Explaining Sustainability Transitions by Bringing Together the Multi-level Perspective and the Multiple Streams Framework

Case Study Dutch Transition to Electric Cars

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Executive Summary

Sustainability transitions are socio-technical developments driving and being driven by policy change while being inherently value-laden and political. Thus, in order to understand how such sustainability transitions, come about, it is crucial to comprehend how socio-technical and policy change co-evolve.

Previous studies that have attempted to study this co-evolution focused on demonstrating the existence and, consequently, the significance of certain feedback mechanisms between socio-technical and policy change in the context of sustainability transitions. While it is important to understand the broader links between socio-technical developments and policy change, it's just as important to unlocking the "black box" of each. This would make it possible to better comprehend the way in which this co-evolution influences the overall progress of a sustainable transition would be understood.

In an attempt to build upon previous studies, this study applied the Multi-level Perspective (MLP) from transition studies and the Multiple Streams Framework (MSF) from the policy studies. The basic premise of the MLP is that transitions are nonlinear processes that result from the interplay of multiple developments at three analytical levels: niche (locus of radical innovations) socio-technical regimes (the locus of established practices and associated rules), and an exogenous socio-technical landscape. The MSF on the other hand, is a framework from policy theories and it is used to explain how and when policy change takes place by differentiating between three independent streams—the problem, the policy, and the political streams.

This research attempted to understand how the three levels of the MLP relate to the three streams of the MSF. In order to bridge this knowledge gap, the Dutch transition to electric cars was chosen as the case study given its strong technical dimension and the significant contribution of Dutch policies to this transition.

Bridging this knowledge gap answered the following main research question:

> How can a study of socio-technical transitions using MLP and policy changes using MSF applied to the Dutch transition to electric cars help to create insights in how to synthesise the two aforementioned theoretical frameworks?

To answer this question, this research adopted a single case study research design for the Dutch transition to electric cars in which two theoretical frameworks (MLP and MSF) were applied separately to the case. Data collection was done using both primary research (by conducting 12 interviews with sector actors) and secondary research (by gathering relevant scientific papers, government documents, news articles and reports). After gathering the data, the information was analysed thoroughly using qualitative coding and causal process tracing. Once the two frameworks were applied to the case, a comparative analysis was performed resulting in the identification of commonalities, differences, and casual relations between the two frameworks. In order to validate the results, three expert validation sessions were conducted with researchers in the field of sustainability transitions. The findings of this research resulted in 13 insights in relation to the commonalities, differences and relations found between the two frameworks. These are:

Relating to Commonalities:
- Exogenous socio-technical challenges form the problems within the policy subsystem
- Niche developments carried out by governmental organisations form the pool of policies within the policy subsystem

Relating to Differences:
- Exogenous socio-technical challenges relating to the technical component of the sustainable transition are not captured within the policy change process
- Exogenous socio-technical opportunities are not captured within the policy change process

Relating to Relations:
- Exogenous socio-technical challenges cause certain problems within the policy subsystem
- Exogenous socio-technical challenges relating to the technical component of the transition can be solved by a set of policies mixes fostering knowledge sharing, development of research and partnerships
- Policies change can stimulate further niche developments (through shielding, nurturing, and empowering them)
- Exogenous socio-technical challenges of landscape level can trigger the policy entrepreneurs to couple the streams)
- Exogenous socio-technical opportunities contribute to the technical feasibility, value acceptability and financial viability of new the new policy change
- Niche developments increase the value acceptability, technical feasibility and financial viabilities of policy change stimulating innovation
- Policy entrepreneurs aiming at ripening the policy stream (and thus couple it with the other streams) will have to focus on breaking down the regime barriers
- Regime actors form the national mood which forms the political dimensions in a policy change processes
- Regime actors influence the party ideology ruling the country which forms the politics dimensions in a policy change processes

The findings of this research proved that certain concepts of the MLP and MSF overlap as they are common between the two frameworks. On the other hand, the findings of this research showed that certain concepts that form an inherent part of the MLP are missing from the MSF. The missing concepts in the MSF relate to the technological innovation. While it is foreseeable that a policy change framework is not expected to include the technical dimensions of its targeting socio-technical change, it is still important for such a framework to incorporate the implications that such technical developments have on the general course of events leading to the policy change. This is where the potential of the MLP comes in to compensate for this limitation.

Furthermore, certain relations found between the different concepts of the MLP and MSF were validated by the previous literature which proved that the findings of this research are to a certain extent generalisable. This was also revealed during the expert validations in which the three experts were able to resemble the findings of this research in their own studies and reflect on them using their own knowledge. This research also proved the existence of relations that have not yet been discussed by previous scholar such as the relations between policy entrepreneurs and the regime barriers and the relations between regime actors and the national mood and political ideology.

To further unleash the full explanatory power of the MLP and MSF, it is recommended to synthesise the two frameworks together. This research offers the possibility of a future synthesis of the two frameworks by using the propositions that this research has developed. Such a new framework, combining both concepts of transition studies and policy literature, would be of great added value to both transition scholars as well as policy analysts aiming to understand how sustainability transitions come about.

Table of Content

Acknowledgements **3**

Executive Summary **4**

List of Tables **8**

List of Figures **10**

Table of Contents **11**

1Introduction **12**

1.1 Background on Sustainability Transitions *12*

1.2 Processes Involved in Sustainability Transitions *14*

1.3 Knowledge Gap *16*

1.4 Research Scope *19*

1.5 Research Questions *20*

1.6 Research Relevance to the Engineering and Policy Analysis Programme *21*

1.7 Research Outline *22*

2Theoretical Background **24**

2.1 Multi-level Perspective *24*
2.1.1 Regime Level 25
2.1.2 Niche Level 27
2.1.3 Landscape Level 28

2.2 Multiple Streams Framework *28*
2.2.1 The Problem Stream 30
2.2.2 The Policy Stream 30
2.2.3 The Political Stream 30

3Methodological Framework **31**

3.1 Research Design *31*

3.2 Case Relevance for the MLP *32*

3.3 Case Relevance for the MSF *34*

3.4 Rationale for Selecting The Netherlands as Case *34*

3.5 Data Collection *36*
3.5.1 Desk Research 36
3.5.2 Semi-structured Interviews 37

3.6 Data Treatment: Qualitative Coding *39*

3.7 Data Analysis: Causal-Process tracing *40*

3.8 Performance of Comparative Analysis *41*

3.9 Research Validity *42*
3.9.1 Credibility (Internal Validity) 42
3.9.2 Transferability (External Validity) 43
3.9.3 Dependability (Reliability) 44
3.9.4 Confirmability (Objectivity) 44

4Case Study Background **45**

4.1 Case Background Information *45*

4.2 EVs Through Time *46*

4.3 EVs is in the Netherlands *47*

4.4 Stakeholder Analysis *49*
4.4.1 Governmental Organisations 49
4.4.2 Consumers 50
4.4.3 Industry Players 51
4.4.4 Research Institutions 52
4.4.5 Environmental Organisations 52
4.4.6 Formula E-Team 53

5Results of the MLP Analysis **55**

5.1 Emergence Phase (1990-2000) *57*
5.1.1 Landscape Phase 1 57
5.1.2 Regime Phase 1 58
5.1.3 Niche Phase 1 59

5. 2 Diffusion Phase (2001 -2011) *59*
5.2.1 Landscape Phase 2 59
5.2.2 Regime Phase 2 60
5.2.3 Niche Phase 2 63
Niche Innovations 63
National Government Policies 64

5.3 Establishment Phase (2012-2022) *65*
5.3.1 Landscape Phase 3 65
5.3.2. Regime Phase 3 68
5.3.3 Niche Phase 3 70
Niche Innovations 70
National Government Policies 70

5.4 Summary of the MLP Analysis Results *71*

6Results of the MSF Analysis **74**

6.1 E-mobility Action Plan 2009 -2011 *75*
6.1.1 Problem Stream 78
6.1.2 Policy Stream 79
6.1.2.1 At the Global Level 79
6.1.2.2 At the European Level 79
6.1.2.3 At the National Level 80
6.1.3 Politics Stream 81

6.2 National Climate Agreement 2019 *83*
6.2.1 Problem Stream 85
6.2.2 Policy Stream 86
6.2.2.1 At the Global Level 86
6.2.2.2 At the EU Level 87
6.2.2.3 At the National Level 87
6.2.3 Politics Stream 90

6.3 Policy entrepreneurs Seizing Policy Windows *91*

6.4 Summary of the MSF Analysis Results *92*

7Comparative Analysis **95**

7.1 Comparison *95*
7.1.1 Landscape Level and MSF Streams 95

7.1.2 Regime Level and MSF Streams 97
7.1.3 Niche Level and MSF Streams 97
7.1.4 Policy Entrepreneurs and the three levels of the MLP 98

7.2 Insights for Future Synthesis *99*
7.2.1 Commonalities Between the Two Frameworks 100
7.2.2 Differences Between the Two Frameworks 101
7.2.3 Causal Relations Between the Two Frameworks 102

7.3 Generalisability of Insights *105*

8Conclusions & Recommendations **107**

8.1Main Findings of this Research *107*
8.1.1 Results of the MLP Analysis 108
8.1.2 Results of the MSF Analysis 109
8.1.3 Results of the Comparative Analysis 111

8.2 Academic Contribution *112*

8.3 Limitations & Recommendations *114*

8.4 Policy Recommendations *115*

10Bibliography **118**

11Appendices **145**

Appendix 1: Stakeholder Analysis *145*

Appendix 2: Interview Protocol *150*

Appendix 3: Interview Questions *154*

Appendix 4 External Validation Interview Questions *156*

Appendix 5 Governance System in the Netherlands *157*

Appendix 6 Coding Scheme *160*

List of Figures

Figure 1 Socio-technical transitions to achieve high improvements in environmental efficiency (European Environment Agency, 2018) adapted from (Weterings et al., 1997) 13
Figure 2. A Conceptual Framework of Edmondson et al., (2019). **Figure 2.B**: Conceptual Framework of Gomel & Rogge (2020) 15
Figure 3 Knowledge gap that will be addressed in this research. Source: own compilation 18
Figure 4 Research Flow Diagram of the underlying study. Source: own compilation 23
Figure 5 Multi-level perspective on transitions (Geels & Schot, 2007) 25
Figure 6 Three interrelated dimensions of the regime (Geels, 2005a) 26
Figure 7 Schematic of the multiple streams framework (MSF) and scenarios in which a policy agenda may (d) or may not be formed (a,b,c) (Cooper-Searle et al., 2017) 29
Figure 8 The case study design of this research. Source: own compilation 32
Figure 9 Example of a socio-technical system (Geels, 2005a) 33
Figure 10 A brief history of electric cars based on Simpson & van Barlingen (2021) distinct periods 46
Figure 11 Realisation: EVs as a percentage of new passenger car sales. Source (RVO, 2022) 49
Figure 12 Formula E-Team Parties and their relationship. Source own compilation 54
Figure 13 MLP analysis for the Dutch Transition to electric passenger cars between 1990 and 2022 Source: own compilation 57
Figure 14 Share of fuels in new sales (Vedder, 2011) 61
Figure 15 Barriers to the entry of an EV. Source: own compilation 61
Figure 16 Price of Li-ion batteries between 1991-2018 (Ritchie, 2021) 66
Figure 17 Number of electric passenger cars in the Netherlands from 2017 to 2022 by type (RVO, 2022) 68
Figure 18 Number of charging points in the Netherlands (RVO, 2022) 69
Figure 19 Broader processes within the MLP. Source: own compilation 73
Figure 20 MSF analysis for the E-mobility Action Plan. Source: own compilation 77
Figure 21 Prime Minister Balkenende and minister Eurlings driving an electric car in the AutoRai 2009 (Autokopen.nl, 2009) 82
Figure 22 MSF analysis for the National Climate Agreement Source: own compilation 84
Figure 23 Timeline of policy stream factors at the national level of the Netherlands. Source: own compilation. Source: own compilation 88
Figure 24 Broader processes within the MSF. Source: own compilation 94
Figure 25 Relations found between the three levels of the MLP and the three streams of the MSF. Source: own compilation 100
Figure 26 Law- making process in the Netherlands (Instituut voor Publiek en Politiek, 2008) 158

List of Tables

Table 1 Respondents number and their respective organisation. Source own compilation 38
Table 2 Example table of how the relations between the different concepts are identified. Source own compilation 42
Table 3 Researcher names, organisation and field of expertise. Source own compilation 43
Table 4 Reasons for purchasing electric cars and percentage according to ANWB survey. Source (ANWB, 2021c) 51
Table 5 Energy Label (A to G = highest to lowest fuel economy) and Dutch sales tax reductions/additions, effective February 1, 2008 Adapted from International Energy Agency (2009) 81
Table 6 Incremental tax rate for company cars that are used for private purposes (Compendium voor de Leefomgeving, 2019) 89
Table 7 Important resources of the actors of the Formula E- Team. Source own compilation 145
Table 8 Coding scheme used in the application of the MLP and MS. Source own compilation 160

1 Introduction

1.1 Background on Sustainability Transitions

Climate change, environmental degradation, resource depletion, pollution, and greenhouse gas emissions are all pressing sustainability challenges that the world is currently facing. These challenges have a global dimension and confront present and future generations (Lindberg et al., 2019). The Paris Agreement and the global initiative to target 17 Sustainable Development Goals (SDGs) highlight the urgency of addressing these challenges. Despite the urgency, progress in addressing sustainability challenges has however been limited due to the high degree of inertia that prevails in existing systems of provision and consumption (Markard et al., 2020). Inertia in such systems stems from their complex, persistent, and ill-structured nature which is often coupled with and aggravated by strong path dependencies and lock-ins (Markard et al., 2012). The path-dependencies and lock-ins relate to sunk investments, behavioural patterns, vested interests, infrastructure, favorable subsidies, and regulations (Geels, 2010).

The inertia of existing systems is at the centre of a growing field of research on 'sustainability transitions' (Markard et al., 2012). The underlying motivation for research on sustainability transitions stems from the recognition that many environmental problems are brought about by unsustainable patterns of consumption and production (Köhler et al., 2019). Incremental adjustments (system optimisation) and partial system change in the short and medium term may offer some environmental efficiency (European Environment Agency, 2018). However, as shown in Figure 1, achieving large environmental improvements requires long term shifts to new kinds of systems of provision and consumption which could be achieved by sustainability transitions (European Environment Agency, 2018; Köhler et al., 2019).

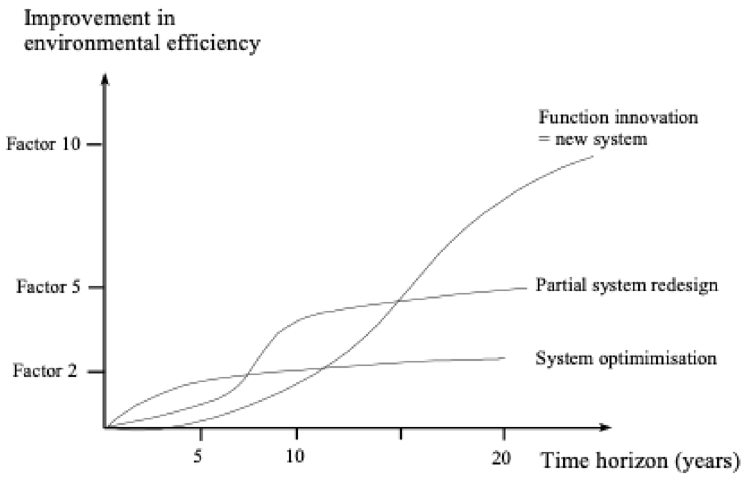


Figure 1 *Socio-technical transitions to achieve high improvements in environmental efficiency (European Environment Agency, 2018) adapted from (Weterings et al., 1997)*

Markard et al., (2020) define sustainability transitions as deep-structural changes in socio-technical systems that aim to address challenges such that the needs of the present are met without compromising the ability of future generations to meet their own needs. Such transitions are multi-dimensional and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption (Markard et al., 2012). Socio-technical systems in return are conceptualized as a configuration of elements (e.g., technology, markets, consumer practices, infrastructure, cultural meaning and scientific knowledge) that are necessary to fulfill a specific societal function (e.g., transportation, communication, nutrition) (Geels, 2004).

In literature, deep structural changes in socio-technical systems are labelled as socio-technical transitions (Geels, 2012). According to Rotmans and Kemp (2003), a transition can be defined as a gradual, continuous process of change that typically unfolds over considerable time spans (e.g., 50 years and more). The latter involves several developments in different domains at different scale levels that come together to reinforce each other (Rotmans & Kemp, 2003).

Sustainability transitions are thus socio-technical transitions guided by sustainability goals. This rather simplistic definition entails additional complexities compared to the socio-technical transitions that lack a sustainability drive. According to Geels (2010), sustainability transition is a normative goal and a collective good problem. Being a normative goal entails deep-seated values and beliefs related to the relative importance of various environmental problems. Actors involved have different interpretations of sustainability problems and normative struggles that unfold over the pace and directions that such transitions take (Markard, 2016).

A collective good problem means that sustainability transitions are associated with prisoner dilemmas and free-riding problems. Consequently, this entails that public authorities and civil society are crucial drivers for sustainability transitions while private actors have no immediate incentive to address them (Geels, 2010). Such actors, however, can influence policy processes by deploying a broad range of strategies, including lobbying, donations to political campaigns, or shaping public discourses (Lindberg et al., 2019).

1.2 Processes Involved in Sustainability Transitions

Given the complexities associated with being a normative goal and a collective good problem, it is no surprise that policies play a central role in sustainability transitions. Policies are central to understanding, analysing, and shaping transformations towards sustainability (Markard et al., 2016; Patterson et al., 2017). According to Lindberg et al. (2019), policies shape the different pathways that transitions take. They formulate long-term sustainability targets, request emission reductions, provide funding, grant market support for new technologies or even phase-out unwanted technologies.

But "behind policy, there is always politics" (Meadowcroft, 2011). Political negotiations can have a major influence on policy change, which in turn influences sustainability developments (Edmondson et al., 2019). Thus, one can say that sustainability transitions are socio-technical developments driven by policy change while being inherently value-laden and political.

Given the multiple barriers, path dependencies and resistance to change, there will be no one single policy that can act as the silver bullet to foster transitions. Instead, sustainability challenges require a multiplicity of instruments – or instrument mixes to foster changes in the socio-technical realm (Rogge et al., 2017). Over the past decades, research has focused largely on how policy instruments can promote environmental innovation and societal transitions (Kern & Rogge, 2018). This research focus generated thousands of academic articles on the design of policies and instruments that can be drawn upon for achieving environmental sustainability (Meadowcroft, 2011).

However, it is important to acknowledge that instrument mixes can also change over a prolonged period to align with changing objectives and different stages of innovation. The ways in which policies evolve can have a significant influence on the rate and direction of transitions which, over a prolonged period, can lead to virtuous cycles of causation between policy change and socio-technical transitions (Edmondson et al., 2019).

Similarly, Meadowcroft (2011) explains that the politics of sustainability transitions requires a redefinition of societal interests related to sustainability transitions. This entails political engagement to build reform coalitions, creating new centres of power, buying off powerful lobbies, compensating losers, and so on. And since sustainability transitions may take decades, there will be repeated cycles of interaction that draw lessons from previous rounds (Meadowcroft, 2011).

It is for the long-term, dynamic, and politically contested nature of change processes associated with sustainability transitions that Kern & Rogge (2018) called for a much more explicit consideration of policy processes. Policy processes cover all stages of the policy cycle starting from the problem identification, agenda-setting and policy formulation up to the implementation, assessment, policy adaptation, succession and termination (Reichardt et al., 2017). Thus Kern & Rogge (2018) argue that understanding sustainability transitions requires cross-fertilising transition studies with policy theories that have developed a variety of analytical approaches to analyse policy processes.

To address the calls of Kern & Rogge (2018), Edmondson et al. (2019) developed a novel conceptual framework for analysing the co-evolution of policy mixes and socio-technical systems by drawing on insights from the policy feedback literature. As visualised in Figure 2. A, the key idea of this framework is that policy mixes affect the evolution of the socio-technical system and that in turn, developments in the socio-technical system influence the policy mix through a range of feedback mechanisms. However, rather than influencing the policy mix directly, these feedback mechanisms influence the 'policy subsystem'. They explained that such a policy subsystem can be conceptualised as the relationships between actors responsible for policy decisions and pressure participants with which decision-makers consult (Edmondson et al., 2019).

Building on the work of Edmondson et al. (2019), Gomel & Rogge (2020) also tried to incorporate a policy mix approach in their transition study. By drawing on insights from the Advocacy Coalition Framework, they developed a novel analytical framework that explains the role of the policy beliefs of advocacy coalitions or advocacy communities in the emergence of policy mixes for sustainability transitions. Figure 2. B visualises the resulting framework of Gomel & Rogge (2020), portraying the dynamics between the policy process, which shapes the instruments and strategies of the policy mix which in turn leads to socio-technical change. Socio-technical change then enables policy learning and thus influences subsequent policy processes.

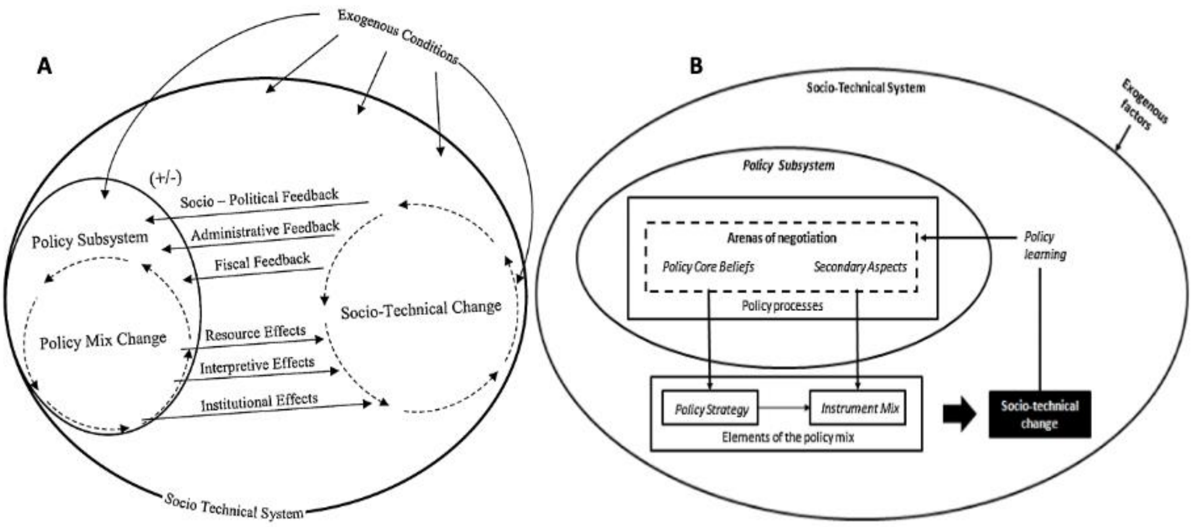


***Figure 2. A** Conceptual Framework of Edmondson et al., (2019). **Figure 2.B**: Conceptual Framework of Gomel & Rogge (2020)*

1.3 Knowledge Gap

The aforementioned studies attempted to study the co-evolution of policy mixes and socio-technical systems in the context of sustainability transitions. The core of the two frameworks entails a virtuous cycle in which the policy mix influences the socio-technical change, and the resulting feedback mechanism influences the development processes in a policy subsystem which in turn influences the policy mix.

While it is important to understand the broader linkages that connect policy change to socio-technical transitions, it is essential to elaborate on the "black box" of each. Studying the different processes, occurring within the policy subsystem and during a socio-technical transition helps in better understanding how the two co-evolve and how this co-evolution in return influences the general pathway of a sustainability transition.

Scholars that have attempted to take a step into this direction are Derwort et al., (2021). These scholars cross fertilised the theories of transition studies and policy change by bringing together the Multi-level Perspective (hereafter MLP) from transition studies and Multiple Streams Framework (hereafter MSF) from the policy theories to study the German energy transition.

The MLP is a framework used to understand socio-technical transitions that involve many actors, unfold over many decades, transcend spatial boundaries and lead to uncertain outcomes (Sorrell, 2018). The basic premise of the MLP is that transitions are nonlinear processes that result from the interplay of multiple developments at three analytical levels: niche (locus of radical innovations) socio-technical regimes (the locus of established practices and associated rules), and an exogenous socio-technical landscape (Rip and Kemp, 1998; Geels, 2002).

The MSF on another hand, is a framework from policy theories and it is used to explain how and when policy change takes place by differentiating between three independent streams—the problem, the policy, and the political streams. The problem stream contains perceptions of public problems while the policy stream consists of solutions that are developed by experts in specialised policy communities. The politics stream includes public discussions, changes in governments or legislatures, or interest group lobbying (Kingdon, 1984).

Using the German energy transition as an illustrative case, Derwort et al., (2021) have shown how two different theoretical frameworks—the MSF and the MLP—can cross-fertilise each other to understand societal transformations, which in this research are denoted as sustainability transitions. According to their research, the application of multiple, and complementary lenses offers important insights into why and how transitions may follow a trajectory of path-dependent and path-deviant changes which otherwise might have been eluded.

While Edmondson et al. (2019) and Gomel & Rogge (2020) proved the existence of a virtuous cycle of feedback mechanisms between policy mix and socio-technical change, Derwort et al. (2021) took a step further to prove the presence of important policy-technology feedback cycles, where:

I. Political decisions triggered socio-technical change directly or paved the way for new, innovative technological developments shielded from strong market pressure;
II. Technological advances provided new solutions in the policy stream feeding back into the political agenda .

Elaborating on the feedback mechanisms existing between socio-technical and policy change through the application of two theoretical frameworks is an important contribution of Derwort et al. (2021) to the literature. Nevertheless, it is important to acknowledge that they have not fully explored the feedback mechanisms that exist between the different processes of the MLP and MSF. For instance, the socio-technical change in the MLP transcends technological advances to include the interplay of multiple developments such as radical innovations at the niche level, established practices and rules at the regime level and exogenous socio-technical developments at the landscape level. Similarly, policy change in the MSF results from the convergence of problems, solutions and political interests at the problem, policy and politics stream respectively at a certain period of time through the efforts of certain system actors denoted as policy entrepreneurs.

Thus how the different processes taking part in the socio-technical change are driving and are being driven by the different processes of the policy mix change have not been explored by Derwort et al. (2021). Therefore, this research aims to address this limitation by applying the MLP and MSF separately to a selected case study at a more granular level than the research of Derwort et al. (2021). As shown, in Figure 3, the relation between the landscape, regime and niche levels of the MLP and the problem, policy and politics stream of the MSF will be studied. The knowledge gap that is still persistent in literature and that this research aims to bridge is the systematic understanding of how socio-technical transitions (resulting from the pressure of landscape and niches on the regime) and policy change (resulting from the intersection of the three streams) combined affect each other and consequently influence sustainability transitions.

It is important to note that the three levels of the MLP converge when a window of opportunity opens while the three streams of the MSF converge when a policy window, seized by policy entrepreneurs, opens. The role of the window opportunity, policy window and policy entrepreneurs in the co-evolution of socio-technical and policy change will also be highlighted in this research. What the elements of each of the two frameworks entail will be thoroughly explained in Chapter 2. The gained insights will then be used to extract similarities, differences and propositions highlighting the causal relations between the two frameworks. These relations will then be discussed in relation to the feedback mechanisms and effects of Edmondson et al., (2019) (as shown in Figure 2.A), policy learning process of Gomel & Rogge (2020) (as shown in Figure 2.B), as well as the findings of Derwort et al. (2021) in order to reflect on the academic contribution of this study.

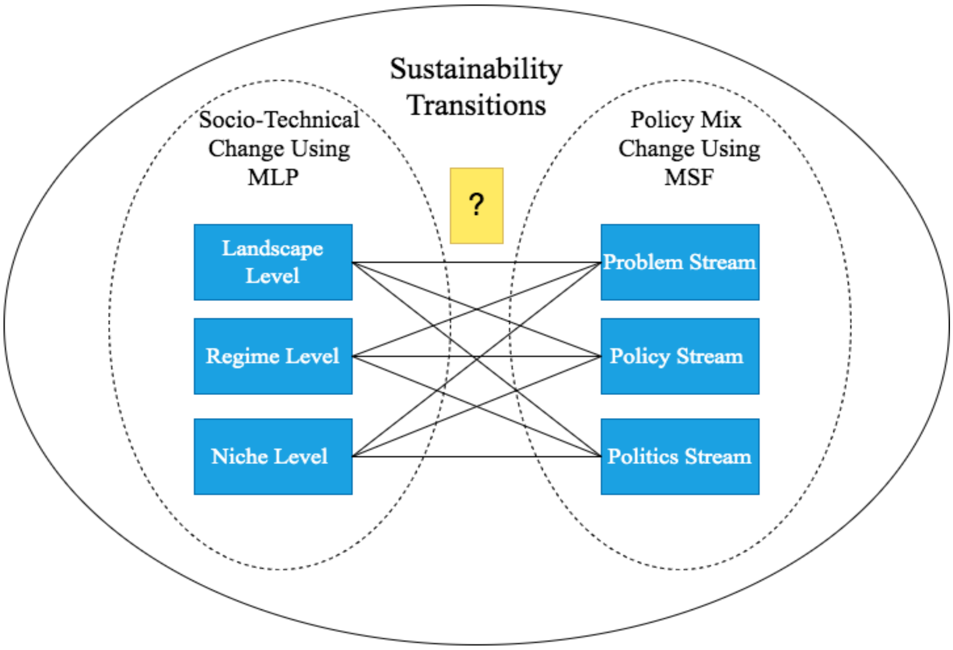


Figure 3 *Knowledge gap that will be addressed in this research. Source: own compilation*

Bringing the two frameworks in the form of propositions:

1. Contributes to a better understanding of how sustainability transitions come about, both in the political and the socio-technical realm as well as the interlinkage of those.
2. Enables more meaningful understanding of the socio-technical developments driving a transition that go beyond technological "solutions" and includes the political context of system developments.
3. Enables more meaningful policy recommendations that go beyond political dimension and integrate the "solutions" offered by the socio-technical developments.
4. Forms a basis for a possible synthesis of the two frameworks aimed at studying future sustainability transitions.

1.4 Research Scope

Several decisions have been made that form part of the research scope. To begin with, literature on socio-technical transition offer many theoretical frameworks for the analysis of such transitions, such as Technological Innovation Systems (TIS) (Gallagher et al., 2012, Transition Management (TM) (Rotmans et al., 2001), Strategic Niche Management (SNM) (Kemp et al., 1998), and the MLP (Geels, 2002). Among these frameworks, the MLP is chosen due to its multi-dimensional analytical framework that combines concepts from evolutionary economics (trajectories, regimes, niches, path dependence, etc.), science and technology studies (social networks, innovation as a social process shaped by broader societal contexts), structuration theory and neo-institutional theory (rules and institutions as 'deep structures') (Geels, 2004; Geels and Schot, 2007). These theoretical assumptions offered the MLP multi-dimensionality that would allow for the understanding of the co-evolution of technology, markets, consumer practices, politics, culture, business, science, and the environment.

Policy process theories on the other hand, offer among other frameworks, the Advocacy Coalition Framework (Sabatier, 1998), Policy Feedback theory (Béland, 2010), Punctuated Equilibrium Theory (Jones & Baumgartner, 2012), and the MSF (Kingdon, 1984). The MSF is particularly useful because of its ability to capture the complications of policymaking. Rather than attempting to describe the policy process rationally or linearly (i.e., in one dimension), the MSF challenges assumptions of comprehensive rationality, focuses on ambiguity and sheds light on the dynamic interplay between problems, prospective solutions, politics, and policy entrepreneurs within windows of opportunity (Cairney & Jones, 2015).

The selected case study for this research is the Dutch transition to electric cars. The case is chosen due to the fact the Netherlands is among the frontrunners in transitioning mobility to a low-carbon energy sector. In 2021 the Netherlands ranked among the top five nations making progress in the transition to electric vehicles (The rEV Index, 2021). This progress is, among other factors, a result of a strong technological transition combined with policy change transcending over a long period of time. These factors make the case suitable to be studied using both the MLP and MSF. More detailed information justifying the case selection could be found in Section 3.4.

The temporal scope of this analysis is demarcated to the years 1990-2022. This period of time includes the return to EVs, its evolution and the tipping point stages. More over these stages is explained in Section 4.2. Thus these stages will involve most of the developments that have happened in recent history and can give a clear overview of the interplay of process at both the MLP and MSF analysis.

1.5 Research Questions

In order to achieve the objective of this research study, the following research question will be answered:

How can a study of socio-technical transitions using MLP and policy changes using MSF applied to the Dutch transition to electric cars help create insights in how to synthesise the two aforementioned theoretical frameworks?

Answering this research question entails answering the following four sub-questions:

I. How can the MLP explain the socio-technical transition to electric cars in the Dutch mobility sector?

II. How can the MSF explain the policy changes that are helping in the transition to electric cars in the Dutch mobility sector?

III. What are the main commonalities, differences and relations between the MLP and MSF?

IV. What are the insights gained regarding the relation between the MLP and MSF that can help the future synthesis of the two theoretical frameworks?

To answer the first sub-question, the MLP framework will be applied. By using this theoretical framework, the evolution of the socio-technical developments that are driving the transition to electric cars will be studied. To answer the second sub-question, the MSF will be applied. This framework will help in understanding the way in which policy processes translate demands into outputs—with change resulting from coupling problems with policies and politics. After answering the first two sub-questions, a comparative analysis will be done for the results obtained by each framework. This analysis will answer sub-question 3. The analysis will subsequently be used to highlight the way in which socio-technical changes co-evolve with the policy processes in sustainability transition. These relations found between the MLP and MSF will at last result in identifying the commonalities, differences and relations that could help future research synthesise the two frameworks.

