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**Sustainability transition studies – A case study of
electric vehicle mobility in Trondheim**

Master's thesis in MSc: Globalization: Transnationalism and Culture

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Abstract

The following thesis deals with sustainability transitions and their implementation in the municipality of Trondheim with a focus on a case study of electric mobility. Several technical concepts regarding electric vehicles are explained, and a detailed discussion on several main theories is followed by a broad analysis of climate policies in Trondheim and Norway. The core theory used is the multi-level perspective with a spatial approach. The thesis' outline is mainly focusing on a qualitative and a quantitative approach on the vast topic of electric mobility and various incentives.

To Blind Willie Johnson.

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Abbreviations

BEV	battery electric vehicle
ECM	electronic control module
EU	European Union
EV	electric vehicle
IC	internal combustion
ICEV	internal combustion engine vehicle
MLP	multi-level perspective
MSP	multi-stakeholder process
TIS	technical innovation system
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle
R & D	research & development
SNM	strategic niche management
TM	transition management
UEMI	Urban Electric Mobility Initiative
UN	United Nations

1. Introduction

The rise of sustainable policies in various countries, regions and cities across the world leads to a process of re-thinking, changing, and adapting of different political, economic, and societal aspects. Public spaces such as streets, housing, schools, and universities are changing in terms of being more environmentally-friendly. Such policies regarding sustainability affect different parts of the local society whilst being a part of a broader, national, and global process. Those policies reaching out to various societal groups changing their daily lives through several entities, e.g. technical innovation, research and development, or simply lower maintenance costs, should be deeply analyzed and understood. The field of sustainability transition is yet about to be more important in the upcoming decades since it is matching various theories, studies and research projects focusing on the rise of sustainable development, environmentally-friendly policies, and a shift in the way of thinking in many parts of the world. Also, in terms of academic research, “[transitions] to more sustainable technologies, consumption and production receive increasing attention in research, and public discourses” (Raven, et al., 2015, p. 63).

The increasing awareness of those research fields leads to a process of re-thinking of modern innovations, and it also affects already existing and established sectors, e.g. the highly-debated automotive industry. New legal, often environmentally-motivated frameworks in various countries across the world are actively forcing automobile companies to introduce new technologies, such as electric vehicles, to cope with a shift in the perception and role of mobility in the nearest future. Adapting existing forms of transportation to new policies is an increasingly important part in both public and private transportation.

In this master’s thesis, I am going to research how various factors discussed by scholars analyzing the field of sustainable transition studies contributed to electric vehicle mobility in the city of Trondheim. Norway has the highest percentage of pure electric vehicles in the world, and the political authorities in Trondheim have introduced different incentives matching the national policies of the central government to make such vehicles more appealing to a broader spectrum of its inhabitants. The first and most important research question is how exactly the city of Trondheim implied national incentives regarding electric vehicle mobility? From my point of view, it is of high importance to focus on this research question to fully understand which incentives, such as economic factors, did play a leading role in the municipality’s plan to boost electric mobility. A second research approach is an empirical analysis of the current state of electric vehicle mobility in the city of Trondheim. This minor question is crucial to

understand the process of the shift regarding sustainable transition studies. Many critical articles on electric cars and buses state that the environmental impact of electric-driven transportation is not as positive as assumed by policy makers (Jaffe 2015). An empirical approach to such critical voices may explain the current state of the city's implementation of its climate goals in pure numbers, figures, and statistics.

Electric vehicles are a crucial part of a new, sustainable automotive trend found in various countries throughout the world, especially since the 'traditional' vehicles using combustion engines are regarded as non-sustainable and environmentally harming. Furthermore, national policies in Norway are targeting pure electric vehicles and the laws introduced throughout the last two decades are giving more importance to electric mobility than to any other form of automotive engine. This is the reason for delimitating the thesis to electric vehicles. It is of high importance to highlight why the policy makers decided on supporting electric vehicles. This is going to be discussed in the first part of the first chapter.

Electric vehicles are becoming a very crucial part of incentive-oriented frameworks introduced by various policy makers and actors, especially since the engines and batteries of such electric cars are being rapidly and radically developed and improved. Current disadvantages of electric vehicles are factors such as the range or battery capacity. Matching the development of sustainable transportation, the new research & development in the field of electric mobility, and e.g. new municipal policies might be of high importance to a more sustainable transport.

In the outline of the thesis, I am mixing the content of the thesis with a detailed discussion of it and I am also including possible limitations. This approach might be unconventional, but from my point of view it is the most accurate and reader-friendly way of outlining the content of the thesis. In the first part of the second chapter of the thesis, I am going to briefly define important technical terms, both for my own and the reader's knowledge. Before working on this thesis, I was already highly interested in the automotive industry, especially in electric vehicles. I am going to briefly explain and discuss such theoretical terms as the automotive industry, mobility, and quote the technical nuances and definitions of terms regarding electric mobility, such as e.g. plug-in electric vehicles. The discussion of these terms could have been more detailed, but such a broad analysis of different engines and technical terms would have been too farfetched for the delimited topic of my thesis. This is the reason a broad focus on the technical site of electric vehicles, such as the history, engines, models, and performance are missing. A detailed discussion on the so-called life cycle assessment of long life batteries, e.g. lithium electrode, of different car and bus companies, the innovations in the

field of electric vehicle batteries and how those are contributing to a cheaper, more customer-friendly policy of changing the modern transport from fuel-based engines to electric-driven should be implemented in a possible further research paper.

In the second part of the second chapter, I am discussing and debating various articles focusing on different theories in the field of sustainability transitions. The newest research on sustainability transitions should be analyzed to fully understand the factors driving actors towards electric vehicle mobility. I am focusing on various terms, such as sustainability, sustainable development, and resilience. I am also analyzing various theories crucial for the content of the thesis, such as sustainable transition studies, green niches and socio-technical systems, the concept of protective space and reconsidering niches, the multi-level perspective, a spatial interpretation of it, the technical innovation system, and a metatheoretical perspective on sustainability journeys. All those theories are discussed and analyzed in the upcoming chapters.

A possible disadvantage of my thesis might be a brief discussion of the mentioned terms without a detailed background to those terms. The reason for this is that I am mostly focusing on sustainable transitions, and I used other terms for myself to understand the broad context of the sustainable transitions. It would have been interesting to conduct a qualitative analysis of sustainable transitions in the context of, e.g. sustainable development in a following research paper. This may be analyzed in the nearest future.

In the third chapter, I am going to briefly analyze and discuss the first climate plan of the city of Trondheim 2010-2020. It was a first draft of a possible climate-oriented framework for the city, and it mostly focused on how to reduce CO₂-emissions; it also briefly mentions the role of electric mobility. I used this climate plan because it focuses on the implementation of different national incentives. In the following parts of the second chapter, I am moving on to the second, current climate plan of Trondheim for the years 2017-2030. This plan is giving a precise research and outlook on such aspects as energy, emissions, public transportation, and electric vehicle mobility in Trondheim. Furthermore, I am discussing different goals mentioned in the climate plan which the municipality has set itself to reach by 2030 latest. I am going to discuss both the use of electric vehicles and briefly focus on three other ways of mobility mentioned and analyzed in the climate plan, i.e. cycling, walking, and public transport. The field of public transport seems to be crucial since it may be closely connected to the newest research in sustainable transition studies. Public transport in growing cities is a significant part of a shift to environmentally-friendly, emission free transport systems. This is the reason I am switching my focus from electric vehicle to public transportation since the climate plan is also

trying to explain why the city of Trondheim must analyze and focus on different ways of mobility in a more nuanced and detailed way.

As I have already thought of possible downsides of such an approach, I feel obliged to state that it should be possible to conduct a broad analysis of the public transportation system in the city of Trondheim in another article or research paper. The choice of Trondheim's authorities to cooperate with several sub-companies based in the Trøndelag region might be crucial to fully understand the climate goals. Some of the companies are using environmentally friendly automotive only. Moreover, the number of passengers using public transport in Trondheim is going to increase to 35 million in 2030. The authorities of Trondheim are introducing three new lines of so-called 'metrobuss', starting in 2019. The city bought 56 new 'superbusser' fabricated by Van Hool, 40 of them will be electric busses (Terjesen, 2018). Combining the development and performance of electric vehicle batteries in public transportation with the field of sustainable transition studies might be a thought-provoking research for future investments of the municipality of Trondheim. In the next two sections of the third chapter I am going to analyze the current state of market shares and sales of electric vehicles in Trondheim and Norway from an empirical perspective. From my point of view, it is important to add such statistics to the discussion of sustainable transitions in Trondheim to underline the qualitative approach with various quantitative sources.

I am analyzing the incentives introduced by the Norwegian government and their implementation in the fourth chapter. Firstly, I am broadly discussing and debating the national incentives, providing a historical background to the incentives, and then implementing those incentives in the local framework in Trondheim. It could have been better to 'zoom out' from the local perspective to a nation-wide, but since Norway is a centralistic country and local stakeholders do not have a strong position in implementing a change in such incentives in, e.g. federal countries or regions, I decided on the current approach. I could have also turned the multi-level perspective upside down, which would have been interesting, but from my point of view it could have been too confusing. This is the reason I decided on zooming in to the local perspective and then out. It would have been useless to discuss local incentives without providing any background information. Moreover, I am 'zooming out' even more, hence I am debating the implementation of European and international climate goals and frameworks in Norway. Providing a global context to the policies and incentives introduced by various governments in Norway is frankly a nuanced way of dealing with this tricky and difficult topic. Another possible disadvantage of such an approach would be the lack of a detailed analysis of international climate plans, the political decisions which influenced such climate goals, possible

problems faced by the stakeholders, and the lack of a discussion on how non-governmental organizations are pressuring public and private stakeholders in, e.g. the automotive and transportation sector. It would be interesting to conduct surveys on electric vehicle owners and their perception of such incentives and their motivation of acquiring such vehicles. Such topics may be discussed in a future research paper.

I used different figures, graphs, statistics, and images to enrich this thesis with colorful background information to the discussed topic. I did not translate quotes into English because most of the quotes in Norwegian are easy to understand and I would like to empower the use of this language in academia.

2. Technical terms and theoretical framework

2.1. Defining technical terms

Before I am going to define the technical terms strictly related to electric vehicles, I am going to briefly highlight different terms. I am fully aware of the fact that some terms could have been defined far more detailed in the next two upcoming sections, but a broad discussion with a historical background for each term could have led to an overuse of various theories. Therefore, I am mostly using ‘plain’ definitions for many terms and only discussing the most important theories terms in detail.

The **importance of the auto industry** across the world is the first topic I am focusing on. It is said that “[building] over 66 million vehicles a year (...) requires the employment of about 9 million people directly in making the vehicles. That is over 5 % of the world’s total manufacturing employment” (Muneer & García, 2017, p. 1). The auto industry is also one of the major innovators, “(...) investing over €84 billion in research, development, and production” (Muneer & García, 2017, p. 2). According to this quote, the auto industry is significantly focusing on **research & development (R & D)**, and this matches the environmentally-friendly trend set by sustainable transition studies. Furthermore, “(...) innovation should generate economic results and, simultaneously, a social and positive environment, which is not easily attained given the uncertainties that innovations bring about (...)” (Vaz, et al., 2017, p. 3). The use of the term innovation seems to be crucial in terms of how and what the R & D of the auto industry should be targeting. It is therefore of high importance to have a sort of “(...) a discourse that incorporates the theme of sustainable development which boils down to merely good intentions, if not a means to appropriate an idea that is gaining momentum with the population and opinion leaders” (Vaz, et al., 2017, p. 3).

A new term matching the new direction of R & D and sustainable development is **eco-innovation**, which is defined as “the production, assimilation or exploration of a product, production process, service or method of management or business that is new to the organization (...) which results (...) in the reduction of environmental risk, pollution and other negative impacts of the use of resources, including energy (...)” (Vaz, et al., 2017, p. 3).

Other important terms include the concept of **mobility** which is defined as “[the] ability to move or be moved freely and easily” (Anon., 2018). This term is easy to define, and it does not require any further explanation. **Electric mobility** is a special sort of mobility which is combining both the field of transportation and electric vehicles.

There are different types of **electric ground vehicles**, i.e. plug-in electric vehicle, hybrid electric vehicles, on- and off-road vehicles, and rail borne vehicles. I am going to focus on pure electric vehicles only since these cars are the only vehicles actively acknowledged by a significant number of policy makers across the world, and especially in Norway. The main incentives of various Norwegian governments are targeting electric vehicles only.

Electric vehicles (EVs) are currently getting popular in various countries, “due to technological developments and an increased focus on renewable energy” (Anon., 2018). An electric vehicle is, thus, a vehicle which “(...) uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity” (Anon., 2018).

The most prominent form of EVs used by private individuals are such using a battery to drive. Analyzing and understanding how a battery-based EV works is crucial to understand why these cars are said to be emission free and sustainable. The so-called “(...) power/torque curves for electric motors are much broader than those for internal combustion (IC) engines, the acceleration of an EV can be much quicker” (Dhameja, 2001, p. 2). Many of the current EVs have different built-in features which allow them to save the energy wasted during driving, e.g. “(...) the regenerative braking, which comes into play when the accelerator pedal is released or the brake pedal is applied” (Dhameja, 2001, p. 2). This is to save the EVs kinetic energy and routing it through the electronic control module (ECM) back to the battery (Dhameja, 2001, p. 3).

There are several downsides of EVs, but the most important ones could be summed up the following: “However, the weight of these vehicles, long recharging time, and poor durability of electric barriers reduced the ability of electric cars to gain a long-term market presence” (Dhameja, 2001, p. 2). Running an EV in Norway could be especially difficult regarding the low temperatures in the winter period across the country: “Aerodynamic drag effects makes a significant impact on cold weather performance. The power required is about 10% higher at 20F than at 70F. The aerodynamic drag increases owing to higher air density (...) as the battery pack temperature increases” (Dhameja, 2001, p. 131). Discussing and addressing the issues of EVs, their technology, the innovations and the research is interesting, but it should not outrun the scope of this thesis.

Some scholars do also use the term **plug-in electric vehicle** (PEVs) which “(...) is any motor vehicle that can be recharged from an external source of electricity, such as wall sockets, and the electricity stored in the rechargeable battery packs drives or contributes to drive the wheels” (Anon., 2018). Both terms can be used interchangeably, but I am going to use the term electric vehicle (EV) in this thesis. In case I use the term electric car, I am referring to EVs only.

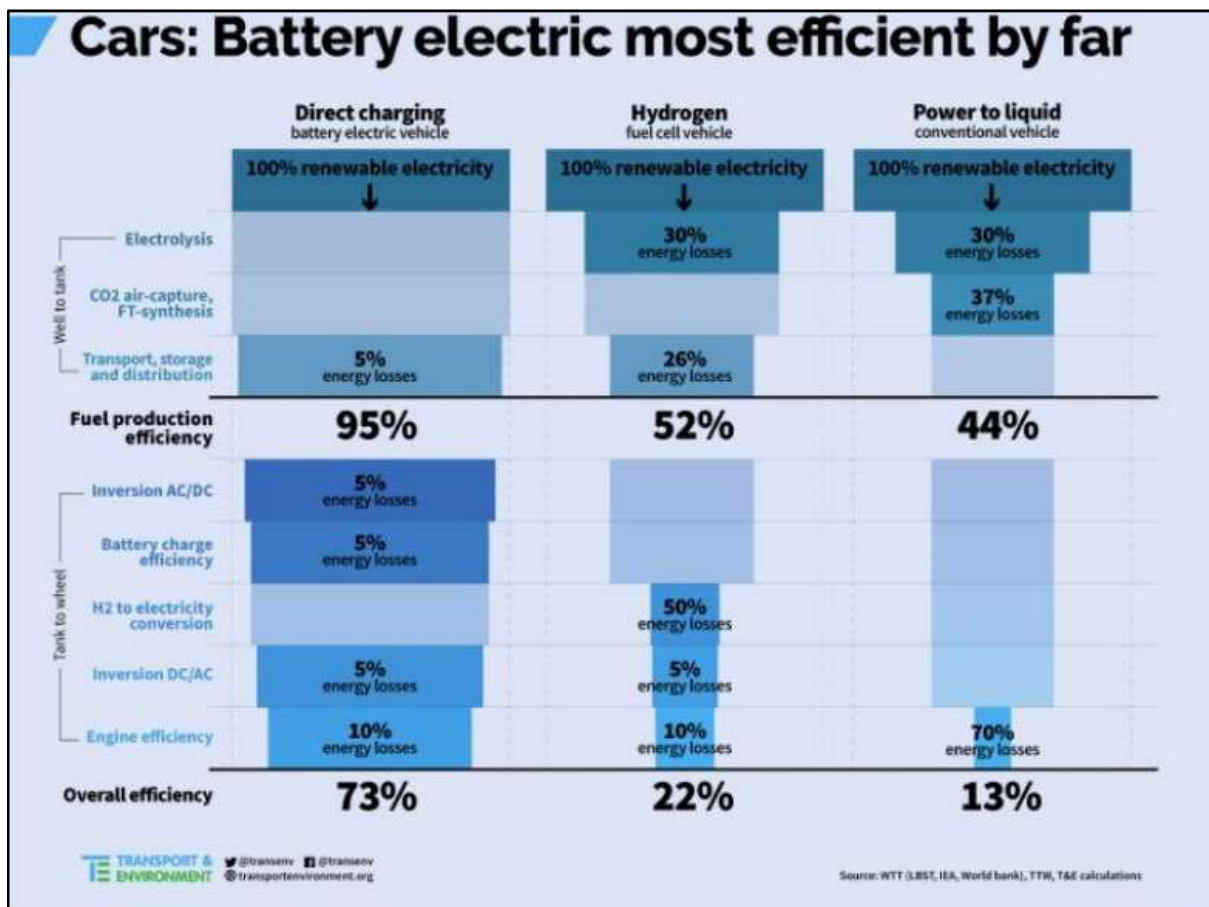
Another form of EVs are the so-called **plug-in hybrid electric vehicles** (PHEVs) which “combine a gasoline or diesel engine with an electric motor and a large rechargeable battery. Unlike conventional hybrids, PHEVs can be plugged-in and recharged from an outlet, allowing them to drive extended distances using just electricity” (Anon., 2018). While conducting the research on EVs, I am not focusing on plug-in hybrid EVs. PHEVs are not in the spotlight of policy makers because the engines are not fully electric. Further research on why PHEVs are not attractive to different actors would be useful to understand the dynamics of the auto industry in the field of electric mobility. Another interesting form of EVs are the so-called **fuel cell electric vehicles** which “(...) power an electric motor and battery by converting hydrogen gas into electricity. Fuel-cell vehicles are only beginning to appear for purchase, but [sic] offer significant promise as a low-carbon clean technology” (Anon., 2018). Also, there are different types of such technologies which “(...) include five major fuel cell designs, each described by the conducting electrolyte in the cell. The anodic and the cathodic reactions for the fuel cells do tend to differ” (Dhameja, 2001, p. 15).

