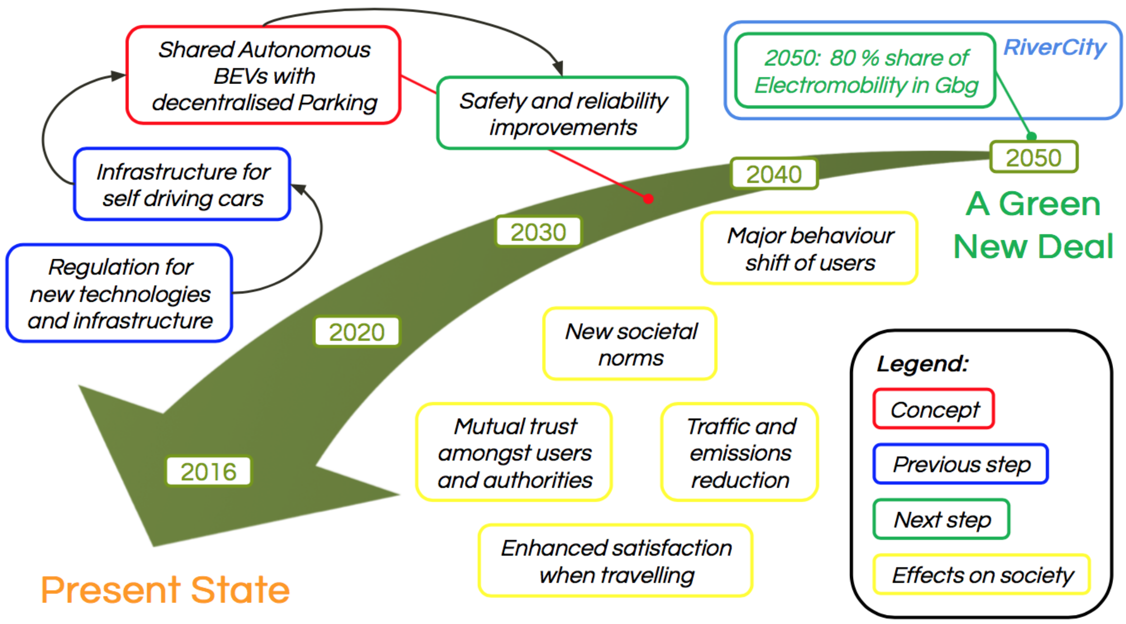


Figure D.3: Strategic steps for the implementation of the *concept 'Shared Autonomous BEVs with Decentralised Parking'*.

Figure D.4: Picture from the workshop conducted at the C-Lab dialogue 'arena' with the focus group of stakeholders

E

Appendix 5

E.1 The Roadmap for the Thesis Project

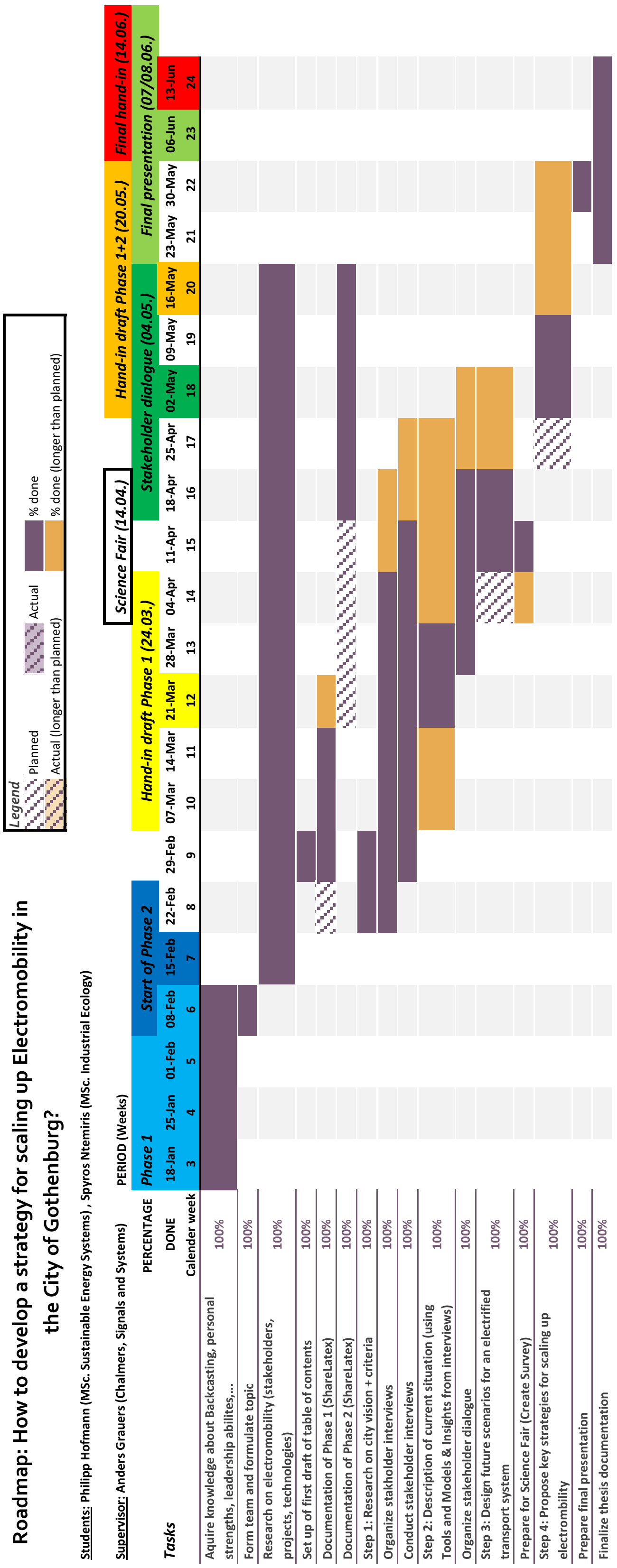


Figure E.1: Roadmap of this thesis project including relevant deadlines and events.