1.6 Research Relevance to the Engineering and Policy Analysis Programme

This master's thesis is done in partial fulfilment of the requirements for the degree of Master of Science in Engineering and Policy Analysis (EPA). The central focus of the EPA programme is on analysing and solving complex societal problems that involve multiple parties with conflicting interests. In today's world, using technology alone to solve complex problems is no longer adequate; organisational, legal, administrative, commercial, and management factors also need to be considered. Therefore, complex problems demand solutions that address not just the technological aspect of them but also the societal and political dimensions through the interactions and involvement of various parties. This is at the heart of the EPA programme, which compared to monodisciplinary engineering studies like chemical, mechanical, or software engineering, is much more interdisciplinary in nature.

This research meets the criteria for a master's thesis in EPA for several reasons. To begin with, this research is about sustainable transitions. Sustainable transitions are embedded within complex sociotechnical systems. Such systems are characterised by a sophisticated societal and global problem (i.e., climate change), interplay of (national and international) institutions and actors (i.e., households, industries and governments) with socially or economically diverging motivations. Therefore, studying such transitions requires an interdisciplinary approach and a multi-actor perspective that involves both technical and social design considerations.

Secondly, the case study of this research has a societal relevance which is intrinsic to the EPA programme. The transition to electric cars is considered an important tool in the sustainable transition towards the decarbonization of transportation, along with capturing other co-benefits associated with reduced air pollution, oil dependency and noise. The global importance of EVs has been legitimised in recent years, at a governmental level, with most major economies setting EV goals in the short (2030) or long term (2050), and at industry level, with most automotive manufacturers introducing one or several EV models already in year 2020.

In addition to the interdisciplinary nature of this study and its societal relevance, the policy recommendations that this research delivers also contribute to the goals of the EPA programme. While EVs have continued to make technological advancements and adoption progress, they continue to face a variety of impediments that governments are trying to tackle through various policy initiatives. As a result, there has been a lot of focus, particularly in academic spheres, on investigating the barriers to EV adoption, aiming to explore the lag in EV sales as compared to the climate benefits they purport. This research, however, tries to understand how the technological advancements are influencing and are being influenced by the governmental actions taken in the form of policies. Whereas it is acknowledged that the findings cannot be extended precisely to other cases, this thesis does provide a set of policy recommendations that may serve as reference material for policymakers who intend to stimulate other sustainability transitions.

1.7 Research Outline

In order to answer the main research question and the subsequent four sub-questions, this thesis is divided into three phases; the preparation, execution and ending phase. These three phases will cover 8 chapters. The first phase of this research is the "Preparation Phase" in which background information will be gathered from literature to introduce the two theoretical frameworks, the methodology used for analysis and background information on the case in Chapter 2, 3, and 4 respectively.

At the "Execution Phase", the research analysis will take place and the four sub-questions will be answered. In order to answer these questions, data will be collected using both primary research, in the form of interviews, and secondary research in the form of scientific papers, government documents, news articles and reports. The secondary research done will define the specific concepts that will be the focus point for the different interviews. After conducting the interviews and gathering the data from desk research, the information will be analysed thoroughly using qualitative coding and process tracing.

The findings of the data gathering will then be used to answer sub-question 1 and 2 in Chapter 5 and 6 respectively. Once these two questions are answered, a comparative analysis will be performed to answer sub-question 3 and 4. Sub-question 3 will help in identifying the commonalities, differences and relations between the two frameworks while the insights gained from this comparative analysis will answer sub-question 4. The comparative analysis will be presented in Chapter 7.

In the "Ending Phase" the conclusion of the research will be presented, and the main research question will be answered. Consequently, the limitations of this research and recommendations for future research will be brought forward. The conclusions, limitations and recommendations will be presented in Chapter 8. The process of this research is outlined in the Research Flow Diagram in Figure 4.

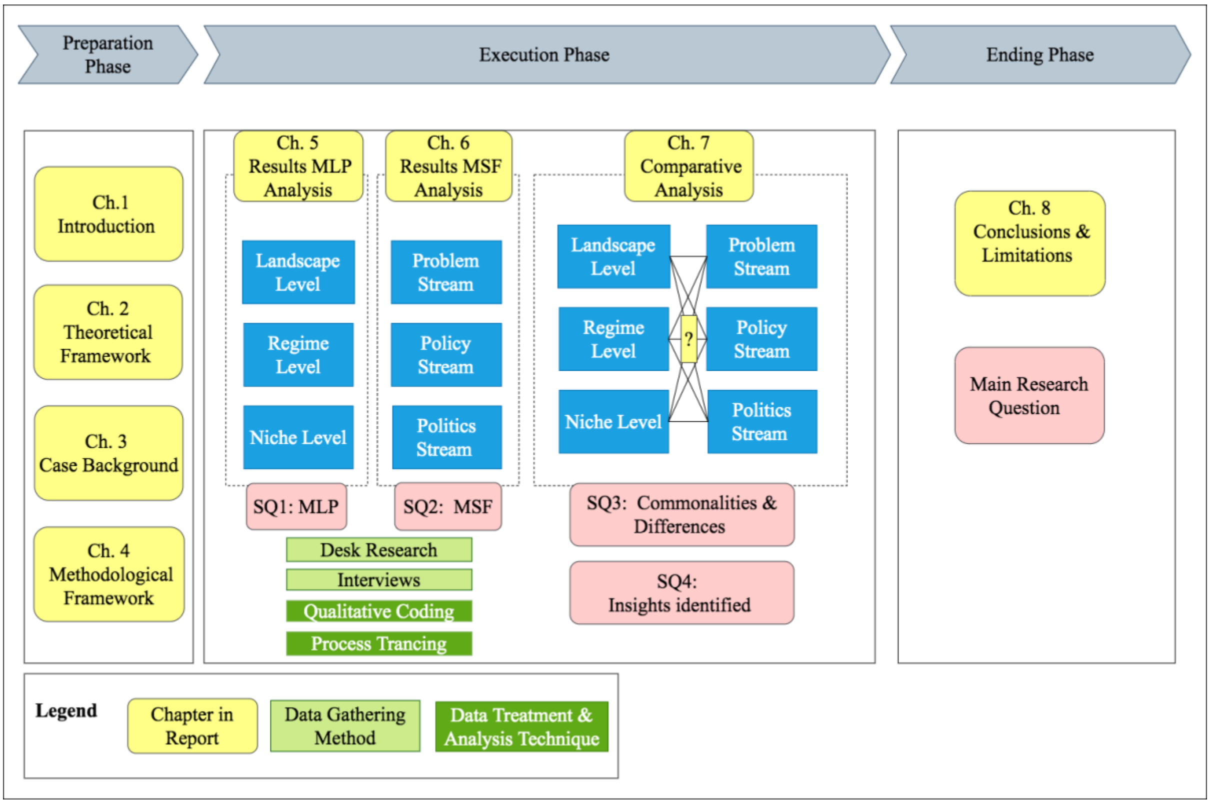


Figure 4 *Research Flow Diagram of the underlying study. Source: own compilation*

2 Theoretical Background

This chapter presents the literature review done for the theoretical background of this research. The review was conducted through search engines Scopus, Google Scholar, and ScienceDirect. Additionally, TU Delft Library was also used to access additional journals and articles. The following keywords were used in permutation and combination to search for the relevant literature “Socio-technical transitions”, “Multilevel perspective”, "Multiple streams frameworks", “Multiple stream approach”, and “Policy change".

Moreover, snowballing was done using a web application called “connected papers”. Given that transition studies and policy literature are mainly published in English, articles published in the Dutch language were not considered for this literature review. This chapter presents the reviews conducted for the MLP and MSF which are presented in sections 2.1 and 2.2 respectively.

2.1 Multi-level Perspective

Socio-technical transitions research emerged in the early 2000s drawing on innovation studies to explain and conceptualise how shifts to new sustainable systems can come about (Geels, 2019)**.** Socio-technical transitions research was initially tested and refined through several hundred historical case studies (in transportation, heating, electricity, and agro-food), and has subsequently been widely applied to study unfolding and future sustainability transitions (Geels, 2019). The geographical and temporal focus of such transition studies is often at the national sectoral level. Historical studies show that transitions may take 30 - 50 years. While breakthroughs can be relatively fast (e.g., 10 years), the preceding innovation journeys that lead to new socio-technical systems generally take considerably longer (20-30 years). Very few studies look far into the future because many transition studies use actual case study methodologies, which describe and explain developments that have happened (Asquith et al., 2018).

A prominent contribution to the analysis of transitions has been made with the development of the Multilevel Perspective (MLP) by the ‘Dutch school of transition studies’ - as stated by Jørgensen (2012). As Geels (2002) explained, the MLP is used to conceptualise transitions as a dynamic interplay of processes in the socio-technical systems across the landscape at the macro level, the regime at the meso level, and niches at the micro-level. Radical innovations emerge in niches, which may break through if landscape developments create pressures on the regime and create a "window of opportunity" for change (Geels, 2002).

Although people often summarise the MLP as 'micro-meso-macro', Geels (2011) argued that the relation between these levels is not necessarily hierarchical. He explained that the levels are defined as referring to different degrees of stability and structuration of local practices, which relate to differences in scale and the number of actors that reproduce regimes and niches (Geels, 2011). Figure 5 presents the MLP framework along with the level of structuration at each level. To understand what constitutes each of these levels, the following sections will outline the main characteristics of the regime, niche and landscape levels.

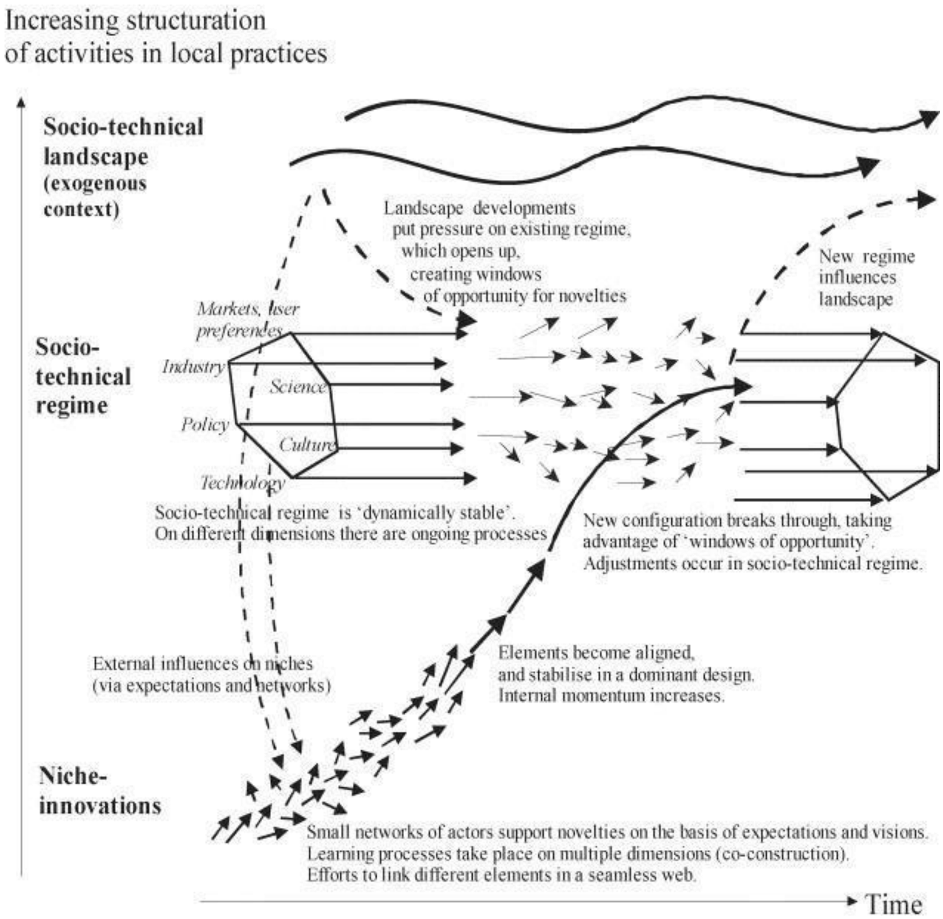


***Figure 5** Multi-level perspective on transitions (Geels & Schot, 2007)*

2.1.1 Regime Level

According to Geels (2011), the socio-technical regime level is of primary interest while the niche and landscape levels can be seen as 'derived concepts' because they can be defined in relation to the regime. The socio-technical regime forms the meso-level in the MLP and consists of three interlinked dimensions, as shown in Figure 6: (a) network of actors and social groups; (b) formal, normative and cognitive rules that guide the activities of actors; (c) material and technical elements (Geels, 2005a).

The technical and material components constitute a seamless configuration of heterogeneous elements (e.g., technology, material resources, infrastructure, etc.). However, the different elements found in the socio-technical transitions do not function autonomously but are the outcome of the activities of specific actors (Geels, 2005b). The interdependencies between the different groups of actors lead to the coordination and alignment of the elements and linkages in socio-technical systems.
Furthermore, human actors, organisations and social groups are not entirely free to act as they want. Their perceptions and activities are coordinated and guided by institutions which could be regulative, normative or cognitive (Geels, 2005b). The regulative rules refer to explicit, formal rules which constrain behaviour and regulate interactions, the normative rules confer values, norms, role expectations, duties, rights, and responsibilities, and the cognitive rules, constitute the nature of reality and the frames through which meaning or sense is made (Geels, 2004).

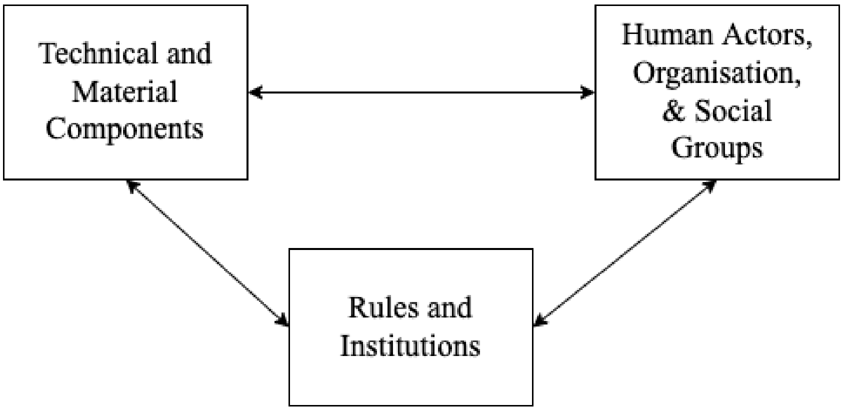


Figure 6 *Three interrelated dimensions of the regime (Geels, 2005a)*

At each of the three dimensions, stabilising mechanisms exist which consequently result in path dependence and lock-ins at the regime level (Verbong & Geels, 2007). Geels (2004) explains that (a) actors are resistant to major changes and have vested interests in the continuation of the current system because of the interdependent relationships they have with other actors as well as the patterns of culture, norms and ideology that emerge between the actors throughout the years. Rules and institutions (b) are also set and fixed, cognitive routines may blind actors to developments outside their focus, normative rules might develop mutual role perceptions and expectations of proper behaviour form certain actors, and regulative rules may stabilise the system by legally binding contracts. Last but not least, existing machines and infrastructures (c) have sunk investments and economies of scale. There are also complementarities between components and subsystems which creates an important source of inertia in complex technologies and systems. Material artefacts are also stabilised because they are embedded in society; hence the term socio-technical systems causes people to adapt their lifestyles to the artefacts (Geels, 2004).

All in all, under a strong and stable socio-technical regime, radical innovations have a hard time diffusing beyond the niche level. They may eventually break through when the regime is weak causing a transition process that drives a regime shift. This regime shift involves changes in the configuration of the latter such as the technologies, technical artefacts, user practices, policies, markets, industrial structures, supporting infrastructures, etc. (Geels, 2002).

2.1.2 Niche Level

Niches form the micro-level of the MLP and represent the local level of the innovation process. At this level, the seed for any radical innovation to emerge in the socio-technical system is planted. The novelties in niches are produced on the basis of knowledge and capabilities and geared to the problems of existing regimes (Geels, 2002). Important niche-internal processes are the building of social networks, learning processes, and articulation of expectations to guide learning processes (Geels, 2011).

Geels (2004) presented some of the uncertainties that might exist at the niches level that are related to the technical design rules, search heuristics, user preferences, behavioural patterns, and public policies. Additionally, uncertainties could also be related to the social network given that there are no clear role relationships, interlinked dependencies, and normative rules at this level (Geels, 2004). Moreover, he explained that the socio-technical configuration also tends to be in flux. In sum, as shown in Figure 5, rules in technological niches are less articulated and the activities are less structured. Therefore, actors in niches need to put in a lot of work to uphold the niche, work on the articulation of rules and social networks and create new paths.

On another note, niches are commonly referred to as protected spaces or incubation rooms. Protection here is important because novelties are initially unstable socio-technical configurations with low price/performance ratio (Verbong & Geels, 2007). Therefore, at the niches level, new technologies or socio-technical practices emerge and develop isolated from the selection pressures of ‘normal’ markets or regimes.

According to Geels (2011), niches could gain momentum under three conditions if: (a) expectations become more precise and more broadly accepted, (b) the alignment of various learning processes results in a stable configuration (‘dominant design’), and (c) networks grow to include the participation of powerful actors that may convey legitimacy and resources to niche-innovations.

2.1.3 Landscape Level

Socio-technical landscapes form the macro-level of the MLP. Geels (2002) chose the metaphor ‘landscape’ because of the literal connotation of relative ‘hardness’ and the material context of society. The landscape forms an exogenous environment beyond the direct influence of niche and regime actors (Geels & Schot, 2007) and is composed of a set of heterogeneous factors which Van Driel and Schot (2005) distinguished into three types: (1) factors that do not change or that change only slowly, such as climate; (2) long-term changes, such as the European industrialisation in the late 19th century; (3) rapid external shocks, such as wars or fluctuations in the price of oil. As shown in Figure 5, socio-technical landscapes provide even stronger structuration of activities than regimes and take much longer to change (sometimes decades) (Geels & Schot, 2007).

Despite having a stiff structure, once sudden changes in the landscape level occur, major changes in the selection environment of the regime would be created (Geels, 2004). Such forces may weaken and destabilise a regime as they disturb the coherence of its elements. This creates windows of opportunity for innovation to break out of its niche and surprise incumbent firms (Geels, 2002). While under a strong and stable regime, radical innovations have a hard time diffusing beyond the niche level, they may eventually break through when the landscape weakens the regime and opens a window of opportunity. However, if niche ideas aren't completely developed, they won't be able to take advantage of this window, which may close in the future (Geels & Schot, 2007).

In a nutshell, the underlying concept of the MLP is that niche innovations gain internal momentum through learning processes, price/performance improvements, and powerful groups' endorsement. Changes at the landscape level put pressure on the regime, and regime destabilisation generates windows of opportunity for developed niche innovation to diffuse.

2.2 Multiple Streams Framework

To incorporate the role of a policy change into the understanding of sustainability transitions, this research will be complemented by John Kingdon’s multiple streams framework (MSF). In his work Agendas, Alternatives, and Public Policies, Kingdon (1984) laid the foundation of the MSF to understand agenda-setting in public policy. He explained that agenda-setting is the result of interactions among three relatively independent streams; problem, policy, and politics streams, each including their unique set of activities, associated behaviours and involved actors (Kingdon, 1984). As shown in Figure 7, these three streams flow along different channels and remain independent of one another until, at a specific point in time, a policy window opens. Only then do the streams cross and policy change can occur (Jones et al., 2015).

In the figure below the window of opportunity opened at point (d). Window openings could be triggered by unrelated external events, such as crises, accidents, or the presence or absence of “policy entrepreneurs” (Béland & Howlett, 2016). Policy entrepreneurs form another core element of the MSF. According to Cairney and Jones (2015), policy entrepreneurs are actors that develop solutions in anticipation of future problems, seeking the right time to exploit or encourage attention to their solution via a relevant problem (“solutions chasing problems”). Thus timing is crucial in the MSF because it influences which problems, policies, or politics are in the forefront at any particular point.

In sum, issues are brought up for discussion when all three streams are "ripe," and "policy entrepreneurs" take advantage of "windows of opportunity" to "couple" (or align) the streams and advance the process. This paradigm has been expanded in subsequent studies to examine additional phases of the policy process, such as policy adoption (Zahariadis 2003). Consequently, the architecture of the framework has changed. For instance, Zahariadis (1992) thought the change from agenda-setting to decision-making would be seamless, while Herweg et al. (2015) suggested that the process needed a "decision window" and policy entrepreneurship that can move the process from one stage to another. In this research, Zahariadis’s (1992) architecture will be applied in which the transition from agenda-setting to decision-making would be smooth without the need for additional intermediate processes.

Although Kingdon focused on one country; the United States and two policy areas; transportation and health, the concepts and metaphor are “universal” in the sense that they have been shown to be flexible enough to be applied to nearly any place or policy (Cairney & Jones, 2015). To better understand the components of this framework, the three streams will be explained in the sections below.

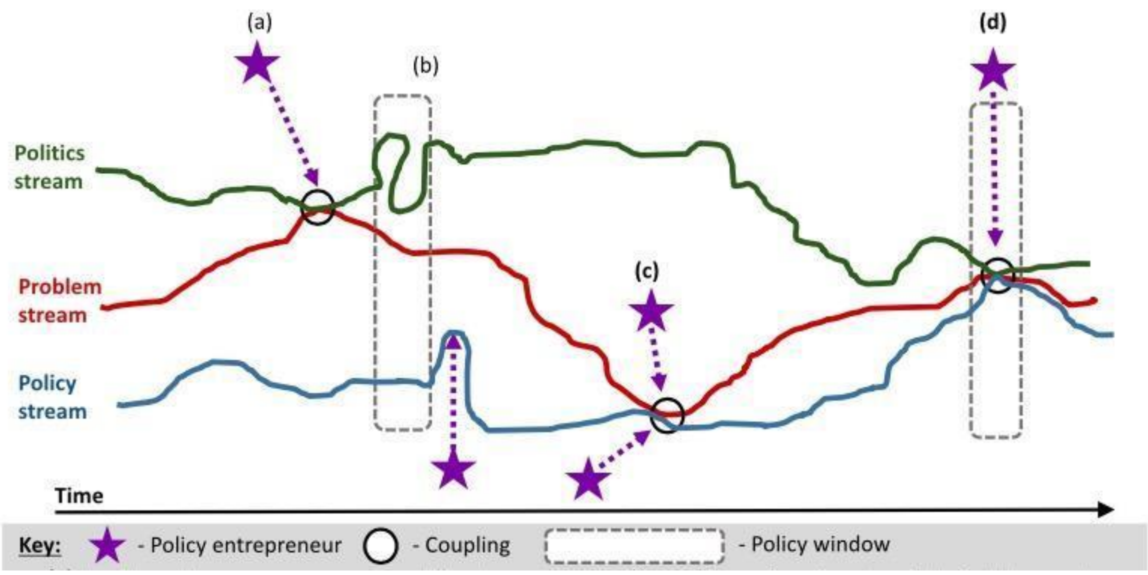


Figure 7 *Schematic of the multiple streams framework (MSF) and scenarios in which a policy agenda may (d) or may not be formed (a,b,c) (Cooper-Searle et al., 2017)*

2.2.1 The Problem Stream

The problem stream includes the components and conditions of a problem, specifically one that receives policy maker's attention (Cairney & Jones, 2015). According to Béland & Howlett (2016), the problem streams are usually considered as public in the sense that government action is needed to resolve them. These problems usually reach the awareness of policy makers due to dramatic events, known as “focusing events”, data that form “indicators” for the severity of a problem, and at last “policy feedback” that may direct attention to specific conditions.

2.2.2 The Policy Stream

The policy stream contains a collection of policy ideas, alternatives or proposals which may or may not solve the problem at stake (Kingdon, 1984). These elements involve developed, refined and either discarded or endorsing solutions through an iterative process of modification, reconsideration and softening (Cairney & Jones, 2015). In general, the policy stream becomes ripe when there is “value acceptability”, “technical feasibility” and “financial viability” to compete and win acceptance by policy-makers (Jones et al., 2015).

2.2.3 The Political Stream

The political stream consists of a variety of elements that motivate policy-makers to focus on specific problems and possible solutions for the agenda (Béland & Howlett, 2016; Cooper-Searle et al., 2018; Storch & Winkel, 2013). Two important factors, among others, may signal increased receptivity to an issue, allowing it to rise in priority on the policy agenda: internal interests such as “party ideology” and external features such as public opinion or “national mood” encourage governments to focus on particular problems and solutions (Cooper-Searle et al., 2017).

In summary, there are different factors that relate to each of the three streams and that can contribute to the ripeness of a stream to get coupled with the other ones. The figure below summarises the different concepts discussed in each of the three streams. The problem stream represents perceptions of societal conditions based on indicators, focusing events, and policy feedback. The policy stream depicts the evolution of policy alternatives as they undergo mutations based on the technical feasibility, financial viability, and value acceptability criteria. The politics stream models characteristics such as party ideologies, and the national mood, which influence the ability and willingness of governments to take action.

3 Methodological Framework

In this chapter, the methodological framework of this research will be discussed. The research design will be presented in Section 3.1. Following that, the relevance of the transition to electric cars, as a case study, for the application of the MLP and MSF will be discussed in Section 3.2 and 3.3 respectively. Afterwards the rationale for choosing the Netherlands for the study will be put forward in Section 3.4. The data collection, treatment, and analysis will be laid out in Sections 3.5, 3.6, and 3.6. In Section 3.8 the comparative analysis done for the results of the application of the two frameworks will be explained. At last, the research validity will be discussed in Section 3.9

3.1 Research Design

The design adopted in this research is a single case study using two theoretical frameworks. A case study is an established research design that is extensively used in a wide variety of disciplines, particularly in the social sciences. The essence of a case study lies in its ability to generate an in-depth understanding of a complex issue in its real-life context where the boundaries between phenomenon and context are not clear (Yin, 2009). Thus, case study research assumes, among other things, that studying the context and other associated factors are critical to comprehending the case.

The case study adopted in this research is of explanatory nature. This type of case study is used to explain the presumed causal links in real-life interventions that are too complex for survey or experimental research (Baxter & Jack, 2008). This type of case study is useful for this research to explain the causal links and interacting variables prevailing the complex situations of socio-technical transitions and policy change. Moreover, Asquith et al., (2018) explain that case studies enable the investigation of non-linear processes across time (known as "process tracing"), which accommodates real-world dynamics such as setbacks, accelerations, and unintended effects, shifting coalitions, or shocks. As a result, case studies can offer a conceptual understanding of how complicated processes such as transitions occur in the real world.

Besides addressing longitudinal processes of socio-technical transitions, Asquith et al., (2018) also reflected that case studies are able to address the co-evolution of such processes. The processes taking part in a transition often have very different temporalities — relatively gradual or long-run social trends such as sudden mood swings of public opinion, accidental happenings, medium-run political strategies, oscillating economic or climate patterns — which are brought together in specific ways, at specific places and times, in a particular sequence. Case studies enable the study of co-evolutionary alignments and lateral interactions

between these different processes that take part in socio-technical transitions (Asquith et al., 2018).
A case study can consist of single or multiple cases and can be either holistic or have embedded sub-cases in which there will be more than one unit of analysis within an overall holistic case (Yin, 2011). The resulting two-by-two matrix leads to four different case study designs: (i) a holistic single case, (ii) a holistic multiple cases, (iii) a single embedded case, and (vi) multiple embedded cases designs. Since this research studies a single case, the Dutch transition to electric cars, the research design is a holistic single case study. Within the single case study design, the MLP framework was first applied to the case followed by the MSF. Afterwards a comparison between the two frameworks was performed. The case study design adopted is illustrated in Figure 8 with the dashed lines representing the blurred boundary between a case and its context.

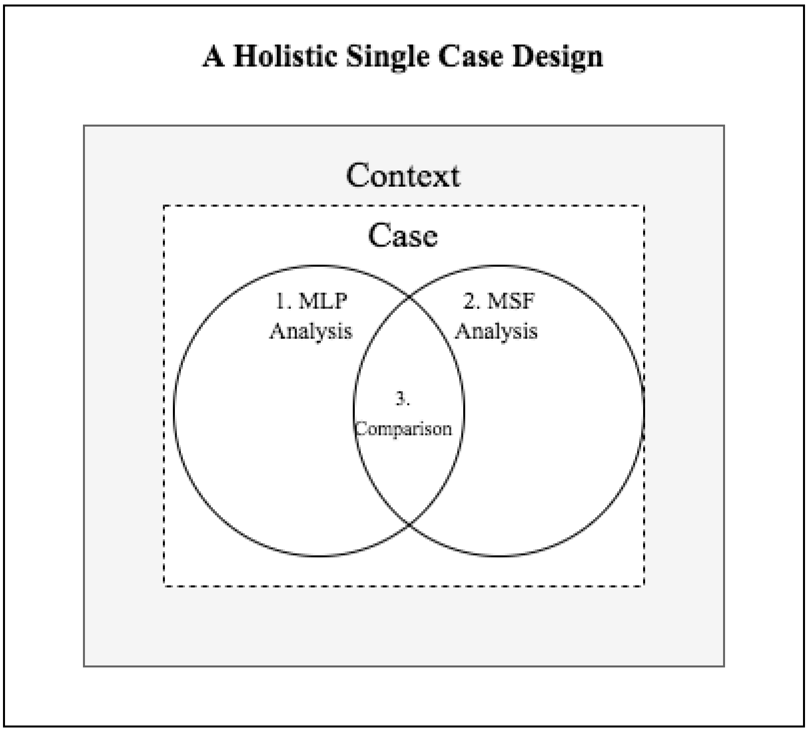


Figure 8 *The case study design of this research. Source: own compilation*

3.2 Case Relevance for the MLP

The land-based road transportation system manifests the characteristics of a mature and a well-established sociotechnical system. As shown in Figure 9, this system consists of an interdependent and co-evolving mix of elements such as automobile technologies, production systems, fuel and road infrastructure, distribution networks, regulations, users' practices, and cultural meanings. The interlinkage between these heterogeneous set of elements ensures that the transportation function is fulfilled (Geels, 2002).

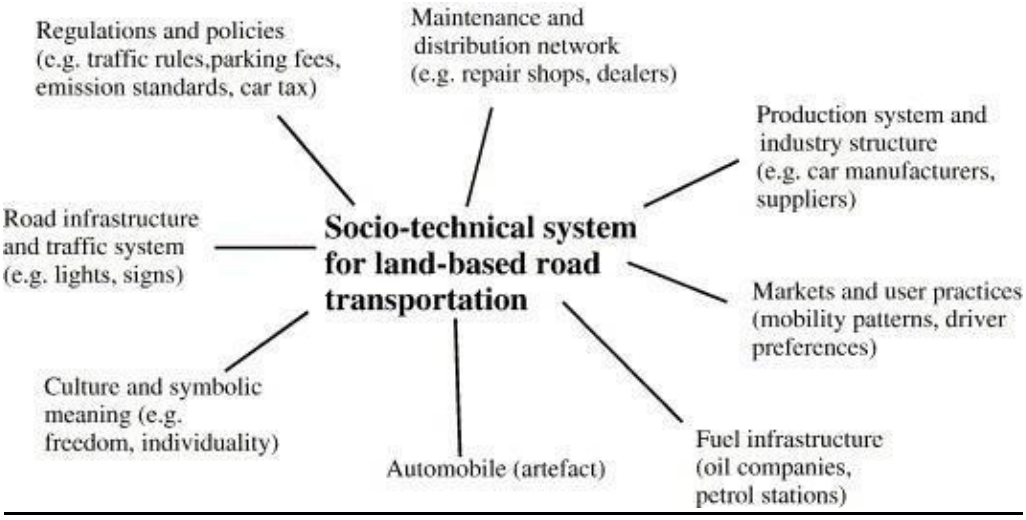


Figure 9 *Example of a socio-technical system (Geels, 2005a)*

The actors and social groups that form and sustain these elements highly vary in the transportation sector. Geels (2002) explains for instance that the road infrastructure and car regulations are built and maintained by transportation ministries, while the interaction between users, media, and societal groupings produces the cultural and symbolic connotations of driving a car. The everyday use of cars by users results in mobility trends and the industry structure is the result of the interactions between vehicle manufacturers and their suppliers. Last but not least, car designers and engineers create the technological knowledge embedded in cars, whereas car manufacturing companies build the artefacts (Geels, 2002).

Furthermore, Geels et al. (2017) used the car-based transportation system to explain that the activities of the different groups are guided and co-ordinated by formal and informal institutions and rules. The preferences and habits of car drivers, the cultural associations of car-based mobility with freedom, modernity, and individual identity, and the assumptions of transport planners form the informal institutions of this sector. The traffic rules, regulations, governmental taxes and subsidies form the formal institutions. Together these two forms of institutions ensure that the activities of the different actors are aligned and coordinated.

The system elements, actors and rules of the land-based road transport system form three interrelated dimensions involved in the socio-technical transition to electric cars. The interlinkage between these elements make this transition a well suited case to apply the MLP framework. The framework could be used to explain how the three dimensions are interrelated together among the three levels of the MLP and how the interlinkages are driving the transition to electric cars.

3.3 Case Relevance for the MSF

Despite playing a role in the transition to electric cars, the maturity of the interlinkages between the three dimensions makes it difficult to escape persistent path dependencies. The interdependencies between the supply and demand enterprises (maintenance, equipment manufacture, training, and research), the co-evolution with other functional subsystems (chemical industry, electricity distribution), and the broader patterns of human activity and settlement (the design of cities, patterns of international trade) all create a 'lock-in' a fossil fuel-based energy system and a 'locking-out' of 'alternative carbon saving technologies.