There are various reasons why modern policies try to underline the importance of such electric vehicles regarding a more environmentally-friendly public and private transport. One longer quote interestingly sums up the main advantages of EVs:

“Plug-in cars have several benefits compared to conventional internal combustion engine vehicles. They have lower operating and maintenance costs, and produce little or no local air pollution. They reduce dependence on petroleum and may reduce greenhouse gas emissions from the onboard source of power, depending on the fuel and technology used for electricity generation to charge the batteries” (Anon., 2018).

This cited statement briefly discusses the advantages of electric vehicles (EVs and PHEVs and fuel-cell) which one may compare to vehicles with an internal combustion engine. Furthermore, it is also important to highlight why I am going to focus on pure electric-vehicles only: “When it comes to comparing types of vehicles – hydrogen, standard gasoline and diesel, or battery electric – then a full accounting of the averages reveals that electric cars are the total efficiency winners” (Blanco, 2017).

[Figure 1.1 Cars: Battery electric most efficient by far (Blanco, 2017)]



The figure 1.1. shows the efficiency of the three different types of EVs discussed in this thesis. The fuel production efficiency (electrolysis, CO2 air-capture, FT-synthesis, and transport, storage, and distribution) causes only 5 % of energy losses in a direct charging, pure EV. This percentage is lower when using a hydrogen car, i.e. 30 % of losses due to electrolysis and 26 % of losses regarding transport, storage, and distribution. Conventional vehicles (power to liquid) are losing 56 % of its fuel production efficiency caused by a 30 % loss due to electrolysis and 37 % because of CO2 air-capture, FT-synthesis. According to this research, direct charging battery EVs are the most efficient ones at fuel production (wheel to tank). The overall efficiency is composed by inversion AC/DC, battery charge efficiency, H2 to electricity conversion, inversion DC/AC and engine efficiency. Pure EVs score 73 % at overall efficiency, hydrogen (fuel cell vehicles) 22 %, and conventional vehicles 13 %. Again, the direct charging battery EVs are by far the most efficient vehicles. This research conducted by ‘UK’s Transport & Environment’ clearly shows that electric cars are the most efficient. Such statements are difficult to generalize since “(...) similar comparisons of EVs and hybrids in the U.S. [show],

there are a lot of regional differences – to say nothing of the variations in your specific vehicle” (Blanco, 2017).

2.2. Defining theoretical terms and frameworks

Firstly, one should define the two basic terms used in this thesis, i.e. ‘sustainability’, ‘transition’, and then the other terms. A brief discussion on the history and development of those two terms is useful regarding the following chapters.

Sustainability is defined as “the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance (...)” (Harper, 2010). This definition reflects on something being ‘harmful to the environment’, which shows that it is closely connected to environmental issues. One could also define this term as “a socio-ecological process characterized by the pursuit of a common ideal” (Anon., 2018). Others define sustainability as “(...) a fundamental transformation towards more sustainable modes of production and consumption (...)” (Markard, 2012, p. 955). The content of the terms has changed within the last three decades, and one of the most important approaches to this topic was the Brundtland commission 1987 (Olerud, 2016).

A so-called Venn diagram regarding the term sustainability and its parts, discusses the use of three different parts, i.e. environment, economic, social. Environmental sustainability is defined as “(...) the ability to maintain rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely” (Anon., 2018). Thus, economic sustainability is “(...) the ability to support a defined level of economic production indefinitely” (Anon., 2018). The latter part of this definition of sustainability, social, is defined as “(...) the ability of a social system, such as a country, to function at a defined level of social well being (sic) indefinitely” (Anon., 2018). As one can see above, the term sustainability is divided into three different aspects regarding the so-called “Three Pillars of Sustainability”. To put it briefly, sustainability is “(...) the ability to continue a defined behavior indefinitely” (Anon., 2018).

Sustainable development, though, is defined as “[development] that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Anon., 2009). Also, it is “(...) about five key principles: quality of life; fairness and equity; participation and partnership; care for our environment and respect for ecological constraints –

recognizing there are ‘environmental limits’; and thought for the future and the precautionary principle” (Anon., 2009). One should also mention – again – three pillars being part of this concept, i.e. “(...) economic growth, environmental stewardship, social inclusion [which] carry across all sectors of development, from cities to agriculture, infrastructure, energy development and use, water, and transportation” (Anon., 2018). One other definition underlines the importance of not only focusing on the technical and ‘material’ part of sustainable development, but also on the social or ‘soft’ side of this theory: “Sustainable development demands a combination of technical and social changes, since these are all closely related” (Vaz, et al., 2017, p. 3). One has to also keep in mind that sustainable development may be difficult to define and approach because it “(...) is a mixed concept, comprising values (such as environmental protection and equity) and strategies (such as healthy economic growth, stakeholder involvement and global perspective)” (Hemmati, 2002, pp. 8-9).

Resilience is another term one should define to fully understand the twisted concept of sustainable transition studies. It is defined as “the ability of an ecosystem to return to its original state after being disturbed” (Anon., 2018). It may be closely linked to the term sustainable transition.

Transitions, though, “are [a] long-term process of radical and structural change at the level of societal systems (e.g. sector, city, region)” (Anon., 2018). It is also defined as “a movement, development, or evolution from one form, stage, or style another” (Anon., 2018). This definition may be like the process of change, but a transition is narrowly connected to a process of evolution. Change is defined as “to replace with another”, or “to make a shift from one to another” (Anon., 2018). Therefore, a transition might be also regarded as a planned process of changing. Seen from a more ecology-based perspective, the term ‘transition’ is defined as “a radical transformation towards a sustainable society, as a response to a number of persistent problems confronting contemporary modern societies” (Grin et al 2010).

The definition of the term ‘**sustainable transition**’ should be deeper and longer since this term is touching upon various fields of research. It is a recent term used in different aspects of sustainability studies. It is also connected to the widely used term **sustainable transport**, i.e. “transport that is sustainable in the senses of social, environmental and climate impacts and the ability to, in the global scope, supply the source energy indefinitely” (Anon., 2018). This term is used in a narrow context, though, mostly regarding a certain field or sector. Nonetheless, a more detailed discussion on the emergence of ‘sustainability transitions’ or ‘sustainable

transitions' is advised. I am using the terms sustainability transition studies and sustainable transition interchangeably.

In one of the main papers used while writing this thesis, J. Markard, R. Raven and B. Truffer summed up the current condition in the field of sustainable transition studies, or, how they named it, sustainability transitions. I am discussing this paper in detail since it is one of the core elements of my theoretical approach. Those scientists claim that "(...) established socio-technical systems undergo incremental rather than radical changes (...), and such incremental changes will not suffice to cope with the prevailing sustainability challenges" (Markard, 2012, p. 955). They do also mention four different frameworks in the field of transition studies, i.e. transition management, strategic niche management, multi-level perspective on socio-technical transitions, and technological innovation systems (Markard, 2012, p. 955).

Markard et. al start defining sustainable transition studies with a brief definition of so-called 'socio-technical systems', which "(...) consists of (networks of) actors (...) and institutions, as well as material artifacts and knowledge" (Markard, 2012, p. 956). A transition in such a system "(...) involves far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural" (Markard, 2012, p. 956). Such a transition leads to an emerge of various new products, models, services or even organizations, which are replacing older, outdated actors or sets. Moreover, "[technological] and institutional structures change fundamentally, as well as the perceptions of consumers regarding what constitutes a particular service (or technology)" (Markard, 2012, p. 956). Markard et. al name different historical examples for such transitions, such as "(...) the introduction of pipe-based water supply (...), the shift from cesspools to sewer systems (...), and the shift from carriages to automobiles (...)" (Markard, 2012, p. 956).

In the next section following this brief introduction in transition studies, the scientists are defining and discussing the term of 'sustainability transitions', which are "(...) long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (Markard, 2012, p. 956). It is also worth mentioning that different major actors, such as policy makers or companies, might have their interest in introducing sustainability transitions.

Smith, though, introduced another perspective on sustainability transitions, i.e. the transition between Green Niches and socio-technical systems. Such niches are defined as "(...)

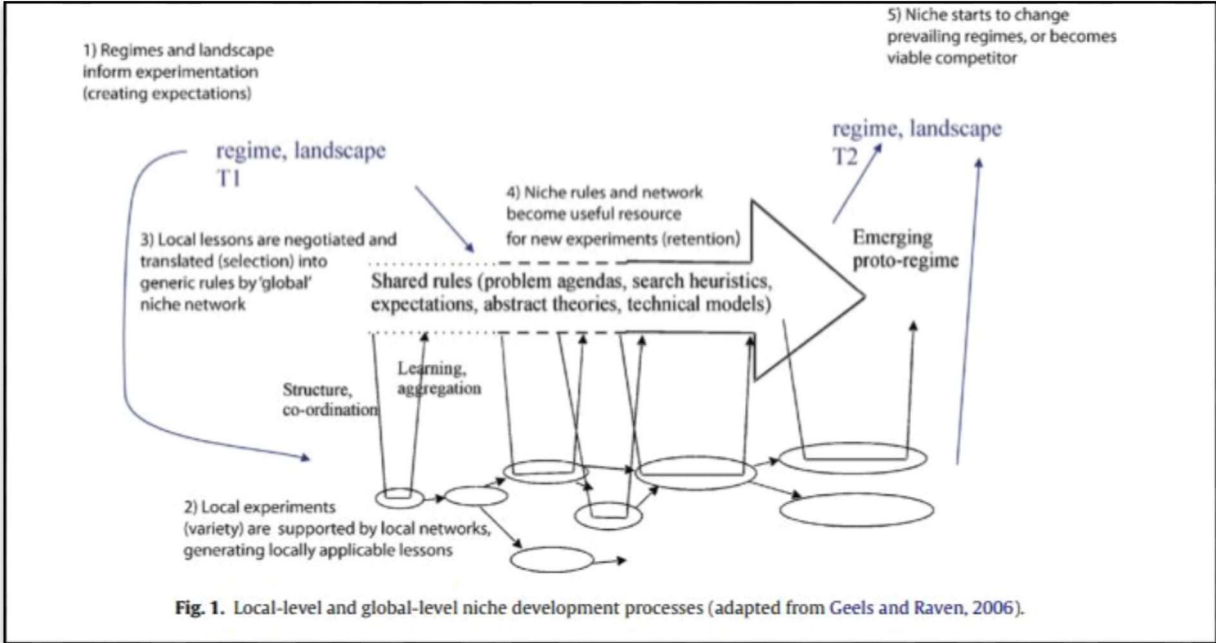
spaces where networks of actors experiment with, and mutually adapt, greener and organizational forms and eco-friendly technologies” (Smith, 2007, p. 427). This paper highlights how two different niches, i.e. eco-housing, and organic food, became part of a ‘normative advocacy’, even though no major actor initially planned to become a ‘niche’. Smith’s approach leads to a first conclusion that “[a] policy goal for sustainable production and consumption *systems* [sic] imply a different kind of innovative activity to that traditionally associated with a single product or new business practice” (Smith, 2007, p. 428). This quote highlights the core of how certain goals affect sustainability transitions. The main aspect of sustainable transition is overcoming preset settings, habits, or approaches by different actors to a more modern, newer, and ecologically friendlier setting. Furthermore, Smith states that “[historical] experience suggests radical changes begin within networks of pioneering organizations, technologies and users that form a *niche* [sic] practice on the margins of the regime” (Smith, 2007, p. 429).

According to this paper, is the case of electric-mobility in the municipality of Trondheim an effect of emerging Greener Niches? Smith discusses the importance of institutions and policy makers in introducing more sustainable technologies by stating that “[institutional] embedding relates to the robustness of niche development, in terms of technical, market, social and institutional support” (Smith, 2007, p. 429). The author uses two different approaches to justify his statements, strategic niche management (SNM) and transition management (TM). The first approach is highlighting that “(...) niches *alone* [sic] are unlikely to transform regimes” (Smith, 2007, p. 430). Smith provides a helpful approach to the role of niches in the transition management approach: “(...) transformation depends upon contingencies and processes beyond the unilateral control of niche actors. Niches still play a role (...) as sources of innovative ideas for resolving regime tensions – even if they do not become models or blueprints for wider transformation” (Smith, 2007, pp. 430-431). Transition management discusses the role of niches in changing an existing regime’s approach to, e.g. a new technology, but it fails to address the link between a niche and a regime (Smith, 2007, p. 431).

Smith’s approach directly links the research conducted on the theory of sustainability transitions to another paper which is discussing the concept of protective space and reconsidering niches: “A defining characteristic of these niches is that they afford temporary ‘protective space’ for the configuration and development of such innovations” (Smith & Raven, 2012, p. 1025). The concept of protective space seems to be crucial for introducing niches and establishing them as major actors in different fields, such as automotive industries. It is widely

believed that protective spaces “(...) shield the innovation against (...) the prevailing selection pressures” (Smith & Raven, 2012, p. 1025). This protective space is a kind of a ‘shelter’ for the innovation itself to flourish within the given legal framework, or, in the words of the authors, “(...) it becomes more robust through performance improvements and expansions in supportive socio-technical networks” (Smith & Raven, 2012, p. 1025). After a certain time given by policy makers, the niche has become robust enough to be able to compete with other, already existing actors in a given setting and space. Smith & Raven, though, do not agree with the previous research conducted in the field of sustainability transitions mentioned above. They are introducing a concept of ‘empowerment’, which “(...) refers to either niche-innovations becoming competitive within unchanged selection environments or to niche-influenced changes in regime selection environments in ways favourable to the niche-innovation” (Smith & Raven, 2012, p. 1026). The figure 2.1 shown below shows the development processes of local-level and global-level niches, where local “(...) relates to experimentation in specific places with local contexts, supported by local networks, and generating lessons accordingly” (Smith & Raven, 2012, p. 1028). Global refers to “(...) an emerging institutional field or proto-regime supported by a network of actors that is concerned with knowledge exchange and resource flows transcending local contexts” (Smith & Raven, 2012, p. 1029).

[Figure 2.1. Local-level and global-level niche development processes (Smith & Raven, 2012)]



Smith & Raven introduce numerous theories on their own case study on solar electricity, such as the passive protective space which is defined as “(...) generic spaces that pre-exist

deliberate mobilization by advocates of specific innovations, but who exploit the shielding opportunities they provide” (Smith & Raven, 2012, p. 1027). Furthermore, apart from a ‘passive’ space, one should also note that creating a protective space may also be active, “(...) through strategic niche management interventions” (Smith & Raven, 2012, p. 1027). Active may be “(...) deliberately created spaces through innovation-specific public or private interventions (...)”, while passive is defined as “(...) generic spaces pre-existing mobilization by advocates of specific innovations (...)” (Smith & Raven, 2012, p. 1027). They do also highlight the importance of shields for the establishing of innovation: “Whenever and wherever shields are mobilized or established, the space that becomes available provides an opportunity to nurture a path-breaking innovation” (Smith & Raven, 2012, p. 1027). Most notably the approach of the so-called ‘technological innovation systems’ is suitable to discuss the introduction of electric vehicle mobility in Norway and the municipality of Trondheim.