For this reason, Köhler et al., (2020) highlighted the particular role of policy-makers in identifying and boosting the momentum of relevant niche discoveries and breaking through the lock-ins of the fossil fuel sector. Köhler et al., (2020) also explained that the legitimacy of actions or the removal of specific resistances is ensured by relying on other participant groups. Strict policies can only be successfully executed if they have the requisite backing and coalitions of actors. For instance, a fair amount of public pressure for environmental issues (conveyed by lobbying and social movements) as well as experimentation – often at local level – play an important role in supporting path-breaking innovation and reducing commitment to established regimes.

In this case, the central role of actors' interdependencies (industries, activists, researchers, and policy-makers) as well as the dynamic interplay between problems, prospective solutions, and politics, are central to delivering policy objectives linked to mobility. This makes the chosen case applicable for the MSF. In other words, the transition to electric cars in the Netherlands encompasses the needed input to apply the MSF. In return the MSF can be used to uncover the political procedures behind driving this transition.

3.4 Rationale for Selecting The Netherlands as Case

The Netherlands is chosen for this case study due to the progress this country has been showing over the past few years in transitioning to electric cars. In an assessment made by the Economist Impact to measure the readiness of 40 nations and regions for EVs, the Netherlands ranked among the top five countries (The rEV Index, 2021). The readiness of the country for EVs is reflected in the percentage of new passenger electric cars' sales (zero-emission as well as hybrid cars) which has reached around 30% in 2021. In comparison to other countries and in absolute numbers, the Netherlands comes close to Norway and Sweden, because the annual sales of new cars in those two countries are much smaller than in the Netherlands. While several studies have analysed the transition to electric cars, especially in the Scandinavian context (Figenbaum, 2017; Nykvist & Nilsson, 2015; Ryghaug & Skjølsvold, 2018), the Dutch transition has not been explored yet in such a multi-dimensional way in which the socio-technical transition is studied along with a policy mix change analysis.

A factor used by the Economist Impact to determine the readiness of a country for EVs is the existing charging infrastructure (The rEV Index, 2021). Lack of sufficient charging stations contributes to the concerns of consumers in the uptake of EVs. This pillar evaluates how well the infrastructure for charging has developed to help consumers get over their anxiety. After China, the Netherlands has the most public EV charges of any other country, with nearly one charger per 2 km of road (The rEV Index, 2021). In Europe, while only accounting for 1% of the EU surface area, the Netherlands has around 30% of the total EU charging stations. The amount of stations is as many as the number of charging stations found in 23 member states combined (ACEA, 2022). Moreover, the country also has more public charging stations per car than any other country, with one station for every five electric cars currently on the road (Mathews, 2021).

Besides the technical actions taken, the Dutch legislative environment and the degree to which it promotes EV adoptions also score particularly high in the assessment of the Economist Impact (The rEV Index, 2021). This is of no surprise as the country is stimulating electric driving through a number of policy incentives. For instance, a subsidy scheme has been designed to make the purchase or lease of a new or second-hand electric car more interesting. In 2021 individuals purchasing a new electric car received a subsidy of € 4000 while for a used electric car this was € 2,000 (Wappelhorst, 2022). The budget set for both new and used cars in 2022 has been fully exhausted and no more registrations for such subsidies are possible. As of January 2, 2023, registration will be possible again for new and used electric cars for which the purchase agreement was concluded on or after that date (ANWB, 2022c). There is also an exemption on purchase tax and motor vehicles tax until 2024 (The rEV Index, 2021). In addition, compared to other European markets, taxes associated with purchasing a gasoline or diesel vehicle are notably expensive (Wappelhorst, 2022). The price difference between an EV and a traditional vehicle has been lowered due to these incentives making the purchase of an electric car more attractive for a consumer.

In conclusion, the Dutch transition to electric cars has a strong technological dimension combined with policy change transcending over a long period of time. These two factors placed the Netherlands among the frontrunners in the transition internationally and made the case study suitable for this research. The technical dimensions of this transition is analysed using the MLP while the legislative processes are studied using the MSF. Finally these two studies are put together to understand how one has affected the other in this sustainable transition.

3.5 Data Collection

To answer the first two sub-questions, data needs to be collected. The data collected in case studies are usually related to a great variety of contextual variables which results in a wide range of issues to be covered by one case study. Thus the data gathered in any case study usually originate from various and not single sources of evidence (Yin, 2011). This variety in data sources results in data credibility and more reliable results which adds strength to the research and provides a better understanding of the case (Baxter & Jack, 2008). In this research, the two sources of evidence that were used were documentation and interviews. Both sources offer qualitative data which can be considered as non-numeric data that can be presented in a narrative form (Yin, 2011). Documentation was collected from desk research while interview information was collected from primary research in the form of semi-structured interviews. Each of the data collection processes is discussed in the sections below.

3.5.1 Desk Research

The first form of data used in the research is documentation. Documentary information is always relevant for case studies because of its broad coverage including information related to the long time spans, many events and different settings (Yin, 2009). Yin (2009) also explains that documents are of unobtrusive nature meaning that the information found is not created because of the specific case studied. This eventually would help in generating new original information that is based on the researcher's understanding. However, this advantage of documentation could also be seen as a limitation since the judgement of the researcher is subject to human error and thus to reporting bias (Yin, 2009). The way in which bias and other limitations accompanied by the research methodology are handled are explained in Section 3.7.

To retrieve the relevant documents, desk research was done. The documentation that this research included was either gathered from scientific literature such as academic studies related to the case, or from grey literature such as administrative documents in the form of government reports and proposals, and news clippings and articles appearing in the mass media. For the scientific literature Google Scholar, SCOPUS and TU Delft Library were predominantly used to ensure the authenticity and reliability of the documents found. The grey literature was retrieved through the backward snowballing of academic scholarship or by a Google search. It is worth noting the grey literature was handled a bit more carefully due to its lack of credibility, as non-peer-reviewed documents are used (Benzies et al., 2006). To handle this limitation, grey literature findings were cross-checked against multiple sources and, where possible, academic sources. Additionally, since the geographical boundary of the case study is within the Netherlands, Dutch sources were also used to further extend the pool of available data.

3.5.2 Semi-structured Interviews

Since desk research is not enough to fully grasp the sustainability transition under study, an additional source of data is necessary in the form of interviews. And given that this research is of an explanatory nature, semi-structured interviews were conducted. The semi-structured interviews consisted of predefined questions that reflected the concepts found in each of the MLP and MSF while still having questions that are open-ended to extend the discussion further. This format of interviews allows for more open-ended discussions about unanticipated factors while still being structured enough to compare and validate the interviewees' ideas and the information found during the desk research.

Besides being semi-structured, the interviews that were conducted were "focused" interviews meaning that an interview was held in a short period of time (Yin, 2009), in this case up to 45 minutes. Given the time constraints, the purpose of conducting interviews was two-fold: (i) to corroborate certain facts found in the documents and (ii) to obtain information that cannot be obtained in any other way. Asking about broader topics that the interviewee has limited prior knowledge about is not done for this research.

The semi-structured format means that throughout the interview process: (i) a certain line of inquiry should be followed as reflected by the case study protocol, and (ii) conversational questions should be asked that also serve the needs of the line of inquiry (Yin, 2009). This is challenging because certain forms of open-ended questions can trigger reflexive forms of answers in which the interviewee answers what the interviewer wants to hear (Yin, 2009). To minimise such risks, conducting case study interviews requires satisfying the needs of the line of inquiry while simultaneously putting forth well-articulated types of questions. Further elaboration on how such limitations are handled in this research are discussed in Section 3.9.

Now that the format of the interviews is known, it is useful to understand what the steps taken prior to conducting the interviews were. First, approval from the Human Research Ethics Committee (HREC) was requested by filling in the needed documents that ensure the research ethics of this study. Following this application process, the interview questions were made based on the documents read and the information gathered during the desk research. The questions were then discussed with the thesis supervisors to check and confirm. Once the HREC approval was received and the list of questions were confirmed, the potential participants were contacted. If they agreed to do an interview, the informed consent was sent to them. Informed consent is a form of a written agreement between the researcher and the participants (in this case the interviewees) that ensures that the participants know what they are contributing to the research and that the researcher preserves the legal, ethical physical and emotional security of the participants. The questions that were asked and the informed consent could be found in Appendix 3. The interviews were held online using Microsoft Teams and were recorded to be transcribed later.

Furthermore, to comply with the data handling requirements and to ensure the data is stored safely, the contact information, the recordings and the transcribed audio of the interviews will be kept on the researcher's TU Delft OneDrive, with separate storage for the informed consent forms. All the data will be automatically deleted approximately 10 days after completion of the project except for this thesis report and the anonymised transcripts, which may be retained by the TU Delft.

In order to perform the interviews 20 active stakeholders in the system were contacted. At the end, 12 interviewees accepted the interview invitation. The interviewees were selected partially in correspondence with the actors forming the Formula-E Team (the public-private partnership driving the transition in the Netherlands) as analysed in Section 4.4.6. Other actors taking part in transition independent from the Formula E- Team also have been interviewed (e.g., TNO, EV Solutions, and independent entrepreneurs). The interviews were conducted with a diverse set of interviewees as shown in Table 1.

Table 1*Respondents number and their respective organisation. Source own compilation*

Respondent Number	Respondent	Organisation
# 1	Anonymous	MRA-Elektrisch
# 2	Peter Soonius	Nature and Environment (Natuur en Milieu)
# 3	Maarten Van Biezen	Route Zero, Association Electric Drivers (VER), Klimaatakkoord Rotterdam
# 4	Anonymous	TNO-research institute
# 5	Ronald de Jong	ANWB/ Louwman Group
# 6	Gino Slot	Association electric drivers (VER)
# 7	Matthijs Kok	Municipality Utrecht
# 8	Ruud Koornstra	Sustainable Entrepreneur/ past board member of Formula E-team
# 9	Anonymous	EV-solutions
# 10	Wijnand Veeneman	TU Delft, Next Generation Infrastructure

# 11	Anonymous	Ministry Infrastructure and Water Management
# 12	Jacco Lammers	ANWB/ past participant in the “C,mm,n” project

Note: the names of the respondents are only shared if they approved in the consent form

3.6 Data Treatment: Qualitative Coding

The qualitative data collected from the documents and interviews led to a plethora of in-depth information presented in the form of words. Analysing this data entails reading a large amount of unstructured text-based data. In order to facilitate this data analysis process, qualitative coding was done. Coding is a key structural operation in qualitative research, enabling the successive data analysis processes that serve the purpose of the study (Williams & Moser, 2019). It merely entails subdividing the huge amount of raw information and assigning them into distinct codes to allocate units of meaning to the descriptive or inferential information (Basit, 2003).

Traditionally, coding was done manually, with the use of coloured pens to categorise data, and subsequently cut and sort them out. To ease this laborious task, advancements in technology provided online software to do the coding automatically (Wong, 2008). This research made use of the ATLAS.ti software. This program is particularly useful as it gives access to sophisticated tools to categorise the data into codes, subcodes and categories and then arrange them in a creative, yet systematic way (ATLAS.ti, n.d.).

Literature differentiates between inductive and deductive coding. This distinction relates to the process by which textual data is coded. While the inductive approach departs from scratch, formulating codes based on the analysed content itself, the deductive method starts with a set of predefined codes (Chandra & Shang, 2019).

In this research, both inductive and deductive approaches in qualitative coding were adopted. Primarily, inductive coding was utilised to explore the processes underlying the transition to electric driving in the Netherlands. However, since this research is of explanatory nature and is bound to existing pre-developed theoretical frameworks, the study additionally employed deductive techniques. The predefined codes are used to guide the open codes and link them to the concepts found in the MLP and MSF. To be more specific, the pre-defined codes in this research are the three metaphorical streams of the MSF and the three levels of analysis of the MLP. The way in which these different elements are defined in this research are presented in Table 5 of Appendix 6.

Coding could be in three steps; open coding, axial coding and selective coding.
These steps are not necessarily performed in this strict order, in fact there may be several iterations of each in a cyclical coding process. As the coding process progresses the nonlinear

directionality enables essential themes to be identified, codified, and interpreted in the service of a research study's focus. The sections below explain each of the three steps based on the description provided by Williams & Moser (2019) as well as how they are applied in this research:

1. **Open coding:** is a common first step in data treatment in which the collected data is broken down into discrete parts with broad thematic concepts or codes assigned to them. The purpose of breaking up the data and labelling them with codes is to enable the researcher to continuously compare the data found and to avoid preconceived notions and biases about the research. To perform open coding, first the data collected are segmented into smaller samples of similar sorts (e..g., transcribed interviews, policy documents, scientific papers, etc.) which can be done with the "Document Group" option in Atlas.ti. After this data organisation, the concept of open coding is applied while also adding the years related to the data to the coding list to support the process tracing procedure.

2. **Axial coding:** is done as a second step of the qualitative coding, in which the identified open codes are organised and brought together in the form of distinct thematic categories. At this step, the open codes are re-read to find the relations between them and how they can be grouped together in categories. The categories thus emerge as aggregates of the most closely interrelated or overlapping open codes for which supporting evidence is strong. In Atlas.ti axial coding can be done using the option "Code Groups" in which the open codes can be dragged and dropped underneath a category known as a code group in Atlas.ti.

   .

3. **Selective coding:** At last, selective coding is when categories of the axial coding are connected around one core category. Thus, selective coding could be seen as a continuation of axial coding at a higher level of abstraction. In this research, the selective coding is based on a set of predefined codes or categories that are related to the concepts found in the MSF and MLP. How the different categories are defined could be found in Appendix 5. In Atlas.ti selective coding can be done using the option "Code Groups" in which the found subcodes of the axial coding can be dragged and dropped underneath one of the pre-defined concepts of the theory.

3.7 Data Analysis: Causal-Process tracing

To make sense of how the codes generated during the data treatment process relate to each other, the Causal Process Tracing (CPT) analytic approach is adopted. This data analysis approach is particularly well suited to answer 'why' and 'how' questions because it is outcome-centred meaning it focuses on the causal conditions, configurations and mechanisms which make a specific outcome possible (Blatter & Haverland, 2014). Reasons why this analysis approach is useful for this research is because CPT emphasises the relevance of 'timing', 'interaction effects', and 'contexts' (Blatter & Haverland, 2014), which supports the research objective in understanding how the transition to electric driving and the appurtenant policy change are coming about.

In this research, the CPT analysis approach was closely related to the above-described qualitative coding process. Since all theoretical codes are labelled according to their year, this gave a chain of events that follow each other. In order to verify the causal relation between two events, various sources (documents or interviews transcripts) are utilised to test the validity of the event.

3.8 Performance of Comparative Analysis

After gathering the data and analysing the information using both frameworks, a comparative analysis was performed. The distinguishing feature of this comparative study is the identification of conceptual commonalities and differences between the different concepts found in the MLP and MSF. The understanding of the various concepts taking part in the MLP and MSF (as described in Chapter 2) provided an important foundation for this cross-framework comparison. Moreover, the comparison of the two frameworks extends beyond the identification of commonalities and differences to developing propositions that describe causal relations between the different concepts of the two frameworks.

In order to perform this comparison, factors at the landscape, regime and niche level of the MLP (relating to the socio-technical system) were compared to the factors of the three streams of the MSF (relating to the policy subsytem). This was done by:

- Examining if a certain factor of a level of the MLP is also a factor of a stream of the MSF. In such a case that factor would be denoted as a commonality between the two frameworks.

- Examining if a certain factor of a level of the MLP is not a factor of a stream of the MSF, and no causal relationship could be traced. In such a case that factor would be denoted as a difference.

- Examining if a certain factor of a level of the MLP is not a factor of a stream of the MSF but a causal relationship could be traced. In such a case that factor would be denoted as a casual relationship which would result in a proposition.

The table below shows an example of how the comparison is done.

Table 2 Example table of how the relations between the different concepts are identified. Source own compilation

Factor	Concept in MLP?	Concept in MSF?	Relation?
Rising concerns over climate change	Yes, at the landscape level	Yes, in the problem stream	Commonality
Emergence of Li-ion battery	Yes, at the landscape level	No	Difference
Decrease in battery prices	Yes, at the landscape level	No, but relates to technical feasibility of EV policies	Causal relation

3.9 Research Validity

Persuading the readers that the research findings are worthy of attention continues to be a challenging aspect in designing and conducting case study research. A researcher must ensure that the threats to validity are minimised. For this reason, Lincoln and Guba (1985) distinguished four criteria to ensure validity which are; credibility, transferability, dependability, and confirmability. These criteria run parallel to the conventional quantitative assessment criteria of validity as credibility corresponds to internal validity, transferability to external validity, dependability to reliability and confirmability to objectivity (Malterud, 2001; Whittemore et al., 2001; Kivunja, 2018). The criteria are briefly defined below according to the explanations of Nowell et al. (2017) then followed by an explanation on how this research attempts to meet them.

3.9.1 Credibility (Internal Validity)

Credibility addresses the selection bias of the case as well as the alignment between respondents' views and the researcher's representation. This research addresses credibility by prolonged engagement with the data and persistent observation of the context and processes involved in the study. The interviews that are conducted also play a role in enhancing the engagement with the context of the study. Furthermore, data collection triangulation ensures the credibility of the research as it entails checking and rechecking the consistency of the findings from different as well as the same sources (Yin, 2011).

In this research, the data collection, as described in Section 3.4, relies on three main data sources: (i) documents in the form of scientific and (ii) grey literature as well as (iii) interview transcripts. Moreover, peer debriefing in the form of weekly meetings with the supervisor and monthly meetings with the thesis committee provides an external check on the research process as well as feedback on the preliminary findings and interpretations against the raw data. Furthermore, the pool of respondents chosen for this research interview is very diverse in terms of their expertise and their role in the transition to electric cars. This diversity ensures that the information retrieved during the interviews are not bound to the specific expertise of the respondent.

3.9.2 Transferability (External Validity)

Transferability refers to the extent to which the findings are generalizable to other cases. Perhaps the most reasonable stance toward generalising results is that we can generalise to other cases to the degree that they are like the case of the original study (Johnson, 1997). The more comparable a research case study's context is to another case context, the more valid the generalisations will be. This research tries to make the findings transferable to other transition cases by providing (in Chapter 4) extensive descriptions regarding the case boundary and context. These descriptions allow other researchers to depart from this research and transfer elements from this case study to similar future studies.

Furthermore, three external validation sessions (in the form of semi-structured interviews) have been conducted with researchers working in the field of sustainability transitions, policy sciences, and socio-technical sectors. These interviews were done to test the extent to which the results of this analysis could be generalisable to broader contexts of sustainable transitions. In Table 3 the researchers that took part in these interviews, where they work and their field of expertise are presented. The process of these validation interviews was the same as that of the interviews conducted with the stakeholders (described in Section3.5.2). The questions asked and how they were asked during these sessions could be found in Appendix 4. The outcome of these discussions are discussed in Section7.3.

***Table 3** Researcher names, organisation and field of expertise. Source own compilation*

Respondent	Organisation	Field of Expertise
Dr. Johan Schot	Utrecht University	Global History and Sustainability Transitions
Dr. Sebastian Sewerin	ETH Zurich	Political science and Innovation studies
PhD. Researcher Jerico Bakhuis	Delft University of Technology	Socio-Technical Sector Coupling of Power and Transport

3.9.3 Dependability (Reliability)

Dependability ensures the research process is logical, traceable, and clearly documented. Dependability in this research is ensured by providing extensive descriptions on the research methodology which include the data collection, data treatment, and data analysis processes. This allows those who seek to repeat the steps taken in this study to refer to its research methodology sections.

3.9.4 Confirmability (Objectivity)

Confirmability is concerned with establishing that the researcher's interpretations and findings are clearly derived from the data and not from the researcher's bias. This requires the researcher to demonstrate how conclusions and interpretations have been reached. According to Guba and Lincoln (1989), confirmability is established when credibility, transferability, and dependability are all achieved (Nowell et al., 2017). However, since bias cannot be completely eliminated, this research will try to be transparent about the biases by communicating the acknowledged limitations and explaining their residual effects. In this research a separate section discussing the limitations of this research is found in Chapter 8.

4 Case Study Background

To give context to the case study chosen, background information will first be presented in section 4.1. Afterwards a brief historical overview of the EVs will be outlined in section 4.2. In section 4.3, EVs within the Dutch context will be described followed by a stakeholder analysis in section 4.4.

4.1 Case Background Information

Transportation accounts for 17% of global greenhouse gas (GHG) emissions, second only to the power sector (Statista, 2022). Scenarios that achieve an 80% greenhouse gas (GHG) emission reduction target relative to 1990 by 2050 in the EU require 60% reduction efforts in transport CO_2 emissions (Köhler et al., 2020). In terms of transportation modes, passenger cars have the highest share (41%) of the distribution of CO_2 emissions produced by the sector worldwide (Statista, 2021). According to the Climate Change Committee, UK's independent advisor on climate change, reducing the emissions from road transport represents one of the largest sources of emissions reductions needed to align to the Paris Agreement (Climate Change Committee, 2021). A promising pathway to reduce the emissions in this sector is the transition to electric vehicles (EV). In Europe, for instance, electric cars emit on average almost 3 times less CO_2 than equivalent petrol or diesel cars (Transport & Environment, 2020).

The awareness of emission reduction improvements is being translated into the high adoption rates of electric cars. According to the IEA (2022), the number of electric cars sold (including light commercial vehicles such as vans and light trucks) reached 6.6 million in 2021, accounting for about 9% of the global car market. Today, around 16 million electric cars are on the road worldwide, consuming roughly 30 terawatt-hours (TWh) of electricity per year, which is equivalent to all the electricity generated in Ireland. In Europe, electric car sales increased by nearly 70% to reach 2.3 million in 2021, while the monthly sales peaked in December when European sales of electric cars surpassed diesel vehicles for the first time with a 21% market share (IEA, 2022).

4.2 EVs Through Time

While EVs have only recently begun to challenge the internal combustion engine (ICE), these eco-friendly cars do not represent recent 'high tech', but a comparatively simple technical concept, meanwhile available as a series product for more than 110 years. The long history of EVs has been one of many twists and turns. So Simpson & van Barlingen (2021) broke this history into six distinct periods as shown in Figure 10. These periods will briefly be highlighted in the sections below.

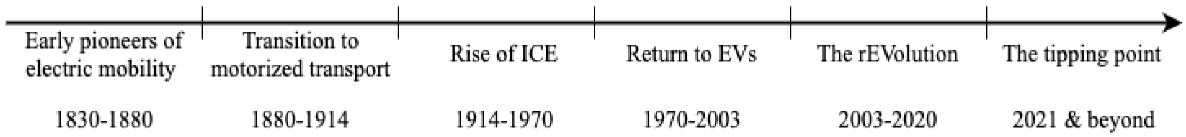


***Figure 10** A brief history of electric cars based on Simpson & van Barlingen (2021) distinct periods*

Early pioneers of electric mobility (1830-1880): The first period entails a series of technological breakthroughs in batteries and motors in Europe and the U.S which paved the way to the first EVs. For a long period of time, the technological developments were little more than prototypes of electrified carts—travelling at top speeds of 12 km/h with cumbersome steering, and little range. It wasn't until the late 1880s that these inventions batteries and electric motors were put together by electric mobility pioneer William Morrison to create the first "practical" EV which carried a maximum of 12 people and had a maximum speed of 32 km/h.

Transition to motorised transport (1880-1914): During this period of time people started swapping their horses and carts for motorised vehicles. This caused the automobile industry to rapidly grow in popularity while offering steam, gasoline, or electric vehicles as the three options. Among these options, electric cars proved to be competitive since they did not emit any unpleasant pollutants, require changing gears or have long startup times. As a result electric cars quickly became popular among urban residents where electricity was readily available. However, this momentum came to a slow end, with the creation of Ford's cost-efficient assembly line and the wider availability of gasoline.

Rise of ICE (1914-1970): Cheap and abundant gasoline, continued improvements to the ICE, and the lack of electricity outside cities, all hampered demand for alternative fuel vehicles and solidified gasoline vehicles' dominance. As a result, the electric vehicle lay dormant for the better half of a century.

Return to EVs (1970-2003): During the seventies, oil prices and gasoline shortages reached a new high—peaking with the 1973 Arab Oil Embargo— and interests in lowering society's dependence on oil grew. Automakers, feeling this social shift, started to explore options for alternative fuel vehicles, including electric cars. Over the next years, there were modifications happening on popular models to create electric variations, hoping that the batteries would be improved and a range and speed closer to that of gasoline-powered vehicles would be achieved. The real turning point happened in 2003, when Martin Eberhard and Marc Tarpenning formed Tesla Motors.

The rEVolution (2003-2020): In 2006, Tesla Motors announced it would start producing a luxury electric sports car that could go more than 320 km on a single charge. Tesla's breakthrough caused numerous major manufacturers to accelerate the development of their own electric vehicles. With the introduction of the Nissan LEAF in 2010, Nissan increased its level of competitiveness. At the same time, new battery technologies entered the market, helping to improve range and cutting EV battery costs. For instance, the price of Lithium-ion (Li-ion) batteries has declined by 97% since 1991 which has helped make EVs more affordable for consumers. In the following years, almost every mass-market automotive manufacturer has hopped on the electric bandwagon with many pledging to abandon the ICE completely

The tipping point (2021 & Beyond): From whatever metric—EV sales, EVs on the road, government EV regulations, EVs as a percentage of all vehicle sales, or just automotive manufacturers announcing electric mobility pledges—the rise in passenger EVs has been substantial in the previous years. According to McKinsey& Company, in the second half of 2020 we have already reached the tipping point—or the point beyond which significant and often unstoppable effects or changes take place—in terms of passenger EV adoption. Moreover, by 2035, all of the world's main car markets (EU, US and China) are predicted to be electric as many governments, businesses, and individuals are looking towards a more sustainable future (McKinsey & Company, 2021).

4.3 EVs is in the Netherlands

While the transition to electric cars is happening in most developed countries, this research will only focus on the transition happening in the Netherlands. To begin with, the Netherlands is a parliamentary democracy meaning that Dutch citizens have the right to elect their representatives which in return decide on the laws, rules and regulations that will govern the country. Further information on the formal governance system of the Netherlands could be found in Appendix 5.

Further, the Netherlands is a relatively small but densely populated country located in Europe and a member state of the European Union. The Dutch population is around 17 million and the country's land area is 37,354 km^2. This gives the country a population density of 519 people per square kilometre (CBS, 2022c). Despite its relatively small size, the Dutch gross domestic product (GDP) per capita stood at over 49 thousand euros in 2021, putting the Netherlands in fifth position within the EU (CBS, 2022b).

Around 75% of the country's population is resident in the Dutch urban areas, especially in the Randstad metropolitan region. The Randstad region is generally used to refer to a polycentric metropolitan area in the western part of the Netherlands, comprising the four largest Dutch cities (Amsterdam, Rotterdam, The Hague and Utrecht) as well as several medium-sized cities (Stead & Meijers, 2015).

Given the densely populated and highly developed nature of the Netherlands, it is foreseeable that the country has a very dense and modern road infrastructure. The quality of Dutch road infrastructure was ranked by the World Economic as the greatest in Europe and second only to Singapore out of 141 nations in the world in 2019. This rating beat out even the renowned German roads with a 6.4 score compared to 5.3 on a 7-point scale (Schwab, 2019).

Improvements in road infrastructure were accompanied by an increase in car ownership. Since 1990, the Dutch car ownership has increased from 0.8 to almost 1.1 cars per household. As of the beginning of 2020, in the Netherlands there were around 8.7 million private and commercially owned vehicles, 17.4 million inhabitants, and 8 million households. This means that there were 500 automobiles per 1,000 people, or little over 1 car per household on average. The number of cars per capita in the Netherlands is more than that in France, Sweden and the UK, but slightly fewer than in Belgium and Germany. By 2040 there will be an estimated 10 million cars (523 cars per 1,000 inhabitants) in the Netherlands (Zijlstra et al., 2022).

When calculating the number of cars per square kilometre of land area, the Netherlands has the highest spatial density among its neighbouring countries. In Europe, only Malta has a higher spatial car density than the Netherlands (Zijlstra et al., 2022). Given the small land area, the average Dutch driver only drives around 25 km per day and spends around 62 minutes on the road (CBS, 2022a). These figures are relatively small compared to the larger-sized countries such as Germany, France and the UK.

As the other developed European countries, the Netherlands too is transitioning to electric cars. In Figure 11, the realisation of EVs as a percentage of new car sales from 2016 up to July 2022 is presented. As shown by the percentages in the figure, the two most dominant types of electric cars found in the Netherlands are Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) while the Fuel Cell Electric Vehicle (FCEV) is still at an infant stage.

BEV relies solely on electricity for propulsion, meaning that it does not have an ICE, fuel tank or an exhaust pipe. Instead, a BEV has one or more electric motors which can be recharged by an external outlet. Due to the absence of a gas engine, BEVs do not emit any harmful emissions at all. The PHEV, on the other hand, is a hybrid vehicle that combines an ICE with an electric motor. This car is typically capable of running purely on the battery power, as well as on gas or a mix of both. The FCEV is an electric car that makes its own power in a fuel cell. The fuel used for this is hydrogen, a gas that is stored in one or more gas tanks in the car. One can fill up the gas in a similar way to petrol or diesel. The only thing that an FCEV emits while generating power is water vapour. This sounds like a promising solution, but the technology is very complex and expensive and needs yet to be developed (SKODA, 2020).

Realization: EVs as percentage of new passenger car sales					
	All EVs (BEV, FCEV, PHEV)	Zero-emission (BEV, FCEV)	BEV	FCEV	PHEV
2016	5.8%	1.1%	1.1%	0.0%	4.7%
2017	2.2%	1.9%	2.0%	0.0%	0.3%
2018	6.3%	5.5%	5.5%	0.0%	0.8%
2019	14.9%	13.7%	13.7%	0.03%	1.2%
2020	24.8%	20.5%	20.5%	0.04%	4.3%
2021	29.8%	20.0%	20.0%	0.04%	9.7%
2022 (YtD: June)	31,65%	19.3%	19,2%	0.06%	12,4%

Figure 11 *Realisation: EVs as a percentage of new passenger car sales. Source (RVO, 2022)*

Note YtD: Year-to-Date - refers to the period beginning the first day of the current calendar year up to the most recent date of which data is provided in this document

4.4 Stakeholder Analysis

The current 31% market share of EVs is not unexpected. There are various stakeholders working together to drive this transition. In the sections below these stakeholders will be presented along with their specific role in the system. Introducing the stakeholders will help better understand the course of events in the MLP and MSF analysis that will follow in the subsequent chapters.

4.4.1 Governmental Organisations

A fundamental stakeholder in the socio-technical system of EVs is Dutch government. To combat climate change, the Dutch government aims to reduce the Dutch greenhouse gas emissions by 49% by 2030, compared to 1990 levels, and a 95% reduction by 2050. These goals are laid down in the National Climate Agreement of 2019 (Ministry of Economic Affairs and Climate Policy, 2019a). As a part of realising these ambitions, the national government expressed its “Zero-emission from well to wheel” goal for the entire Dutch fleet in the year 2050 (RVO, 2019). In order to achieve this goal, the government has set the National Charging Infrastructure Agenda which ensures smart charging infrastructure across the country (RVO, n.d.). Besides, the agreements and agendas the national government also has been developing strong policy incentives (i.e., lowering and/or removing taxes and giving subsidies) to stimulate the Dutch consumers to purchase EVs.

At the regional and local governance levels, provinces and municipalities are also deploying initiatives and forming policies to accelerate the roll-out of electric transport. For instance, a number of Dutch cities already introduced environmental zones to support the roll-out of clean modes of transport (RVO, 2019). In addition, cities such as Amsterdam are aiming to have all traffic throughout the city emissions-free by 2030 (Wappelhorst, 2021). In recent years municipalities along with provinces organised large-scale tenders. As a result, residents in hundreds of municipalities who do not have access to a private parking space can have a charging point installed for free in a public place. Further and as part of the smart charging policy, the existing charging infrastructure is being prepared to charge electric passenger vehicles more intelligently (RVO, 2019).

4.4.2 Consumers

Consumers are the central stakeholders in the system as they form the target group that the transition must be adopted by. A large- scale study done by the ANWB (Travellers' association in the Netherlands, supporting all modes of travel) showed that the number of people willing to make the switch to electric cars is growing in the Netherlands. Over the past five years, the number of Dutch people with a short-term purchase intention (0-5 years) has increased from 17% in 2017 to 25% in 2021 (ANWB, 2021b).

According to this study, this increase in the willingness to buy electric cars is mainly due to the purchase subsidy for both new and used electric cars. In addition, the amount of affordable new car models has increased and the battery range has greatly improved in recent years. The total running costs of an average electric car are also now lower than that of an average petrol car. Due to the cheaper electricity when charging at home, the price per kilometer based on four years of use and an average of 15,000 kilometers per year is lower than the kilometer rate of a comparable petrol car.

Additionally, 41% of the Dutch say they have their own driveway or private parking space. If they can charge there, electric driving becomes extra worth consideration for them. These people have cheaper electricity than when they charge in the street and are less affected by possible problems in the public charging network. If they also have solar panels, the electric car can be charged 'free' with electricity generated by themselves. This is a sustainable and, in many cases, cheaper alternative than a fuel car. These factors form important turning points for the consumers to purchase an electric car (ANWB, 2021b). The different reasons for the Dutch consumers to purchase an electric car along with the percentage of people considering these factors according to the ANWB survey could be found below.

Table 4 *Reasons for purchasing electric cars and percentage according to ANWB survey. Source (ANWB, 2021c)*

Reasons for the Dutch consumers to purchase an electric car	Percentage
For the environment	51%
No more need to tank	32%
Economical to use	32%
Good driving characteristics	24%
Preparation for the future	23%
Driving using own energy	23%*

Note: * 41% of the Dutch have a private parking space. For them, “driving using their own energy” is the fourth reason to buy an electric car.

4.4.3 Industry Players

The Netherlands does not have passenger car manufactures. However, the industry stakeholders are involved in the transition to electric cars in various different ways. For instance, charging point operators sell the actual energy to the EV driver and are responsible for the day-to-day operation of charging stations. The manufacturers of these charging stations form another major player in the system. EV drivers can use these charging stations via service providers which in return grant the driver access to the charging station with an RFID-tag or card. Through the development of the Open Charge Point Interface Protocol (OCPI), an open protocol between the service provider and operators, drivers could charge their car in a standardised way across the whole country (Wolbertus et al., 2020) .

The electricity needed to charge the vehicle is supplied by the utilities and grid operators active in the energy market (Wolbertus et al., 2020). This energy supply is of high quality and superior performance in the Netherlands which made the infrastructure for charging EVs well organised (Nederland Elektrisch, n.d.-a). Utilities are also active as charging point operators and service providers and therefore can take on multiple roles in the discourse. Grid operators facilitate by providing a sufficient network for the rising number of charging stations connected to it (Wolbertus et al., 2020).

Besides the actors working on the infrastructure, other stakeholders in the automotive industry offer services related to the purchase or lease of an electric car (e.g., Bovag, RAI Automotive Industry NL, Association of Dutch Car Leasing Companies, etc.). The services these automotive companies offer range from offering electric cars for sale or for lease to providing relevant information for customers and attractive purchase and maintenance benefits.

4.4.4 Research Institutions

All actors in the field are advised by research from universities, research institutes and consultancy agencies. Such stakeholders provide insight into the transport sector by analysing the entire vehicle chain, cost and environmental aspects, performing measurements and developing models (TNO, n.d.). Besides these independent organisations, specific specialised institutes have been established to support the research on electric mobility. For instance, the Netherlands Knowledge Platform for Charging Infrastructure (Nationaal Kennisplatform Laadinfrastructuur- NKL) is a specialised institute for charging infrastructure. The aim of this institute is to accelerate electric mobility by contributing to a more cost efficient and future-proof charging infrastructure in the Netherlands through innovative projects and knowledge sharing (NKL Nederland, 2022).

Another Dutch knowledge centre that is making an important contribution in the transition to electric cars is ElaadNL. ElaadNL contributed to the international standardisation of charging infrastructure in recent years. Since the spring of 2018, it has had a hyper-modern test lab spread over several locations with access to all the various types of charging stations used in the Netherlands for testing electric vehicles. This facility, among other things, makes it possible to test how the charging of new car models affects the energy system in terms of three different aspects: smart charging, power quality, and interoperability (i.e., standardising electric charge cards throughout the Netherlands) (RVO, 2019).

4.4.5 Environmental Organisations

Despite not being evident enough, environmnetal organisations are important stakeholders in the Dutch transition to electric cars. The role of these organisations is to contribute to a more sustainable system by influencing the legislation and regulation processes. Such organisations have been exerting pressure on the national government, the House of Representatives and the Senate and sometimes at a local or European level. This is done through personal conversations or via campaigns. Their views are also communicated through the media with surveys and opinion articles.The other influence that environmental organisations have is on the public. They encourage people to make sustainable choices in everyday life from eating to traveling. The influence in this case would be through campaigns that inspire and inform people to have significant positive impact on the climate or nature (Natuur & Milieu, 2022).

4.4.6 Formula E-Team

The much-acclaimed Dutch polder model, (i.e, a government that works via partnerships and where policies are created through consultation with private parties) is at the heart of the Dutch transition to electric transport. An important manifestation of this polder model is the Formula E-Team. The Formula E-Team is a public-private partnership in which the aforementioned stakeholders are brought together. The team is made of umbrella organisations, between the business community, knowledge institutions, NGO's and the Dutch government (RVO, 2018).

The Formula E-Team was formed in 2010 with the goal of further developing e-mobility in the Netherlands. The project includes promoting and connecting various initiatives and partnerships to achieve critical mass and speed in the transition as well as removing adoption obstacles (RVO, 2018).

Up till today, the Formula E-Team formed the groundwork for various Green Deals that has hastened the adoption of electric transportation and elevated the Netherlands to the forefront of the world (RVO, 2019). For instance, the team is working on realising the ambition of the Coalition Agreement of 2017 of 100% of new sales being zero emissions by 2030. It is doing so through strengthening the consumer market, supporting innovation, improving the connection with sustainably generated energy and collaborating with international companies in electric transport (RVO, 2017). Moreover, the Formula E-Team is currently working on the National Charging Infrastructure Agenda which ensures a charging infrastructure that provides (RVO, 2017):

- Enough charging points throughout the country;
- Shorter delivery times and a future-oriented placement of charging infrastructure;
- Accessible information, such as the location and availability of charging points and charging rates;
- Future-proof charging infrastructure focused on smart charging, to prevent capacity strain on the electricity grid as much as possible.

The specific actors forming the Formula E-Team and how they relate to each other through formal and hierarchical relationships are illustrated in Figure 12. In Appendix 1, further information on the role of each actor is presented. Generally speaking, industry players offering the product or service (i.e, the electric car, its infrastructure and related services), and the consumers purchasing them are central to the system. The governmental organisations influence this system through its governance mechanisms while consumers influence the government by voting for specific parties during the general elections. Environmental and industry stakeholders lobby against the government if specific actions need to be taken while research institutes attempt to influence the system through research, knowledge sharing and providing advice. Moreover, environmental groups are supported by the consumers through donations while they try to influence the lifestyle of the consumer through sharing specific information. In the sections below, further information on the role of each of the stakeholders in the socio-technical system will be presented.

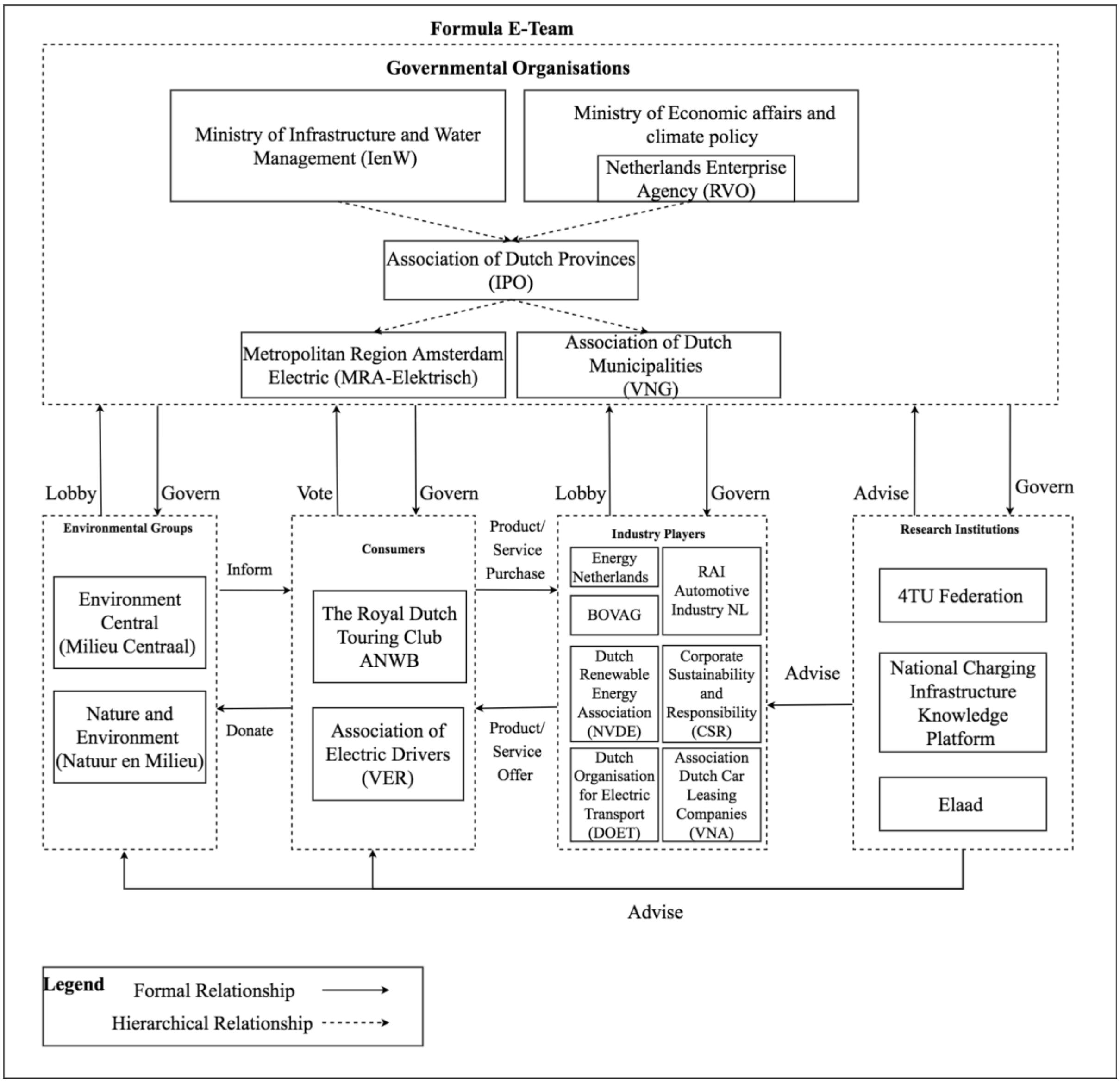


Figure 12 *Formula E-Team Parties and their relationship. Source own compilation*

Note these actors are found according to (Nederland Elektrisch, n.d.). More information on these actors could be found in Appendix 1.

5 Results of the MLP Analysis

In this chapter the MLP framework is applied to the transition to electric cars in the Netherlands. This framework is used to understand how the niche-level developments, coupled with pressures on the landscape level, including incremental changes in the regime context, were—over time—able to destabilise the conventional ICE regime. By applying the MLP framework to the case under study the following sub-question will be answered:

How can the MLP explain the socio-technical transition to electric cars in the Dutch mobility sector?

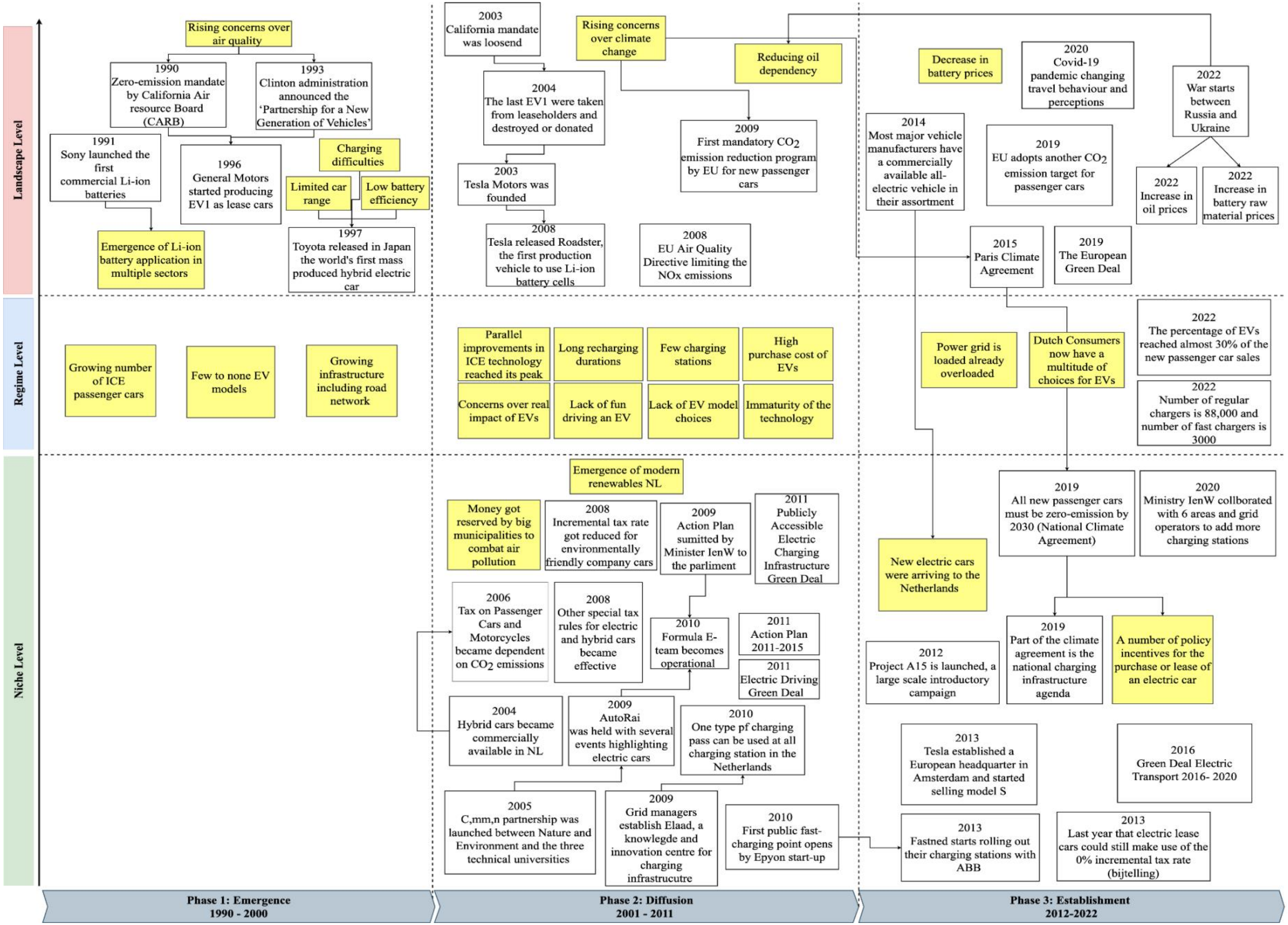
The results of the analysis applied to the framework are visually represented in Figure 13. It is important to note that the yellow boxes, unlike the white ones, do not represent temporal events, instead they are related to events that span over multiple years. As shown in this figure, three distinct stages are identified for this transition:

- Phase 1 (1990 and 2000): Distinguished by the (re)emergence of electric cars. Given that electric cars have been developing since the early 1800s (See section 4.2), the term re-emergence is a more accurate terminology to describe this phase. However, for simplicity reasons and not to cause confusion, the rest of this study will refer to this phase as the "Emergence Phase".

- Phase 2 (2001- 2011): Characterised by the diffusion of electric cars into the Dutch mobility regime. In this phase, the developments happening at the niche and landscape level will be put forward in relation to the barriers existing at the regime level.

- Phase 3 (2012- 2022): Distinguished by the establishment of electric cars in the road transport sector. It is reasonable to consider that in this phase, electric cars have been establishing in the road transport sector especially since the market share of newly bought electric cars exceeded 30% in 2022 (See Figure 11). Therefore, it is chosen that the policy and innovation developments still form a part of the niche level at this phase while the technical outputs of these developments (i.e., number of electric cars and the number of charging infrastrucutre) will form a part of the regime level.

In the following sections, the three phases are explained for each of the landscape, regime and niche level.



Landscape Level
Regime Level
Niche Level
Rising concerns over air quality
1990 Zero-emission mandate by California Air resource Board (CARB)
1993 Clinton administration announced the 'Partnership for a New Generation of Vehicles'
1991 Sony launched the first commercial Li-ion batteries
1996 General Motors started producing EV1 as lease cars
Charging difficulties
Limited car range
Low battery efficiency
Emergence of Li-ion battery application in multiple sectors
1997 Toyota released in Japan the world's first mass produced hybrid electric car
2003 California mandate was loosend
Rising concerns over climate change
Reducing oil dependency
2004 The last EV1 were taken from leaseholders and destroyed or donated
2009 First mandatory CO_2 emission reduction program by EU for new passenger cars
2003 Tesla Motors was founded
2008 Tesla released Roadster, the first production vehicle to use Li-ion battery cells
2008 EU Air Quality Directive limiting the NOx emissions
Decrease in battery prices
2020 Covid-19 pandemic changing travel behaviour and perceptions
2022 War starts between Russia and Ukraine
2014 Most major vehicle manufacturers have a commercially available all-electric vehicle in their assortment
2019 EU adopts another CO_2 emission target for passenger cars
2022 Increase in oil prices
2022 Increase in battery raw material prices
2015 Paris Climate Agreement
2019 The European Green Deal
Growing number of ICE passenger cars
Few to none EV models
Growing infrastructure including road network
Parallel improvements in ICE technology reached its peak
Long recharging durations
Few charging stations
High purchase cost of EVs
Concerns over real impact of EVs
Lack of fun driving an EV
Lack of EV model choices
Immaturity of the technology
Power grid is loaded already overloaded
Dutch Consumers now have a multitude of choices for EVs
2022 The percentage of EVs reached almost 30% of the new passenger car sales
2022 Number of regular chargers is 88,000 and number of fast chargers is 3000
Emergence of modern renewables NL
Money got reserved by big municipalities to combat air pollution
2008 Incremental tax rate got reduced for environmentally friendly company cars
2009 Action Plan sumitted by Minister IenW to the parliment
2011 Publicly Accessible Electric Charging Infrastructure Green Deal
2006 Tax on Passenger Cars and Motorcycles became dependent on CO_2 emissions
2008 Other special tax rules for electric and hybrid cars became effective
2010 Formula E-team becomes operational
2011 Action Plan 2011-2015
2011 Electric Driving Green Deal
2004 Hybrid cars became commercially available in NL
2009 AutoRai was held with several events highlighting electric cars
2010 One type pf charging pass can be used at all charging station in the Netherlands
2005 C,mm,n partnership was launched between Nature and Environment and the three technical universities
2009 Grid managers establish Elaad, a knowlegde and innovation centre for charging infrastrucutre
2010 First public fast-charging point opens by Epyon start-up
New electric cars were arriving to the Netherlands
2019 All new passenger cars must be zero-emission by 2030 (National Climate Agreement)
2020 Ministry IenW collborated with 6 areas and grid operators to add more charging stations
2012 Project A15 is launched, a large scale introductory campaign
2019 Part of the climate agreement is the national charging infrastructure agenda
A number of policy incentives for the purchase or lease of an electric car
2013 Tesla established a European headquarter in Amsterdam and started selling model S
2016 Green Deal Electric Transport 2016- 2020
2013 Fastned starts rolling out their charging stations with ABB
2013 Last year that electric lease cars could still make use of the 0% incremental tax rate (bijtelling)
Phase 1: Emergence 1990 - 2000
Phase 2: Diffusion 2001 - 2011
Phase 3: Establishment 2012-2022

Figure 13 MLP analysis for the Dutch Transition to electric passenger cars between 1990 and 2022 Source: own compilation

Note 1: The yellow boxes indicate system factors that are not bound to a certain temporal event. That is to say they refer to factors that span over a number of years across a phase.

5.1 Emergence Phase (1990-2000)

5.1.1 Landscape Phase 1

According to Høyer (2008), the 1990s are considered the most intensive period in relation to both electric and hybrid car research and development. All of the world's leading automobile manufacturers have embarked on massive development programs. New efforts were made to develop more energy-efficient batteries as well as worldwide R&D conferences were held devoted entirely to electric vehicles (Høyer, 2008). The origin of the re-emergence of electric cars can be traced back to the air pollution problem that had risen back to the agenda in the United States by the end of the 1980s (Collantes & Sperling, 2008). The government and industry believed that mainstream technologies could not by themselves solve the problem, leading to a rising sense of urgency that drastic steps would be needed. It was in this context that the California Air Resources Board (CARB) imposed the Zero Emission Vehicle mandate in 1990 obliging major car manufacturers to build and sell zero-emission vehicles if they wanted to stay in business in the state (Collantes & Sperling, 2008). This mandate is arguably one of the most daring air quality policy that were ever adopted as it was often credited for launching a revolution in clean automotive technology (Collantes & Sperling, 2008).

Following the CARB mandate, the Clinton administration launched the 'Partnership for a New Generation of Automobiles' project in 1993, with the goal of encouraging the development of low-emission vehicles (Sperling, 2001). Notably, these policies prompted GM to produce the EV1 which was the first mass produced electric car (Top Gear, 2021). Between 1996 and 1999, over 1,000 General Motors EV1s were made available through a leasing programme in several US cities (Yu et al., 2011).

Besides the all-electric cars, this period was also important for the rise of gasoline-electric hybrid vehicles. In the early days the hybrid cars were produced to combat the limitations experienced by electric cars; limited range, low battery efficiency and charging difficulties (Høyer, 2008). A hybrid electric vehicle represents a combination of advantages of both types of vehicles as it is a mixture between a conventional vehicle with a thermal engine and an electric motor reducing the drawbacks (Fileru, 2015). A successful pioneer in the hybrid vehicle world was Toyota. In 1997, Toyota released the first hybrid Prius in Japan and three years later, the car model became available on the American market as well (Høyer, 2008). Thereafter Toyota quickly got promoted to the top of the hybrid vehicle producers, while the Prius successfully accomplished its mission to “open the road” for other hybrid vehicles (Fileru, 2015).

Simultaneous to the progress happening in the electric cars industry, batteries were also undergoing major developments. In 1991, Sony launched the first commercial Li-ion batteries (Ruiz et al., 2018). The energy density, safety, recharge time, cost, weight, and other aspects of the technology made Li-ion batteries the more sought-after alternative to nickel-metal batteries (Placek, 2022). Since its launch, Li-ion has emerged as the dominant energy storage technology used in most consumer electronics such as cell phones and laptops (Ritchie, 2021). It is believed that the advancements that the battery technology underwent were a contributing factor for increasing the level of optimism regarding electric cars. Several respondents highlighted the effect that the developments of battery technology in multiple sectors had on the general belief in electric mobility . For instance, Respondent 2 working at the mobility Nature and Environment organisation stated:

> "Back then everyone had a Nokia and they were the Tesla's, so to speak, in the mobile industry. And what you saw of that is how fast they became, until within ten years to a smartphone with a big battery. So, if you can go that fast, then that's actually been the preliminary phase and the opening to also develop the battery for the car."

5.1.2 Regime Phase 1

While California was trying to stimulate zero-emission cars through its policy mandates, the number of conventional ICE cars was growing steadily in the Netherlands. In 1990, the number of cars surpassed 5 million and 9 years later it increased to 6 million. By 2000, the number of passenger cars reached 400 per thousand inhabitants (CBS, 2019). The increase in the number of cars can be explained by the growth in real incomes as well as the direct effects of suburbanisation causing people to travel further away to reach their work locations. Moreover, already in the early 1950s, the car was a desirable product that offered an unprecedented increase in freedom, which made it worth sacrificing some spending patterns to afford a car (CBS, 2019).

The increase in the number of cars was accompanied by large investments spent on developing the road network. During the 1990s, the economic importance of infrastructures rose on the political agenda and the transport lobby gave infrastructures positive symbolic meanings with metaphors such as "Netherlands Distribution Country" (Geels, 2007). Moreover, Geels (2007) explained that during the 1990s, also high investments in public transport took place. The investments rose from 300 million guilders (140 million euro) in 1986 to 2.25 billion guilders (1 billion euro) in 1997. However, despite the high investment in public transport, there was no modal shift from cars to public transport. In fact, the number of road vehicles continued increasing while the number of traffic jams escalated on the Dutch roads (Geels, 2007). Hence, the ambitions to slow down car diffusion and facilitate a modal shift were abandoned and in the National Traffic and Transport Plan (2000), a new principle was proclaimed: "Car driving is OK!" So, public transport was no longer seen as a substitute for the car (Geels, 2007).

5.1.3 Niche Phase 1

Information from the documents analysed and the interviews conducted all revealed only EV niche developments as per the early 2000s in the Netherlands. A possible explanation for the lack of data would be that there were no significant developments happening at the niche level in the Netherlands. This in return could be related to the fact that the regime at that time, as explained in Section 5.1.2, was heavily dependent on the ICE cars. Moreover, there were no incentives at that time to develop the technology as the climate change and air pollution did not yet gain momentum in the Netherlands.

5. 2 Diffusion Phase (2001 -2011)

5.2.1 Landscape Phase 2

Despite the progress done during the 1990s, electric cars were soon proven to be large, both technologically and economically, oversold. Before the turn of the century, the hopes, visions and interests of car manufacturers had faded out as the setbacks were many (Høyer, 2008). Generally speaking, the mobility sector was heavily relying on and dominated by the fossil fuel industry. The vested interest of the fossil fuel companies exerted influence on the car companies to stop the production of EVs (Steen et al., 2011). This led the CARB mandate to be loosened in 2003 (California Air Resources Board, n.d.). Consequently, motivation by car manufacturers to pursue all-electric vehicles declined. General Motors discontinued leasing plans for its electric vehicles, claiming that its continuation would be unprofitable (Yu et al., 2011). In 2004, the last of the EV1s were taken back from leaseholders and destroyed or donated (Shahan, 2016). This was an unexpected move from General Motors which had been documented in the "Who Killed the Electric Car?" documentary in 2006. The documentary explored the creation, limited commercialization and subsequent destruction of the battery electric vehicle in the United States, and specifically the General Motors EV1 as well as the disappointment of the leaseholders for the forceful withdrawal of their electric cars (Paine, 2006).

However, things quickly changed. The discontinuation of General Motors inspired a new Silicon Valley startup, Tesla Motors, to enter the market. Tesla Motors was founded in 2003 and in 2008 it launched its all-electric Roadster sports car. In 2017 Elon Musk, the CEO of Tesla Motors (nowadays named Tesla), made it clear that Tesla Motors was inspired by the drawback of General Motors. He wrote on his Twitter account: "Few people know that we started Tesla when GM forcibly recalled all electric cars from customers in 2003 & then crushed them in a junkyard" (Musk, 2017).

The Roadster was the first electric vehicle to use a Li-ion battery pack, as well as the first to have a range of over 320 kilometres on a single charge (Rajashekara, 2013). The car was successful for Tesla because it achieved its main objectives; it changed people's perception of what electric cars can be and catapulted the EV to exotic supercar status (Fileru, 2015). Besides the fun that came along with riding the Roadster, the car made a statement about the feasibility of using Li-ion batteries in cars. According to Robert Lutz, the CEO of General Motors, the announcement of the Tesla Roadster flipped a switch that renewed serious interest in electric vehicles. He has been quoted saying "All the geniuses here at General Motors kept saying Li-ion technology is ten years away, and Toyota agrees with us, and, boom, along comes Tesla (van der Zee, 2020). A few years later, Li-ion batteries were used to power several electric vehicles available on the market, e.g. BMWi3, Tesla Model S, Nissan Leaf, Mitsubishi iMiEV, Chevrolet Volt, Renault Zoe (Ruiz et al., 2018).

While the development of electric cars was in progress, the EU was also working on stimulating the production of electric cars to reduce air pollution among its member countries. In 2008 EU Air Quality Directive was issued to tighten NOx emissions. As a result, cities (i.e., the prime centres of air pollution, and threatened with EU fines if they do not improve) were taking steps to promote electric mobility (McKinsey & Company, 2014). Besides air pollution, concerns relating to climate change were also rising to the political agenda. In the EU performance criteria for new cars were introduced in 2009 to reduce CO_2 emissions in the road transport sector. The regulation set a fleet-wide target of 130 g CO_2/km for the period 2015-2019 and 95 g CO_2/km for the period 2020-2024, as well as particular CO_2 emission objectives for each manufacturer (or pool of manufacturers) (European Environment Agency, 2021). These tightening regulations were pressuring Original Equipment Manufacturers (OEMs) to reduce their fleet emissions– which was challenging with ICE optimization alone and required some form of electrification (McKinsey & Company, 2014).

Another incentive for the EV growth in European countries is reducing dependence on foreign oil. According to Steen et al. (2011), current reliance on foreign oil necessitates significant capital investments in nations and regimes with which Western economies may find themselves at odd. It exposes the government to political vulnerability for oil pricing and boycotts. Furthermore, the capital that goes from the West to oil-producing countries, returns back as investments in enterprises and real estate in the West. This is how capital, fueled mostly by oil reliance, is gradually shifting the structural balance of global relations. Thus the West is not just reliant on foreign oil, but also on a far larger and deeper level (Steen et al., 2011). Reducing such dependency created another driving factor for governments with major OEMs to start stimulating development of EV technology with the aim to pioneer the technology and keep the value chain in the country (McKinsey & Company, 2014).

5.2.2 Regime Phase 2

Despite the progress at the landscape level, the ICEs, during this phase, were still enjoying the monopoly as the power source for road transport vehicles. As shown in Figure 14, the fuel market in the Netherlands share during this phase was dominated by petrol and diesel (Vedder, 2011). Many developments in the ICEs and their fuels were happening in parallel to the developments of electric cars. However, it was during this phase, that the ICEs reached their mature levels that any further development to increase engine efficiency and minimize the emissions was expected to be very little if ever possible (Soylu, 2011). Any improvements would either increase the cost to uncompetitive levels or bring additional environmental problems when considering the life cycle of the engines and fuels. This made the adoption of electric vehicles a more promising alternative to remedy the road transport externalities.

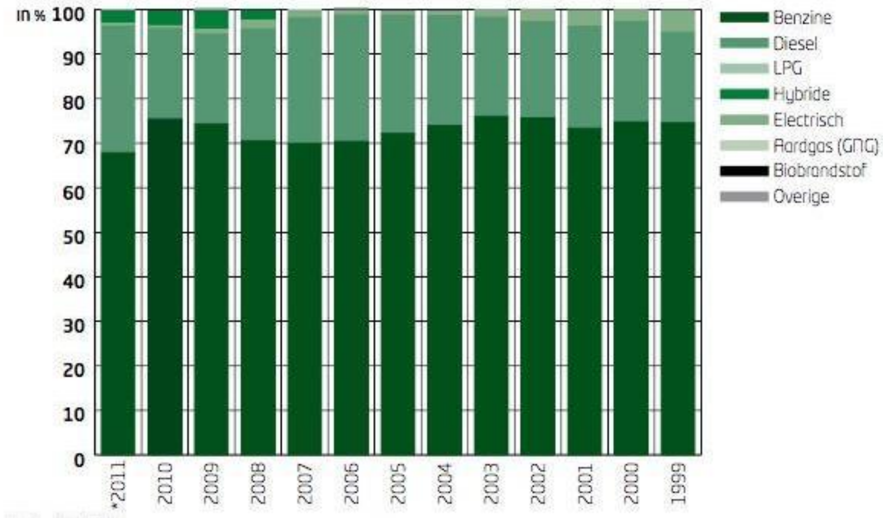


Figure 14 *Share of fuels in new sales (Vedder, 2011)*

Dutch/ English translation: Benzine= Petrol; Diesel= Diesel; LPG=LPG; Hybride= Hybrid; Elektrisch= Electric; Aardgas=Natural Gas; Biobrandstof=Biofuel; Overige= Others

Nevertheless, the adoption of electric cars during this phase still faced multiple barriers related to the regime structure. As shown in Figure15 below, these barriers can be clustered into three categories: i.e, technical, economic and social barriers.

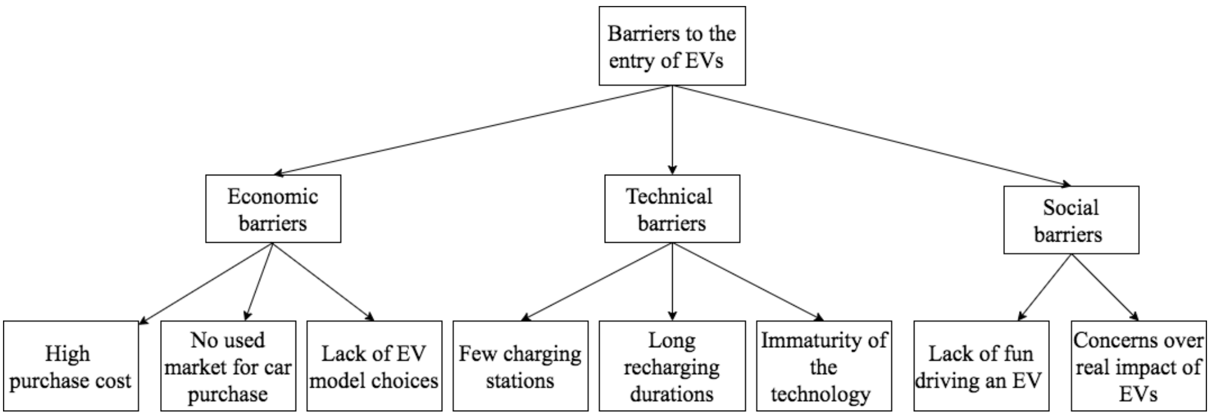


Figure 15 *Barriers to the entry of an EV. Source: own compilation*

According to several of the interview respondents, one of the most important barriers to the adoption of EVs is the purchase price which was -and still is- much higher than for the conventional ICE cars. To buy vehicles at a lower price, it is common amongst people to approach the used market Krishna (2021). However, during the early 2000s used electric vehicles were either scarce in the used market or still expensive compared to a used ICE vehicle. On the contrary, the conventional car (ICE) market consisted of multiple "segments" of products to cater to different audiences. Moreover, the market was still infant and people found a void in the choice of electric vehicles in the market and expected a wider variety of offerings. Electric vehicle model choice would help in expanding the market share (i.e., higher adoption) (Krishna, 2021).

As for the technical barriers, compared to the conventional ICE vehicles, electric cars lacked a refuelling infrastructure and a distribution and service network. To frame the problems using the language of potential market failure, introducing an electric vehicle meant facing network externalities such as the need for new charging stations compared with the fueling stations that ICE vehicles already have (Vijayashankar, 2017). The lack of charging stations increases the anxiety that drivers get for fearing a battery depletion before the destination or a suitable charging point is reached, also known as range anxiety.