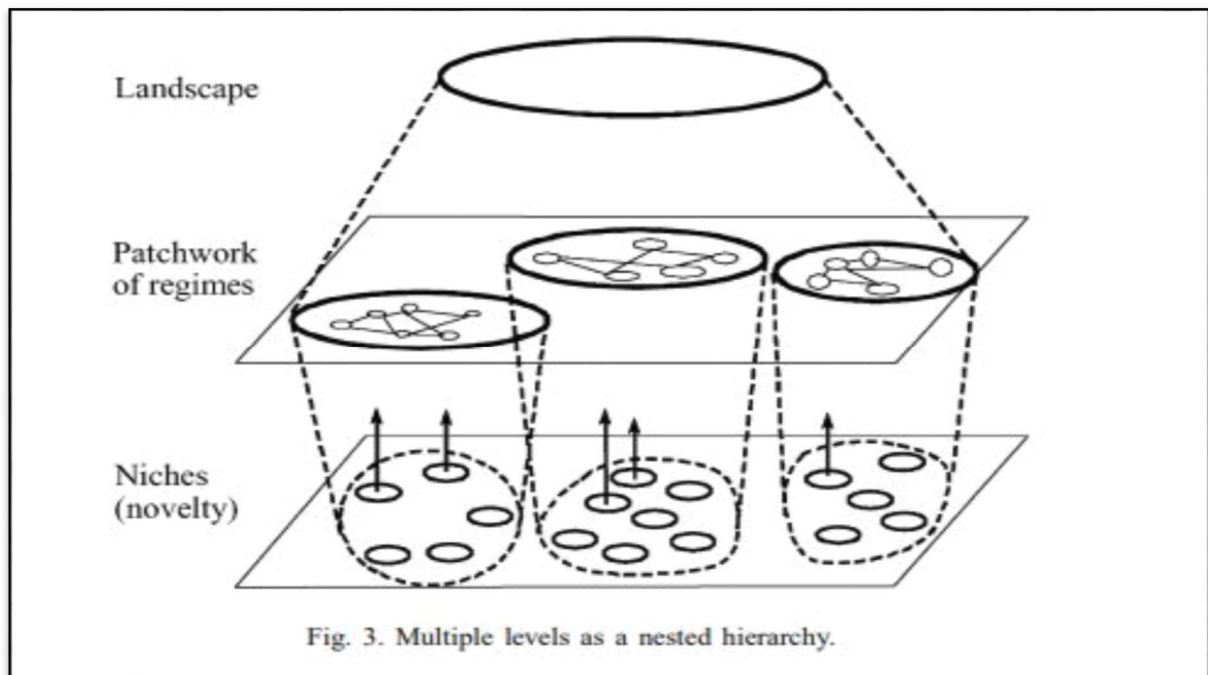
Smith & Raven do also introduce their own theory of empowerment, which may be categorized in two different stages. The first stage is what those researchers label as “fit and conform empowerment and define it “(...) as processes that make niche innovations competitive within unchanged selection environments” (Smith & Raven, 2012, p. 1030). This form of empowerment is set within an environment which cannot be changed. On the other hand, there is the “stretch and transform empowerment, [defined as] processes that re-structure mainstream selection environments in ways favourable to the niche” (Smith & Raven, 2012, p. 1030). The authors of the cited paper do highlight two different ways of complementary in the field of transitions to sustainability, i.e. “(...) institutional reforms that transform incumbent regimes; and (...) political capacity to avoid protective space becoming captured by sectional interests [which ensures] protection stimulates the dynamic accumulation of innovative capabilities for sustainable development” (Smith & Raven, 2012, p. 1030).

One should also note the ‘danger’ of overprotecting a niche which “(...) can be problematic when, rather than removing redundant protections or institutionalising productive ‘protection’, it actually results in *protectionism*” (Smith & Raven, 2012, p. 1031). The broad discussion provided by the research paper highlights the current condition of the research conducted on transition studies and the role of niches in it. It shows how highly debated the emerging field of sustainability transition studies truly is. Also, one should consider that “(...) dynamic relationships between variation, selection environments and the emergence of new technological regimes are relevant to evolutionary perspectives in innovation studies generally” (Smith & Raven, 2012, p. 1034). In contradiction to the relational perspective, “(...) the

evolutionary perspective considers agency as determined by prior events, selection environments as given, and the criteria for success as unequivocal, the relational perspective draws attention to the many ways in which agency is distributed, selection environments are molded, and evaluation criteria are equivocal” (Garud & Gehman, 2012, p. 984). This quote highlights the importance of agents or actors involved in shaping the environment in which they affect, e.g. niches or other actors. Garud & Gehman add the ‘market’ to this approach, and they state that “[the] “market” is no longer a selection environment, but an important battlefield in which the criteria of what counts, how it counts and for whom are themselves being shaped and reshaped” (Garud & Gehman, 2012, p. 984). The following quote shows how the scholars are trying to examine every single actor involved in different processes and their meaning and contribution to the process itself: “Multiple actors (consumers, producers, regulators, evaluators and other concerned groups) are involved (...) operating from different (and often conflicting) frames of reference (...)” (Garud & Gehman, 2012, p. 984).

One of the most prominent theories in the field of transition studies is the so-called ‘multi-level perspective’ (MLP), discussed in detail by Geels in 2002. Geels later defined this theory as “(...) a middle-range theory that conceptualizes overall dynamic patterns in socio-technical transitions” (Geels, 2011). The figure 2.2. shown below explains how Geels summed up three different concepts discussed in his paper in one nested hierarchy. It is a way of graphically explaining how technological transitions are influenced and influence a regime and landscapes. Such transitions are “(...) defined as major technological transformations in the way societal functions such as transportation, communication, housing, feeding are fulfilled” (Geels, 2002, p. 1257). The level of landscapes, or macro-level, “(...) consists of slow changing external factors, providing gradients for the trajectories” (Geels, 2002, p. 1261). The level of patchwork regimes, or meso-level, “(...) accounts for stability of existing technological development and the occurrence of trajectories” (Geels, 2002, p. 1261). The bottom level of niches, or micro-level, “(...) accounts for the generation and development of radical innovations” (Geels, 2002, p. 1261). This model shows how niches lead to radical changes in a given field, e.g. technology. Niches are therefore a certain kind of ‘shields’ which are not fully affected by the forces driving the market.

[Figure 2.2. Multiple levels as a nested hierarchy (Geels, 2002)]



They do also allow different actors to create a certain network around them. On the meso-level, the so-called ‘patchwork of regimes’ gives the niche a legal framework. It can lead to improvement, or even affect the macro-level. The landscape level is the part in this model which is slow to change because it also consists of ‘third-party’ factors, such as, e.g. legal frameworks, policies, prices, and other economic factors which may not be in the scope of the development of niches. One should also note that the effects discussed in this part can also move in the other direction, interact, and turn bottom-up. The landscape level is, so to say, the broad framework which the two other levels are embedded in (T., 2012).

This multi-level perspective is one approach to combine various views on the evolution of transitions. “Evolution as ‘variation and selection’ is encompassed by conceptualising niches as the locus where radical variety is generated, and regimes as selection and retention mechanism” (Geels, 2002, p. 1272). This quote highlights how the process of introducing a novelty, and after a certain period turning into a niche has a clear effect on regimes.

Geels’ concept and thoughts on the research on technological transitions was highly debated, and often criticized by scholars, also by himself (Geels, 2011). Geels does state that this perspective “(...) is not an ontological description of reality, but an analytical and heuristic framework to understand [technological transitions]” (Geels, 2002, p. 1273). The scholar responded to seven criticisms which were uttered by various scholars in 2011, giving many interesting thoughts on sustainability transitions. Geels claimed that sustainable transitions

“(…) are goal-oriented or ‘purposive’ in the sense of addressing persistent environmental problems, whereas many historical transitions were ‘emergent’” (Geels, 2011, p. 25). Furthermore, Geels argues that what “(…) makes sustainability transitions unique is that most ‘sustainable’ solutions do not offer obvious user benefits (because sustainability is a collective good), and often score lower on price/performance dimensions than established technologies” (Geels, 2011, p. 25). A third and last aspect pointed out by Geels discusses the positions of large actors in the field of sustainability transitions: “These domains are characterized by large firms (…) that possess ‘complementary assets’ such as specialized manufacturing capability, experience with large-scale test trials, access to distribution channels, service networks, and complementary technologies (…)” (Geels, 2011, p. 25). Geels tried to justify his statements on the MLP and explain new approaches to this theory with coming up with new ideas. The main point is that there are different views on how sustainability transitions should be classified, understood, and debated. Discussing other approaches of the MLP would hinder a fruitful and accurate analysis on the main research question of the thesis.

The final research paper I am going to discuss deals with ‘metatheoretical perspectives on sustainability journeys’, which is examining evolutionary, relational and durational perspectives. Luckily, the authors of this paper have focused on various case studies conducted on EVs (Garud & Gehman, 2012). Many examples are directly linked to the emergence of EVs which makes the paper useful regarding my own research. This research paper conducts research on how EVs can be theoretically examined with the help of those three different perspectives and the MLP.

The first sort of approach, i.e. evolutionary, “(…) emphasizes *selection* as a mechanism of change as fields and firms transition from one “regime” to another” (Garud & Gehman, 2012, p. 980). Relational, thus, refers to a “(…) *translation* as a mechanism of transformation, drawing attention to framing issues that emerge as concerned stakeholder groups become implicated as sustainability is performed” (Garud & Gehman, 2012, p. 980). The last part of those researchers’ emphasis is “[the] *durational* perspective [which] emphasizes *durée* as a mechanism of migration, highlighting the possibility and importance of going “back to the future” (Garud & Gehman, 2012, p. 980).

The authors of the article are also trying to define sustainability transitions. Instead of using the term transition, Garud & Gehman are using the term ‘journey’: “One approach is to think about sustainability journeys as transitions from one set of sociotechnical requirements to

another” (Garud & Gehman, 2012, p. 981). These scholars try to match their three different approaches with the multi-level perspective, discussed above. Garud & Gehman claim that “[the] emergence of sustainability represents a shift in the landscape, triggering transition dynamics in areas such as the design and use of automobiles capable of reducing fossil fuel consumption and greenhouse gas emissions” (Garud & Gehman, 2012, p. 981). This thought matches the exogenous context of the multi-level perspective, i.e. the socio-technical landscape.

The scholars discuss the failure of EVs several decades ago, and why EVs are again being introduced to markets across the world: “Once again, an account from an evolutionary perspective attributes the failure of EVs to their “lack of fit” with the prevailing sociotechnical regime” (Garud & Gehman, 2012, p. 982). This criticism might be connected to the discourse on the concept of evolutionary economics (McMaster & Watkins, 2012).

The authors of the analyzed paper do also debate how the term ‘actor’ should be defined and approached. They do also come up with a slightly different understanding of how the role and importance of actors should be understood. According to these scholars, actors “(...) are neither insiders nor outsiders, but instead are part of ongoing entanglements” (Garud & Gehman, 2012, p. 983). This new approach to major actors in shaping the regime and the transition changes the way of thinking about sustainability transitions. Furthermore, “(...) it is through the mutual entanglement (...) of social and material actors that meaning emerges and is translated in practice” (Garud & Gehman, 2012, p. 983). According to this quote, actors are playing a major role in the introduction of new technologies.

The scholars do also discuss the importance of the market in their paper, and they do also match their new approach to the three different levels: “Rather than simply a market failure that might be remedied through institutional work (...), the relational perspective conceptualizes externalities as the emergent and ongoing overflows that result as disparate social groups interpret the social and material entanglements involved (...)” (Garud & Gehman, 2012, p. 983). They do also re-think the actual state of sustainability transitions: “As a consequence, sustainability journeys are no longer a matter of shifting from one equilibrium state to another, but the continuously negotiated accomplishment of an assemblage of humans and things involving deviation and contestations” (Garud & Gehman, 2012, p. 984). According to the scholars, the process of sustainability transitions is a constant process of inconsistency, with long and short periods of change and stability. This might be a hint why the scholars named their definition of such processes ‘journeys’, not transitions.

More interestingly, Garud & Gehman criticize the current definition of sustainability by coming up with four different arguments. The most interesting point of criticism of the given definition is that “(...) we could get caught up in local rationality traps (...) that result in our inability to even visualize and articulate the needs of future others” (Garud & Gehman, 2012, p. 985). Furthermore, the authors use the framework of the MLP to combine this theory with their three own approaches to sustainability transitions. Garud & Gehman’s paper is important to my own research because it also matches their three different perspectives with policy and strategy implications for EVs. The policy implications could be summed up as the following:

“(...) driven by the evolutionary perspective [policy implications] focus on sustaining new ideas that otherwise would have been selected out. The relational perspective suggests the creation of “hybrid” forums” to facilitate interactions between concerned stakeholders as sustainability journeys unfold. The narrative perspective sensitizes us to the temporal issues associated with policy initiatives” (Garud & Gehman, 2012, p. 988).

The implications for strategy differ slightly from the implications for policy: “From a relational perspective, dynamic capabilities imply an ability to not only navigate such shifts, but to also frame and reframe situations. From a durational perspective, it means an ability to re-narrate, such that firms can go back to the future” (Garud & Gehman, 2012, p. 989).

The last theory I am going to discuss is the so-called multi-stakeholder process (MSP). I am using the multi-level perspective to focus on how different actors are involved in introducing the shift to more sustainable and environmentally-friendly ways of transport in Trondheim. Unfortunately, the MLP “(...) under-theorizes the role that governance plays in sustainability transitions” (Konefal, 2015, p. 612). For this reason, I am adding the MSP to highlight the importance of actors in creating regimes and niches. In this theory, actors are called ‘stakeholders’ which are defined as “(...) those who have an interest in a particular decision, either as individuals or representatives of a group. This includes people who influence a decision, or can influence it, as well as those affected by it” (Hemmati, 2002, p. 2). Adding stakeholders or actors and embedding them more interconnected in the MLP puts a more detailed focus on how the legal framework and the decisions made by the stakeholders are affecting the other levels of the MLP, such as creating a niche. The term MSP itself “(...) describes processes which aim to bring together all major stakeholders in a new form of communication, decision-finding (and possibly decision-making) on a particular issue” (Hemmati, 2002, p. 2). It may focus on various kinds of the decision-finding or -making process, although one should note that “(...) the exact nature of any such process will depend

on the issues, its objectives, participants and time lines, among other factors” (Hemmati, 2002, p. 2).

In this thesis, I am mostly going to focus on the MLP whilst adding the stakeholder-perspective of the MSP. From my point of view, it is interesting to discuss how different stakeholders in the municipality of Trondheim interacted and cooperated on introducing more sustainable ways of transport in the city. Some scholars do state that “(...) it looks as if stakeholder dialogues, ways of feeding them into decision-making and concrete follow-up are mostly being organized and prepared on a rather ad hoc basis” (Hemmati, 2002, p. 5). Conducting research on whether this also took place in Trondheim seems to be interesting.

To sum it up, the different approaches above show how difficult and exhausting the approach to sustainability transitions really is. The research on this term evolved during the past years, and various scholars came up with different ideas on how to define the field of sustainable transition studies.

2.3. Discussion on the need of a spatial perspective on sustainability transition studies

Several articles focus on a local, spatial perspective of transition studies and the need of introducing a geographical analysis approach to both the MLP and the TIS. The authors of an interesting article focusing on a spatial perspective on sustainability transitions state that “(...) what is gained in a historical treatment has come at the expense of a neglect of spatial dimensions” (Coenen, et al., 2012, pp. 968-969). The lack of a spatial perspective on sustainability transitions has the effect of “(...) neglecting the spatial contexts in which individual case analyses of sustainability transitions are situated thus reducing comparability between places which in turn limits particular transition analyses coalescing into a coherent body of theory” (Coenen, et al., 2012, p. 969). These scholars try to implement the concept of space in the research conducted with the use of both the MLP and the TIS theory. Their concept of space is described as a “(...) distance between actors affects how they interact – but distance has to be understood as more than the ‘as-the-crow-flies’ route on a map” (Coenen, et al., 2012, p. 969). Such an understanding of space between different stakeholders is crucial to understand how relationships and proximity might influence the connection itself and how those actors are able to cooperate and build lasting networks. Therefore, it is of high importance to understand the key role played by a geographical analysis in a given scenario, framework, etc. as “(...) an

appreciation of the importance of these overlapping relationships and networks, alongside providing a set of conceptual tools for understanding their place-specific impacts” (Coenen, et al., 2012, p. 969).

To precisely address the scholars’ critique of the TIS and its lack of a spatial approach, they highlight two different problems, one is the “(...) insufficient elaboration of coupling structures between TIS and sectoral and spatial context systems (...)”, while the second issue is “(...) an underconceptualization of relationships between different sub-system structures” (Coenen, et al., 2012, p. 970). These two downsides of the TIS concept do bring up an important thought on the theory itself. Ignoring a spatial perspective in a TIS analysis may be “(...) leading to oversimplified conclusions on isolated “success factors” and “barriers” that cannot be taken “out of context” [sic]” (Coenen, et al., 2012, p. 970). The authors of the analyzed paper conclude that one of the several reasons for a lack of a spatial perspective in the TIS could be “(...) that it pursued a strong urge to inform (primarily national) technology policy – a trend particularly emphasized in the later turn toward functional system description” (Coenen, et al., 2012, p. 971).

The second part of the paper written by Coenen, et.al deals with the neglect of a spatial perspective in the popular MLP. The scholars argue that adding a ‘geographical scale’ might be defined as “(...) a territorial level at which significant relationships exist between actors” (Coenen, et al., 2012, p. 972). The main critique of the MLP seen from the authors’ perspective is the lack of a spatial approach in the three scales of the MLP. It seems that “(...) MLP’ levels are not geographical in their nature; rather they are conceptually related to the maturity of the socio-technological system via the socio-cognitive development of actors” (Coenen, et al., 2012, p. 972). The scholars conclude their interesting critique of the current lack of a spatial perspective in the field of sustainability transitions by arguing that “[a] central topic for further investigation concerns the existence of complementarity and strategic coupling effects between localized assets (...) and institutions on the one hand and activities, needs and interests of trans-local actors on the other” (Coenen, et al., 2012, p. 976).

The approach of using three dimensions to analyze a spatial perspective on sustainable transition studies is going to be one of the central statements while conducting research on the status of electric mobility in the city of Trondheim. I am going to research the spatial status in Trondheim itself and then discuss the given framework, such as legal affairs, set by the central government in Norway in the past decades.

A second, thought-provoking article analyzed while conducting research on this topic criticizes the current state of transition research in a similar way by saying that “[transition] research has recently been criticized to lack of geographically sensitive concepts to address sustainability transitions and environmental innovation processes” (Raven, et al., 2015, p. 63). These scholars highlight the importance of introducing a spatial perspective in the field of sustainable transition studies, with the use of a societal approach. The authors of the article claim three different dimensions of a geographical transition, i.e. socio-spatial embedding, multi-scalarity and issues of power (Raven, et al., 2015, p. 64). The first dimension “(...) relates to the conditions of specific places, regions, cities, which may be more or less amenable for the promotion of sustainability transitions (...)” (Raven, et al., 2015, p. 64). It addresses the geographical issue of, e.g. a city and its networks or political systems and how likely it is to create a certain ‘movement’ or ‘climate’ for a change in, e.g. a technology or a system. This approach is directly linked to the authors’ claimed second dimension, multi-scalarity, which is “(...) associated with the evolution of sociotechnical systems (...) [with] a need to trace the ways in which innovations emerge in different places and then enter into contact with each other (...)” (Raven, et al., 2015, p. 64).

This second dimension is an enhanced ‘update’ of the first one, so that a process taking place in one place could be linked with a similar or identical process in a second place. Matching those two dimensions leads us to the third one, the issues of power, “(...) namely the need for greater attention for the uneven power relations in sustainability transitions” (Raven, et al., 2015, p. 65). This dimension addresses the relations and actions taking place among various stakeholders or actors in a given frame and spatial dimensions. The authors of the article state that “(...) we should address whose voices, concerns, and socioeconomic and environmental conditions are more or less heard, addressed, and improved through transition initiatives (...)” (Raven, et al., 2015, p. 65).

To match the theories discussed above with the field of automotive and sustainable transitions, I am going to discuss how the MLP and a spatial perspective might be linked to transitions in transport. Geels, the ‘inventor’ of the MLP, wrote a thought-provoking article on how the MLP could be applied to low-carbon transitions (Geels, 2012). Geels introduced six different niche-innovation crucial to understand how the importance of EVs in a low-carbon transitions changed within the last two decades, i.e. intermodal level, cultural and socio-spatial innovations, demand management, public transport innovations, information and communication technologies and green propulsion technologies (Geels, 2012, p. 476). An in-

detail discussion of those six innovations would be out of the scope of this chapter, but they contributed to low-carbon transitions by, respectively, new modes of transport; reduced travel distance, new ownership styles; reduced car use, behavioural/organisational [sic] change; modal shift; and a more efficient fulfilment of existing travel needs (Geels, 2012, p. 476). Geels states that, seen from a landscape development perspective, “[the] automobility regime faces both destabilizing and stabilizing landscape pressures” (Geels, 2012, p. 477). Among the few destabilizing pressures, Geels names the discussion of climate change, especially in terms of reducing emissions and introducing tougher CO2 regulations. Some of those goals can only be reached by “(...) more radical innovations, such as fuel cells, hybrids or battery-electric vehicles” (Geels, 2012, p. 477). Among the stabilizing pressures, Geels highlights the role of cultural and economic changes in the private property and the ongoing political, economic, and cultural changes in so-called developing countries. Furthermore, the role of globalization is addressed: “The demand for mobility increases because globalisation and a shift towards a network society (...) increase the flow of goods and people” (Geels, 2012, p. 477).

The thoughts of Geels are crucial to understand why the case of electric mobility in Trondheim is somehow unique. Most of the global stakeholders in the automotive industry have other ‘problems’ than meeting the goals set by mostly political actors. It seems “(...) that survival in cut-throat competition and under-utilisation of factories and cost pressures are the two main problems, which lead them to focus on cost-savings, e.g. through mergers and attempts to improve production and efficiency” (Geels, 2012, p. 478). Therefore, a city with an ambitious goal and climate plan like Trondheim should be well-aware and pushing its own environmental incentives as far as possible to create a certain frame for different stakeholders to be actively engaged in a sustainable transition. Geels sums this thought up by arguing that “[the] reason for this assessment is not that the problems are small, but that important regime actors are neither fully committed (yet) to acknowledging these problems nor to placing them on agendas with a high sense of urgency” (Geels, 2012, p. 478). The author does also an interesting prophecy for the upcoming years in the conclusion of his article: “For the next 20 years it therefore seems likely that the car-based transport system remains dominant (...); that public transport modes (...) experience some further growth; and that we see a gradual greening of technology” (Geels, 2012, p. 479). This thought might be linked to a possible path dependence theory (Prado & Trebilcock, 2009).

Other scholars, though, try to implement both the theory of space and scale in socio-technical transitions. “Hence our contribution is a second generation MLP that explicitly

incorporates not only structure and time, but also a conception of space” (Raven, et al., 2012, p. 65). The case of electric mobility and sustainable transition studies is also a part of an analysis conducted by other scholars. Some papers directly address the impact of EVs through an MLP analysis. “Many governments seeking to reduce carbon emissions and oil dependency, and given urban air quality concerns, have invested significantly to support the transition to a greener, more sustainable automobility” (Berkeley, et al., 2017, p. 320).

The whole process of adding the spatial perspective to the MLP is crucial for a better understanding of the role of EVs in the field of sustainable transition studies in Trondheim. As analyzed above, the current state of the TIS and the MLP are clearly lacking a space and sphere perspective. Adding the newest critique and research to this topic allows the analysis of electric mobility in the municipality of Trondheim to take a spatial, local look and then a zoom out to the national and central regulations and incentives set by the Norwegian government and international stakeholders.

3. Electric mobility in Trondheim – Current state and future goals

3.1. First climate plan of Trondheim – 2010-2020

The municipality introduced a detailed and ambitious climate plan already in 2010 for the upcoming decade, i.e. 2010-2020. This first sketch of a climate plan for the city of Trondheim is actively debating and discussing the role of reducing CO₂ emissions and reaching the goals set by the United Nations (UN) and the Norwegian government in the next decades of the 21st century. It also directly addresses the importance of the local stakeholders in Trondheim: “Det betyr at Trondheim kommune må planlegge for å bli en tilnærmet utslippsfri kommune noen få tiår fram i tid” (Bratt, 2010, p. 2). This first climate plan shows how ambitious and open-minded the stakeholders in Trondheim tried to approach the climate goals set by other stakeholders.

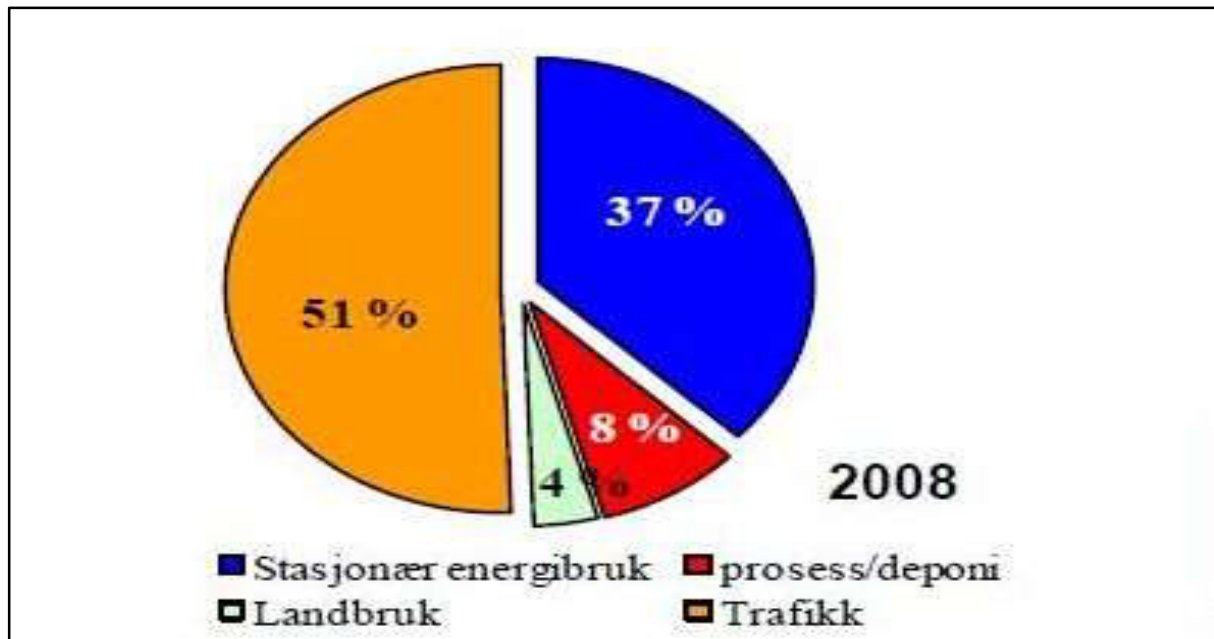
The work on this plan already started in 2007 and was conducted by “(...) Rådmannen i et nært samarbeid med det tverrpolitiske Klimautvalget” (Bratt, 2010, p. 2). The process of working on the climate plan was also supported by Enova and the Fylkesmannen in the region Sør-Trøndelag, AF Energi- og Miljøteknikk. These stakeholders are both representing the political and industrial and/or technical side of the private market in the process of introducing new policies in a municipality. All these actors cooperated on the climate plan, though other actors were also actively engaged in discussing and debating, such as “(...) Byplankontoret, Byggesakskontoret, Trondheim eiendom, Stabsenhet for byutvikling, Rådmannens fagstab og Miljøenheten” (Bratt, 2010, p. 2). The list of the actors involved in the making of the first climate plan clearly shows that the stakeholders did want to have as many points of views and thoughts on this topic as possible. The climate plan itself should “(...) være førende for andre planer i Trondheim kommune. Det legges opp til en årlig evaluering av tiltakene i planen” (Bratt, 2010, p. 2). It does focus on a debate and a fruitful discussion between the different actors involved in a possible reduction of emissions in the city: “Planen foreslår å arbeide for at andre offentlige og private virksomheter i Trondheim forplikter seg til å strekke seg minst like langt som Trondheim kommune” (Bratt, 2010, p. 6).

The figure 3.1. depicted on the next page shows how the CO₂ emissions were distributed among four different sectors in 2008. The climate plan’s goal is to reduce the CO₂ emissions up to 25 % within the next few years. To reach this goal, a drastic cut has to be made in two sectors, i.e. ‘stasjonær energibruk og trafikk’. The latter is within the scope of this thesis. This goal is both favorable to match the national and international requirements: “Både EU og Norge

har som målsetting å begrense den globale oppvarmingen til 2 grader sammenlignet med førindustriell tid“ (Bratt, 2010, p. 5).

The analyzed climate plan does also focus on the importance of electric mobility in the city of Trondheim. In the chapter on ‘Areal- og transportpolitikken’ the authors of the climate plan state that to reach the goal set by the city and other, national stakeholders there

[Figure 3.1. Distribution of the emissions (Bratt, 2010)]



should be a “(...) reduksjon av biltrafikken (12 prosentpoeng) og gjennom overgang til lavutslippskjøretøy og biodrivstoff (8 prosentpoeng) (...)”, especially by “(...) [tiltak] og tilrettelegging for å øke bruken av miljøbiler og miljøvennlige drivstoffer (lavutslippskjøretøy og biodrivstoff)“ (Bratt, 2010, p. 7). This quote shows how the stakeholders in Trondheim try to match local needs to the legal framework set by other stakeholders, such as the Norwegian government.

The former climate plan does also discuss the role of electric mobility in Trondheim, especially to build a proper charging infrastructure: “(...) “å etablere inntil 300 ladepunkter for el-bil med gratis parkering og strøm innen 2011” (Bratt, 2010). Furthermore, the city of Trondheim is undermining the importance of an efficient and well-connected public transport in order to attract more inhabitants of the city to use it: “Andelen som reiser med miljøvennlig transport (...) skal øke til 50 % av alle turer innen 2018 (fra 42 % i 2008)” (Bratt, 2010, p. 21).

This can only be achieved by reducing the use of cars owned by private persons, and “(...) en vesentlig del av bilreisene skal foretas med biler med lavt utslipp” (Bratt, 2010, p. 21).

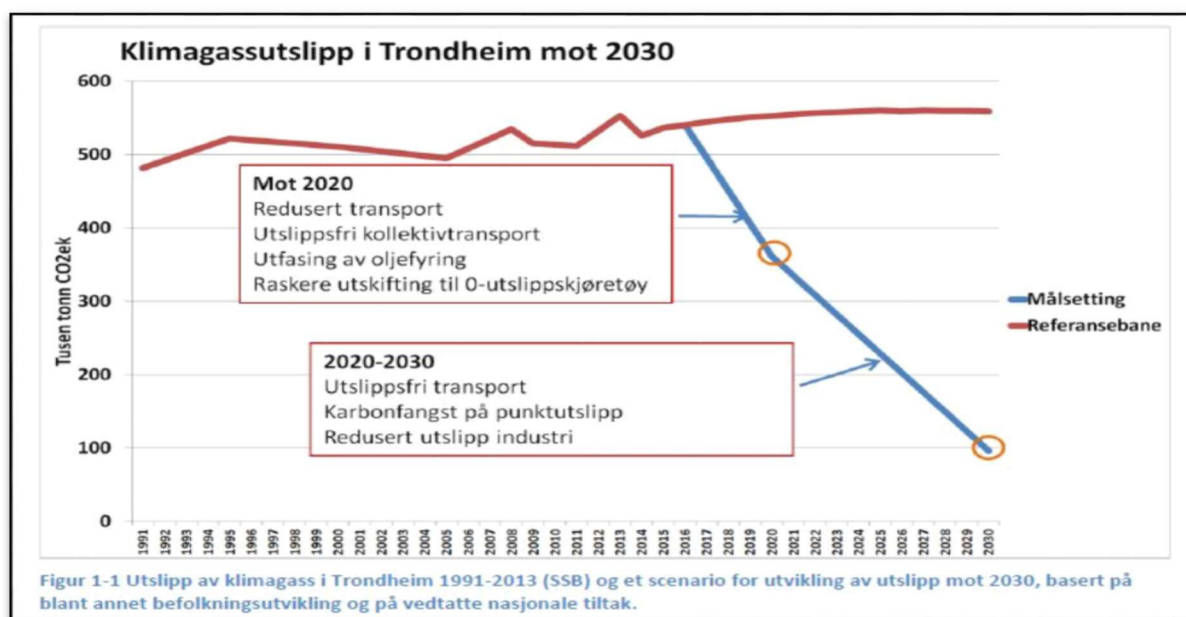
Moreover, the authors of the climate plan from 2010 state that the city of Trondheim should at least meet the expectations set by national frameworks and stakeholders: “Alle miljøkrav knyttet til lokalt bymiljø skal ivaretas minst i henhold til nasjonale forskrifter” (Bratt, 2010, p. 21).

The analyzed climate plan from 2010 does set a first approach and framework for the actors in Trondheim, but unfortunately it is not too specified in terms of the role of electric mobility. It does focus on traffic and transport in general, but it misses a detailed discussion and highlight of electric mobility.

3.2. The Trondheim energy and climate plan 2017-2030 – General overview

The municipality of Trondheim gave itself a new and more detailed climate plan 2017-2030 in the year 2010. The climate plan of the municipality of Trondheim is more restrictive than the goals set by the European Union, the central government of Norway or the Trøndelag authorities. Furthermore, it is also interesting to compare how Trondheim’s plan corresponds with the Paris climate summit hold in 2016: “Norway is expected to reduce 50% in CO₂-emissions by 2030 and zero emissions in 2050. However, as per the Paris Agreement in 2016, Norway plans to bring forward its target for reaching carbon neutrality to 2030, two decades sooner than its current 2050 goal” (Kolhe & Madusha, 2017, p. 318). The main goal of this climate plan is to reduce CO₂-emissions up to 70-90 % in 2050, compared to the level of 1991, as it is graphically depicted in the figure 3. 2.. It says it would reduce the CO₂-emissions in 2020 to 25 % compared to the emissions measured in 1991. In 2030, it should be reduced up to 80 % (Trondheim kommune, 2016, p. 2). The climate plan states that “(...) [det] er nødvendig med et trendbrudd som drastisk reduserer utslipp fra transport og som faser ut oljefyring i husholdninger, nærings – og fjernvarmeanlegg“ (Trondheim kommune, 2016, p. 3).