In addition to the lack of charging stations, charging an electric car took much more time than people were used to when refuelling a car. According to Krishna (2021), people usually think that the ideal charging time would be under five minutes. Range and recharge duration seesaws, bigger batteries take a longer time to recharge while smaller batteries have a lower range. This problem however can be solved with fast chargers (Krishna, 2021). However, it was not until 2013 that Fastned started working on a nationwide network of fast charging stations along the Dutch road network (Lubbers, 2014). Another technical barrier during this phase was that the technology was still in its primary stage of development (Krishna, 2021). Thus, people were reluctant to adapt to a technology that needed improvement. They did not want to be the "guinea pigs" of this technology. The technology required further innovation and development to inspire confidence as an alternative to conventional ICE technology.

Last but not least, there were also societal challenges for the entry of EVs. Due to the lack of research, people in the earlier days believed that the technology is not as environmentally friendly as claimed (Krishna, 2021). One of the main reasons for this belief is that mining is required for the production of batteries and other associated components which in return include emitting CO_2. In order to clear the misconceptions several research institutes proved this wrong. For instance, Milieu Centraal (n.d-a.) showed that an electric car emits 60% less CO_2 over its entire life than a car with an exhaust. This calcualtion is done for the production (including battery for EV), maintenance and the (future) use the car. The use is based on a new middle class car that drives 12,000 kilometers per year for more than 18 years (Milieu Centraal, n.d.-a).

Furthermore, the association of the electric car with environmental goals formed an extra barrier or the EV adoption. The design of a car is of high importance in the car industry and could act as a significant factor for the consumers' acceptance. Initially electric cars lacked an attractive design and were considered boring. According to Respondent 10, it wasn't until Tesla introduced the Roadster that people knew that electric cars could be fun and appealing.

In conclusion, the favourable experience that the drivers had with the ICE cars formed high barriers for the entry of EVs. These barriers created extra challenges for the developments that were happening at the niche and landscape level to form the window of opportunity for electric cars to get established in the Dutch regime.

5.2.3 Niche Phase 2

Niche Innovations

Many of the developments happening at the national landscape level are somehow related to events happening at the niche level. For instance, a big success was the introduction of the second generation of the Toyota Prius which became commercially available in the Netherlands in 2004 (NU.nl, 2018). On another note, in 2008, the environmental organisation Nature and Environment (Natuur en Milieu) started lobbying for stimulating electric driving. In 2005 it even initiated the "C,mm,n" partnership with the three technical universities of Eindhoven, Twente and Delft to build a prototype electric car (Jansen, 2009). The car was then presented at the International Motorshow in Amsterdam known as AutoRai in 2009. This motor show was an important event for initiating the work towards electric driving. During the event, the "C,mm,n" car was visited by 220,00 including prime-minister Balkenende and minister Eurlings of Traffic and Water Management (today known as Infrastructure and Water Management- Ministry IenW) (Jansen, 2009). During the AutoRai event in 2009, Nature and Environment also presented an action plan that laid out the way to rolling out electric cars in the Netherlands (Natuur en Milieu, 2009). In the action plan, the first step that the NGO advised is to set-up the Formula E-team. One year later the government made the team operational. According to Respondent 3, serious work towards stimulating electric driving in the Netherlands started due to this action plan.

At the same motor show of 2009, the two ministers, Balkenende and Eurlings drove an electric race car that belonged to the environmental entrepreneur "Ruud Koornstra", who was Respondent 8 in the interviews. The race car was made in the backyard of Willem van der Kooi. He basically converted the engine of a Lotus into an electric motor, just like how the Roadster of Tesla was built. The actual ride of the two ministers sparked the interest in stimulating electric riding. It was at that moment that government representatives knew that electric driving was possible and not a futuristic plan. According to Respondent 8, the personal interest of the two ministers in the automotive industry played a role in stimulating electric cars. The race car was then driven by several chauffeurs of the ministers as a way to convince and have influence on their bosses.

In 2009 the grid managers also established Elaad, a knowledge and innovation centre for charging infrastructure. The Elaad soon worked on interoperability or in other words "a one type charging pass" that can be used at all charging stations. This was an important milestone as it offered EV drivers the possibility to use any charging station across the Netherlands to charge their car. In 2010, the first public fast charging point (DC charging point) was opened by startup Epyon. The startup was soon acquired by ABB, a leading global technology company that works on the transformation of society and industry using technology (ABB, 2019), to roll out the supply of fast chargers (Lubbers, 2014; Respondent 3). This was also quite important for the uptake of EVs in the Netherlands, Respondent 10 highlighted this when asked why the Netherlands is doing well in the transition to electric cars. She said:

> "I think that we had the eye for charging infrastructure from the start and also the understanding that to make this market successful, that it had to be an open market for everybody. So that right from the start, interoperability was established in the Netherlands with all the different companies sitting together to make sure that for all the consumers it would be seamless. And we are still the only country in the world where this is happening because other countries have some close networks, several close networks just alongside the country. How strange it is still to be the only country where companies also saw that this is needed to make a transition happen."

National Government Policies

According to several respondents, the niche in the Netherlands started stimulating electric cars in the early 2000s due to the rising air pollution problems in the large-sized cities. The first charging stations were built in the cities by the money reserved by municipalities to combat air pollution (Respondent 1, Respondet 2, and Respondent 3). Simultaneously hybrid cars were also slowly entering the Dutch market.

The government started stimulating electric cars with tax reductions in 2006. Starting 2006, the tax on Passenger Cars and Motorcycles became increasingly dependent on the CO_2 emissions of the car (Compendium voor de Leefomgeving, 2019). However, the real breakthrough was in 2008 when the government adopted a reduction in the incremental tax rate (bijtelling) from 25% to 14% for company cars that were environmentally friendly (Nu.nl, 2018). This reduction caused a sudden increase in the number of hybrid company cars registered as it increased from 3,500 to more than 12,000 in 2009 (CBS, 2009). Moreover, special tax rules also came into effect in 2008 (International Energy Agency, 2009). Hybrid vehicles have qualified for a substantial bonus/tax reduction as high as € 6,400 while conventional cars that are very energy efficient also earned a tax reduction, depending on their fuel efficiency. Also since the same date, less fuel-efficient vehicles are subject to an extra tax that can be as high as € 1,600 (International Energy Agency, 2009).

In 2009, the ministry of Traffic and Water Management, submitted the first action plan relating to stimulating electric cars to the parliament. Based on this action plan the Dutch government reserved €65 million to make the Netherlands the main test ground for e-mobility and urged forming Formula E-Team, a national private-public platform for e-mobility (RVO, 2018). In 2010, the Formula E-team was operational in the form of a partnership between business, knowledge, NGOs, and government players. The team had Prince Maurits as a chair and Ruud Kroonstra as the vice-president. The royal figure that the Formula E-team had gave the impression that the Netherlands was taking electric driving seriously (RVO, 2018).

Afterwards, the Formula E-team contributed to the governmental action plans such as the action plan “E-mobility Gets Up to Speed- Action Plan 2011-2015”. This action plan laid out the actions needed to help citizens, businesses and government bodies accelerate electric driving by removing obstacles, providing full information and creating partnerships (RVO, 2011). After this action plan, several agreements between the Dutch government and the sector players, in the form of Green Deals, followed to realize the ambitions related to e-mobility (Deuten et al., 2020). Green Deals form an accessible way for the central government to work with organizations, local and regional governments and interest groups on green growth and social issues (Green Deal, n.d.). For instance, work has been carried out on the electrification of transport through the “Electric Driving Green Deal” (Green Deals, 2011a). Moreover, thousands of charging stations were being rolled out in public spaces through the “Publicly Accessible Electric Charging Infrastructure Green Deal” (Green Deal, 2011b).

On another note, renewable energy sources were also emerging at the niche level during this phase. At the end of the 20th century, the Netherlands started to transition to a low-carbon economy, causing a revival of renewable energy sources such as wind and solar energy (de Jong & Stremke, 2020). Several respondents referred to this parallel evolution of electric mobility and renewable energy sources as an extra motive for accepting the adoption of EVs.

5.3 Establishment Phase (2012-2022)

5.3.1 Landscape Phase 3

Despite the challenges, most major vehicle manufacturers had a commercially available all-electric vehicle in their assortment by 2014. Prominent vehicles include the Tesla Model S, Nissan Leaf, Renault Zoe, Ford Focus Electric, Volkswagen e-Golf, BMW i3 and Mitsubishi i-MiEV. Additionally, multiple plug-in hybrids have been released (Energy.gov, 2014).

The EU also continued stimulating electric driving through different targets. In 2014, a second CO_2 emission target was adopted by the EU. The target entailed that the 95 g CO_2/km must be met by each manufacturer by 2021. A few years later, namely in 2019, a third set of CO_2 emission targets were set. The targets included a 15% CO_2 emission reduction by 2025 and 37.5% by 2030.

Internationally, climate change was also gaining attention. In 2015 196 parties signed a legally binding agreement in Paris to combat climate change. This agreement is called the Paris Agreement and its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (United Nations, n.d.). Implementing the goals of the agreement requires economic and social transformation, based on the best available science. The agreement is a turning point in the multilateral efforts to combat climate change because it is the first legally binding agreement that brings all nations together to fight climate change and adapt to its repercussions (United Nations, n.d.).

The EU internally also agreed on a Green Deal in 2019 which became the EU's main new growth strategy to transition to a sustainable economic model. The Green Deal aims to make the EU the first climate-neutral continent by 2050, resulting in a cleaner environment, more affordable energy, smarter transportation, new jobs, and a higher overall quality of life. (Norton Rose Fulbright, 2021). As transport emissions represent around 25% of the EU's total greenhouse gas emissions, the goal of being the first climate-neutral continent by 2050 requires ambitious changes in transport. Therefore it is agreed that transport-related greenhouse gas emissions need to be reduced by 90% by 2050 (European Commission, n.d.). More specifically, by 2030 there should be at least 30 million zero-emissions cars according to the sustainable and smart mobility strategy of the Green Deal (European Commission, 2020).

Besides policy stimulants, the decrease in battery prices also played a major role in increasing the adoption rate of electric vehicles. This decrease has a direct effect on the total purchase price of an EV since a study by Ricardo-AEA (2015) proved that the battery pack determines about 75% of BEV powertrain cost (Wolfram & Lutsey, 2016). As shown in Figure 16, in the last three decades, the cost of Li-ion battery cells has dropped by 97%. In 1991, a one-kilowatt-hour battery cost $7500, while in 2018, it only cost $181. That's a 41-fold reduction (Ritchie, 2021). Putting the price decline into perspective; the 40kWh battery of a Nissan Leaf electric cost in 2018 around $7,300. Buying the same model in 1991, the battery alone would cost $300,000. Similarly, the 75 kWh battery of the Tesla Model S 75D cost in 2018 $13,600, while in 1991 it would have been $564,000. These price reductions are the result of innovations in the production of these batteries that make it possible to produce them at lower costs. As production increases there are more opportunities and incentives to achieve such innovations. That is why prices often fall when technologies begin to scale (Ritchie, 2021).

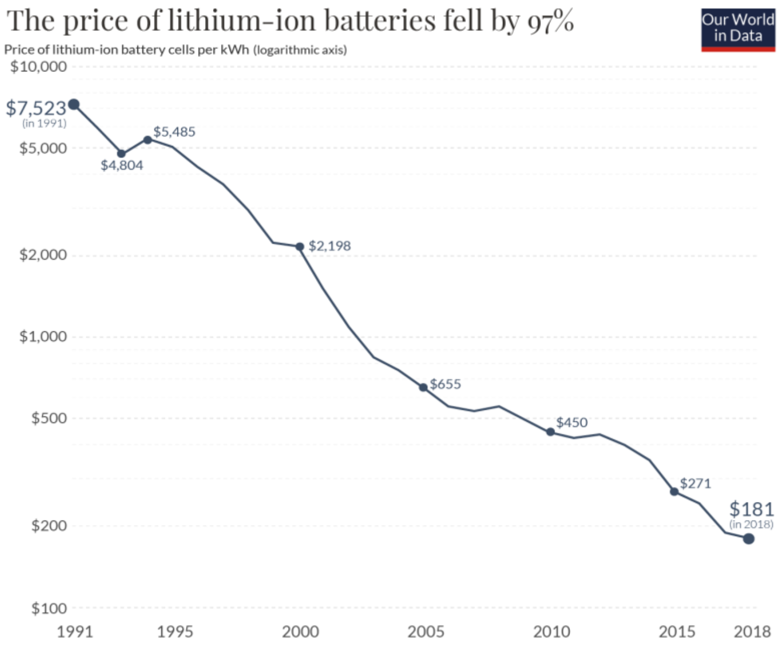


Figure 16 *Price of Li-ion batteries between 1991-2018 (Ritchie, 2021)*

Furthermore, the COVID-19 pandemic formed a new additional catalyst for the adoption of EVs. According to Gorner & Paoli (2021), the story of worldwide electric vehicle sales in 2020 is a two-act play. Over the first half of 2020, lockdown measures paralyzed manufacturing facilities and supply chains on the one hand, and consumer demand on the other. Global electric car sales were on average 15% lower than over the same period in 2019. However, Europe was a notable exception where electric car sales were 55% higher mainly due to the fact that 2020 was an important target year for emissions standards. During the second half of the year, lockdowns were lifted or relaxed for some time, and the automotive market started to recover. For electric cars, monthly sales surpassed those between July and December in 2019 in every month in all large markets including the EU (Gorner & Paoli, 2021).
Additionally, according to the EY Mobility Lens Consumer Index, some of the biggest shifts were seen globally in both buying intentions and motivations among consumers after the pandemic. After the pandemic and for the first time, environmental concerns topped the list of reasons for considering an EV across all age groups. With millions of home workers spending more time in their local surroundings and enjoying the pleasures of cleaner air and reduced pollution levels, the pandemic has cemented attitudes toward the environment. COVID-19 has raised overall levels of concern – 78% of potential non-ICE car purchasers feel it has raised their environmental knowledge — and, more importantly, these worries are now reflected in plans to acquire more sustainable vehicles (Miller et al., 2021).
After the pandemic, a new geo-politcal event unravelled in 2022: Russia invaded Ukraine. This global event also had its repercussions on the adoption of EVs worldwide. However, its repercussions were rather complicated and its direct effect on the sales of EVs are yet to be discovered. On the one hand, oil prices spiked to the highest level since 2008 (Jin, 2022). Increase in oil prices in the past had little effect on EV purchases, but this time it is different. There are more electric vehicle models on the market now, and the market has progressed past the point where only the wealthiest purchasers could afford one (McKerracher, 2022). Although not everyone can make the move right away, it is generally believed that the increase in oil prices will affect the number of sales of EVs.

On the other hand, the war also caused an increase in the prices for nickel and other battery metals (Jin, 2022). This will buck the trend of decades of falling prices, and likely push EV price parity with combustion vehicles back by a couple years. Internal combustion vehicles do not escape this unscathed either. The cost of platinum and palladium used in catalytic converters also have risen recently, and aluminium prices are near record highs (McKerracher, 2022). Thus it could be concluded that the different effects that this war has had on the prices of different raw materials makes it hard to predict what the exact consequences will be on the adoption of EVs. Nevertheless, McKerracher (2022), claims that there will be probably a net positive EV share of car sales globally in percentage terms, but not necessarily in unit sales terms.

5.3.2. Regime Phase 3

As a consequence of all the efforts emerging from the niche level and the changing factors happening at the landscape, the barriers to the entry of electric cars into the regime is starting to slowly break down. This led to having the past ten years resemble the relative establishment phase of the EVs in the Dutch regime. Thus at this stage the electric cars were no longer part of the niche but an established vehicle within the Dutch mobility sector. This is proven by the maret share of EVs that has exceeded 30% in June 2022.

This establishment changed the structure of the regime in terms of cars driven on the Dutch roads. In 2020, for every five new cars being sold, at least 1 BEVs was being sold resulting in a market share of 20.5% in 2020 (RVO, 2021a). In 2021, the Netherlands became among the top five countries that are making progress in the transition, surpassed by Norway, China, Germany and Sweden (The rEV Index, 2021).

Today, and despite the economic stagnation caused by the COVID-19 pandemic, there are around 268,000 BEVs and 153,000 PHEVs on the Dutch roads with a market share of EVs as a percentage of new passenger car sales 17% and 13 % respectively (RVO, 2022). It is worth noting that the FCEV cars were almost insignificant on the Dutch roads due to the immaturity of the FCEV technology. Moreover, today there is a variety of electric cars driving on the Dutch roads while the most common registered BEV and PHEV passenger cars in the Netherlands as of 30 April 2022 were the Tesla Model 3 and the Mitsubishi Outlander respectively (RVO, 2022).

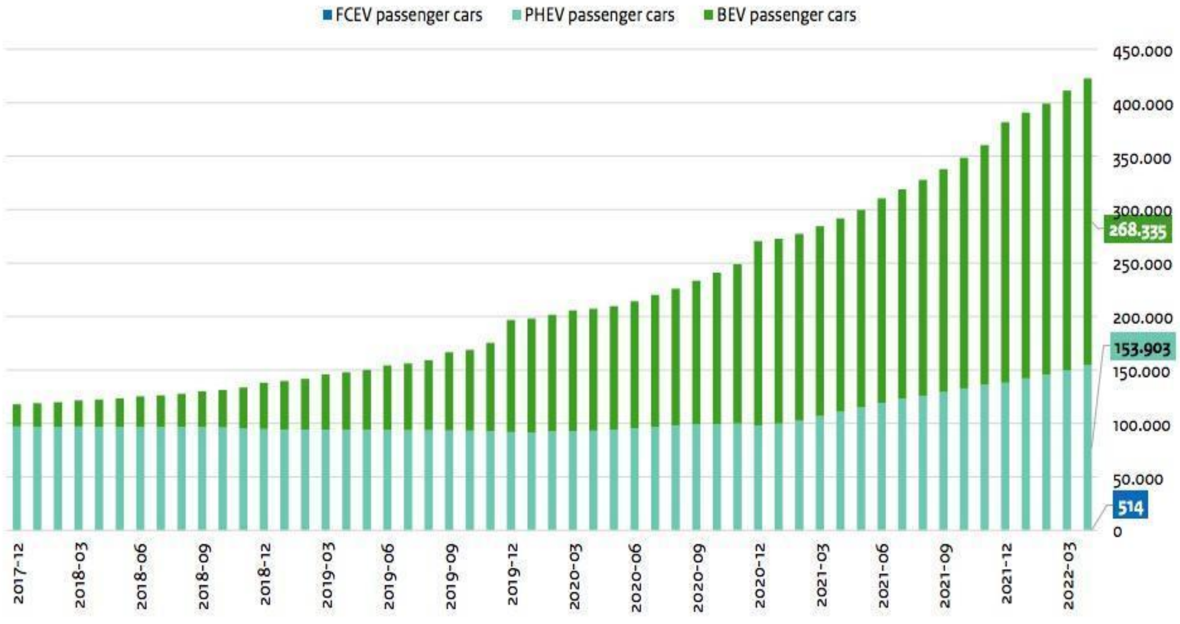


Figure 17 *Number of electric passenger cars in the Netherlands from 2017 to 2022 by type (RVO, 2022)*

As a matter of course, an increase in the number of EVs is also associated with a change in the infrastructure in order to facilitate the charging of these cars. In 2018, the Netherlands owned 28% of the total charging stations in Europe while accounting for only around 1% of the total land area of the continent (KPMG, 2019). In 2021, the Netherlands had the highest number of public chargers in Europe per km with around 50 charger points for every 100 kilometres of the road (ACEA, 2021). However, nearly 98% of these chargers are slow-speed, requiring EVs to be parked for long periods of time (Economist Impact, 2021).

As shown in Figure 18, the charging stations are mostly public and semi-public. Today, there are around 88,000 regular public and semi-public points and 3000 fast-charging points across the Netherlands (RVO, 2022). Moreover, it is estimated that there are an additional 232,000 private charging points in the Netherlands in 2022 (RVO, 2022). Additionally, the Netherlands has the highest number of connectors, per capita, with around 5000 connectors per one million inhabitants (Eco-Movement B.V., 2022).

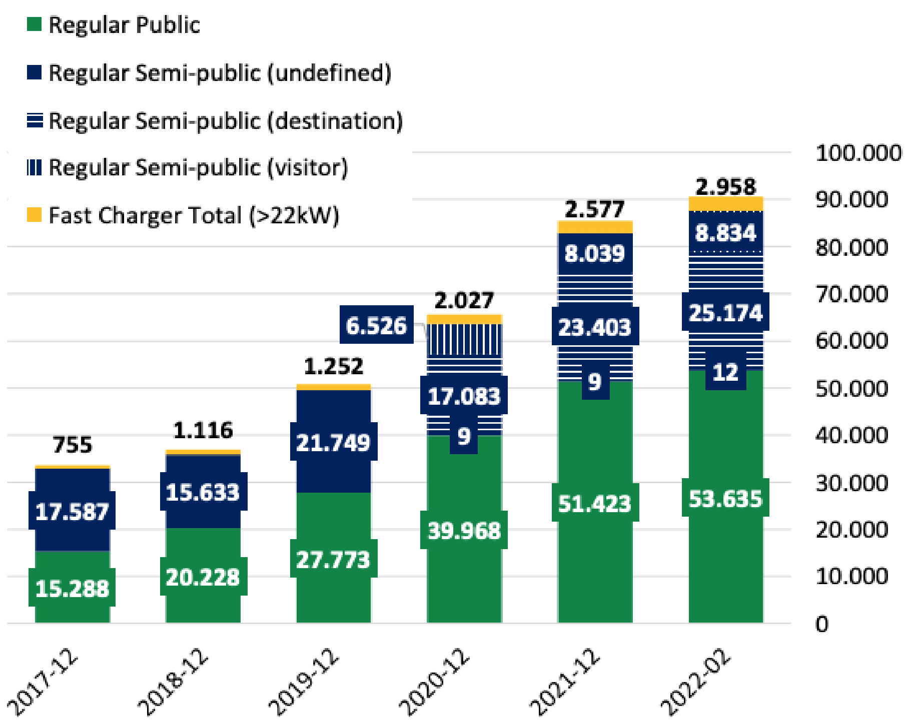


Figure 18 *Number of charging points in the Netherlands (RVO, 2022)*

However, it is important to note that one of the respondents (Respondent 10) highlighted an important challenge that is currently being faced which might cause a serious threat to the further establishment of the EVs. He noted that the power grids are already strained while the increased adoption of EVs adds further electricity load, potentially requiring new investment in grid infrastructure to meet this increased demand. Forecasting when and where this power is needed is a further challenge faced by utilities and power generators as the EV market is rapidly growing.

5.3.3 Niche Phase 3

Niche Innovations

In 2013, Tesla established a European headquarter in Amsterdam and started selling its Model S, an all-electric car. Despite the low number of EVs on the roads, Fastned already started working on building a nation-wide netwok for fast charges in 2013. This was a personal decision of two entrepreneurs, Bart Lubbers and Michiel Langezaal. While many industry players were asking the chicken and egg question, "Should electric cars be stimulated first or should the charging infrastructure be first set", Bart Lubbers and Michiel Langezaal just skipped this question and founded Fastned to start the roll-out for charging stations across the Netherlands (Lubbers, 2014). Since the launch of the first pilot project there was a close relationship between ABB, the company that was offering the fast chargers (ABB, 2019). The importance of establishing charging points for the adoption of EVs was also highlighted by Respondent 11 who said:

> "The fact that we have always stressed the importance of charging infrastructure has been important for the uptake of electric cars. In many countries, especially in the beginning there was like a chicken and egg question, what do you do? First, you make sure that there are electric cars or do you make sure there are charging points? And we just skip this discussion by just constructing a charging infrastructure."

National Government Policies

Besides the niche innovations, the Dutch government was also still helping stimulate electric driving during this phase. Until the end of 2013, cars given by companies to employees for personal use were excluded from the tax ordinarily imposed on such vehicles if they emit less than 50 g/km CO_2. However, by the end of the year, the tax break expired which sparked a surge in electric vehicle sales towards the end of 2013, followed by a sharp drop at the start of 2014. Low-emission vehicles are nonetheless taxed at reduced rates (4% or 7%), compared to other company cars (14% to 25%), offering some budgetary incentive (Yang, 2014). In the following years, the government continued stimulating electric cars through different policy papers as for instance the "Electric Transport Green Deal 2016-2020" which had the ambition of having 10% of all newly sold electric cars to be electric (Green Deal, 2015).

Additionally, the Paris Climate Agreement of 2015 greatly increased the political urgency of dealing with climate change which in the Netherlands has been reflected in the 2019 National Climate Agreement. The agreement strives for having all new cars sold to be zero-emission vehicles by 2030 latest (RVO, 2020). Based on these targets, the Dutch Environmental Assessment Agency concluded that this transition would require strong political will at the national level, by means of financial incentives for users (Planbureau voor de Leefomgeving, 2017). Consequently, today there are a number of policy incentives for the purchase or lease of an electric car which are explained in the following chapter of the MSF.

Moreover, part of the National Climate Agreement was the National Charging Infrastructure Agenda. The latter is a widely endorsed multi-year policy agenda containing aims and measures for developing a charging infrastructure network in the Netherlands. As the worlds of mobility and energy become increasingly complex and intertwined, the Agenda focuses on developing an integrated method to meet future charging demands (RVO, 2020).

In the light of achieving the governmental ambitions for the charging infrastructure, the Ministry of Infrastructure and Water Management stated in July 2020 that it was collaborating with six areas and the grid operators to swiftly and strategically add more charge stations around the Netherlands. The development of a nationwide, dependable, and future-proof network of charging stations is being advanced through this collaboration. To assist the regions in establishing a national network, the national government has allocated 15 million euros that will be allocated equally across the areas (Nederland Elektrisch, n.d.-c).

5.4 Summary of the MLP Analysis Results

In this chapter the results of the MLP analysis were presented that answer the following sub-question:

How can the MLP explain the socio-technical transition to electric cars in the Dutch mobility sector?

The processes that were extracted from the MLP analysis are represented in Figure 19. The illustration is different from the conventional MLP framework. The reason behind this is to facilitate the comparison between the two results of the MLP and MSF.

To begin with, the landscape level offered various drivers to stimulate the adoption of electric cars. These drivers could be considered as challenges as they are difficult to be solved and span over multiple years forming stress on the system. The challenges in this case study were air pollution, climate change, increasing oil dependency, and limitations of EV technology. These challenges formed drivers that pressured the global and the Dutch national government to take actions.

Global governmental actions came in the form of policies that in return pressured industry players to work on the technology of electric cars as well as the related products, services and infrastructure that had to be set in place. For example, at the global landscape level, the California Air Resource Board imposed the zero-emission mandate which was credited for launching a revolution in clean automotive technology. Similarly at the EU level, the performance criteria for new cars were introduced in 2009 to reduce CO_2 emissions in the road transport sector. The regulation set a fleet-wide target of 130 g CO_2/km for the period 2015-2019 and 95 g CO_2/km for the period 2020-2024, as well as particular CO_2 emission objectives for each manufacturer.

At the Dutch niche level, the policies targeting industry players came in the form of agreements with different parties in the market such as the Green Deal “Electric Transport 2016-2020”. No strict regulations for the sector parties were found which can be related to the fact the Netherlands does not have car manufacturers.

Nevertheless, the Netherlands had a prominent role in steering the public towards the adoption of EVS through various policy incentives such as tax reductions and subsidies. Moreover, the Dutch government also formed partnerships with niche players that were either environemntalists, such as Nature and Environment organisation, or industry players offering the charging stations, charging passes and other related services. The most prominent public-private partnership is the Formula E-team which contributed to the development of various policies, action plans and green deals.

At the regime level, various economic, technical and social barriers were present that were hindering the adoption of EVs by the potential EV drivers. However, the landscape level was offering other forms of drivers for the industry players which came in the form of opportunities. In this case, the emergence of Li-ion batteries in various applications across multiple sectors, the emergence of renewable energy as a source of energy and the decrease in battery price, formed new opportunities for industry players to exploit. For instance, Tesla Motors was the first car company that used Li-ion battery in its Tesla Roadster car. Other opportunities however, stemmed from the barriers that were prevalent at the regime level. For example, in 2013 Fastned was founded to form a nation-wide fast charging stations across the Netherlands in order to tackle the technical barriers of lack of charging stations and long recharging durations.

The environmental groups in the Netherlands, namely Nature and Environment, played a crucial role in supporting the transition to electric cars. The organisation took part in various initiatives either by lobbying for governmental action or by incentify the public to buy electric cars. Back in 2009, Nature and Environment presented an action plan to the government at the AutoRai in which the steps needed to transition to electric mobility were presented. The first step in the plan was forming the Formula E-team which became operational in 2010 and in which Nature and Environment is still a partner at. The environmental group together with other industry players such as driving schools and lease companies also worked on various projects, namely project A15, to raise public awareness on the ease and importance of driving an electric car.

It is important to note here that there was no specific window of opportunity that opened at a certain moment in which electric cars moved from the niche to regime level. This analysis has shown the incremental small niche and landscape developments have both helped break certain regime barriers over time and increase the diffusion rate of the cars into the existing market.

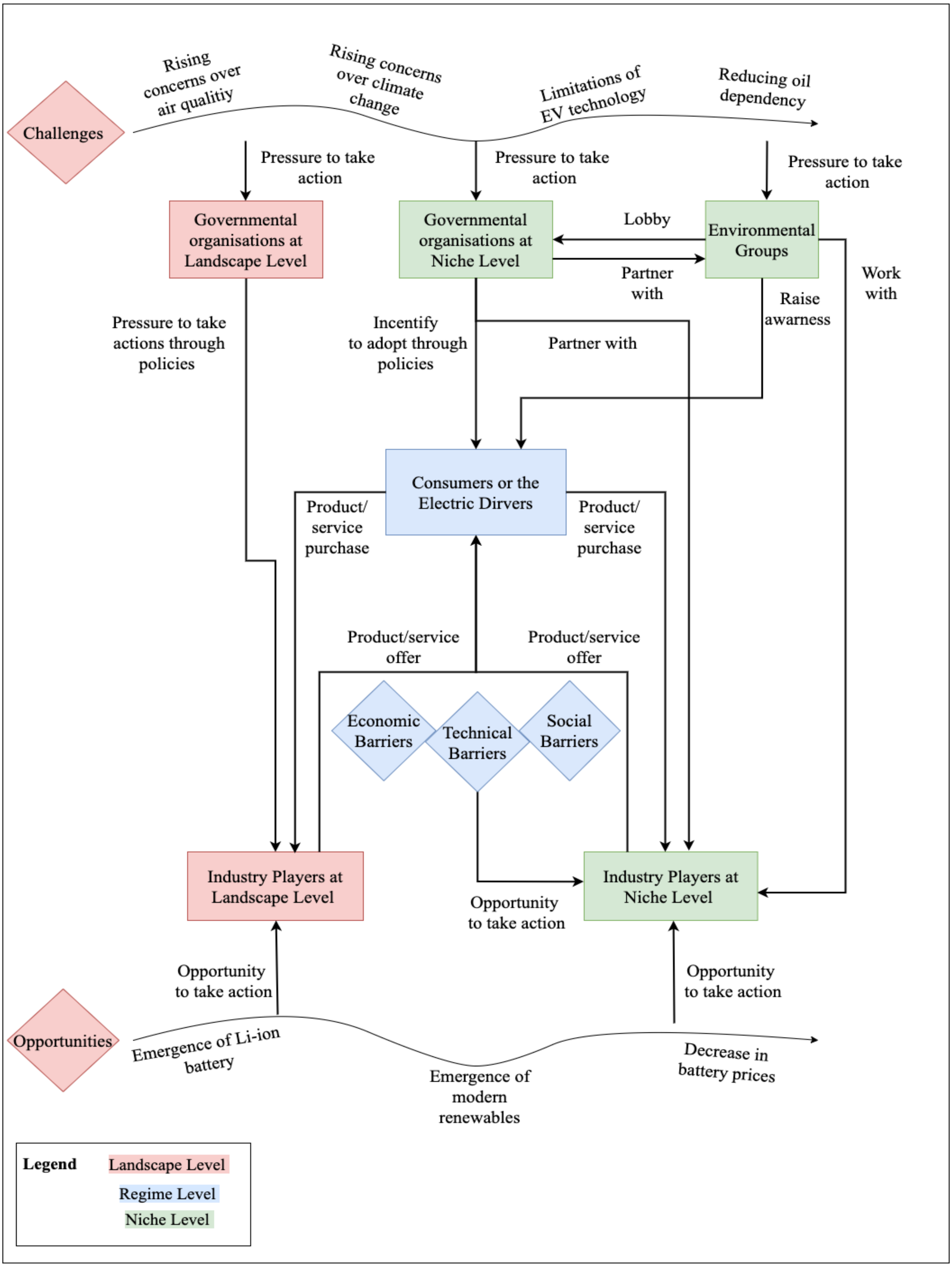


Figure 19 *Broader processes within the MLP. Source: own compilation*

6 Results of the MSF Analysis

In this chapter the MSF is applied to study the policy mix change that has been driving the transition to electric cars in the Netherlands. Two policy changes were selected to be studied; the E-mobility Action Plan of 2009 and the National Climate Agreement of 2019. It is important to note here that the action plan and the agreement are not typical policies in themselves, but rather a meta-governance structure that is guiding the policy making, including those on electric vehicle stimulation.

Nevertheless, given that this research intends to extend the scope of analysis from an individual policy instrument to include policy mix that accounts for multiple policy effects on socio-technical change, the action plan and the agreement do serve the purpose of this research. In this regard, the conceptualisation of policy mixes understood by this research combines the three building blocks of Rogge & Reichardt (2016):

- the instrument mix which comprises the elements of a policy mix, that is its content;
- the policy making and implementation processes which shape these elements;
- the characteristics of the policy mix, such as its consistency, coherence, comprehensiveness and credibility.