[Figure 3.2. Emissions in Trondheim by 2030 (Bratt, 2010)]



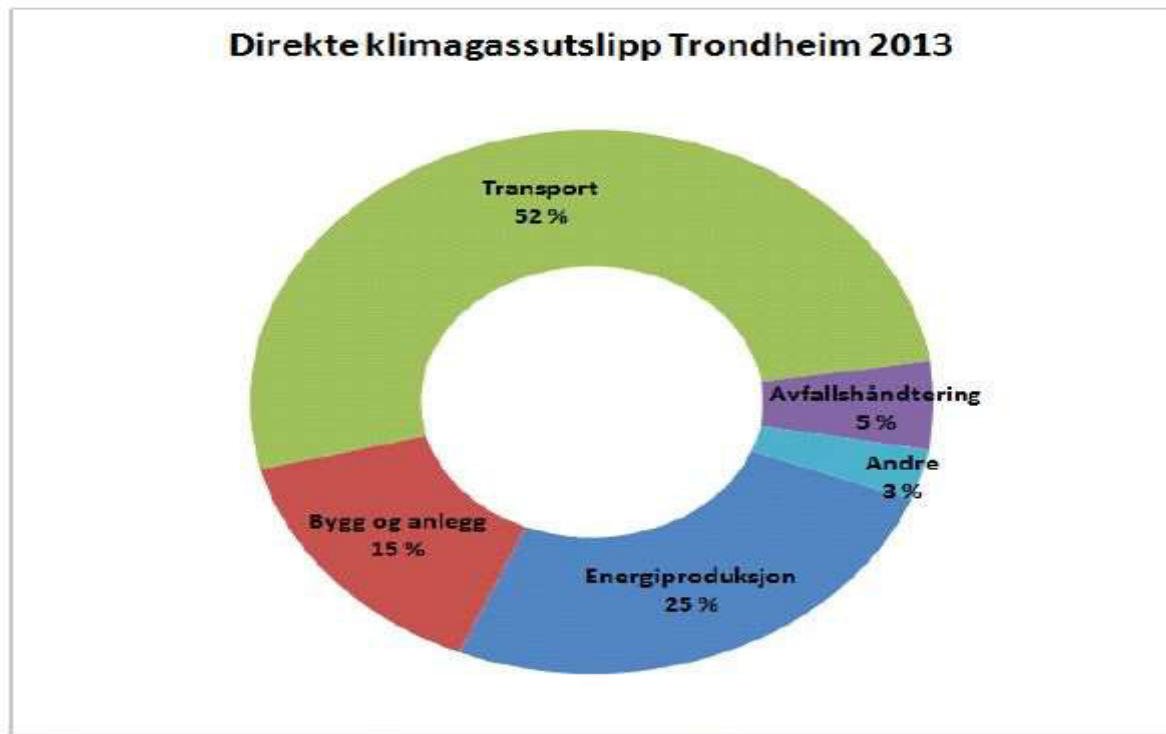
Trondheim’s climate plan introduces several different approaches on how to tackle its own goals. The first part of the climate plan touches upon the use of energy which is highly depending on the energy prices. Based on research conducted by TrønderEnergi og Statkraft Varmes, Trondheim’s number of inhabitants is going to rise by the year 2030, but it is expected to keep the CO₂-emissions at the same level as in 2010.

Another important aspect of the climate plan is discussing the reduction of so-called “indirect emissions” (“indirekte utslipp”). These emissions are not directly set free in Trondheim, but by transporting or producing goods which are used in the city itself. This approach seems to be fair enough since emissions do not know any kind of boundaries and do not ‘know’ how to keep track of emissions set free around the municipality of Trondheim. It is all about reducing the so-called “ecological footprint” of the city. By using the national average of such indirect emissions of ca. 2-3 mil tons of CO₂ which is a couple of times larger than the actual amount of direct emissions. By reducing such indirect emissions, the municipality of Trondheim could reach its climate plans easier, thanks to analyzing and paying attention to the indirect emissions.

The figure 3.3. shows the percentage of different factors of the direct emissions in Trondheim in 2013. The green field “transport” is 52 % of the whole measure, energy production is 25 %, buildings and facilities 15 %, whilst waste management and others made up 3 %. It is visible that the transport sector is by far the biggest cause of direct CO₂-emissions in the city of Trondheim.

To sum it up, there is a huge potential to minimize the CO₂-emissions caused by the factor transportation in Trondheim. Also, one should notice that this factor is connected to the sector of energy production. If one reduces the emissions caused by the production of CO₂, the emissions caused by transportation are also very likely to slow down/fall.

[3.3. Percentage of various factors of direct emissions in Trondheim 2013 (Bratt, 2010)]



(7 %). Disse utslippene har blitt noe redusert siden 1991.

3.3. Current state of transport in the city of Trondheim

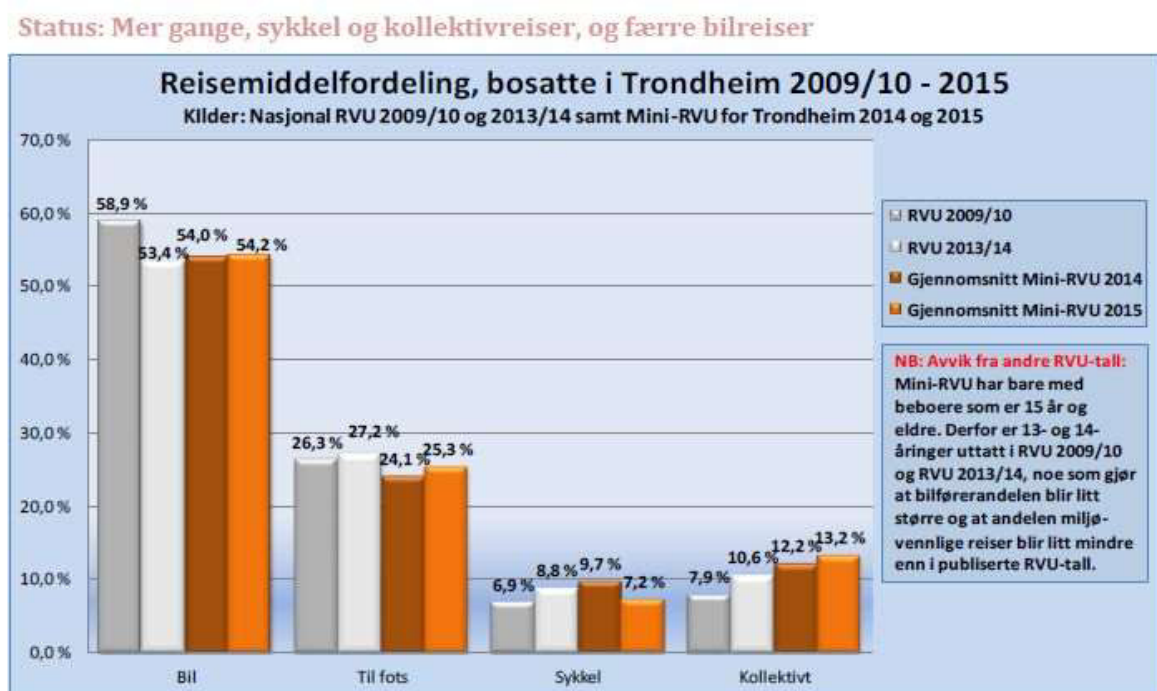
An analysis of the current state of transportation in the city of Trondheim is crucial to understand why this city is aiming to change the peoples' habits towards a more sustainable traffic structure in Trondheim. As of 2009, according to figure 3.4., 58,9 % of the people in Trondheim chose to travel by car. This percentage dropped to 54,2 % in 2015. 26,3 % of people chose to walk in 2009, and this number did decrease by one percent in 2009. A slight increasing change in the use of bicycles can be observed, i.e. 6,9 % in 2009 and 7,2 % in 2015. The highest increase of the percentage was measured in the sector of public transportation. It steadily grew from 7,9 % in 2009 to 13,2 % in 2015. If one sums up all the various percentages measured in 2015, the total amount of people traveling not using a car is 45,7 %, which is an impressive number.

The authors of the climate plan do explain why the four different parts of transportation in Trondheim were measured. People who are voluntarily walking are usually walking “(...) 2-3 km eller kortere som domineres av gange” (Trondheim kommune, 2016, p. 19). The percentage of people walking in Trondheim is steadily around 25,0 %, which is most likely to change in the upcoming years since “Miljøpakken har utarbeidet en egen gåstrategi for å øke andelen av gående (...)” (Trondheim kommune, 2016, p. 19).

Another important focus of the city’s climate plan is the rise of the use of bicycles in Trondheim. The goal set by the city is to double the amount of the percentage of people using bicycles by the year 2025. Through different investments, the percentage of the usage of bicycles “(...) viser at det er stor vekst i mellomlange reiser, sannsynligvis fordi det har blitt tilrettelagt bedfre for sykling” (Trondheim kommune, 2016, p. 19).

The most impressive increase, almost 50 %, of the amount of people using different ways of transportation has been observed in the field of public transport. No other city in Norway has experienced such a growth (Trondheim kommune, 2016, p. 19). Also, the climate plan does mention a “interkommunal arealplan for Trondheimsregionen” (IKAP) which is another, broader climate and transportation plan for Trondheim and the region circumventing

[Figure 3.4. Percental use of different transport modes in Trondheim 2009/10-15 (Trondheim kommune, 2016)]



Figur 4-2 Reisemiddelfordeling i Trondheim 2009/10 til 2015. Kilder: Nasjonal reisevaneundersøkelse (RVU) 2009/1 og 2013/14 og Mini-RVU for Trondheim 2014 og 2015.

the city. It is stated that “(...) arealutviklingen er dreid i riktning retning, men i motsetning til i Trondheim, så øker bruk av bil blant bosatte i omegnskommunene i Trondheimsregionen“ (Trondheim kommune, 2016, p. 20). The rise of the use of cars by people living in the neighboring cities is leading to problems within the policies and goals set by the city of Trondheim. The city discussed higher fuel taxes with the other municipalities, but this tax has not been introduced yet. Furthermore, the authorities of Trondheim are focusing on the use of parking lots in the city. Another survey conducted by NAF shows that “(...) billister i Trondheim opplever mindre kø og at færre bedrifter i Trondheimsregionen sier de taper penger på forsinkelser enn det bedriftene sier i andre storbyregioner“ (Trondheim kommune, 2016, p. 20).

The authors of the climate plan do also sum up their own research and indicate various incentives and goals the city has to follow in order to reduce the amount of CO₂-emissions in the upcoming years: “Riktig lokalisering av boliger og arbeidsplasser, sett i sammenheng med fortetting og transportsystem er den mest effektfulle og varige måten å oppnå redusert biltransport“ (Trondheim kommune, 2016, p. 20). Matching the city’s housing infrastructure, its offices and jobs with the transportation system’s network is an interesting approach to a more sustainable city planning. This thought is crucial due to the steady increase of inhabitants in Trondheim: “(...) mot 2050 angir prognoser en forventet befolkningsvekst på ca. 65.000 innbyggere. Dersom alle parameter i prognosen slår ut maksimalt positivt kan tallet bli over 100.000“ (Trondheim kommune, 2016, p. 21). Keeping track of those factors, a strategic city development plan and a sustainable change in the transportation is important to reach the city’s own climate plan by 2030.

3.4. The Trondheim energy and climate plan 2017-2030 – The role of electric mobility

Measuring the percentage of transportation as part of the CO₂-emissions in the city of Trondheim shows that there is a lot of potential to reduce such emissions by re-thinking the use of transportation, both public and private.

Around 24 % of the emissions in the field of transportation are set free by industrial vehicles (*anleggsmaskiner*), another 22 % by heavy vehicles (*tunge kjøretøy*) and almost 54 % by light vehicles (*lette kjøretøy*). This graphic clearly shows that the so-called light vehicles, i.e. cars, are causing the most emissions, and the climate plan directly discusses this issue by saying: “Vi

må redusere den motoriserte trafikken, ikke bare nøye oss med målet i Bymiljøavtalene om nullvekst av biltrafikken. Den transporten som gjenstår må tas i mye større grad med nullutslippskjøretøy“ (Trondheim kommune, 2016, p. 18). This openly states that the municipality’s goal is not just keeping the use of cars at the same level, but it should be also transitioned to zero emissions vehicles.

The climate plan debates the introduction of EVs broadly and detailed in chapter 4.3. The authors highlight the importance of a cooperation of local authorities with the central government. The government of Norway introduced various incentives throughout the past two decades, e.g. “(...) avgiftssystemet (elbil-fordelene, drivstoffavgifter mm.) og implementering av større investeringer (vei og jernbaneutvikling osv.)” (Trondheim kommune, 2016, p. 21).

Before I am going to discuss the role of EVs, I am briefly focusing on the other ways of transport in Trondheim, which is walking, cycling and public transportation. The authors mention several factors which may contribute to a more efficient and sustainable infrastructure in the city center of Trondheim. One is the location of housing estates and its distance to the main streets, bus stops and railway stations. It is stated that “[fortettingen] og transformasjonen må være sentrumsnær og rundt lokalsentra. I Trondheim er det bare Midtbyen som i dag er senter/stort kollektivknutepunkt (Trondheim kommune, 2016, p. 22). This means that the main agglomeration areas must be located as close as possible to the very city center. To match this new trend in the city planning, the authorities of Trondheim decided to reduce the use of cars and to increase the use of more sustainable ways of travelling, i.e. walking, cycling and public transportation.

The climate plan debates different strategies of matching the goals of the municipality: “Trondheim kommune vil benytte virkemidler i avtaler med staten, samarbeidet i Miljøpakken og i byregionen til å fremme gange, sykkel og kollektivtransport og redusere biltrafikken“ (Trondheim kommune, 2016, p. 23). Various approaches are mentioned, such as using splitting the resources in the so-called “Miljøpakken” (‘climate group’) in 50 % for car-focused projects and the other 50 % for sustainable ways of transportation. Furthermore, current surveys in Trondheim show that adding new tolls on the roads do not effectively change the use of cars (Trondheim kommune, 2016, p. 23). It is also discussed to actively inform the local society of Trondheim at schools, offices, and sport clubs on how to increase the use of public transportation. The authors of the climate plan do also debate the importance of keeping a steady increase of a public transportation network which secures a high frequency, high standard, short

distances, and a competitive price (Trondheim kommune, 2016, p. 23). It is also highly debated how different ways of transportation should cooperate: “Det må vurderes løpende hva som er optimale løsningsvalg og at superbuss, tog, bane(r), øvrige bussruter og båt ses i sammenheng“ (Trondheim kommune, 2016, p. 23). The two last bullet points mentioned in the climate plan focus on how the municipality of Trondheim should focus on prioritizing the use of public transportation and how to introduce a more restrictive use of parking lots to reduce the use of cars in the city center of Trondheim: “En ensidig restriktiv parkeringspolitikk i sentrum vil medføre bedre konkurransevilkår for bilbaserte kjøpesentra“ (Trondheim kommune, 2016, p. 23).

To sum it up, the climate plan mentions various strategies to introduce a more sustainable infrastructure and transport in Trondheim, but it somehow does not give any detailed information on how those goals should be reached. Furthermore, the goals set by the municipality of Trondheim must match the legal framework with the central government of Norway. This issue is not in the scope of the policy makers in Trondheim itself. Such laws can only be introduced by the central government in Norway’s capital, Oslo. The authors of the climate plan touch upon this problem by saying “(...) Trondheim kommune vil være pådriver for å utvikle nasjonale virkemidler slik at vi kan gjennomføre de nødvendige utslippsreducerende tiltakene“ (Trondheim kommune, 2016, p. 24) It is also stated that “Trondheim kommune vil i dialog med staten legge vekt på nasjonale insentivordninger og statens avgiftspolitikken som virkemidler. Det må sørges for forutsigbarhet i avgiftspolitikken, slik at både brukere og leverandører våger å satse på ny teknologi“ (Trondheim kommune, 2016, p. 24). Speaking of which, the use of electric vehicles in Trondheim is rapidly growing (Trondheim kommune, 2016, p. 18).

Moreover, the case study of electric mobility shows how different municipalities across the world try to match their own goals with national policies. Trondheim is, apart from Oslo, Norway’s leading place for being keen on the reduction of CO₂-emissions. One should consider such approaches of the municipality of Trondheim towards reducing CO₂-emissions as pushing national and regional authorities and policy makers to a more sustainable and environmentally-friendly approach to city structures and transportation issues: “Trondheim kommune skal tilstrebe å bruke kjøretøy med lavest mulig utslipp og drivstofforbruk, uansett teknologi“ (Trondheim kommune, 2016, p. 24). This quote clearly states that the introduction of vehicles with the lowest possible emission and fuel use is one of the main priorities in reducing CO₂-emissions in the municipality of Trondheim. Also, one should keep in mind that Norway is

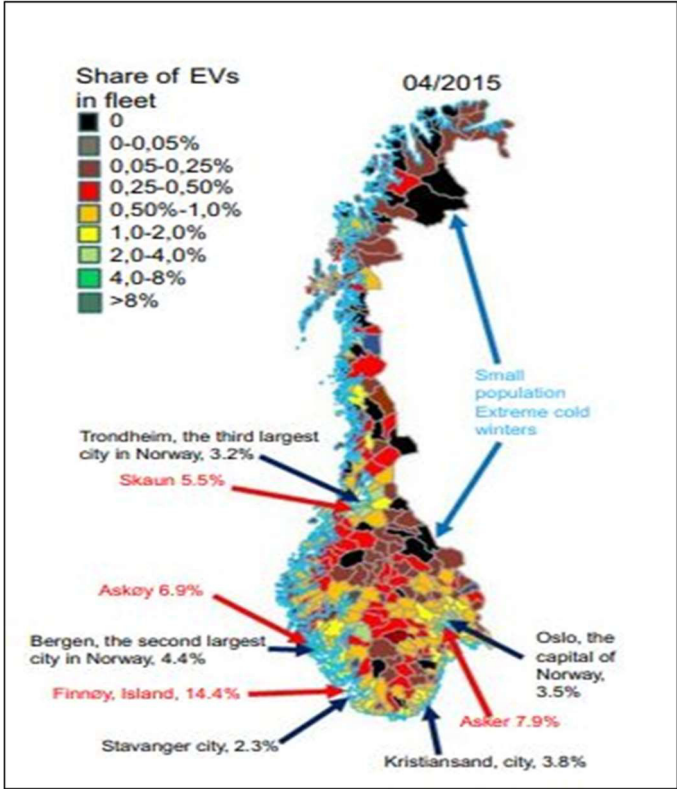
already one of the leading countries to introduce zero emission vehicles, both in the public and the private field of transportation.

3.5. The market share and sales of EVs in Norway

Norway has become one of the leading countries of introducing EVs on its automotive market: „The market for EVs has increased between 2010 and 2014 in most countries, but most profoundly in Norway, which currently is the European leader in EV adoption both in absolute numbers and in market share (...)” (Fearnley, et al., 2015, p. 4). In the year 2017, „(...) ble det registrert 158 650 nye personbiler, det er 4047 flere enn i 2016 og vi må helt tilbake til 1986 for å finne et år med høyere registreringstall for nye personiler. Gjennomsnittlig CO2-utslipp for alle nye personbiler registrert i 2017 var 82 g/km, 11 g/km lavere enn i 2016“ (AS, 2018).

As of 2016, the market share of Battery Electric Vehicles (BEV) in Norway was 15.7 %, while Plug-in Hybrid Vehicles (PHEVs) had a market share of 13.4 % (Figenbaum & Weber, 2017, p. 1). The combined market share in 2016 was 29.1 %.

[Figure 3.5. Share of EVs in fleet (NPRA, 2017)]



As already stated above, “[electromobility] is high on the political agenda in Norway. The political target is to increase the share of electric vehicles in the fleet, as a contribution towards meeting Norway’s climate policy targets” (Figenbaum & Weber, 2017, p. 1). This political agenda corresponds with the rising sales of EVs throughout the last 10-15 years. The percentage of the market share of EVs, thus, grew to 39.2 % in 2017, with PHEVs holding a market share of 18.4 %, and BEVs of 20.8 % (NPRA, 2017) In total numbers, 67.171

PHEVs were used in 2017, whilst there were 141.951 BEVs (NPRA, 2017).

This made Norway the world's leading EV market. A breakthrough came in December 2016, when "(...) the milestone of 100.00 BEVs registered was reached (...). This is equivalent to about 3% of the total fleet of 3 million passenger and light commercial vehicles in Norway" (Haugneland, et al., 2017, p. 1). Providing an empirical background to the theoretical approach highlights the close connection between different stakeholders, such as the automotive industry, global climate policy actors, national governments, local actors, and the sales of EVs in general.

3.6. The market share of EVs in Trondheim

Trondheim is among the cities with a high number of EVs in Norway, even though it is far behind such cities as Oslo or Bergen. The market share of EVs in the municipality in Trondheim is set to be around 3,2 %, which is a number above the national average. The market share was 3,5 % in the capital, Oslo, and 4,4 % in Bergen, Norway's second largest city (Kolhe & Madusha, 2017, p. 320). The table 1.1. depicts different statistics made by various research institutes, both public and private, in Norway in 2017. Discussing the table chart is useful to understand how Trondheim's local policy is different than in other Norwegian cities, with regards to the limited scope of local frameworks due to the Norwegian central law. The research is focusing on BEVs only, not on PHEVs. Norway's capital "Oslo har derimot en elbilandel på 6,9 prosent, mens Trondheim har 5,9 prosent elbiler og Stavanger har 4,7 prosent elbiler, ifølge foreningen" (Hovland, 2017).

As of 2017, there were 4.675 registered BEVs in the municipality of Trondheim, which was 5,9 % of the total number of cars, as stated above. This is 25 cars per 1000 inhabitants. Among the four biggest Norwegian cities, the market share of sold new cars in Trondheim 2017 was the lowest with only 17,1 %. The infrastructure of the charging stations seems to be quite competitive, though, with 19 EVs per charging stations in Trondheim. Trondheim is performing quite bad in another field, i.e. the number of EVs per fast charging station with only 312. This factor might be a hindrance for a growth in EV mobility. Trondheim has, as of 2017, no electric bus and the number of BEV-taxis remains unknown. Only 1,3 % of the companies registered in Trondheim used BEVs. The percentage of BEVs used by the municipality and their staff is quite high with 35 %. The table 4.1. shows detailed information about where the local stakeholders in Trondheim still must improve regarding the use of BEVs. The most critical part may be the fact that there is still no single BEV-bus in Trondheim, even though both climate plans are highlighting the importance of a well-performing public transport system in the city.

The strategy of the local bus companies is to use hybrid busses instead. A discussion on reasons for being that is useful to understand the city's goals. The market share of new electric cars sold in Trondheim is by far lower than in Oslo, Bergen, and Stavanger. A reason for that might be a local customer bias or the specific city landscape, e.g. less traffic and thus less traffic jams compared to other cities, where positive discrimination of EV appear more effective for the car driver/owner. Also, other cities' policies are far more detailed and ground-breaking than Trondheim's plans: "(...) Oslos strategi var mer offensiv, med tydelige klimamål og elbilplaner (Hovland, 2017). Trondheim seemed to be unique with setting itself very ambitious goals, but other cities in Norway are also trying to compete in terms of introducing the 'best' climate goals and plans.

[Table 1.1. Various empirical factors regarding EVs in the four biggest cities in Norway (Hovland, 2017)

	Oslo	Bergen	Trondheim	Stavanger
Antall elbiler	19.821	10.896	4.675	2.807
Andel elbil av total bilpark	6,9 %	9,6 %	5,9 %	4,7 %
Elbiler per 1000 innbyggere	30	39	25	21
Markedsandel nybilsalget 2017	25,8 %	27,4 %	17,1%	20,5 %
Antall elbiler per ladepunkt	10	25	19	19
Antall elbiler per hurtiglader	336	320	312	561
Eltaxier	10	5	?	8
Elbusser	0	7	0	5
Elvarebilandel	1,7 %	1,3 %	1,3 %	0,7 %
Andel elbil i kommunal flåte	60 %	27 %	35 %	9 %
Antall stemmer fra Elbilisten 2017 blant Norges elbileiere	3949	900	298	320

Kilder: Motorvognregisteret, SSB, Opplysningsrådet for Veitrafikken, NOBIL og Norsk elbilforening.

FLERE ELBILER: Denne tabellen viser fakta om elbiler i de store byene. Tallene er innsamlet av Norsk Elbilforening.

FOTO: NORSK ELBILFORENING

Bergen and Oslo do also have "(...) et mål om 50 prosent reduksjon i klimagassutslipp i 2020 og 95 prosent innen 2030, mens Bergen skal kutte utslippene med 30 prosent innen 2020 og være fossilfri i 2030 (...)" (Hovland, 2017). Moreover, many municipalities around Trondheim have a higher percentage of BEVs than Trondheim because of many commuters. Cities such as Malvik, Klæbu or Skaun have a market share reaching 10,4 %, 9,7 % and 8,9 %, respectively (Østraat, 2017). A reason for the lower market share of BEVs in Trondheim might be a lower share of commuters. When analyzing such statistics, one should be aware of the

city's location, its number of inhabitants and infrastructure. It is easy to state that Oslo and Bergen are 'better' markets for EVs, but this would limit the frame of the analysis, e.g. both cities suffer from more commuter traffic and more traffic jams. It would be useful to conduct a more detailed analysis on the other cities' statuses regarding electric mobility to have a broader insight and analysis.

When comparing Trondheim to other big cities in Norway, the city's climate plans are becoming more generic. An interesting aspect of the analysis is how the sudden change in the city's EV-oriented policies leads to a rapid decline in the sales of EVs: "Salget av elbiler i Trondheimsregionen har falt med 22 prosent i år- Samtidig er salget stadig økende i Oslo. Elbilforeningen mener Trondheim fører en elbilfiendtlig politikk" (Haudemann-Andersen & Sae-Khow, 2017). It seems that Trondheim is being less competitive than other big cities in Norway, despite the city's ambitious policies and goals. This might be a reaction or a political signal of less positive discrimination of EVs in Trondheim. One should also note that introducing national incentives by the Norwegian government created a special competition among the bigger cities in Norway regarding the 'best' goals and incentives. Creating such a landscape of competitiveness among local stakeholders is favorable for Norway's national and international climate goals.

4. A theoretical approach to the incentives and sustainable policies

4.1. National incentives for EVs

The Norwegian government has undertaken different approaches to introduce various incentives to EVs on the Norwegian market, as the figure 4.1. shows: “[The] Norwegian Ministry of Transport and Communication has gradually developed generous incentives to continue the development of EV market throughout the country over the years” (Kolhe & Madusha, 2017, p. 324). All those incentives are, in some cases, world-wide leading and first-to-come. Norway has since then been very keen on introducing new laws to make EVs more attractive. The national level of the incentives may be linked to the landscape level of the MLP, since it forms the broad structure and the context for the stakeholders involved in the MLP. The government, i.e. the landscape level, directly affects several factors, such as the market shares and sales of EVs. It creates a certain niche for EVs in Norway, which may be connected to the discussed research on sustainable transition studies.

The incentives can be listed in three different categories, i.e. fiscal, economic, and practical incentives. Fiscal incentives are aiming to reduce the purchase price and taxes to give EVs an economic advantage over other automobiles. The first step of introducing fiscal incentives in Norway was already started in 1990/1996 with a law on the exemption from registration tax. The tax itself depends on the engine power, weight, and emission (Figenbaum & Kolbenstvedt, 2016, p. 98). The current government is trying to continue subsidizing this incentive until 2020. VAT exemption was introduced in 2001, and it means that “[vehicles] competing with BEVs are levied a Vat of 25% on sales price minus registration tax” (Figenbaum & Kolbenstvedt, 2016, p. 98). The third important fiscal incentive was introduced in 1996/2004 and it reduced the annual vehicle license fee. The fourth incentive allows companies to lower taxes, but it failed since most EVs are not used by companies. This “(...) incentive may be removed from 2018” (Figenbaum & Kolbenstvedt, 2016, p. 98)

The second ‘dimension’ of incentives depicts upon economic incentives. Already in 1997, the Norwegian state introduced a toll road exemption for EVs which was, seen from a historical perspective, a very early and radical change compared to other European countries. EV owners in “(...) the Oslo-area (...) saved (...) 600-1000 € per year for commuters” (Figenbaum & Kolbenstvedt, 2016, p. 98). Another economic incentive was introduced in 2009 which reduced fares on ferries for EV owners. The economic impact of those two incentives will be analyzed by the government which “(...) will appraise the environmental effects of

[Figure 4.1. Developments of the EV fleet and in EV policies in Norway 1997-2013 (Figenbaum & Kolbenstvedt, 2013)]

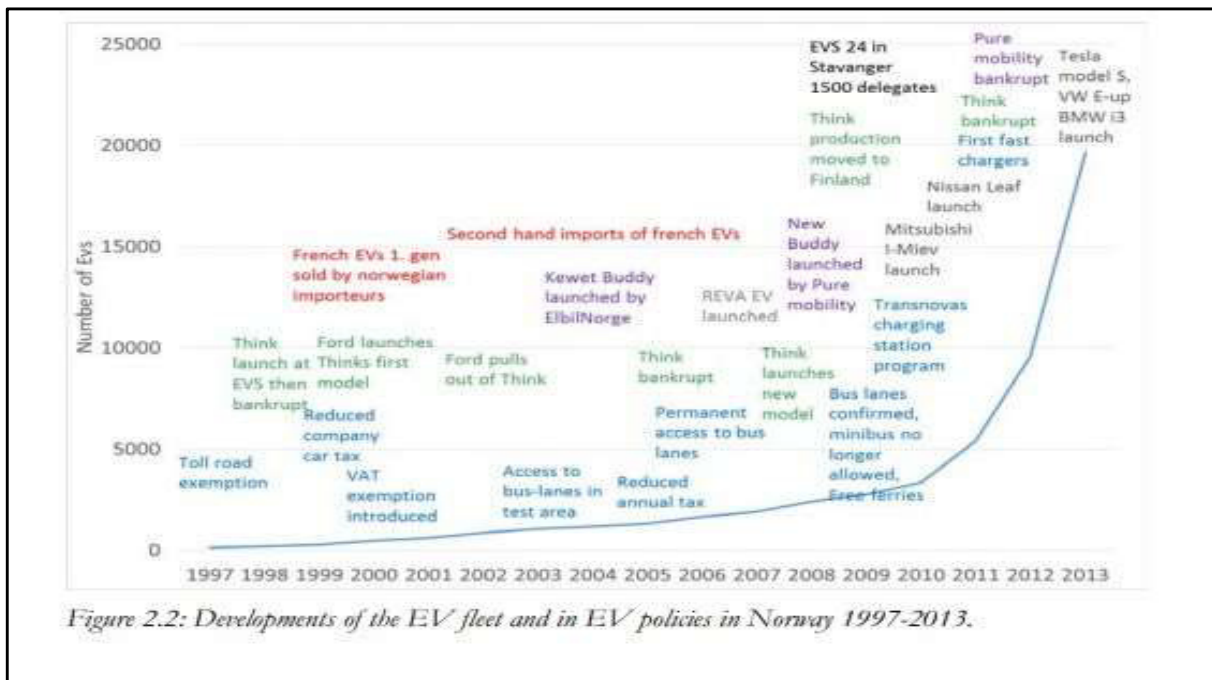


Figure 2.2: Developments of the EV fleet and in EV policies in Norway 1997-2013.

introducing differentiated fees for toll roads and ferries based on the environmental characteristics of vehicles (...)" (Figenbaum & Kolbenstvedt, 2016, p. 98). As of February 21, 2018, BEV owners must pay 50 % for using national road ferries (Edvardsen, 2018). The third economic incentive introduced in the year 2009 directly addressed severe issues of using an EV, i.e. charging the battery. The government gave financial support for charging stations to support investors, improve the charging itself and the different usage options. In 2001, though, the government of Norway supported the infrastructure of so-called ‘fast charge’ stations, which “(...) increases BEV miles driven & market” (Figenbaum & Kolbenstvedt, 2016, p. 98).

I personally do think that especially the infrastructure of charging stations is crucial to make EVs more appealing for a broader spectrum of the society. Such changes do also directly change the city landscape, especially in Trondheim, which will be discussed in the next section. The final ‘dimension’ are practical incentives, such as a granted access to bus lanes introduced in 2003/2005. This incentive has a “[high] value to user in regions with large rush-hour delays” (Figenbaum & Kolbenstvedt, 2016, p. 98). The government, though, gave the local authorities the possibility to restrict the access to bus lanes. Free parking was already introduced in 1999, and local authorities were also given the option to restrict this incentive in case of any legal abuse. The last incentive is free charging which is also in the competency of local authorities. Furthermore, some municipalities offer “[reserved] EL number plates” (Assum, et al., 2014, p.

1). These practical incentives were introduced by the central government, but local stakeholders can increase or decrease the scope of the incentives. Especially the free parking incentive is of high importance in highly-populated cities, such as Trondheim.

It is interesting to highlight the difference between a BEV and a PHEV made in the government's incentive policy. PHEVs "(...) do not benefit from the BEC incentives, except for some reduction in the registration tax and free parking in public parking facilities." (Assum, et al., 2014, p. III) Also, one has to take into account the technological improvement of BEVs made in the last two decades since the introduction of various incentives in Norway. The government is revising its incentives, and it is likely that those "(...) revisions will result in a gradual reduction of the incentives over time, assuming that technology improvements over the next years will make BEVs attractive with a lesser need for incentives" (Figenbaum & Kolbenstvedt, 2016, p. 49). Therefore, one must consider the importance of local incentives while discussing the need for central regulations. The municipality of Trondheim has, not surprisingly, introduced different incentives, many of which were addressed by the government. Nonetheless it should be discussed how Trondheim's climate plan tries to match its goals not only by focusing on BEVs, but on a wide-spread mixture of transport in the city.