In order to understand the processes that have led the policy mix of the E-mobility action plan and the National Climate Agreement to evolve over time (i.e., to be introduced, adapted and maintained) the MSF is applied. The constraints acting upon the emerging problem, policy and political streams can give structure to the processes that stimulated the policy mix changes as well as explain the different factors that affected the dynamics within and between these streams. Thus, by applying the MSF to the case under study the following sub-question will be answered:

How can the MSF explain the policy changes that are helping in the transition to electric cars in the Dutch mobility sector?

In the sections below, the action plan and the agreement will first be put forward to understand what they entail for the mobility sector and to distinguish the policy mixes that they form for the mobility sector. Afterwards, the processes shaping these policy mixes will be explained using the MSF.

6.1 E-mobility Action Plan 2009 -2011

On 3 July 2009 the Ministry of Traffic and Water Management (Ministry IenW) and the Ministry of Economic Affairs (Ministry EZK), submitted the first action plan for electric driving. The central ambition of this plan was to help the Netherlands in the period 2009 – 2011 to be the leading country and international testing ground for electric driving. On the basis of the preconditions created and the learning experiences gained, the Netherlands would then be able to scale up and continue to grow towards large-scale market introduction of the cars (Eerste Kamer der Staten-Generaal, 2009).

According to the action plan, the government's contribution to this ambition will be maximum € 65 million. The grant supports all the efforts of market parties, social organizations and local authorities. As a result, the national investment in this ambition is much greater. The cabinet expects that the aforementioned government grant will trigger approximately €500 million in spending by other stakeholders working on stimulating EVs.

The action plan presented the opportunities offered by the accelerated introduction of electric cars, the initiatives in the market, the obstacles and uncertainties still to be overcome and the needed government contribution to accelerating the introduction of electric cars in the period 2009-2011. The government measurements that still needed to be taken consist of three main components (Eerste Kamer der Staten-Generaal, 2009):

Creating a Formula E- Team: Back in 2009, electric driving was still at its early stage as only hybrid cars were present on the roads (as described in the Diffusion Phase in Section 5.2). Obstacles and uncertainties had to be overcome while an abundance of research and development work still had to be done. This resulted in many deadlocks that the government believed it could resolve by a joint approach including the governments, market parties, and social organizations. To steer this interplay in the coming years, the government announced in the action plan its initiative of creating the Formula E-Team. The focus of the team would mainly be driving the market development and removing barriers.

Developing concrete government measures for the period 2009-2011: Since the central ambition for the period 2009-2011 is to make the Netherlands an international testing ground for electric driving, market parties and social organizations will have to work on it. For supporting their efforts, the government announced it will work on the following domains:

- Field trials and demonstration projects,
- Launching customer ownership,
- Charging and Energy infrastructure,
- Research, development and production of electric vehicles and/or parts for this,
- Consortium and coalition formation

- Policy incentives for customers

Safeguarding a coordinated and phased (programmatic) market entry approach: Introducing electric cars in the Netherlands under the guidance and direction of the Formula E- Team guarantees a coordinated, but above all phased programmatic approach, where step by step the right things at the right time are maintained for as long as possible. On the other hand, essential components must be given sufficient direction to provide the market with starting points for investment and product development.

To understand the processes that have led to this action plan, the MSF is applied. The results of the analysis are illustrated in the Figure 20 and will be explained in the sections below

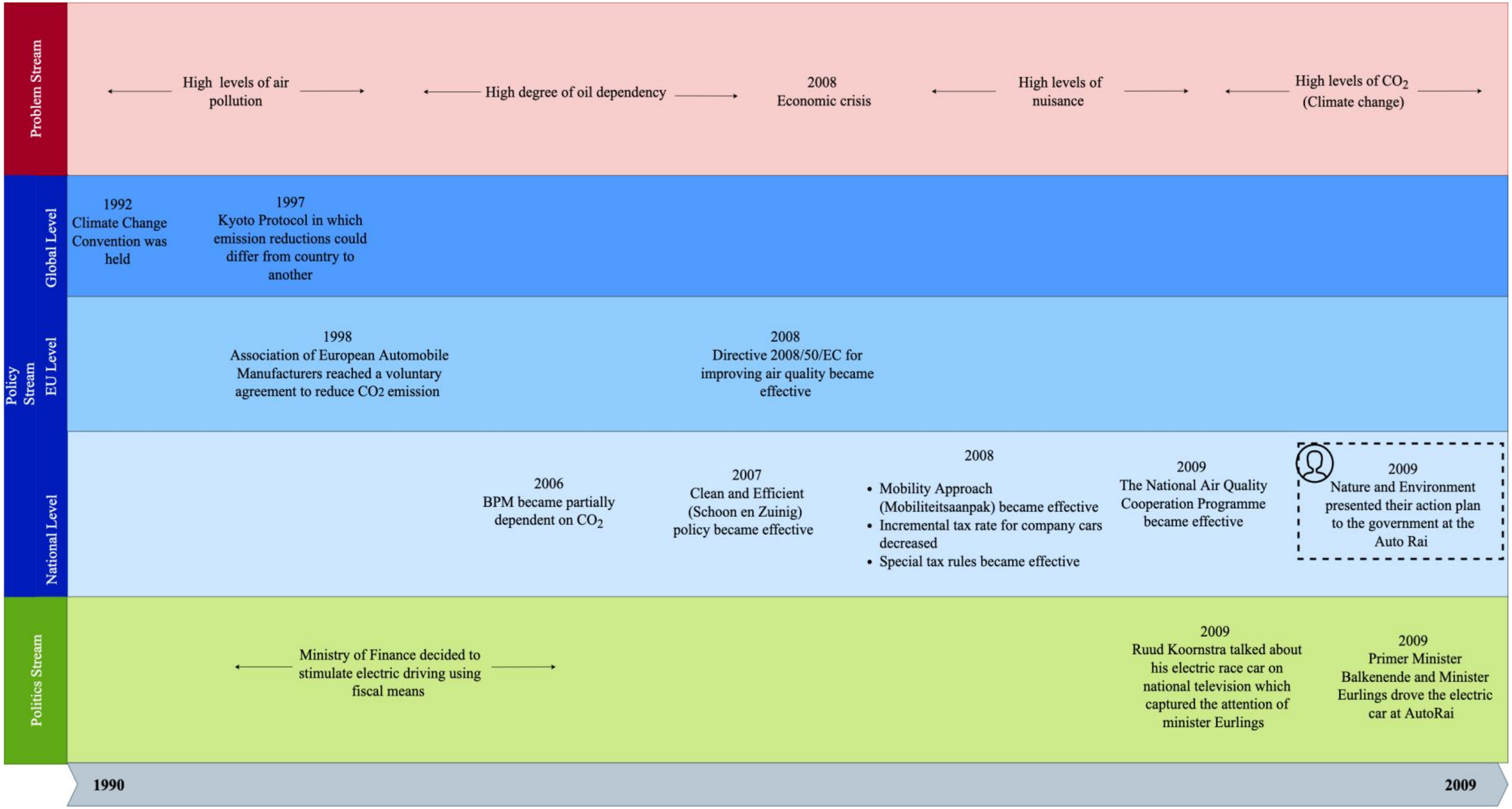


Figure 20 *MSF analysis for the E-mobility Action Plan. Source: own compilation*

Note: person icon refers to policy entrepreneurs, and factors surrounded by arows refer to events that span over multiple time periods (months or years)

6.1.1 Problem Stream

According to the action plan, electric driving can make a good contribution to a number of problems that the Netherlands was (and is still) facing. To begin with, the financial crisis of 2008, was a severe worldwide economic crisis. The Dutch government expressed in its action plan that in times of economic decline, the cabinet has to set everything up to help the economy recover and keep the Netherlands moving. The cabinet saw that this is only possible if economic, environmental, and social interests are combined. Although the Netherlands has no (extensive) car industry, it does have many suppliers, knowledge institute, research and development companies respected by the international car industry. Therefore, the early adoption of electric driving will offer these actors new opportunities to develop (Eerste Kamer der Staten-Generaal, 2009).

Secondly, electric driving helps with reducing the dependence on finite supplies of fossil fuels and oil producing countries. This can improve the security of supply and allow for a trade balance as oil imports can be reduced. On the other hand, electric driving also offers opportunities to better balance supply and demand of energy. In case a significant amount of electric cars charge overnight, they can form a storage reservoir and provide regulatory potential for the energy companies (Eerste Kamer der Staten-Generaal, 2009).

Thirdly, electric driving also has environmental benefits that the cabinet refered to in the action plan relating to climate change, air quality and nuisance. In 2009, the Netherlands Environmental Assessment Agency (PBL) published a report that examine the role of electric vehicles in the transition to sustainable mobility. In the report, the PBL proved that electric cars – in combination with electricity production based on renewable sources and clean fossil – have the long-term potential of reducing CO_2 emissions from passenger cars and other light vehicles by 80-90% (PBL, 2009). This paper was used as supporting evidence in the action plan (Eerste Kamer der Staten-Generaal, 2009).

Moreover, electric vehicles do not emit any exhaust gases and are therefore cleaner than petrol and diesel cars. This is an important driver for stimulating electric mobility especially since many Dutch cities have been dealing with increasing levels of air pollution that they were trying to combat. This was reflected in a number of responses from the interviews such as:

> "A lot of cities installed different new measures to have air pollution reduced, and a lot of them were quite negative as they were forbidding and limiting activities. Therefore, there was the idea of starting with positive activities. Cities started with some small projects, very small projects, maybe ten charging stations and ten vehicles as early as in 2008 just to to to learn to learn about that and to see if it's all possible." (Respondent 1)

“We were pointed out by the European Union that the Netherlands was lagging and not doing well in terms of air quality. And that was somewhat in the same period around 2008, when new incentives with large budgets were made to tackle air quality. Electric cars were seen to fit in well within these measures, because they emit much less particulate matter and NOx.” (Respondent 3)

Last but not least, while it is not considered a major issue, nuisance was also one of the problems that government wanted to tackle with stimulating electric driving (Eerste Kamer der Staten-Generaal, 2009). Electric vehicles are quieter than combustion engine vehicles, especially at lower speeds (at higher speeds tire noise is dominant).According to the action plan, quieter traffic, especially in combination with cleaner traffic, will provide more space for spatial planning in the Netherlands.

6.1.2 Policy Stream

The policy stream is seperated by the three levels: the Global, EU and National level.

6.1.2.1 At the Global Level

In the policy stream several factors were paving the way for the E-mobility action plan. To begin with, the Dutch participation in various climate conferences and commitment to a number of international agreements formed important institutional settings for stressing the importance of climate change mitigation. For instance, in 1992, the Netherlands participated in the climate treaty of the United Nations (UN), the Climate Change Convention. In 1997, it took part in the Kyoto Protocol which states that the emission reductions could differ from country to country and can be traded among each other (Ministry of Infrastructure and Water Management, 2022).

6.1.2.2 At the European Level

The rising concerns about climate change and the various international agreements had to convert into policy changes to stimulate concrete actions. In Europe CO_2 has historically been an important driver for the EU's passenger car emission policies. In the framework of the 1998 Kyoto Protocol, the European Commission and the Association of European Automobile Manufacturers reached a voluntary agreement to reduce the average CO_2 emissions from new cars to 140 g/km by 2008 (Hooftman et al., 2018). The European OEMs significantly invested in powerful diesel technology but nevertheless failed to reach the 2008 target (Hooftman et al., 2018).

Moreover, in 2008, various European directives on air pollution were merged into Directive 2008/50/EC (RIVM, n.d.). This prescribes limit and/or target values for different particulate matter (e.g., NO2, fine dust and Benzene) which member states must adhere to. Limit values must be reached within a certain period of time, and may not be exceeded once they have been reached. Target values must be reached within a specified period as far as possible. In the case of target values, it is therefore an obligation to make an effort.

6.1.2.3 At the National Level

In order to comply with the European limit values for particulate matter, the Netherlands formulated the National Air Quality Cooperation Programme (Het Nationaal Samenwerkingsprogramma Luchtkwaliteit - NSL). The NSL became effective on the 1st of August in 2009. It takes into account major planned projects that deteriorate air quality and sets measures to improve air quality in return. The package of measures has been drawn up in such a way that compensates for the negative effects of the spatial projects (Rijkswaterstaat, n.d.). Therefore, a large-scale introduction of electric vehicles is not necessary for this in the period up to 2015. However, the E-mobility action plan declared that transitioning to electric mobility would complement this programme and further improve the air quality (Eerste Kamer der Staten-Generaal, 2009).

Besides working on air quality, the Netherlands was also adopting policies to incentify drivers to buy environmentally friendly cars in order to combat climate change. Starting 2006 car taxes have become increasingly dependent on the car's CO_2 emissions. For example, the purchase tax (the BPM; Tax on Passenger Cars and Motorcycles) has been adjusted a few times since 2006 to a CO_2-dependent tax. Before 2006, the BPM depended on the list price of the car, so the incentive to buy an economical car was much smaller (Compendium voor de Leefomgeving, 2019).

In 2007 the Dutch government set the ambitions for having a 30% reduction in greenhouse gases in 2020 compared to 1990. This ambition was published in the Clean and Efficient (Schoon en Zuinig) policy (VROM, 2007). In 2008, the cabinet presented specific ambitions for the transport sector in the Mobility Approach (Mobiliteitsaanpak). In this approach sustainability was chosen as the central point in which problems such as air quality, climate change, damage to nature and landscape, energy security, external safety and road safety are seen as both a challenge and an opportunity. The Netherlands can internationally set the stone by addressing these types of issues in innovative method based on the trio of people, planet, and profit (Ministry of Transport and Water Management, 2008).

In 2008 specific policy instruments were also bought into effect to special tax rules also came into effect (International Energy Agency, 2009). As shown in Table 5, hybrid vehicles have qualified for a substantial bonus/tax reduction as high as € 6,400. Conventional cars that are very energy efficient also earned a tax reduction, depending on their fuel efficiency, which is based on the fuel-consumption rating as shown on the specific model’s energy label. Effective as of February 1, 2008, the credit can be as high as € 1,400. Also since the same date, less fuel-efficient vehicles are subject to an extra tax that can be as high as € 1,600 (International Energy Agency, 2009).

__Table 5__ Energy Label (A to G = highest to lowest fuel economy) and Dutch sales tax reductions/additions, effective February 1, 2008 Adapted from International Energy Agency (2009)

	A	**B**	**C**	**D**	**E**	**F**	**G**
General [Euros]	-1,400	-700	0	+400	+800	+1,200	+1,600
Hybrid [Euros]	-6,400	-3,200	0	+400	+800	+1,200	+1,600

Moreover, in 2008, the incremental tax rate (i.e. 'bijtelling' in Dutch) for business cars used for private purposes also became dependent on the car's CO_2 emissions. In 2008, it decreased from 25% to 14% for company cars that were environmentally friendly (Overheid.nl, 2007). This reduction caused a sudden increase in the number of hybrid company cars registered as it increased from 3,500 to more than 12,000 in 2009 (CBS, 2009).

In 2009 Nature and Environment presented its action plan "Towards one million electric cars by 2020" to the prime-minister Balkenende and minister Eurlings of Infrastructure and Water Management at the International Motorshow in Amsterdam (AutoRai) (Respondent 3). In this action plan, the NGO presented 12 steps that the government needed to take to stimulate electric cars and the first one being establishing the Formula E-team (Natuur en Milieu, 2009). The action plan was taken seriously by the government as the formation of Formula E-Team was one of the target goals of this E-mobility Action Plan under study. In this case, the Nature and Environment organisation acted as a policy entrepreneur as they succeeded in presenting a package of solutions to policy makers (i.e., the presented action plan) for the problem of increasing CO_2 emissions at the right moment (i.e., in 2009 at the AutoRai where political figures and ministers were present). When Respondent 3 (a member of the Nature and Environment NGO) was asked about the reason behind them stimulating electric mobility since the early 2000s his response was:

'It was clear that traffic should be emission-free, otherwise you will not achieve climate goals. So electrification or biofuels, those were the only routes you could grow towards. And biofuels was increasingly a discussion, because in principle the environmental movement was also positive about biofuels, but it soon became very clear that this was accompanied by so many extra problems that it was not a convenient route. So that couldn't be it. Electrification was clearly possible. We only had to scale it up and this is done using policies and then the market would follow."

6.1.3 Politics Stream

The various fiscal incentives that have been enaction since 2006 were an initiative of the State Secretary at the Ministry of Finance. According to Respondent 3, the state secretary at the Ministry of Finance was one of the first people that believed that steering towards greening the mobility sector could be done with taxes. So he was the first to propose that a sustainable car could get purchase and road tax reductions. Such tax reductions were mainly put into effect to stimulate hybrid as zero-emission cars were not fully developed yet.

Besides having political figures actively looking for ways to stimulate electric cars, a special moment in 2009 took place which helped accelerate all the initiatives. In 2009 Ruud Koornstra (Respondent 8 in this research) was invited to “Pauw en Witteman” show to talk about his innovative LED lamps. Unplanned the entrepreneur shared that he also drives an electric race car which was built in the backyard of his friend “Willem van der Kooi”. The picture of the race car was shown on the TV program. The next morning the Minister of Transport and Water Management at that time, Camiel Eurlings, called him and asked if he really drives an electric race car and whether they could partner together to further stimulate the adoption of such cars. Later during that year, the prime minister Balkenende and minister Eurlings drove the electric race car that belonged to Ruud Koornstra during the Auto Rai of 2009. The actual ride of the two ministers sparked the serious interest in stimulating electric driving. It was at that moment that government representatives knew that electric driving was possible and not a futuristic plan. According to Respondent 8, the personal interest of the two ministers in the automotive industry was one of the factors why electric driving was taken seriously. The figure below shows the picture taken of the two ministers driving the electric race car during the AutoRai show.

Figure 21 *Prime Minister Balkenende and minister Eurlings driving an electric car in the AutoRai 2009 (Autokopen.nl, 2009)*

6.2 National Climate Agreement 2019

The National Climate Agreement was sent by the Ministry of Economic Affairs and Climate to the parliament on 28 June 2019. It contains more than 600 agreements to combat greenhouse gas emissions agreed upon with over 100 parties across 5 sectors. The central goal of this agreement is to reduce greenhouse gas emissions in the Netherlands by 49% compared to 1990 levels (Ministry of Economic Affairs and Climate Policy, 2019a).

For the mobility sector, this goal entails that by 2030, only emissions-free vehicles will be allowed to be registered in the Netherlands. The preconditions must also be in place. Charging the electric car must be as easy as charging a mobile phone, thus the ambition is to offer approximately 1.8 million charging stations by 2030 (Ministry of Economic Affairs and Climate Policy, 2019a). To realise these goals the National Agreement set a budget of €250 million to stimulate electric driving (IenW, 2020).

These goals seem to be daunting. However, according to the Climate Agreement, taxes will be adjusted in such a way that they help citizens and companies make the transition to clean mobility, such as lower car taxes (BPM, MRB) plus a purchase subsidy for emission-free passenger cars (Ministry of Economic Affairs and Climate Policy, 2021). Today, the following policies are in place to realise the ambitions of the Climate Agreement. For instance, today there are number of policy incentives for the purchase or lease of an electric car, namely (ANWB, 2021a):

- **Purchase subsidy:** This subsidy is available to private individuals who purchase or privately lease an electric car. Business drivers or entrepreneurs cannot make use of the purchase subsidy.
- **Lower incremental tax rate:** This tax for business drivers is 16% in 2022, instead of 22% for non-electric cars. This lower tax to fully electric cars only applies to the first € 35,000 of the list price. If the car is more expensive, the usual 22% addition is charged on that part. The addition of electric cars will be increased in steps, until it is equal to that of other cars in 2026.
- **No purchase tax (BPM):** The bpm, or the tax on passenger cars and motorcycles, is an additional tax when purchasing a car. This tax is based on the CO_2 emissions of a car and because an electric car has no (direct) CO_2 emissions, it is exempt from bpm - at least until 2024.
- **No road tax (MRB):** A fully electric car is exempted from motor vehicle tax (MRB), also known as road tax. This exemption will also be maintained until 2024. This results in a saving of a few tens to more than a hundred euros per month.

In order to understand the different processes that have played a role in developing and adopting this National Climate Agreement, the MSF is applied and will be put forward in the sections below.

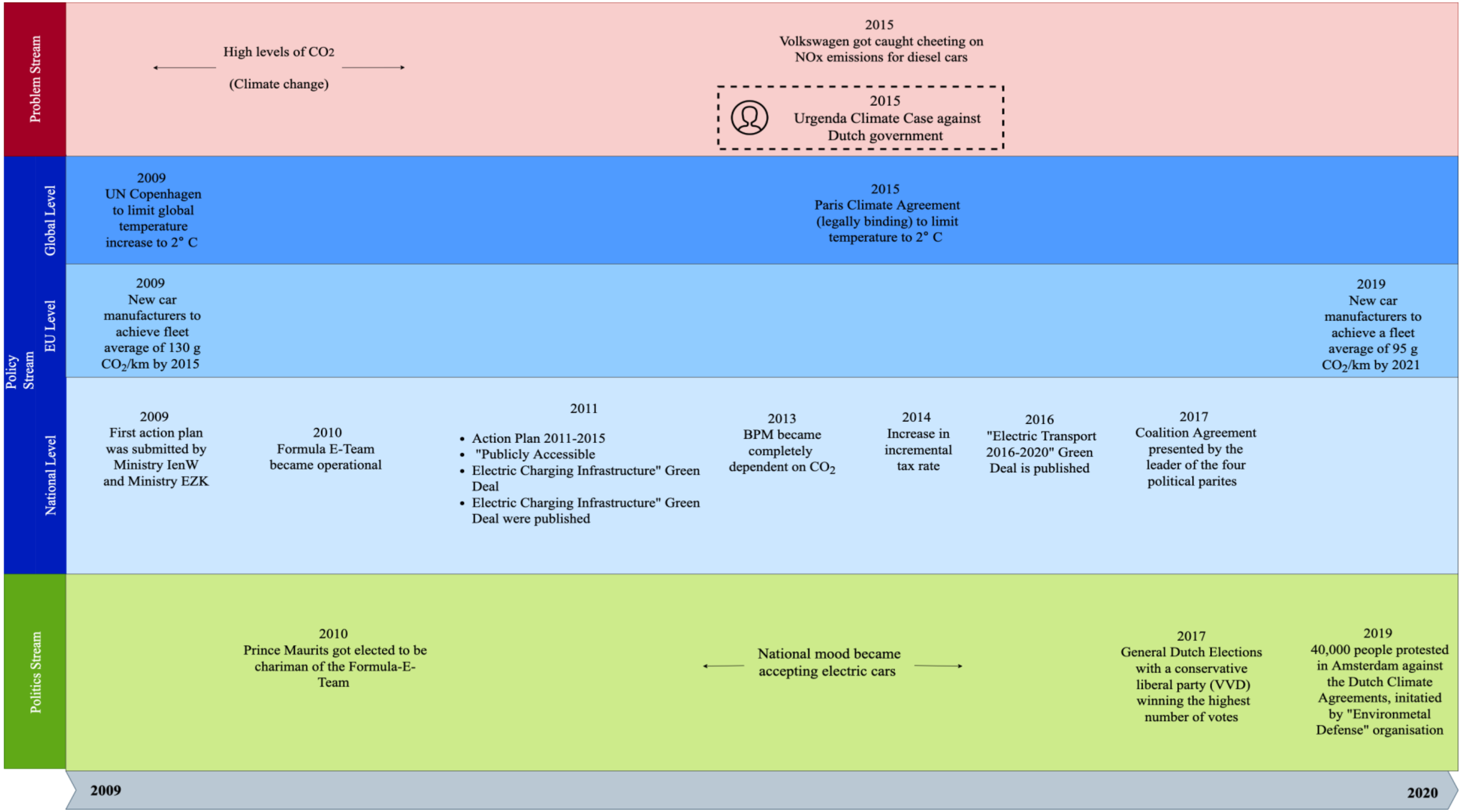


Figure 22 *MSF analysis for the National Climate Agreement Source: own compilation*

Note: person icon refers to policy entrepreneurs; and factors surrounded by arows refer to events that span over multiple time periods (months or years)

6.2.1 Problem Stream

The most conspicuous factor in the problem stream behind the adoption of the National Climate Agreement is climate change. The government's central goal with the National Climate Agreement is to reduce greenhouse gas emissions in the Netherlands. In 2018, greenhouse gas emissions in the Dutch transport sector stood at 26 billion CO_2 equivalents forming 12% of total GHG emissions by the Dutch economy. Within the transport sector, road transport emitted 21% of the emissions followed only by aviation and water transport contributing to 49% and 26% of the total emissions respectively (Statistics Netherlands, 2019). These figures act as indicators that help with evaluating the magnitude of the public problem and monitor the changes over time.

A promising pathway to reduce the emissions in this sector is the transition to electric vehicles (EV). Commissioned by the Netherlands Enterprise Agency (RVO), the TNO researched the total CO_2 emission of electric cars. According to the research, the total CO_2 emissions for the material life cycle and usage of the car, range from a maximum of almost 250 g/km for an average petrol vehicle up to a minimum of approx. 70 g/km for an electric vehicle driving on green electricity (-70%). An electric car still has an approx. 30% lower CO_2 emissions when using predominantly gray electricity. The total CO_2 gain of a PHEV when using predominantly gray energy is relatively modest by approx. 15% compared to a petrol vehicle, because it is assumed that on average only 30% is driven entirely electrically. If this PHEV vehicle runs on green energy, a reduction of the CO_2 emissions of approx. 25% (Verbeek et al., 2015). Thus all in all, electric vehicles have been proven scientifically that they deserve governmental and local support given their environmental benefits.

In this problem stream, focusing events, conceived as periods of crisis or disaster, also played a role in highlighting the legal obligations of urgently and significantly reducing GHG emissions. An important focussing event in this case was the Volkswagen emission scandal. In 2015, the Environmental Protection Agency (EPA) in the US found out that many Volkswagen (VW) cars being sold had a "defeat device" - or software - in diesel engines that could detect when they were being tested (Hotten, 2015). These devices would then adapt to laboratory tests, making the cars appear to comply with environmental standards when, in fact, they emitted pollutants called nitric oxides at levels that were on average four times the applicable European test-stand limit (Chu, 2017). The EPA's findings cover 482,000 cars in the US only, but VW has admitted that the "defeat device" was installed in around 11 million cars globally, including eight million in Europe (Hotten, 2015). As a consequence VW were fined $ 14.7 billion as part of a civil settlement in the US (United States Department of Justice, 2016) while the European Commission fined automakers up to 30,000 euros ($37,131) per faulty car (Automotive News Europe, 2018) . Of course, the public also paid dearly, as Dutch researchers valued the health damage caused by the VW fraud at $39 billion, or 45,000 disability-adjusted life years due to the added pollution created by the rigged diesel cars (Oldenkamp et al., 2016). An interview respondent revealed the 'VW scandal' had its repercussions on the Dutch institutions too as it reinforced the idea that the government should not be "Nice" to the car industry. He stated:

> "Not to forget the diesel scandal that caused the car industry on all sides to suddenly become suspicious of and consider that it is all lies and deception what is being said there. The scandal showed that we shouldn't be too nice about that. They need to be tackled a bit stronger." Respondent 3

On a more local level, an important event that pressured the government to take action was the Urgenda Climate Case against the Dutch Government. On 24 June 2015, the District Court of The Hague ruled the government must cut its greenhouse gas emissions by at least 25% by the end of 2020 (compared to 1990 levels) (Urgenda, 2021). The court found that the government's existing pledge to reduce emissions by 17% was insufficient to meet the state's fair contribution toward the UN goal of keeping global temperature increases within two degrees Celsius of pre-industrial conditions (LSE, n.d.). The ruling required the government to immediately take more effective action on climate change. This made climate change a major political and social issue in the Netherlands and transformed domestic climate change policy (LSE, n.d.).

The Urgenda Climate Case was brought by the Urgenda Foundation and 900 Dutch citizens and was the first in the world in which citizens established that their government has a legal duty to prevent dangerous climate change (Urgenda, 2021). The case was also rendered the world's 'Strongest" Climate Ruling Yet', according to a headline in the New York Times (Schwartz, 2019). In this case, the Urgenda Foundation, the 900 citizens and the judge could be considered policy entreprenurs as referred to by the MSF. More on how these policy entrepreneurs seized the window of opportunity to create an intersection between the three streams could be found in Section 7.1.4.

With the Climate Agreement, a target must be achieved by 2030 (a 49% reduction), the measures for the Urgenda judgment (25%) will have to lead to results much faster, namely by 2020. After the ruling, the cabinet decided to implement the Urgenda judgment together with the measures in the Climate Agreement, without these getting in each other's way (Ministry of Economic Affairs and Climate Policy, 2019b). Thus, the Urgenda Climate Case was an important motivation and opportunity for the policymakers to consider climate change as a public problem and reflect on possible solutions to combat it.

6.2.2 Policy Stream

The policy stream, similar to the policy stream of the action plan analysis, is separated by the three levels: the Global, EU and National levels.

6.2.2.1 At the Global Level

In the policy stream international agreements were paving the way for the National Climate Agreement to occur. In 2009, the Netherlands took part in the United Nations climate change conference (COP15) in Copenhagen. This conference resulted in the Copenhagen Accord that entailed that the global average temperature increase should be kept below 2 °C (United

Nations Climate Change, n.d.). However, the global financial crisis and national special interests colluded to derail the success of the accord (Lilleholt, 2020).

In 2015, things changed. At the UN climate summit in Paris, the political environment was very different from that of six years ago (of the Copenhagen accord). At that time, the world economy was rebounding, climate scientists had dispelled any remaining uncertainties on the causes of climate change, and the business community had joined the environmental movement (Lilleholt, 2020). The summit resulted in a legally binding international agreement which is called the Paris Climate Agreement of 2015. In the agreement, the Netherlands, among 195 other parties, committed to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (United Nations, n.d.).

6.2.2.2 At the EU Level

Since the European OEMs significantly invested in powerful diesel technology but still failed to reach the 2008 target, a legally binding target was imposed in 2009, targeting a new car average of 130 g CO_2/km by 2015 and 95 g CO_2 /km from 2020 onwards (European Union, 2009). The most recent regulation was in 2019, as there was the adoption of a new regulation that established new fleet-wide goals for 2025 and 2030, including a 15% decrease in emissions from 2021 levels by 2025 and a 37.5 % reduction by 2030 (European Union, 2019).

As a result of these agreements, average CO_2 emissions from passenger cars had a steady decline by almost 22 g CO_2/km between 2010 and 2016. There was an increase in average emissions from new passenger cars between 2017 and 2019, due to, among other reasons, the growth in the sport utility vehicle (SUV) and the increase in the average mass of new conventional vehicles. Nevertheless, the average emissions reached 122.3 g CO_2/km in 2019 remaining below the 2015-2019 target of 130 g CO_2/km (European Environment Agency, 2021).

6.2.2.3 At the National Level

Figure 23 illustrates all the policy agreements, action plans and green deals that have been made (from 2006 to 2017) to pave the way for the National Climate Agreement of 2019. In the sections below how these agreements have paved the way and softened the adoption process of the National Climate Agreement will be put forward. The policy incentives prior to the year 2009 have already been explained in Section 6.1.2.3. Therefore, the focus will be on the policies that have followed.

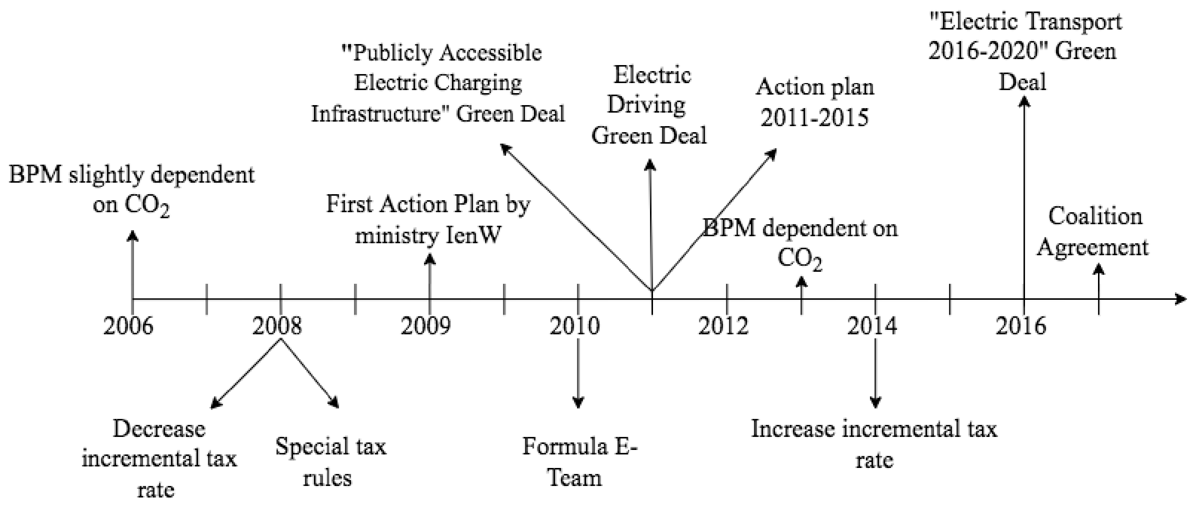


Figure 23 *Timeline of policy stream factors at the national level of the Netherlands. Source: own compilation. Source: own compilation*

Upon the request of the Ministry of Traffic and Water Management and the Ministry of Economic Affairs in the E-mobility Action Plan of 2009, the Formula E-Team became operational in 2010. The operationalisation of this partnership could be seen as another multilateral policy instrument or as a 'meta governance' to facilitate electrical driving.

The Formula E-Team has helped to shape many Green Deals which paved the way for the roll-out of electric transport (RVO, 2019). Green Deals form an accessible way for the Dutch government to work with sector players such as organizations, local and regional governments and interest groups on green growth and social issues (Green Deals, n.d.). For instance, work has been carried out on the electrification of transport through the "Electric Driving Green Deal" (Green Deals, 2011a) and the "Electric Transport Green Deal 2016-2020" (Green Deal, 2016). Moreover, thousands of charging stations were being rolled out in public spaces through the "Publicly Accessible Electric Charging Infrastructure Green Deal" (Green Deal, 2011b). In conclusion one could say the Formula E-team contributed to the technical feasibility of the National Climate Agreement.

Besides the green deals and agreements, the government also continued working on implementing policy incentives. In 2008, the incremental tax rate for environmentally friendly business cars used for private purposes decreased from 25% to 14%. In 2011 it became 0% for zero-emission cars and 14% for cars with a CO_2 emission between 1- 50g/km emissions.

As shown in Table 6, the differentiation in car taxes between zero-emission and hybrid cars has been rolling back since 2014, partly in response to the declining revenues and disappointing environmental effects of hybrid cars. These changes had a major impact on new sales in recent years. The average CO_2 emissions per kilometre of new passenger cars in the Netherlands have been increasing again since 2015 and the Netherlands became no longer a frontrunner in the EU when it comes to the CO_2 emissions of passenger cars (Compendium voor de Leefomgeving, 2019).

Table 6 Incremental tax rate for company cars that are used for private purposes (Compendium voor de Leefomgeving, 2019)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Zero-emission cars	0%	0%	0%	4%	4%	4%	4%	4%	4%
Cars with 1-50 g/km	14%	0%	0%	7%	7%	15%	22%	22%	22%
ICE cars	25%	25%	25%	25%	25%	25%	25%	25%	22%

Since 2013, the bpm has been completely dependent on the CO_2 emissions of the car: the higher the emissions, the higher the BPM. Before 2006, the BPM depended on the list price of the car, so the incentive to buy an economical car was much smaller (Compendium voor de Leefomgeving, 2019). In short, the aforementioned policies and agreements were paving the way for ensuring the value acceptability of the National Climate Agreements goals for electric mobility.

However, the most official starting point of these goals was on 10 October 2017 when the leaders of four parties in parliament (VVD, CDA, D66 and the Christian Union) presented their new coalition agreement (Ministry of General Affairs, 2017). The goals set in this agreement were made to align with the Paris Climate Agreement. In the agreement, the following was stated:

> "We will shoulder our responsibilities under the Paris climate agreement. A national climate and energy agreement will be concluded with all parties in order to sharply reduce CO2 emissions. This means, among other things, making the built environment and transport more sustainable."

The coalition agreement had a set of goals for different sectors, among which for the transport and mobility sector, the goal was set for all new passenger cars to be zero emission by 2030 at the latest. The agreement also entailed that all tax incentives for zero emission cars will be phased out as this ambition is achieved. Moreover, the charging infrastructure had to be in place to meet the needs of the new stock of electric vehicles The municipalities were granted the right to stimulate electric cars by introducing low emission zones or reducing parking charges for zero emission vehicles (Ministry of General Affairs, 2017). The National Climate Agreement was then a follow-up agreement to this coalition agreement as sector parties had to agree on the approach to adhere to the ambitions of the coalition agreement.

Finally, it is important to note that the National Climate Agreement was created in part due to adequate financial viability. The agreement is founded on the idea that everyone must be able to afford decreasing carbon emissions. To minimize the financial impact on households and establish policies that equally divide the financial burden between residents and enterprises, the government sought a cost-effective transition. The annual additional costs for the Netherlands related to the Climate Agreement, according to the Dutch government, will be less than 0.5 percent of GDP in 2030. Thus, it was concluded that Dutch society should be able to afford this change (Ministry of Economic Affairs and Climate Policy, 2020).

6.2.3 Politics Stream

The formation of the Formula E- Team had an important impact on the national mood of electric cars as it led to the development of one of the densest charging networks in the world and to a fleet already in excess of 200,000 electric vehicles (RVO, 2019). Moreover, in 2010 Prince Maurits from the royal family was appointed as a chairman for the Formula E-Team. In a documentary named "Haagse Lobby", Ruud Koornstra (Respondent 8 in this research) expressed the success that came along assigning Prince Maurtis for this role. He said:

"Prince Maurtis is not ignorant, he was able to explain very well that electric driving was not dull or an "orthopedic shoe" but a representation of the future. And yes, you reach the tables of ministers, state secretaries, and civil servant faster with a prince" (WNL [NPO Start], 2016)

In the political arena, electric mobility was also gaining interest. On 10 October 2017 the leaders of four parties in parliament (VVD, CDA, D66 and the Christian Union) presented their new coalition agreement entitled 'Confidence in the Future' in which the ambitions for electric mobility were presented for the year 2030 (Ministry of General Affairs, 2017). This coalition agreement was the result of the general elections that took place on 15 March 2017 and that resulted in a coalition government of the political parties People's Party for Freedom and Democracy (VVD), Christian Democratic Appeal (CDA), Democrats 66 (D66) and Christian Union (CU) (Otjes & Voerman, 2018). A research done by the Association of Electric Drivers (VER) and the Netherlands Enterprise Agency (RVO) showed that among the 1,700 survey respondents, 25% of the Dutch EV drivers supported the biggest political party in the Netherlands (VVD) followed by GroenLinks (16%) and D66 (15%) (RVO, 2021b). This shows that the affiliation of people with a certain party ideology is in a way related to forming the support base for the National Climate Agreement.

Negotiations between the government and sector parties relating to the National Climate Agreement started in 2018 and continued in 2019. After tough negotiations, many parties across different sectors still found the agreement not green and not fair. Large companies wanted money from the government to make it more sustainable, but refused to contribute. As a result, the bill mainly fell on the ordinary citizens and small businesses. The world upside down. The largest polluters received subsidies.

In March 2019, everything accelerated. Environmental Defense (in Dutch Milieudefensie) took the initiative for a Climate March in Amsterdam. In the pouring rain, 40,000 people demonstrated on March 11 for an ambitious and fair climate agreement. The largest climate demonstration ever in the Netherlands (Milieudefensie, n.d.).

Moreover, the Central Planning Bureau (CPB) and the Netherlands Environmental Assessment Agency (PBL) presented a report on the climate agreement on 13 March. According to the report, the Paris goals will not be achieved with this agreement. And it turns out to be unfair, because ordinary Dutch people pay the bill and the big polluters hardly pay anything. In doing so, the planning offices supported the criticism of Environmental Defense and other environmental and social organisations (Milieudefensie, n.d.).

A logical alternative for the rising concerns was a CO_2 tax for industry. Something that was not discussed during the negotiations. But under pressure from 40,000 demonstrators, Prime Minister Rutte agreed in the same week. The, in Rutte's words, 'sensible' CO_2 tax for large polluters was suddenly a fact. In addition, the energy bill for companies was agreed to be higher and that for households to be lower (Milieudefensie, n.d.). And so the climate agreement suddenly turns out to be a lot friendlier for ordinary Dutch people which in return helped the national mood to become in favour of the new agreement.

Last but not least, it is important to note that the general national mood for electric mobility changed after the introduction of the Tesla Roadster and the Tesla Model S, Tesla revolutionized the idea of driving an electric car (also explained in MLP analysis). Based on a survey done in 2021, 15% of EV drivers in the Netherlands are considered pioneers, meaning they drive the car due to technological innovation (RVO, 2021). This affiliation too is contributing to the supporting base that was incrementally being built for the Dutch ambitions for electric mobility.

6.3 Policy entrepreneurs Seizing Policy Windows

The lead of the policy entrepreneurs in creating a policy window were, according to this analysis, necessary for driving the transition to electric cars. The main policy entrepreneur that had a direct contribution to the adoption of the E-mobility Action Plan was Nature and Environment. At the AutoRai in 2009, the environmental organisation presented their own action plan “Towards one million electric cars by 2020” to the prime-minister Balkenende and minister Eurlings of Traffic and Water Management. This action plan had 12 concrete steps outlined for stimulating electric driving in the Netherlands, making by that the policy stream ripe for coupling with the other two streams. At that time, the rising levels of air pollution and increasing concerns around climate change were already ripening the problem stream. At the politics stream, the two ministers drove the electric race car of Ruud Koornstra during that same event (the AutoRai of 2009) making it clear for these governmental figures that electric mobility had a future in the Netherlands. Consequently, the Ministry of Traffic and Water Management and the Ministry of Economic Affairs answered the call of Nature and Environment and published their own E-mobility Action Plan for the years 2009- 2011.

Similarly, the adoption of the National Climate Agreement was driven by policy entrpreneurs that coupled the three streams together. In this case, the Urgenda Foundation and the 900 citizens could be considered policy entrepreneurs as referred to by the MSF. At the problem stream, the policy entrepreneurs saw the rising levels of CO_2 emissions and the limited action taken by the government as sign of having a ripened stream. At the policy stream, the Paris Climate Agreement of 2015 created a sense of urgency among governments to start taking serious actions. This has led the coalition agreement of 2017 to be the starting point in which the National Climate Agreement ambitions were discussed. At the politics stream the general national mood was the main contributing factor for ripening this stream and making it ready to be coupled with the other two ones. Ever since the E-mobility action plan was submitted and the Formula E-Team was formed, the public grew its acceptability for sustainble solutions in general and for electric cars in specific. After having the three streams coupled and a policy window open, the cabinet decided to implement the Urgenda judgment within the measures of the National Climate Agreement (Ministry of Economic Affairs and Climate Policy, 2019b). Thus, the Urgenda Climate Case was an important motivation and opportunity for the policy-makers to consider climate change as a public problem and reflect on possible solutions to combat it.

6.4 Summary of the MSF Analysis Results

In this chapter the results of the MSF analysis were presented that answer the following sub-question:

How can the MSF explain the policy changes that are helping in the transition to electric cars in the Dutch mobility sector?

Governmental ambitions for stimulating electric cars were first made official in the E-mobility Action Plan in 2009. Following this action plan several policy initiatives were taken to either partner with the industry players or to influence the public towards buying or leasing electric cars. All these initiatives taken were seen as important drivers for the transition. However, it was not until 2019 that the government announced it will only accept emission-free vehicles to be registered in the Netherlands starting 2030. Despite being a relatively new policy, it is the outcome of developments that have spanned over several years. These development built momentum for the Dutch government to set such an ambitious target that in return is currently determining the course of events.

In order to understand the processes that played a role in forming the E-mobility action plan of 2009 first and the National Climate Agreement of 2019 next, the MSF was applied. In Figure 24, the results of the MSF analysis are presented. The illustration of Figure 24 is different from the conventional MSF in order to simplify the representation and facilitate the comparison with the MLP.

In the problem stream, several challenges were being experienced that were ripening the stream and offering system actors sources of pressure to react. In this analysis the problems formed pressure on the global, European and national (governmental) organisations. In order to highlight the urgency of the problems, several agreements were made that the Dutch national government took part in. These agreements were mainly targeting climate change. Examples of these agreements were the 1997 Kyoto Protocol, 2009 UN Copenhagen Accord, and most recently the Paris Climate Agreement of 2015.

The rising concerns over climate change also formed a driver for environmentalists to take action. For instance, the Nature and Environment saw that reducing the CO_2 emissions in the road transport sector as inevitable and thus made its own action plan that it represented to the Dutch government as a form of lobbying. Similarly, the Urgenda foundation was triggered by the rising climate change effects and sued the Dutch government for not taking enough actions to combat climate change. As explained in section 6.3 these two environmental organisations formed the policy entrepreneurs.

At the policy stream, the national government stimulated the Dutch public to adopt EVs by various policy incentives. These policies eventually built momentum for the E-mobility Action Plan as well as the ambitious target of the National Climate Agreement. The tax reductions and subsidies helped increase the value acceptability of actually buying an electric car. The policies targeting industry players came in the form of agreements with different parties in the market such as the Green Deal “Electric Transport Green Deal 2016-2020”. No strict regulations for the sector parties were found which can be related to the fact the Netherlands does not have car manufacturers.

At the politics stream, the acceptance and in some cases enthusiasm of political and influential figures for EVs have helped ripen the politics stream. Prominent figures in this transition have been Ruud Koornstra (who had bought the first locally built electric race car), prime minister Balkenende, minister Eurlings and Prince Maurits (that was the first chairman of Formula E-Team).Today, the current cabinet is stimulating the transition which is the direct outcome of the 2017 elections in which the conservative liberal party (VVD) won the highest number of seats. This election resulted in the coalition agreement in which the ambitions of the National Climate Agreement were first brought forward. The fact that the agreements came from a party of high public support also increased the value acceptability of the set ambitions.

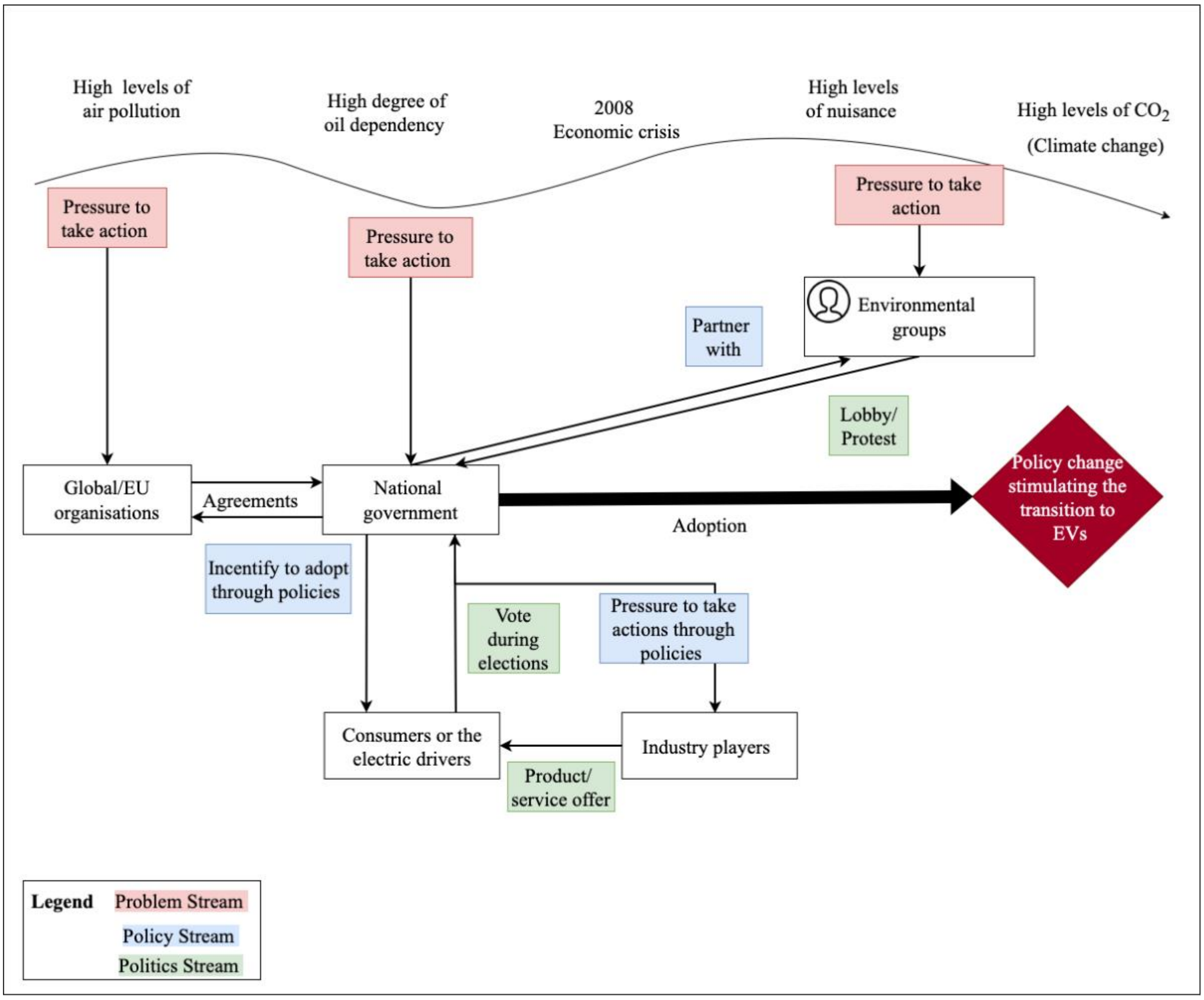


Figure 24 *Broader processes within the MSF. Source: own compilation*

7 Comparative Analysis

In this chapter the results of the MLP and MSF analysis will be compared together in order to extract commonalities, differences and relations between the two frameworks. The results of the comparative analysis will be presented in Section 7.1. The insights gained from this comparative analysis and what it entails for a possible future synthesis of the two frameworks will be put forward in Section 7.2. In section 7.3 the degree to which the insights developed are generalisable will be discussed.

7.1 Comparison

To begin with, a comparison is done between the results of the two frameworks. In the following sections, the three levels of the MLP will be compared with the three streams of the MSF. This comparison entails identifying similar and different concepts as well as how certain aspects in the MLP relate to that in the MSF. This comparison would answer the following sub-question.

What are the main commonalities, differences and relations found between the MLP and MSF?

7.1.1 Landscape Level and MSF Streams

The Landscape developments offered various drivers to stimulate the adoption of electric cars. These drivers were categorised as being either challenges that need to be resolved or opportunities that need to be exploited.

The challenges could be traced back in the MSF as being part of the problem stream which was identified as being problematic and for which action needs to be taken (see Appendix 6). In this case study, the common challenges in both analyses were the rising concerns over climate change, air pollution and oil dependency. Taking a step further, these landscape challengs formed indicators (i.e., high levels of CO_2 emissions, high levels of air pollution, and a high degree of depedency on foreign oil) and resulted in a focussing event (i.e., Urgenda Climate Case) in the problem stream of the MSF. Indicators and focusing events form a part of the problem stream however they were not explicitly captured in the MLP since they related to the challenge itself (i.e., climate change, air pollution) rather than technological innovation evolving (i.e, EVs).

Moreover, the MLP captured technical challenges that the MSF did not capture, namley the limitations of the EV technologies. The reason behind this could be related to the fact that the policy change at the national government level usually does not target innovation challenges since this is left for the industry to solve. For example, a government is not expected to solve the limited car range, charging difficulties or the low battery efficiency. However, it could facilitate the process of solving these technical challenges through a policy mix fostering knowledge sharing, development of research and partnerhsips. This has been reflected in the number of green deals, action plans and the formation of the Formula E-Team partnership that the government had been adopting since its first E-mobility Action Plan of 2009.

Additionally, the challenges at the landscape level pressured international governmental organisations to take action. For instance, at the global landscape level, the California Air Resource Board imposed the zero-emission mandate while at the EU level the performance criteria for new cars were introduced in 2009 to reduce CO_2 emissions in the road transport sector. In the MSF, these landscape policies are found in the policy stream. These policies helped the sector transition to electric cars by pressuring the car manufacturers to produce electric cars. In return the market started developing momentum for the adoption of electric cars which helped gradually build the technical feasibility of the ambitious targets set first in the E-mobility Action Plan and then in the National Climate Agreement. Thus landscape level and policy stream pool of policies can increase the technical feasibility of the national policies of the MSF.

While the MSF did incorporate the challenges of the landscape level of the MLP, it lacked its opportunities. In this case, these opportunities were technology related such as the emergence of Li-ion batteries, the emergence of renewable energy, and decrease in battery prices. The opportunities allowed certain technological innovations relating to EVs to take place. For instance the emergence of Li-ion batteries in multiple applications triggered Tesla Motors to use the technology in their Roadster electric car. This formed a revolution in the world of EV technology as it made reliable and practical electric cars technically feasible to produce. Similarly, the decrease in battery prices decreased the price of purchase which in return formed a new incentive for people to buy the electric cars. In this case, the landscape offered opportunities to increase the technical feasibility and financial viability of the new policies stimulating the transition as EVs became more feasible to produce and affordable to purchase.

7.1.2 Regime Level and MSF Streams

The regime level offered various economic, technical, and social barriers ranging from the high purchase costs of the EVs to the public concerns over the real impact of the latter. These barriers were hindering the adoption of EVs, therefore, the government used its policy incentives to break these barriers. Prominent policies have been the reduction in taxes for the purchase and lease of cars as well as the various green deals and action plans and partnerships done with the industry players.

It is important to note here that the drivers of electric cars also have an important political contribution in the country as they tend to choose who gets to represent them in the Dutch government through the elections that happen each four years. These elections are not captured in the MLP and do not have a direct contribution to the socio-technical developments. However, it is found in the MSF as part of the political stream. In this case, as a result of the general elections of 2017, the conservative-liberal political party, People's Party for Freedom and Democracy (VVD), got the highest number of votes. This election resulted in the coalition agreement in which the National Climate Agreement was discussed. Thus in this case, there is a link between the consumers (i.e., electric car drivers) and party ideology ruling the country. In return, the higher the support for a certain political party and its ideology, the higher the value acceptability would be for the potential policies formed by the government.

7.1.3 Niche Level and MSF Streams

The niche level of the MLP captures specific developemnts that could have a major impact on the course of events in the transition. Such developments are not captured by the MSF. For example, in 2013 Fastned was founded by two entrepreneurs who refused to fall into the “Chicken and Egg” situation as in what should be stimulated first; the purchase of electric cars or the roll out of the charging stations. The two entrepreneurs decided to start developing nation-wide fast charging stations across the Netherlands in 2013 in order to tackle the technical barriers of lack of charging stations and long recharging durations. Fastned was formed while the number of EVs on the road was still not at its minimum.

Similarly, in order to tackle the social barriers (i.e.,concerns over real impact and lack of fun driving an EV), Environmental Defense (Milieudefensie) and Nature and Environment worked on the “A15 project”. The plan of this project was to stimulate the use of electric (shared) cars that are charged with locally generated electricity from the sun and wind. By organizing knowledge sessions, engaging driving school students in experiencing electric cars, allowing a number of companies, employees and entrepreneurs to use electric shared car, and offering electric taxis in Rotterdam for the first time, the project increased the public acceptability towards electric cars.

Such niche developments have helped break certain barriers that were found in the regime. Such niche developments contribute to making the E-mobilty Action Plan and the target set for 2030 in the National Climate Agreement feasible. This is related to the concept of technical feasibility, value acceptability and financial viability of the policy stream in the MSF.

Policy developments at the niche level targeting industry players came in the form of green deals with different sector players. For instance, the transition to electric cars has been carried out through the "Electric Driving Green Deal" (Green Deals, 2011a) and the "Electric Transport Green Deal 2016-2020" (Green Deal, 2016). Additionally, thousands of charging stations were being rolled out in public spaces through the "Publicly Accessible Electric Charging Infrastructure Green Deal" (Green Deal, 2011b). However, no strict regulations for the sector parties were found which can be related to the fact the Netherlands does not have car manufacturers. The Dutch government also formed the private-public partnership, the Formula E-team, which contributed to the successful roll-out of EVs on the Dutch roads. These governmental policies were captured by the MSF and formed the pool of policies of the policy stream of the MSF.

In return the adoption of the E-mobility Action Plan and the National Climate Agreement did create a protected space for the developments at the niche level to evolve and diffuse into the market. For instance, the climate agreement included a special set of agreements for the charging infrastructure known as the "National Charging Infrastructure Agenda". This agenda has been drawn up by different municipalities, provinces, the national government, network managers, Dutch businesses and industry associations and is currently providing the charging capacity needed for the growing number of electric vehicles (Ministry of Economic Affairs and Climate Policy, 2019a). This is an example of how the National Climate Agreement protected the niche developments and allowed them to evolve through working closely with different stakeholders.

7.1.4 Policy Entrepreneurs and the three levels of the MLP

The policy entrepreneurs of the MSF are not specifically captured in the MLP. However, this analysis has shown that three levels of the MLP formed drivers for the policy entrepreneurs to actively bring the three streams together. For instance, the challenges at the landscape level, namely climate change and air pollution, were the driving factors for both the Nature and Environment and the Urgenda foundation to lobby against the government. The social, technical, and economic barriers of the regime level forced the policy entrepreneurs to work on ripening the policy stream through developing a set of solutions for the government to adopt. This was specifically clear in the case of Nature and Environment that presented its set of solutions in the form of the action plan "Towards one million electric cars by 2020" in which the forming of the Formula E-Team was its first recommendation for the government.

While in this case it is not evident how the niche developments affected the course of actions of Nature and Environment or the Urgenda foundation, one could argue that niche developments could help policy entrepreneurs beleive in sustainable transitions as viable solutions for solving the landscape level and the problem stream challenges.

7.2 Insights for Future Synthesis

Now that the comparison is done, it is important to reflect on what this entails in the broader scheme of sustainability transitions. In general and apart from the Dutch context, how the different levels and streams are related to each other will be presented below. This would answer the following sub- question.

> What are the insights gained regarding the relation between the MLP and MSF that can help when synthesizing the two theoretical frameworks in the future?

The comparative analysis resulted in13 insights that explain how the three levels of the MLP (i.e., Landscape, Regime and Niche levels) relate to the three streams of the MSF (i.e., Problem, Policy, Politics stream). Figure 25 illustrates these relations. In the following sections the commonalities found between the two frameworks will be presented along with a brief explanation to support them. It is important to note that the concepts of the MSF (i.e, national mood, party ideology, indicators, focusing events, technical feasibility, financial viability, and value acceptability) have been used here to explain certain relations. To understand these concepts one could refer to Section 2.2.

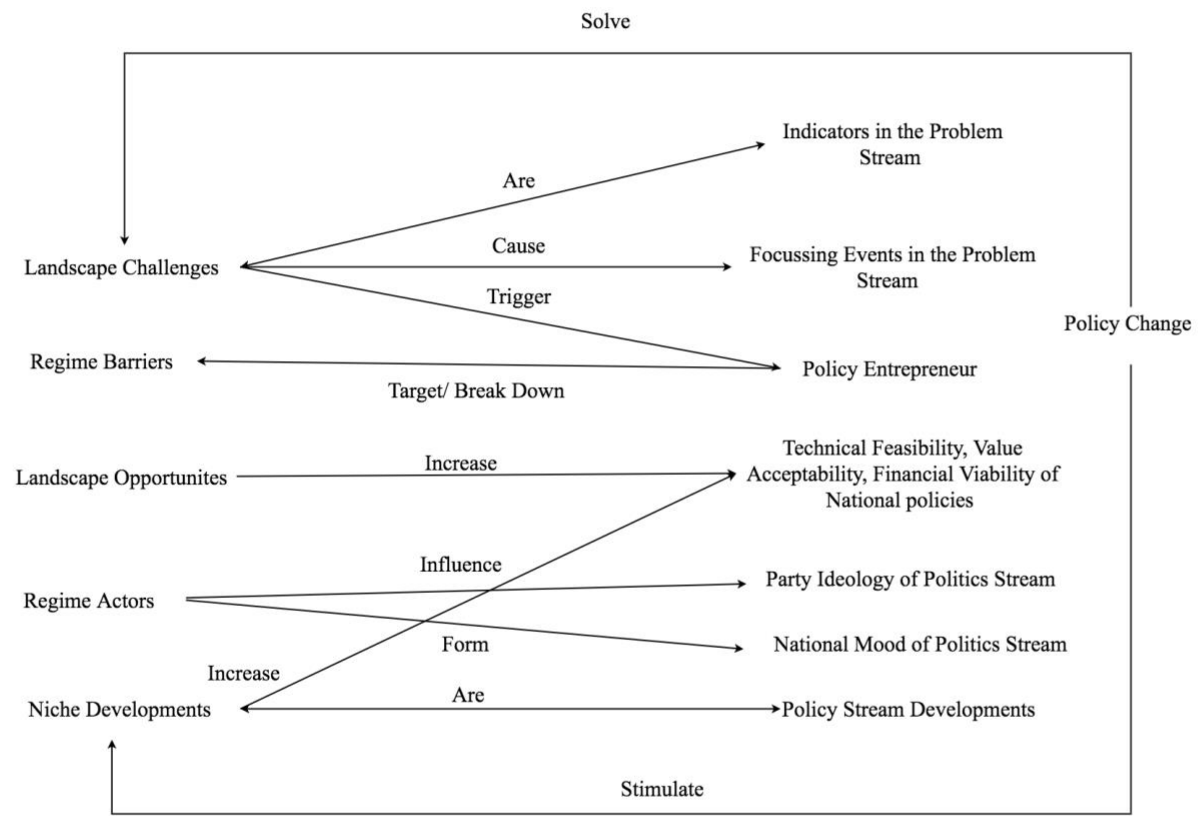


Figure 25 *Relations found between the three levels of the MLP and the three streams of the MSF. Source: own compilation*

Note: the two differences in concepts of the MLP and MSF are not illustrated in the figure .

7.2.1 Commonalities Between the Two Frameworks

In this section the commonalities detected between the two frameworks will be put forward.

1. **Exogenous socio-technical challenges form the problems within the policy subsystem**

Exogenous socio-technical challenges are the landscape challenges in the MLP. These challenges are equivalent to the problem stream of the MSF. However, in the MSF, the challenges take a more explicit form, namely being indicators. For instance, the rising CO_2 emissions is an indicator (in the problem stream of the MSF) for climate change effects (in the landscape level of the MLP). Other indicators could be non-numerical, for example, Russia's invasion on the Ukraine can act as an indicator for the rising challenge of decreasing oil dependency.

2. **Niche developments carried out by governmental organisations form the pool of policies within the policy subsystem**

Niche developments carried out by governmental organisations correspond to the policy stream of the MSF. The policies forming the policy stream are also referred to as the solutions that are developed to carry on a policy change. In the MLP the different government initiatives that have been taking place since the early 2000s all have been contributing to the emergence, diffusion, and later establishment of electric cars into the regime system. The same set of governmental initiatives took part in the policy stream of the MSF and was contributing to enhancing the technical feasibility, value acceptability and financial viability of the policy changes that followed (i.e, the E-mobility action plan and the 100% target of only registering zero emissions cars by 2030 of the National Climate Agreement).

7.2.2 Differences Between the Two Frameworks

In this section the differences detected between the two frameworks will be put forward.

3. **Exogenous socio-technical challenges relating to the technical component of the sustainable transition are not captured within the policy change process**

It is important to note here that the MLP can also include technical challenges but this is not very typical of the MSF. A possible explanation for this would be that policy change in the MSF usually targets specific societal problems that are not of a technical nature. Technical challenges (e.g., charging difficulties, limited car range and low battery efficiency) are often left for the industry to solve and are not targeted by the policy change that is captured by the MSF.

4. **Exogenous socio-technical opportunities are not captured within the policy change process**

Similarly, the MSF does not include the exogenous opportunities. In this study for example, the emergence of Li-ion in battery applications and the decrease in battery prices formed major opportunities for the development of the electric cars. If it was not for these two factors, electric cars would not have gained the momentum it has today. Nevertheless, the MSF does not take into account the opportunities that a system offer and that could foster a policy change.

7.2.3 Causal Relations Between the Two Frameworks

In this section the causal relations detected between the two frameworks will be presented.

5. **Exogenous socio-technical challenges cause certain problems within the policy subsystem**

The exogenous challenges at the landscape level of the MLP can result in focussing events in the problem strea of the MSF, if they are left unhandled. The problem stream in the MSF is defined as "being problematic and for which action needs to be taken" (see Appendix X). If actions are not taken by the responsible authorities to deal with the exogenous challenges, focussing events can erupt. In this case the focussing event was the "Urgenda Climate Case " in which the Dutch government was sued for its insufficient actions taken to combat climate change. In this case the landscape challenge is climate change and the focussing event of the problem stream was the Uregenda Climate Case.

6. **Exogenous socio-technical challenges relating to the technical component of the transition can be solved by a set of policies mixes fostering knowledge sharing, development of research and partnerships**

The MLP captures technical challenges of sustainable transitions that the MSF does not include (as explained before in the "differences" section). However, the MSF has shown that the policy stream could facilitate the process of solving these exogenous technical challenges through a policy mix that fosters knowledge sharing, development of research and partnerships among system actors. This has been reflected in the number of green deals, action plans and the formation of the Formula E-Team partnership that the government had been adopting since its first E-mobility Action Plan of 2009. These policies were mainly put into effect in order to help the industry solve the problems it is facing in relation to the technology of electric cars.

7. **Policies change can stimulate further niche developments (through shielding, nurturing and empowering them)**

Borrowing from the Strategic Niche Management (SNM) framework, the concept of protected spaces can be used here to illustrate the feedback relation existing between policy change and socio-technical change. According to the SNM the protected spaces consist of three main elements; shielding, nurturing and empowering (Smith & Raven, 2012). Shielding is defined as the process of guarding emerging innovations against the selection pressures of the regime. After the niche has been shielded in the protective space it is then nurtured through different reinforcing mechanisms. Finally, the niche is empowered to take on the different challenges of the socio-technical regime in a competitive manner (Smith & Raven, 2012). Having a policy change that stimulates the transitions would consequently either shield, nurture or empower the niche developments according to the phase in which the transition is at.

For example, the National Climate Agreement included several smaller agreements with industry players to enhance communication across the sector, facilitate battery check and warranty, and increase the electrification in leasing. Furthermore, the climate agreement also included a special set of agreements for the charging infrastructure known as the "National Charging Infrastructure Agenda". According to the MLP analysis the transition to electric cars has already reached today its establishment phase. Thus, the National Climate Agreement came to empower the niche developments against the barriers that the regime has imposed through the formed agreements and partnerships.

8. **Exogenous socio-techncial challenges of landscape level can trigger the policy entrepreneurs to couple the streams**

Policy entrepreneurs are mostly triggered to take action if there is a societal challenge that needs to be addressed by the government. Such challenges form part of the landscape level in the MLP. This has been the case with the Nature and Environment orgnaisation that was challenged by the rising levels of air pollution and the increasing effects of climate change.