Therefore, it is important to focus on the stakeholders' perspective on possible problems with EVs in the nearest future, both in Trondheim and in Norway in general: "The stakeholders consider uncertainties about the duration of batteries, the second-hand value of the BEVs and the future of the incentives as the main challenges for the future increase in electromobility" (Assum, et al., 2014, p. III). Nonetheless, "[most] stakeholders consider the present incentives as sufficient for further growth in the BEV sales, but some NGOs have a strategy to improve the EV situation even more" (Assum, et al., 2014, p. III).

It is also important to focus on the government's plan of its incentives since it directly addresses and changes the landscape level. The current government is planning to keep the incentives active until at least 2020: "Samtidig kom de ten viktigst beskjed etter Stortingets vedtak fra statsminister Erna Solberg, som kunngjorde at elbilfordelene nå skal bestå uforandret fram til 2020" (Edwardsen, 2018). One of the newest critiques of the government depicted upon the so-called "Tesla tax": "Despite the successful take-up of electric car in Norway, there is no guarantee that the lavish political support for battery powered transport will continue. The government made headlines in October with its proposal to end tax exemptions for the heaviest electric cars in 2018, quickly labelled a "Tesla tax" because it would initially affect only two

Tesla models” (Vaughan, 2017). The political issue of the national incentives need to be directly addressed. The latest governmental policies on EVs are coherent to many other agreements: “The two broad political agreements (2008 and 2012) on climate in Norwegian parliament have agreed to protect existing incentives until 2018 or until 50,000 EVs reached. It is reported that the average emission in 2015 is 99g/CO₂/km and the most important goal from climate agreement is 85 g/CO₂/km in 2020 (...)” (Kolhe & Madusha, 2017, p. 335).

To sum it up, the government’s incentives and their predictability are playing an important role nowadays but might be decreasing with an improvement of local infrastructure, EVs’ technology and other factors. From my point of view, the incentives analyzed above are a certain form of a discrimination of ICEVs rather than an approach to highlight, e.g. the environmental issues. This might be also one of the reasons for a failure of introducing a reduced company car tax. It seems that most EV owners use their car for private reasons instead of work-related reasons.

4.2. Local incentives in Trondheim

To understand how the spatial approach of the MLP supports a local framework, I am going to focus on various incentives and solutions found in the municipality of Trondheim. One could match the local incentives of Trondheim to a possible spatial perspective on the regime level of the MLP. Firstly, I am going to focus on the incentives made by the city of Trondheim in terms of parking spaces for EVs. The stakeholders in Trondheim have introduced two different kinds of parking lots for EVs and PHEVs. Parking lots marked with a sign saying “Elbil” are for BEVs only, thus parking lots marked with “Ladbar motorvogn” can be used by both BEVs and PHEVs (Parkering, 2018). Furthermore, some parking lots are branded as “ladeplikt” which means that the parked EV must be plugged to a charging station. Charging a car is included in the parking fee in most of the city center’s parking lots. Also, the infrastructure and availability of charging stations is still improving: “Trondheim Parkering bygger fortløpende nye ladestasjoner på flere offentlige P-plasser i Midtbyen” (Parkering, 2018). This refers to public parking lots only; private-owned parking space is varying, depending on the owner’s own policy. Such a parking space policy can only be achieved by raising the costs for other users of the space: “To avoid significant income deficits for city councils, the grating of free/reduced parking to EVs should be accompanied by a raise in the parking fee levels for ICE cars” (Serafimova, 2015, p. 3). The city changed its parking policies in 2017 by introducing a

minor parking fee on some public parking lots in the city center, Midtbyen. It led to a decrease in the use of EVs in the center: “Parkeringssetaten tror innføringen av parkeringsavgift også for elbiler, samt innføringen av maksimal parkeringstid på tre timer, er hovedårsakene til at fire av fem elbiler nå er borte fra sentrum“ (Øksnes, 2017).

Secondly, Trondheim is still excluding EVs from paying a toll for using its main roads. This is nothing extraordinary since every EV is excluded from paying the so-called “bompenger” (toll) in Norway: “Elbiler er fritatt for betaling i alle bompenganeanlegg i Norge, med unntak av i Svinesundsforbindelsen” (Autopass, 2016). The Norwegian toll system is divided into two different tax groups. “Takstgruppe 1” (tax group 1) includes every automotive up to 3,5 tons and every M1-category automotive. “Takstgruppe 2”, though, requires a toll payment by all automotive with a minimal weight exceeding 3,5 tons, both private and company automotive. EVs are excluded from both of these groups by the current Norwegian law, even though some governmental projects may change this policy in the upcoming years, especially in the Oslo district: “30 kroner dagen om under ett år, 45 kroner I 2020 og 71 kroner i 2025 for elbiler som kjører fra Bærum til Oslo” (Juven, 2018). As of April 2018, there are no changes in neither the central nor the local stakeholders’ policies in Trondheim. This incentive is strictly connected to the government’s plans for the upcoming years. A change in the toll policy of Trondheim might still be introduced, though.

Thirdly, the infrastructure of the charging stations plays an important role in attracting more potential customers and users of EVs in Trondheim. The city of Trondheim is currently in charge of approximately 58 public charging stations, most of them are in the center, Midtbyen. The charging stations serve all three different kinds of charging, i.e. fast charging, semi-fast charging, and normal electric plugs which may be used by EV owners to charge their cars. The city is investing in improving the infrastructure of charging stations step by step (Anon., 2018). Furthermore, many private stakeholders are trying to invest in a commercial network of charging stations in Trondheim. Already in 2012, different investors have opened three private-owned, commercial fast charging stations in Trøndelag, two of them in Trondheim (Elbil, 2012). The municipality of Trondheim does also subsidize different neighborhoods for providing their own charging stations for EV owners. Its goal is to “(...) stimulere til trygg og enkel hjemmelading for el- og hybridbiler” (Anon., 2018).

It is important to keep in mind that Trondheim cannot change many of the incentives set by the central government in Oslo. Trondheim may only change some of its outcomes, but it is

– like the research above has proven – more likely to improve the given landscape rather than cutting down on the incentives. Some cities in Norway, especially Oslo, do have enough political power to introduce some penalties, but Trondheim is keen on keeping the positive climate around the use of EVs within its borders. Also, Trondheim is trying to be a sustainable city and the two climate plans discussed clearly prove that improving the infrastructure for using EVs is in the very interest of the local stakeholders. Some actors in Trondheim do also state that the government should do the first step in reducing EVs' incentives, not the local authorities: "Hvis elbiler skal miste fordeler, må det være ei beslutning som tas av Stortinget, sier ordfører Gunnar Krogstad" (Nakrem, 2017).

The whole macroperspective of the current market of EVs is rather mixed, especially in the Trøndela region. Some examples clearly show that even the slightest change in the incentives are having important outcomes for many other stakeholders and actors. The sales of EVs have dropped in 2017, once the city tried to change some of the incentives, i.e. introducing parking fees: „Elbilsalget har i Sør-Trøndelag hatt en nedgang på 22 prosent så langt i år sammenlignet med samme periode i fjor“ (Jacobsen, 2017). Once the local authorities try to change any kind of positive incentives, the customers of EVs are changing their behavioral patterns. It especially affects the sales of EVs in general, and the city of Trondheim may get less tax revenue: “Kommunalråd Sissel Trønstad sier parkeringsavgiften innføres av nærlingslivshensyn, fordi elbilister opptat parkeringsplasser hele dagen” (Jacobsen, 2017).

If the municipality wants to achieve its goal to “(...) redusere utslipp med 25 prosent innen 2020” (Jacobsen, 2017), it should plan their EV incentives wisely and maybe also focus on the long-term goals instead of trying to raise their tax revenues in a short term. Moreover, EVs are still not as competitive as ‘traditional’ ICEVs, due to several facts. Some scholars state that “(...) from a relational perspective, EVs repeatedly emerged only to hit dead ends not because they were inherently inferior to alternatives but because of the strength of the associations that were formed (or failed to form) between heterogeneous elements constituting actor networks” (Garud & Gehman, 2012, p. 985).

Furthermore, as stated in the two climate plans, the city's goal is to limit the use of automobiles in Trondheim, regardless if the individuals are using an EV or ICEV. The city's goal is to reduce as many emissions as possible and still grow which creates an interesting sort of competition among various actors in the field of transport in Trondheim. Especially the public stakeholders such as the local bus companies must be very competitive with their

connections and prices against the private stakeholders. Some scholars tend to argue that “[public] transport systems tend to be more efficient than individually owned vehicles. They represent an easy and convenient means of transport of safety and affordability and are less polluting and some of them faster than a private car (...)” (Muneer & García, 2017, p. 54). To be more competitive than individually owned vehicles, the public transport system should invest more in its infrastructure to attract the commuters living around Trondheim, not in the city itself. This might be the most complicated aspect of keeping a competitive public transport since the minimal salaries in Norway are quite high, workers’ rights and unions are very strong, and it is quite difficult to find any legal loophole to save money. Also, Trondheim is still mostly using hybrid busses, not electric ones. It is rather contra productive to argue in favor of using an emission free public transport system with low prices but still hesitating to introduce pure electric busses. It is also important to focus on how the niches developed in Trondheim and how the management of such niches affected the introduction of electric mobility in this city. Especially the already discussed spatial perspective is useful to conduct research in this field. Analyzing how different stakeholders/actors contributed to an EV-friendly environment in Trondheim is important regarding the research question.

The municipality started cooperating with the national government of Norway to establish a legal framework a couple of years ago. This led the stakeholders of Trondheim to be nation-wide known for their striving for a well-organized sustainable transition: “Trondheim kommune som pådriver for å utarbeide en nasjonal miljøbildefinisjon som grunnlag for (alle) offentlige kjøretøyanskaffelser i Norge” (Bratt, 2010, p. 2009). This highlights how the city of Trondheim was actively engaged in creating a dialogue between different stakeholders. The city started introducing 300 new charging stations in 2011, with a financial support from the government’s ‘Transnova’ fund/project. The cost was 2,67 million NOK. Trondheim also started to cooperate with the central government to ‘force’ the local authorities in Norway to introduce more sustainable policies: “Statlige myndigheter ivrer for at kommuner tar et krafttak for å redusere klimagassutslippet. Trondheim kommune ønsker å påvirke statlige virksomheter i byen til å være minst like ambisiøs som oss med mobilitetsplanlegging og miljøvennlige kjøretøy” (Bratt, 2010, p. 40). The latter shows how important it is to the stakeholders in Trondheim to have an ongoing dialogue with other stakeholder across Norway to maintain policies focusing on sustainable and environmentally-friendly transport. Moreover, it is interesting how other public institutions in Trondheim are trying to cooperate with the local authorities and private stakeholders in Trondheim, such as the local university, NTNU:

“Invitere NTNU til mobilitetsplanlegging for Gløshaugen med sikte på parkeringssanering og økt tilrettelegging for miljøvennlig transport“ (Bratt, 2010, p. 40). Another quote depicts how the authorities of Trondheim are trying to cooperate with other cities and local stakeholders: “Trondheim kommune ønsker å etablere et samarbeid med andre offentlige og private virksomheter i bysamfunnet på området miljøbiler og mobilitetsplanlegging. Gjennom programmet Framtidens byer ønsker vi å utfordre staten til å forplikte seg til å være like god som kommunen i sine virksomheter lokalisert i Trondheim“ (Bratt, 2010, p. 39).

This local policy of Trondheim does match with the national incentives set by various Norwegian governments since the 1990s. One should know that Norway has a central government with a lot of competencies in law-making which cities like Oslo, Bergen and Trondheim have to follow, in many cases without any possibility to re-negotiate. This is one of the main reasons for the pro-active approach of the policy makers in Trondheim regarding having an open and democratic process of debating, discussing, and agreeing with different actors. It is Trondheim’s approach to affect the landscape level of its own niche policies. This process is wisely chosen, and a tight cooperation with the government in Oslo allows Trondheim to strive for a well-organized and profound sustainable transition: “Trondheim kommune ønsker å spesifisere og iverskette flere pilotprosjekt med utprøving og evaluering av el-bil/plug-in hybrid i egen virksomhet og et utvalg private og offentlige virksomheter“ (Blanco, 2017, p. 39).

The spatial perspective on the national incentives and discussion of introducing EVs in different municipalities looks thought-provoking. Seen from a national perspective, some authorities claim that “[the] number of BEVs will increase with the present incentives. The important thing is to make BEVs available in the market. People want to stick to “their own” brand, waiting for “their” brand to market a BEV. The ministry prefers a technologically neutral strategy, i.e. rules benefitting the best technology” (Assum, et al., 2014, p. 9). It clearly shows that the government of Norway is trying to be neutral regarding different incentives for EVs. This policy creates a rather pro-EV environment in Norway: “There is a positive BEV situation in Norway, i.e. the incentives are effective in contributing to the sales and use of BEVs, especially the VAT exemption and the road-toll exemption” (Assum, et al., 2014, p. 29).

Some examples show that radical changes in the incentives in Trondheim negatively affect both the sales and the perception of using EVs by several customers. Once the local municipality introduced parking fees for EVs in the city center, the number of parked cars

drastically decreased by 80% (Lervlik, 2017). In December 2018, 538 EVs were parked in the city center. After introducing parking fees from January 1st, the number dropped to only 113 (Lervlik, 2017). In other words, non-debated and suddenly introduced changes in the city's incentives have and will continue to directly affect the EV market in Trondheim in a rather negative way.

Moreover, the actors in Trondheim do also try to cooperate with other neighboring municipalities, also in Sweden: "Trondheim kommune deltar allerede i dag i et prosjektsamarbeid om miljøvennlig transport og elektriske biler med de svenske kommunene Østersund og Sundsvall" (Bratt, 2010, p. 39). This underlines the importance of an open debate and cooperation within the city itself and the surrounding regions. Another climate plan set by the municipality of Trondheim in 2005 said that there is a goal of "å etablere inntil 300 ladepunkter for el-bil med gratis parkering og strøm innen 2011" (Bratt, 2010). Those local incentives are an embedding of the landscape set by the Norwegian government. It is demanding to analyze how so many different aspects of a very broad sustainable policy process are changing the local niche in Trondheim, while still being a part of a nation-wide policy.

4.3. A global context of Trondheim's and Norway's sustainable transition policies

It is interesting to conduct research on the international landscape frameworks regarding the climate policies of Norway. Putting my analysis in a broader, global context is useful to understand why the Norwegian government and the local authorities in Trondheim are so actively-engaged in sustainable transitions. A possible reason for Trondheim's climate goals may be a way of implementing global, international laws into a local context. Throughout the last decades, the government of Norway has been very keen on introducing new climate-related laws, especially since the 2000s. One reason for that might be Norway's motivation to be one of the leading countries regarding sustainable transitions and environmentally-friendly policies. Analyzing this global issue of climate plans leads this thesis from a local perspective through a national to an international perspective.

In 2016, "Norway signed and ratified the Paris Agreement on 20 June 2016. Norway's NDC includes a target of reducing GHG emissions by "at least 40%" below 1990 levels in 2030, thus aligning itself with the European Union's target" (Anon., 2017). According to this quote, the government of Norway tries to match its own climate goals with existing

international frameworks, especially those set by the UN and the EU, even though Norway is not a member of the latter. Seen from such a perspective, the climate plan of Trondheim seems to be a local way of implementing binding international laws, thus closely collaborating regarding climate policy issues. While conducting the research on this topic, I found several other important laws introduced by the Norwegian government in the recent years which might be a hint that the local policies in various Norwegian cities are implementing binding international laws agreed on by the central government of Norway. It turns out that “[the] Storting (Norwegian Parliament) passed a Climate Law on 16 June 2017 that establishes legally binding emissions reduction targets for 2030 and 2050. The law came into effect on 1 January 2018 and aims for Norway to achieve “carbon neutrality” by 2050” (Anon., 2017). As stated in the two climate plans analyzed in this thesis, Trondheim set itself goals for both 2030 and 2050. Seen from a global perspective, Trondheim’s own goal is just an implementation of binding international laws, which explains the same climate goals found in other cities in Norway.

Furthermore, the European Commission is also trying to bind Norway to the European targets regarding climate issues: “The European Commission has proposed a preliminary 2030 emissions reduction target for Norway” (Sæther, 2016). The Norwegian Climate and Energy Minister Vidar Helgesen commented on these goals the following: “Particularly the areas of transport and agriculture will see large changes in the coming years. (...) It means a higher tempo in the transition to the low-emission society, a green tax shift and other (...) policy instruments (...)” (Sæther, 2016). Those ‘policy instruments’ are crucial for the upcoming years of the sustainable transition in Norway, and especially in the various municipalities across the country. They are “(...) a central element of the Government’s domestic climate policy. Cross-sectoral economic instruments form the basis for decentralized, cost-effective and well-informed measures to ensure that the polluter pays” (Environment, 2008, p. 6).

Moreover, the government of Norway is also trying to work towards more internationally binding agreements regarding climate goals, especially in the field of transportation, industry, and agriculture: “It is therefore important to establish the credibility of broad-based international efforts to reduce greenhouse gas emissions” (Environment, 2008, p. 6). To sum it up, the efforts of the Norwegian government are pro-sustainable transitions, but one should note that some of its efforts are only affordable because of the well-performing economy and the steady growth of the country’s GDP, especially in terms of the EU Emissions Trade System: “A target cut of 40% in the non-ETS sector is the highest a country can be given. The target is based on Norway’s high GP relative to other European countries” (Sæther, 2016).

Furthermore, the policies introduced by the Norwegian government are in many cases favoring different sectors within its economy, such as research and development or other highly-developed fields. This might be one of the reasons why the government is aiming for a well-balanced development of sustainable transitions. One of the most important goals set by international stakeholders is that ‘2 degree goal’: „FNs Klimapanel har angitt nødvendige utslippskutt for å unngå at den globale oppvarmingen overskrider 2 grader (...)“ (Bratt, 2010, p. 5). These goals might be discussed in an EV context, especially in terms of the development of EVs in Norway. Giving this discussion a historical background might be interesting to understand why both national and local actors are keen on sustainable transitions. The development of EVs in Norway “(...) has started since 1970s, and currently, it has become large EV consumption country” (Kolhe & Madusha, 2017, p. 332). One of the main reasons for such a shift in the country’s development of its own car industry might be one of the first EV models, the ‘Think City’ which “(...) was planned to launch for the end of 1998, but it went bankrupt the same year. The Ford Motor Company (the United States) has purchased the company and developed and launched the Think City vehicle in 1999” (Kolhe & Madusha, 2017, p. 334). Introducing the Think City on the Norwegian EV market was crucial for many other smaller companies, such as Kollega, Bill-Elbil Norge-Buddy Electric or Kewet (Kolhe & Madusha, 2017, p. 334). EVs played an important role in Norway because of the electricity provided in the country which is different compared to other countries: “EVs are much cheaper to operate than ICE vehicles in Norway due to low-priced electricity. Further, the incentives on taxes and attractive exemptions are leading to impact on the EV market” (Kolhe & Madusha, 2017, p. 335). Also, comparatively high taxes on petroleum do play an important role here. The fact that electricity is cheap and mostly based on renewable sources and the government’s policies made a very pro-EV environment in Norway, creating a strong and well-organized lobby in various cities, companies, industries and political parties: “The sustainable and cleaner energy in transportation has attracted a worthy attention in Norwegian government and EV consumers are encouraged with new policies and tax exemptions” (Kolhe & Madusha, 2017, p. 335).

Both the EU Commission and the UN issued different strategies and goals regarding low-emission mobility. The EU Commission published its own strategy in 2016 which is detailed and addressing different issues of sustainable transitions. The main elements of the EU Commission’s strategy touch upon three different points, i.e. “[increasing] the efficiency of the transport system”, (...) [speeding] up the deployment of low-emission alternative energy for transport, (...) [moving] towards zero-emission vehicles” (Anon., 2016). Especially the latter

goal addresses directly the case of EVs. Surprisingly, the published strategy plan also focuses on the importance of cities and local authorities since these “(...) are already implementing incentives for low-emission alternative energies and vehicles, encouraging modal shift to active travel (...), public transport and/or shared mobility schemes (...)” (Anon., 2016). It is interesting to see how the highest EU authority discusses the key role played by local stakeholders in a shift towards a zero-emission mobility. The discussed EU Commission strategy plan does also focus on supporting jobs, growth, investments, innovations and how all those goals are going to be financed, which makes it quite unique compared to other plans, in relation to sustainable transition. Moreover, it also highlights the pure benefits for the citizens and customers: “Consumers will benefit from more efficient, less-energy consuming cars. Consumers will also benefit from better infrastructure for alternative fuels, better links between modes of transport and better safety and fewer delays thanks to roll-out of digital technologies” (Anon., 2016).

One has to keep in mind that Norway is not a member of the EU and many of the regulations set by the EU Commission do not directly affect the country’s legislation, but “Norway is a member of the European Economic Area Agreement and has therefore adopted EU energy market rules in its legislation” (Anon., 2018). The so-called EC-Norway Energy Dialogue has been started in 2002 and one of the key concepts is the “(...) implementation of EU energy rules in Norway (...)” (Anon., 2018).

Another interesting climate plan has been published by the UN after the Climate Summit 2014 which took place in its headquarters, in New York City. It focuses on the Urban Electric Mobility Initiative (UEMI). It introduced three different ‘sides’ of actors, i.e. demand side actors (e.g. national and city governments), supply side actors (e.g. EV industry, battery manufacturers, energy suppliers and distributors), international organizations (e.g. UN-Habitat, IEA, Wupertal Institute) (Nations, 2014). The UEMI addresses how different ‘Government and City’ representatives on the demand side “(...) pledge that in pursuing the goal of sustainable urbanisation, they will strive towards a goal of: “by 2030 at least 30% of the individual motorised tavel will be by Electric Vehicles” (Nations, 2014, p. 4). This is a direct hint to the latest climate plan of the city of Trondheim. It is another proof that Trondheim’s climate goals are fully in accord with various national, European, and global climate goals, plans and strategies. The UEMI report states different options on how these goals may be achieved, particularly by “(...) increased electrification of private vehicles (...) accompanied by a significant increase in the uptake of electric mobility in public transportation systems (...)”

combined with a reduction in personally operated [ICEVs] (...)" (Nations, 2014, p. 7). The discussed UEMI report also gives a detailed insight on which private, industrial leaders and companies are cooperating in reaching the set goals by 2030. It states that the industry leaders "(...) will strive to increase the global market share of electric vehicles in cities to reach at least 30% of vehicle sales by 2030, which equals about 15% vehicle stock (...)" (Nations, 2014, p. 10).

The climate goals of the municipality of Trondheim are, again, in fully accord with the binding international frameworks. It is interesting to analyze how the UN try to emphasize the importance of a possible cooperation of different stakeholders. The report is trying to address the issue of a lack of cooperation during the past decades to increase the chances of a well-organized sustainable transition across the world in the nearest future. Well-developed countries such as Norway must be a sort of 'role model' both for developed and for less-developed countries, both in terms of incentives and the economic site of such a transition towards zero-emission mobility. The UEMI report therefore highlights the importance of so-called multilateral development banks which "respond to requests from Member countries for investments in infrastructure to support cities in attaining the goal of 30% of the LDV [light duty vehicles] fleet being comprised of Electric Vehicles" (Nations, 2014, p. 11). This is an important strategy to focus on, especially in cities because some articles stress out that "[an] obvious focal point for Norway and other countries is to encourage fleets to use EVs" (Figenbaum & Kolbenstvedt, 2013, p. 8). To sum it up, the global perspective on the climate plans of the city of Trondheim are a smart way of implementing international laws into a local framework. The background of EVs and their importance to R & D in Norway and the country's effective electricity market created a very special opportunity for EVs, both for the customers and the different manufactures.

5. Conclusion

The research conducted in this thesis shows how tricky the vast topic of electric mobility truly is. Many different fields in both qualitative and quantitative methods play an important role in a full-spectrum analysis of electric-vehicle mobility in Trondheim. Frankly, the spatial approach on the multi-level perspective in the research led to a broad analysis of the framework set by the Norwegian government. As stated in the introduction, a possible limitation of the research could be the fact that Norway is a centralistic country, i.e. a country which has a strong rule of the central government in its capital, Oslo. The different local authorities do not have as much power as they could have in other countries with other political regimes. This limits the scope of the legal possibilities on the local perspective. The research question itself provided a broad view of the national incentives in Norway and it led to a fruitful analysis of the implementation of those policies in a local sphere in Trondheim. The answer to the research question on how national incentives were implemented in Trondheim was approached in the fourth chapter, seen from a pure technical and organizational perspective. The municipality of Trondheim introduced fiscal, economical, and practical incentives, mostly focusing on the infrastructure of the charging stations, no tolls on the main highways, and many free parking spaces in the city of Trondheim. The local incentives are fully matching the given nation-wide landscape set by various Norwegian governments.

The other, minor research position was discussed in the two last sections of the third chapter. The detailed discussion of the market shares and sales in Norway and Trondheim led to the assumption that combining the qualitative and quantitative research is crucial to fully understand the case study of electric mobility in Trondheim. A possible approach in future studies could be conducting a statistical correlation approach to whether changes in incentives affect the sales and market shares of EVs or not.

Providing the reader with a brief background of the technical terms in the very beginning of the thesis should have proven that the field of electric vehicle studies is highly interesting and not as difficult to follow as previously anticipated. The theories used as a framework to approach the topic were quite useful. The MLP turned out to be a helpful tool to understand the different levels on my case study of electric mobility. It gave me a deeper understanding on how different stakeholders interact on various steps in between the levels, especially on the landscape level. The TIS provided a fruitful insight of the processes of the interaction between the city of Trondheim, national stakeholders and international agreements and authorities. I

could have probably also cited other research papers which could be a possible improvement for further research. As I have stated in the introduction, I was not sure about my approach of ‘zooming’ in and out from a national through a local to a global perspective, but it turned out that this method was interesting to follow and useful. Other scholars could have suggested another approach, but I did not feel confused while conducting my research in such a way.

While writing my thesis, I read several articles on electric mobility, and I realized that many of the scholars do not deeply discuss the sense of electric mobility. It also seems that the stakeholders in Norway and Trondheim do not reflect on why EVs are sold as the only emission-free way of transportation. To underline the importance of a nuanced criticism of electric mobility, I am going to briefly discuss the main issues concerning EVs.

Apart from being rather enthusiastic about electric mobility, I feel obliged to make the reader of my thesis aware of possible disadvantages of EVs. The list of such disadvantages is quite long and still highly interesting, so I am going to address as many downsides of EVs and electric mobility as possible. The biggest critique point of the transition from fossil-fuel based transport to an electric-based one is the current lack of competitiveness of electric cars in terms of range and engine performance. In most of the countries across the world, EVs do not play any role in implementing environmental-friendly policies. Only high-developed countries such as the USA, Norway, Sweden, or the Netherlands are trying to introduce incentives, both national and local, to highlight the importance of an emission free transport. The competition among those highly developed countries might be useful and important, but it is limited to those countries only and of a rather minor importance to the rest of the world: “The effect of the interaction of this landscape push and regime pull is, (...) a chasm through which nations seeking to increase share and transition BEVs into the mainstream need to cross” (Berkeley, et al., 2017, p. 324). Such climate plans as e.g. the city of Trondheim has introduced, are not playing any important role in other cities in less developed countries. It seems that this transition to EVs still remains to be an ‘elite’ phenomenon of almost no traceable evidence in the rest of the world. This point is also scientifically proven, e.g. “[de] to millioner elbilene utgjør bare 0,2 prosent av verdens bilpark“ (Hovland, 2017). This quote clearly states that – to meet the climate goals, set by various international organizations – such sustainable transitions should be taking place all around the world. This is, not surprisingly, not the case at all. Introducing EVs, both on a national and a local level, is still a very expensive and difficult step taken by stakeholders. A step that should not only be supported by various local and national stakeholders, but also by international actors. The following quote clearly underlines that such

international actors must be more pro-active in terms of sustainable transitions: “For å nå målet om å begrense global oppvarming til to grader fra førindustrielt nivå må det komme 150 millioner elektriske personbiler på veien innen 2030 og 600 millioner innen 2040, ifølge IEA [International Energy Agency]“ (Hovland, 2017).

Moreover, some of the biggest critique points of electric mobility touch upon the actual CO₂-emissions in general. Many studies show that “manufacturing an electric car uses significantly more energy than manufacturing a conventional car” (Hanley, 2017). Also, it is important to analyze which kind of electricity EVs are using. In some countries and regions, EVs use electricity based on, e.g. burning coal which is not environmentally friendly. It is an approach to simply ‘move’ the problem of pollution from one place to another (Hanley, 2017). The crucial part of any EV is its battery which is mostly made from lithium-ion which “[requires] mining operations to acquire the raw materials” (Hanley, 2017). Such mining operations are in many cases directly causing harm to the environment which negatively impacts electric mobility in total. Moreover, not everyone can simply invest in a brand-new EV. Many of the current models cost more than a ‘traditional’ ICEV: “In terms of greenhouse gas emissions, electric vehicles are still one of the most expensive ways to reduce them” (Lynch, 2017). If you also consider the whole process of reducing emissions, such as investing in wind and solar power, “(...) the cost-effectiveness of converting the vehicle population to electricity as a solution seems questionable” (Hanley, 2017). As of 2018, electric mobility is in many ways far behind ICEVs, and I am still wondering why different stakeholders and lobbyists supported EVs throughout the past few decades. A possible question in a future research could be how EVs claimed their position as ‘the only’ sustainable way of moving people. Even if you use fully renewable electricity, EVs are only competitive regarding emissions (Wilson, 2014). It seems that the batteries of EVs and the used technology still must undergo a lot of improvements till EVs will get as competitive and useful as ICEVs. Another interesting question is why the hybrid vehicles get ignored by any governmental or local incentives in Norway. Hybrid vehicles offer both the emission-free advantages of a pure BEV and the range and comfort of an ICEV. From my own perspective, it would have been useful to introduce some incentives for hybrids as well, as a certain ‘neutral’ step between the negative discrimination of ICEVs and the positive discrimination of EVs. Furthermore, why are many scholars claiming that ICEVs and their engines are outdated? Some private R & D institutes are working on so-called synthetic fuels, and it is possible to develop carbon-neutral synthetic diesel and gas (Anon., 2017). This synthetic fuel “(...) emits carbo dioxide when it’s burned,

but it also captures carbon dioxide as it's being made, so it's considered carbon neutral" (Geuss, 2017). It would be interesting to have a long-period research on the actual emissions of cars using synthetic fuels. Some companies are already using other fuels, such as "cellulosic biofuels, biomass-based diesel, advanced biofuel, and traditional renewable fuel" (Geuss, 2016). A reconsidering of different fuels used in ICEVs could be analyzed in future research papers.

From my point of view, the case study conducted in this thesis should not only be seen in a Norwegian or Nordic perspective. It should be also used as a way of solving fossil fuel-based transport issues throughout the world. Organizing events and public panels is a good way to attract international and foreign stakeholders to re-think the importance of sustainable transitions, such as "The Energy and Climate Dialog in Norway in 2014 [which] described a vision for Norway as a low-carbon society in 2050. The framework conditions and incentives are focused to have almost free greenhouse gas emissions, with efficient energy use and a high proportion of renewables" (Kolhe & Madusha, 2017, p. 336).

Another crucial point of this conclusion should be a broader discussion on why exactly EVs are supposed to be the ultimate solution for both private and public mobility in the nearest future in Trondheim? Traditional ICEVs and EVs competed over several decades, with the ICEVs 'winning' over a long period time, only by free market standards. The EV industry can only 'survive' with the help of governmental incentives: "(...) this represents the orthodox view for the demise of electric vehicles deriving from an evolutionary perspective; ICs won out because they were "better" suited to the selection pressures of the then-prevailing sociotechnical regime" (Garud & Gehman, 2012, p. 982). Would the EV market be as 'successful' as it is now without incentives? If one compares Norway to other countries without any EV-friendly policies, the answer is negative. A broader historical and economic background shows that, "[from a relational perspective, the victory of ICs over EVs was not inevitable during the early stage of ferment" (Garud & Gehman, 2012, p. 984). Regardless of what type of vehicles is the most environmentally-friendly, most of the transport sectors emissions are still caused by private vehicles (Muneer & García, 2017, p. 5).

The thesis has clearly shown that the research field of sustainable transitions is emerging because of many reasons, not only regarding climate issues. There is a certain pressure made by customers on the current market regarding different expenses, such as parking lots, taxes, or other costly issues. I personally do think that the expending sector of EVs might be in many

cases not only be related to climate issues, but simply also just to save money and subconsciously putting pressure on the automotive sector (Kolhe & Madusha, 2017, p. 335). It would be highly informative to compare incentives for EVs with other possible incentives to check if the customers are keen on protecting the climate or simply buying EVs to save taxes and lower their own expenses (Assum, et al., 2014). A possible research could run a simulation or survey of car owners if they would be interested in other vehicles, e.g. hybrids if the government would also offer various incentives. Also, what would happen if some of the incentives would have been improved and other, more unimportant ones, would be cancelled? (Kolhe & Madusha, 2017, p. 336). The market share of EVs in a global perspective has still not reached 1.00 % (Berkeley, et al., 2017, p. 321). Some of the incentives are only stimulating the market in favor of EVs while the other vehicle types are negatively discriminated (Berkeley, et al., 2017, p. 324). One should also consider possible demographic changes in various cities and regions throughout the world which may directly affect the market of EVs (Moradi & Vagnoni, 2017, p. 8). These thoughts are possible limitations of the thesis, and a possible motivation for conducting a broader research on topics related to electric mobility.

I highly enjoyed writing this thesis, not only because I am very interested in cars and the automotive industry. I personally think that the rise of emission-free mobility is one of the most important topics in the 21st century. If humanity wants to preserve planet Earth for upcoming civilizations inhabiting this planet, it is forced to act in a wise and anticipating way. Before colonizing other planets, humankind should try to move from A to B with causing the least possible harm to any animate, inanimate, carbon or silica based, biotic, bionic, cybernetic, or artificial existence.

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