9. **Exogenous socio-technical opportunities contribute to the technical feasibility, value acceptability and financial viability of new the new policy change**

As explained in Section 2.2, technical feasibility, value acceptability and financial viability form the criteria that make certain policy ideas reach the policy agenda. This analysis has shown that certain exogenous factors contribute to making certain policies adhere to the criteria that make a policy change possible. For instance, in this case study the emergence of Li-ion batteries, the emergence of renewable energy, and the decrease in battery prices all allowed certain technological innovations relating to EVs to take place. Tesla Motors decided to adopt the Li-ion battery technology in their Roadster electric car because of the proliferation of Li-ion batteries in various applications. This led to a revolution in EV technology by making the production of reliable electric vehicles technically viable. Similarly, the decrease in battery prices decreased the price of purchase which in return formed a new incentive for people to buy electric cars. In this case, the landscape offered opportunities to increase the technical feasibility and financial viability (and in some cases the value acceptability) of the new policies stimulating the transition as EVs became more feasible to produce and affordable to purchase. If it was not for these landscape developments, the ambitious target of the National Climate agreement (i.e., allowing only electric cars to be registered as of 2030) would not have been possible to adopt.

10. **Niche developments increase the value acceptability, technical feasibility and financial viabilities of policy change stimulating innovation**

Similar to the landscape opportunities (which can be seen as niche developments happening elsewhere), local niche developments relating to the technology itself could also increase the value acceptability, technical feasibility and financial viability of policies aiming at fostering innovation and driving the transition. For example, the various niche developments discussed such as the establishment of Formula E-Team, Elaad, Fastned, the European headquarter of Tesla in Amsterdam, Fastned, etc. all have played big roles in either the technical, financial or value components of the transitions. This in return made certain policies stimulating the transition technically feasible, financially viable and acceptable in terms of their value.

11. Policy entrepreneurs aiming at ripening the policy stream (and thus couple it with the other streams) will have to focus on breaking down the regime barriers

The regime can often have several economic, social and technical barriers hindering the diffusion of an innovation from the niche into the regime. In such cases, policy entrepreneurs influence the system and create a policy window would have to work on ripening the policy stream by offering solutions that can break the barriers of the regime. This has been the case with the E-mobility action plan. Back in the early 2000s, the regime was inherently locked into a structure that favoured the use of ICE cars. Therefore, Nature and Environment saw that an action plan that illustrated the different needed steps to break down this structure would allow the government to consider looking into the transition. Eventually, their action plan was used as a guiding pillar for the E-mobility action plan that the government later that year published.

12. Regime actors determine the national mood which forms the political dimensions in a policy change processes

In the MLP actors in the system tend to be considered external to the political arena. This is not the case in the MSF in which actors from the politics. Forming the political streams comes through the national mood. In general, actors tend to determine the dominating national mood of a political stream. Although the MLP does not differentiate between the actors of the landscape, regime and niche levels, one can consider the actors forming the national mood as regime actors. Today the national mood is accepting change towards sustainability which is reflected in the activities of the different regime actors and the pace through which they are adopting sustainability innovation.

13. Regime actors influence the party ideology ruling the country which forms the political dimensions in policy change processes

Influencing politics happens through influencing the party ideology which in return can determine the topics that reach the political agenda. In some cases, today people are not only forming a certain national mood around a certain topic but also demanding change through actions which in return is affecting the party ideology in the politics stream. This is illustrated in the 2019 protests in which 40,000 people participated in a protest in Amsterdam against the initial discussions over the National Climate Agreement. The government was considered not to be taking enough actions to combat climate change which in return led the government to impose the CO_2 tax as a part of the National Climate Agreement. In this case, one can see how regime actors had a direct influence on politics through influencing party ideology.

7.3 Generalisability of Insights

To test whether the commonalities, differences and relations found between the different components of the two frameworks could be generalisable or not, three external validation interviews were conducted (as discussed in Section 3.9). The interviews started with generic questions and in course of the discussion more specific questions were asked relating to the findings of this research. In general, the interviews focused on answering the questions found in Appendix 4.

Dr Sewerin tried to reflect on the findings of this research by linking them to the "Policy Feedback" thinking concept. He reflected on his study which showed that there exist feedback relations between politics, policy, technology and the final climate impact that the sustainable transitions aim to address (See Figure 26). According to Dr Sewerin, the findings of this study do fit within the paradigm of his study. For instance, the landscape developments correspond to the political concept since it includes all the developments that influence the larger subsystem. The regime forms the sector system while the niche corresponds to the technological change driving transition.

Moreover, he talked about ideational and resource feedback mechanisms which could be reflected in the middle part of the Figure 25. Ideational level refers to the basic conceptions of how the world is and ought to be. The resource level sets out the operational policy objectives for attaining these ideations. For instance, from his point of view, the national mood and party ideology change would fit under ideational feedback while the value acceptability, technical feasibility and financial viability could fit under the resource feedback as in would it be possible to attain a change from a value-related technical, financial stance.

It was further recommended by Dr Sewerin to further generalise the findings to give them more reach to the literature. Boiling down the concepts more abstractly would make it more relevant for the various target groups that this research aims to reach. He acknowledged that it is a challenge to reach a level of abstraction that can also allow for things to get complicated when one looks at the details of the concepts

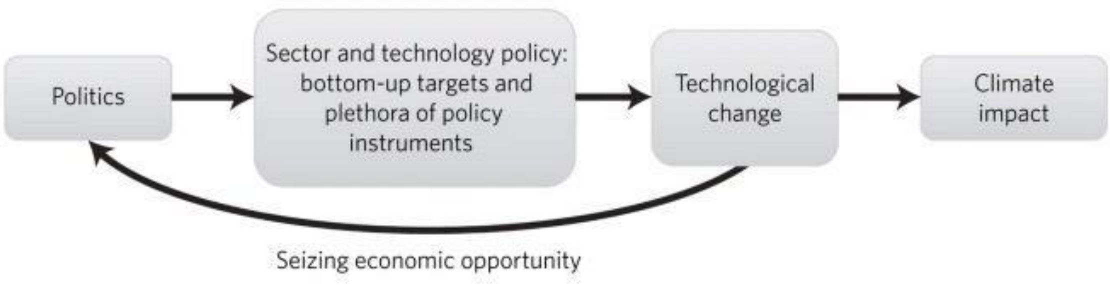


***Figure 26** The interplay between politics, policy, technological change and climate change Source: (Schmidt & Sewerin, 2017)*

The validation session with Dr Schot also revealed that the findings of this research are in general termterms generalisable and understood when discussed outside the scope of the case study. He discussed that policies can generate niche developments through various incentives. He explained that subsidies can be given under conditions that steer development and learning processes in a certain direction. He also discussed that policies can make connections between the different niches because we often need intermediaries that build the ecology of niches. The concept of “ecology of niches” has been directly discussed in relatioaboutn to the Formula E-Team this research has proven to have played a major role in driving the transition. Moreover, through policies the government can destabilize dominant systems by removing subsidies, providing benefits for the niche actors, stimulating research and other various actions.

He also revealed it is important not to forget about the current policies fostering the current regime. Although various initiatives have been taken in articulate electric driving, the fossil fuel sector is still heavily supported by the government. This leads to a set of policies that are not consistent and could thus slow down progress towards a transition. He added that for niche developments to accelerate regime actors have to migrate towards the niche level to add their contribution.

At last, he reflected on the specific case study of this research. He noted that the transition to electric cars is a starting step towards a larger mobility system change in which car ownership would be minimal. This raised the question on whether the transition to electric mobility is changing the car regime or optimising it. In his opinion, the car regime needs to be replaced, while efforts have been set in that direction, electric cars came to prove once more that the cars could not be substituted by other modes of transportation. It is interesting to reflect on this point as it reveals that sometimes transitions understudies might not necessarily lead to a system change but instead it could foster it through optimising its inherent concepts (which in this case is car ownership).

The third validation session was done with Jerico Bakhuis, a PhD researcher at the TU Delft. He also agreed with the general findings of this study. He reflected on the connection of the two frameworks similarly as this study does. He saw that the politics and the problem stream form a part of the landscape level. The landscape level led a to a number of problems that also formed a part of the political developments in the MSF. Also, while this study is focused on one case he saw that the policy change of the MSF can be considered intra-regime and not necessarily bound to driving a transition within one regime structure. The policy stream in return was according to Bakhuis a part of the niche and regime structure.

8 Conclusions & Recommendations

In this chapter, the conclusions and recommendations will be presented. In Section 8.1 the answer to each of the four questions will be presented. Section 8.2 discusses these findings about the literature to reflect on the academic contribution of this paper. In Section 8.3 the limitations followed by a set of recommendations for future scholars will be presented. At last, the recommendations for policymakers will be discussed in Section 8.4.

8.1Main Findings of this Research

Sustainability transitions are socio-technical developments driven by policy change while being inherently value-laden and political. Thus in order toto understand how sustainability transitions come about it is essential to examine how socio-technical and policy change co-evolve. While it's critical to comprehend the wider connections between policy change and socio-technical changes, it's equally vital to go into detail about the "black box" of each. This would enable a better understanding of the relationships and interactions between the many processes taking place in the policy subsystem and during a socio-technical transition, as well as how this coevolution affects the overall course of a sustainable transition.

Scholars that have attempted to cross-fertilise the theories of transition studies and policy change are Derwort et al., (2021). Derwort et al. (2021) studied the German energy transition, using the Multi-level perspective from transition studies and the Multiple Streams Framework from the policy literature. The findings of their research were two-fold:

1. Political decisions triggered socio-technical change directly or paved the way for new, innovative technological developments shielded from strong market pressure
2. Technological advances provided new solutions in the policy stream feeding back into the political agenda.

Derwort et al. (2021) made a significant contribution to the literature studies by demonstrating the existence and, consequently, the significance of feedback mechanisms between socio-technical and policy change in the context of sustainability transitions. However, it is still not clear how the political decisions trigger socio-technical change or how technological advances provide new policy solutions.

In an attempt to build upon the research of Derwort et al. (2021), this study applied the MLP and MSF to the Dutch transition to electric cars while taking an extra step in bridging the two theories. This research attempted to understand how the three levels of the MLP relate to the three streams of the MSF. Thus the knowledge gap that was still persistent in literature and that this research aimed to bridge was the systematic understanding of how policy change (resulting from the intersection of the three streams) and socio-technical transitions (resulting from the pressure of landscape and niches on the regime) combined affect each other and consequently influence sustainability transitions. To bridging this knowledge gap the following main research question was formulated:

How can a study of socio-technical transitions using MLP and policy changes using MSF applied to the transition to electric cars in the Dutch mobility sector help to create insights in how to synthesise the two aforementioned theoretical frameworks?

Answering this research question entails answering the following four sub-questions:

1. How can the MLP explain the socio-technical transition to electric cars in the Dutch mobility sector?
2. How can the MSF explain the policy changes that are helping in the transition to electric cars in the Dutch mobility sector?
3. What are the main commonalities, differences and relations between the MLP and MSF?
4. What are the insights gained regarding the relation between the MLP and MSF that can help the future synthesis of the two theoretical frameworks?

8.1.1 Results of the MLP Analysis

The MLP analysis have shown that the landscape level offered various drivers to stimulate the adoption of electric cars. These drivers were either exogenous challenges or opportunities. The challenges in this case study were air pollution, climate change, increasing oil dependency, and limitations of EV technology. On the other hand, the emergence of Li-ion batteries in various applications across multiple sectors, the emergence of renewable energy as a source of energy and the decrease in battery price, formed new opportunities for industry players to exploit.

The challenges formed drivers that pressured the global and the Dutch national government to take actions. Governmental actions came in the form of policies that pressured industry players to work on the technology of electric cars as well as the related products, services and infrastructure. For example, at the global landscape level, the California Air Resource Board imposed the zero-emission mandate which was credited for launching a revolution in clean automotive technology. Similarly at the EU level, the performance criteria for new cars were introduced in 2009 to reduce CO_2 emissions in the road transport sector. The regulation set a fleet-wide target of 130 g CO_2/km for the period 2015-2019 and 95 g CO_2/km for the period 2020-2024, as well as particular CO_2 emission objectives for each manufacturer.

At the Dutch niche level, the policies steered the industry players through agreements with different parties in the market such as the Green Deal “Electric Transport 2016-2020”.

However, no strict regulations for the sector parties were found which can be related to the fact the Netherlands does not have car manufacturers.

The Netherlands also had a prominent role in steering the public towards the adoption of EVS through various policy incentives such as tax reductions and subsidies. Moreover, the Dutch government also formed partnerships with niche players that were either environemntalists, such as Nature and Environment organisation, or industry players offering the charging stations, charging passes and other related services. The most prominent public-private partnership is the Formula E-team which contributed to the development of various policies, action plans and green deals.

Besides governmental organisations, other system actors also played a role at the niche level. For instance, Nature and Environment, played a crucial role in supporting the transition to electric cars. The organisation took part in various initiatives either by lobbying for governmental action or by incentify the public to buy electric cars. Back in 2009, Nature and Environment presented an action plan to the government at the AutoRai in which the steps needed to transition to electric mobility were presented. The first step in the plan was forming the Formula E-team which became operational in 2010 and in which Nature and Environment is still a partner at. Other stakeholders took part in driving the transition through developing the infrastructure needed such as the grid and charging network.

All in all, the landscape challenges, opportunities and the niche level developments carried out by governmental and industry actors have helped break certain regime barriers relating to the economic, technical and social barriers. It is important to note that there was no specific window of opportunity that opened at a certain moment in which electric cars moved from the niche to regime level. This analysis has shown the incremental small niche and landscape developments have both helped break certain regime barriers over time and increase the diffusion rate of the cars into the existing market.

8.1.2 Results of the MSF Analysis

Governmental ambitions for stimulating electric cars were first made official in the E-mobility Action Plan in 2009. Following this action plan several policy intiatives were taken to either partner with the industry players or to influence the public towards buying or leasing electric cars. All these initiatives taken were seen as important drivers for the transition. However, it was not until 2019 that the government announced it will only accept emission-free vehicles to be registered in the Netherlands starting 2030. Despite being a relatively new policy, it is the outcome of developments that have spanned over several years. These development built momentum for the Dutch government to set such an ambitious target that in return is currently determining the course of events.

The 2009 E-mobility Action Plan established the first explicit government goals for stimulating the use of electric vehicles. Following this action plan, a number of legislative initiatives were launched to either collaborate with key industry participants or to incentify consumers to purchase or lease electric vehicles. All of these actions were considered to be crucial transitional drivers. However, in 2019 a much more serious target came into effect. The National Climate Agreement declared that only zero-emission electric cars will be allowed starting 2030. The Dutch government established such a lofty goal as a result of these developments, which is now dictating the course of events.

In order to understand the processes that played a role in forming the E-mobility action plan of 2009 first and the National Climate Agreement of 2019 next, the MSF was applied. Results have shown that in the problem stream, several challenges were being experienced that were ripening the stream and offering system actors sources of pressure to react. In this analysis the problems formed pressure on the global, European and national (governmental) organisations. In order to highlight the urgency of the problems, several agreements were made that the Dutch national government took part in. These agreements were mainly targeting climate change.

Environmentalists were also motivated to act by the growing fears over climate change. For instance, the Dutch government received lobbying from the Nature and Environment, which regarded a reduction in CO2 emissions in the road transport sector as something that has to be done and created its own action plan for transition to electric cars that it subsequently presented to the government. Similar to the Urgenda foundation, which was spurred by the intensifying consequences of climate change, the Dutch government was sued for not doing more to tackle the issue. Nature and Environemnt and the Urgenda foundation were considered policy entrepreneurs in this study as they succeeded in coupling the three streams of the MSF and cause a policy change relating ot the E-mobility Action Plan and the National Climate Agreement respectively.

At the policy stream, through numerous governmental incentives, the national government encouraged the Dutch population to adopt EVs. Both the ambitious goal of the National Climate Agreement and the E-mobility Action Plan eventually gained pace as a result of these initiatives. The value acceptance of actually purchasing an electric automobile increased as a result of the tax breaks and incentives. Policies aimed at industry participants took the form of contracts with various market participants, such as the Green Deal "Electric Transport Green Deal 2016-2020."

At the politics stream, the acceptance and in some cases enthusiasm of political and influential figures for EVs have helped ripen the politics stream. Prominent figures in this transition have been Ruud Koornstra (who had bought the first locally built electric race car), prime minister Balkenende, minister Eurlings and Prince Maurits (that was the first chairman of Formula E-Team).Today, the current cabinet is stimulating the transition which is the direct outcome of the 2017 elections in which the conservative liberal party (VVD) won the highest number of seats. This election resulted in the coalition agreement in which the ambitions of the National Climate Agreement were first brought forward. The fact that the agreements came from a party of high public support also increased the value acceptability of the set ambitions.

8.1.3 Results of the Comparative Analysis

After applying the two frameworks separately on the case study, the results were compared together. At first the three levels of the MLP were compared with the three streams of the MSF according to the results of the analysis. This comparison entailed identifying similar and different concepts as well as how certain aspects in the MLP relate to that in the MSF.
The comparison resulted in a number of insights that related to the commonalities between the two frameworks, the difference and the relations between the concepts. These will be put forward below.

The commonalities detected between the two frameworks revealed that:

- Exogenous socio-technical challenges form the problems within the policy subsystem
- Niche developments carried out by governmental organisations form the pool of policies within the policy subsystem

The differences between the two frameworks relate to the following concepts:

- Exogenous socio-technical challenges relating to the technical component of the sustainable transition are not captured within the policy change process
- Exogenous socio-technical opportunities are not captured within the policy change process

The relations detected between the two frameworks are:

- Exogenous socio-technical challenges cause certain problems within the policy subsystem
- Exogenous socio-technical challenges relating to the technical component of the transition can be solved by a set of policies mixes fostering knowledge sharing, development of research and partnerships
- Policies change can stimulate further niche developments (through shielding, nurturing and empowering them)
- Exogenous socio-technical challenges of landscape level can trigger the policy entrepreneurs to couple the streams

- Exogenous socio-technical opportunities contribute to the technical feasibility, value acceptability and financial viability of new the new policy change

- Niche developments increase the value acceptability, technical feasibility and financial viabilities of policy change stimulating innovation

- Policy entrepreneurs aiming at ripening the policy stream (and thus couple it with the other streams) will have to focus on breaking down the regime barriers

- Regime actors form the national mood which forms the politics dimensions in a policy change processes

- Regime actors influence the party ideology ruling the country which form the politics dimensions in a policy change processes

In total the 13 propositions formed show that there is indeed relation between the MLP form the innovations studies and the MSF from the policy literature that could be brought together and synthesized in order to understand sustainability transitions. The academic relevance of the findings of this research will further be discussed in the following section.

8.2 Academic Contribution

The findings of this research proved that certain concepts of the MLP and MSF overlap as they are common between the two frameworks. For example, exogenous landscape challenges are equivalent to the problem stream of the MSF. However, in the MSF, the challenges take a more explicit form, namely being indicators. Similarly, niche developments carried out by governmental organisations correspond to the pool of policies within the policy stream of the MSF. In the MLP the different governmental initiatives that have been taking place since the early 2000s all have been contributing to the emergence, diffusion and later establishment of electric cars into the regime system. The same set of governmental initiatives took part in the policy stream of the MSF and was contributing to enhancing the technical feasibility, value acceptability and financial viability of the policy changes that followed.

On the other hand, the findings of this research showed that certain concepts that form an inherent part of the MLP are missing from the MSF. The MLP includes technical challenges but this is not very typical of the MSF. A possible explanation for this would be that policy change in the MSF usually targets specific societal problems that are not of a technical nature. Technical challenges are often left for the industry to solve and are not targeted by the policy change that is captured by the MSF. Moreover, exogenous socio-technical opportunities are not captured within the policy change process. In this study for example, the emergence of Li-ion in battery applications and the decrease in battery prices formed major opportunities for the development of the electric cars. If it was not for these two factors, electric cars would not have gained the momentum it has today. Nevertheless, the MSF does not take into account the opportunities that a system offer and that could foster a policy change. It is foreseeable that a framework on policy change is not expected to include the technical dimensions of the socio-technical change the policy is targeting. However, it is still important for a framework dealing with sustainable transitions to incorporate the implications that such technical developments have on the general course of events leading to the policy change. This is where the potential of the MLP comes in to compensate this limitation.

Applied to the Dutch transition to electric cars, the findings relating to the relations between the two frameworks validated the results of Derwort et al. (2021) research. Proposition 9 and 10 revealed that the landscape opportunities niche developments increased the value acceptability and technical feasibility of a policy change. These propositions are in line with Derwort et al. (2021) finding relating to the solutions in the policy stream feeding back into the political agenda due to the technical developments. Propositions 7 validated the second finding of Derwort et al. (2021) which stated that political decisions could pave the way for new, innovative technological developments by shielding them from strong market pressure.

This research also relates to the study of Schmidt & Sewerin, 2017. This was made clear during the validation session in which Dr. Sewerin reflected on his own study which showed that there exist feedback relations between politics, policy, technology and the final climate impact that the sustainable transitions aim to address. According to Dr. Sewerin, the findings of this study does fit within the paradigm of his study. For instance, the landscape developments correspond to the politics concept since it includes all the developments that influence the larger subsystem. The regime forms the sector system while the niche corresponds to the technological change driving transition.

Further this research has proved the existence of relations that have not yet been discussed by previous scholar such as the relations between policy entrepreneurs and the regime barriers (Proposition 11), and the relations between regime actors and the national mood and political ideology (Proposition 12). In order to further unleash the full explanatory power of the MLP and MSF, it is essential to synthesise the two frameworks together. This research offers the possibility of a future synthesis of the two frameworks by using the propositions that this research has developed. Utilizing the propositions of this research to develop a new framework could reveal the crucial linkages between socio-technical innovation and policy change in sustainability transitions. Such a new framework, combining both concepts of transition studies and policy literature, would be of great added value to both transition scholars as well as policy analysts aiming to understand how sustainability transitions come about.

However, it is important to reflect that this study has focused on proving the existence of relations between two theroetical frameworks in an attempt to help in their future synthesis. However, it is important to understand that there is still a step that needs to be taken before the two frameworks could be synthesised; which is understanding how the different concepts relate. For instance, this study revealed that regime actors can influence the party ideology of the politics stream. Nevertheless, this study did not go into the different mechanisms that such regime actors could take in order to influence a party ideology. Therefore, future studies that would attempt to build up on this study will have to first study the different processes or mechanisms that bring together a concept of the MLP and MSF. By doing so, the study would reveal if the feedback and effect mechanism of Edmondson et al., (2019) and the learning processes of Gomel & Rogge (2020) exist between the three levels of the MLP and the three streams of the MSF.

8.3 Limitations & Recommendations

This research is an extension to the study of Derwort et al., (2021). Their research suggested that a more systematic and extended investigation is needed to contribute to the conceptual development of bringing together the MLP and MSF. This research took up the call of Derwort et al., (2021) and validated their results that were confined to the application of the German energy transition. Nevertheless, the generalisability of the results of this research are not guaranteed despite the validation sessions done. Since this research took an extra step and investigated the relations between the MLP and MSF at a more granular level than that of Derwort et al., (2021). The comparative analysis resulted in the 13 propositions. Whether these propositions still make sense when applied to another case study is not entirely evidenced. For instance, the geographical context could affect the culture, demographics, user practices, and governance system. Similarly, the transition to electric cars could take a different pathway than other transition studies which consequently could falsify certain propositions. In conclusion, external validity is a limitation of this study.

Another limitation centres around the terminology. In order to apply the MLP and MSF, the different processes and events had to be allocated to the three levels of the MLP and the three streams of the MSF. Given that this research was studying a transition process, the different events bled into one another and were difficult to discern, making the allocation subjective to the author's point of view. Moreover, the implementation of the terminologies of the MLP and MSF within the corpus of extant research varied significantly. For instance, some scholars considered global technological innovation (e.g., The mass production of Tesla Motor S) as niche developments while others considered it as landscape developments given that niche actors do not have influence on its development. Similar inconsistencies were experienced when reading the MSF literature. For example, when some scholars merged terminology streams others added new streams to capture new elements. While this might allow scholars to implement the frameworks freely, it did trigger difficulties in applying the approaches coherently. Attempting to address this limitation, the author established a clear definition of the terminologies used within the two theoretical frameworks. Furthermore, the limitation was also addressed by using “Atlas.ti” software which triggers the mind to adhere to a certain coding scheme that is at least consistent across this research study. However, it is still possible that a different individual conducting the same research would have used different codes for the quotations and developed different categories.

Lastly, the available data also resulted in a limitation. Given that this research is about a transition process that was stretched back to the early 1990's, a lot of information was found in the documents. The plethora of information did cause an inconvenience in filtering out the information that was relevant for the Dutch transition in particular. This was especially the case when applying the MLP as many different processes could be allocated to the three levels. So a development in the US or Norway may or may have not affected the developments happening at the Dutch niche level. To minimise filtering out information that was actually relevant for this case study, interviews were conducted. Although the interviewees were not always able to reflect back in time and mention all the things that played a role in the transition they did give an overview of what the author should focus on during the study. Also several interviewees referred me to specific documents, reports and governmental papers that were actually of high value for this research. Thus, the interviews conducted played a major role in verifying the relevance of the data gathered and helped in minimising the risk of filtering out important information for this research.

It is important to recognize that the findings of this research are not entirely conclusive. Given the case study research design and the qualitative nature of the research, the analysis of this research was subject to the interpretation of the author's perspective. Therefore, it is suggested for future research to extend this research application to other applications that differ in geographical boundaries and in nature of the transition. The more applications are made, the more powerful the extracted insights would be about bringing the two frameworks together.

8.4 Policy Recommendations

The results of this research could benefit policy makers engaging with sustainability transitions. To begin with, the results of this analysis have shown that landscape developments in the MSF entail challenges that need to be addressed. These challenges could either be detected through the indicators or the focusing events of the problem stream of the MSF. It is therefore essential for policy makers to be aware of these challenges to address them in a timely manner.

Besides challenges, the landscape level also offered opportunities that the policy makers need to be alert of in order to utilize for a certain transition. For instance, the emergence of renewable energy could increase the adoption of electric cars because it maximizes the environmental benefits of buying an electric car. In such a case, it is recommended for policy-makers to stimulate the adoption of renewables in parallel to adoptions of EVs as it would give the public extra incentives to buy an electric car. An example of such a stimulans would be offering purchase subsidies for installing solar panels along with the subsidies given to buy an electric car.

Similar to the landscape opportunities, niche developments could also help stimulate the transition. Thus, policy makers should be aware of the developments happening at the niche level and support them in order to shield, nurture and empower them against the regime barriers. It is important to note here, that the Dutch government has already been partnering well with the private sector through various agreements and partnerships. The most prominent public-private partnership is the Formula E-team that have been the source of many niche developments driving the transition since 2010.

Additionally, it is important for the policy makers to understand the phase in which the transition is at in order to target the policy change towards the niche development in such a way that it would either shield, nurture or empower the developments against the selection criteria of the regime. In this case for example, the transition to electric cars has already reached the establishment phase. Thus new policies should help empower the niche developments such that they can take on the different challenges of the socio-technical regime in a competitive manner.

At last, it is important to recognize that in a democratic country, regime actors determine and could influence the party ideology that governs the country. Therefore, it is important to involve the public in the policy making process in order to understand the kind of party ideology they are opting for and to avoid clashes as the Urgenda Climate Case of 2015 or the climate demonstrations of 2019.

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11 Appendices

Appendix 1: Stakeholder Analysis

Table 7 *Important resources of the actors of the Formula E- Team. Source own compilation*

Actor	Description	Important Resources	Source
Ministry of Infrastructure and Water Management (IenW)	Dutch Ministry	• Eliminating legal and regulatory barriers for e-mobility • Stimulating new markets • Sharing knowledge • Facilitating collaborative partnerships with other organisations, businesses, citizens and sister authorities	(Ministry of Infrastructure and Water Management, 2022)
Netherlands Enterprise Agency *-Rijksdienst voor Ondernemend Nederland(RVO)*	Department of Ministry of Economic affairs and climate policy	• Implementing government policy for sustainability and innovation. • Offering assistance with grants, finding business partners, know-how, and compliance with laws and regulations	(RVO, n.d)
Association of Dutch Provinces *- Interprovinciaal Overleg (IPO)*	-	• Informing and guiding the (formal) preparation of policy that is important to the provinces. • Sharing knowledge with and providing information to the provincial partners and 'stakeholders'. • Providing provinces a platform for stimulating	(Interprovinciaal Overleg, n.d.)

		innovation and the exchange of knowledge.	
Association of Dutch Municipalities *-Vereniging van Nederlandse Gemeenten (VNG)*	-	• Helping municipalities with the exchange of knowledge regarding the implementation policies. • Lobbying on behalf of the municipalities on numerous platforms.	(VNG, n.d.)
Metropolitan Region Amsterdam Electric (MRA-Elektrisch)	A partnership of governments in the provinces of North Holland, Flevoland and Utrecht	• Constructing a public charging network • Supporting with fast charging and charging on private property • Supporting area development • Advicing municipalities with policy making • Sharing knowledge	(MRA-Elektrisc, n.d.)
The Royal Dutch Touring Club *-Algemene Nederlandse Wielrijdersbond (ANWB)*	Travellers' association in the Netherlands, supporting all modes of travel.	• Advising and informing in the field of cars • Driver's education • Vehicles insurance • Charging Service: fast charging for electric cars along the highway and at the ANWB locations	(ANWB, 2022a)
Association of Electric Drivers *-Vereniging Elektrische Rijders- (VER)*	-	• Offering information about electric driving • Offering community events, meetings and (online) meeting • Lobbying and influencing politics: local, regional, national and international	(VER, n.d.)

Dutch Organisation for Electric Transport (DOET)	Largest trade association in the field of electric transport in the Netherlands	• Developing activities in the field of networking, lobbying, knowledge sharing & subsidies • Stimulating international (cooperation) opportunities	(Over DOET, n.d.)
Energy Netherlands -*Energie Netherlands*	Association for all parties that produce, supply and trade electricity, gas and heat.	• Representing interests in the broad field of energy supply, from energy generation and trade to supply to consumers and companies. • Supporting the development of new services for its members	(Energie-Nederland, 2022)
Corporate Sustainability and Responsibility (CSR, in Dutch MVO)	Network of partners who innovate in order to attain the New Economy (climate-neutral, circular, inclusive and having a fair supply chain)	• Facilitating innovation with useful collaborations. • Lobbying governments and financiers in order to create the right environment for its realisation	(MVO Nederland, 2022)
RAI Automotive Industry NL	Leading authority in Dutch automotive manufacturing and supply chain industry	• Facilitating a network of companies, active in the Dutch Automotive Industry • Supporting mutual cooperation and collaboration with governmental and knowledge institutions	(Koninklijke Rai Vereniging, n.d.)
Dutch Renewable Energy Association -*Nederlandse Vereniging*	Organisation of entrepreneurs in sustainable energy in the Netherlands.	• Improving the market organisation and energy networks • Supporting sustainable energy production	(NVDE, 2020)

Duurzame Energie- (NVDE)		• Supporting sustainable mobility (through partnerships and lobbying) • Supporting regions in drawing up their Regional Energy Strategy (RES) and and making the built environment more sustainable	
Association of Dutch Car Leasing Companies - *Vereniging van Nederlandse Autoleasemaatschappijen -VNA*	-	• Offering electric lease cars with attractive benefits for drivers	(VNA, n.d.)
BOVAG	Association of motor car, garage and allied trades	• Serving members as an, as a platform and as a news and information centre. • BOVAG lobbies, advises and organises quality assurance	(Bovag, n.d.)
4TU Federation	The alliance of the universities of technology in the Netherlands	• Connect human research capacity in the 4TUs • Coordinate necessary investments in crucial research infrastructure • Stimulate active participation in national and international large-scale committees, programmes	(4TU Federation, n.d.)
Elaad	The knowledge and innovation centre on charging infrastructure in the Netherlands	• Acquiring an overview of the measures to be taken to ensure that the network	(ElaadNL, 2022)

		remains reliable and affordable	
National Charging Infrastructure Knowledge Platform (NKL)	Research Institute for charging Infrastructure	• Developing knowledge over partnerships • Connecting relevant parties to accelerate the arrival of charging infrastructure	(NKL Nederland, 2022)
Nature and Environment - *Natuur en Milieu*	Foundation for Nature Conservation and Environmental Protection Independent environmental organisation	• Informs people about sustainable lifestyles; • Works with companies to find sustainable solutions; • Pressures the government to take climate actions	(Natuur en Milieu, 2022)
Environment Central -*Milieu Centraal*	Is the practical guide to sustainable tips and advice	• Offering independent, reliable (scientific) and practical information regarding sustainable advice and tips	(Milieu Centraal, n.d.)

Legend: Stakeholders

Government Organisations
Consumers
Industry Players
Research Institutions
Environmental groups

Note these actors are found according to (Nederland Elektrisch, n.d.)

Appendix 2: Interview Protocol

Opening Statement

You are being invited to participate in a research study titled "Explaining Sustainability Transitions by Bringing together the Multilevel Perspective on socio-technical transitions and Multiple Streams Framework on policy change".

This study is being done by Rima Arab from the Delft University of Technology. The study is done as a master's thesis submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in Engineering and Policy Analysis. The purpose of the research is to study the co-evolution of socio-technical transitions and policy change by bringing two theoretical frameworks together using the Dutch transition to electric cars as a case study.

I will be asking you to provide some relevant empirical or theoretical information regarding the factors that are contributing to the transition to electric cars. The audio recorded interview will take you approximately *[45]* minutes to complete.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential. I will minimise any risks by keeping your personal data anonymous in the thesis report (unless you allow for using your name). During the research phase, your contact information, interview recording, and transcripts will be stored in a project storage drive "OneDrive" that is connected to the university email address and will be only shared with the thesis supervisors. The interview recordings will be deleted after the research ends in August 2022 and the anonymized interview transcripts will be stored up to 10 years in the 4TU.ResearchData with public access. Note for this research only the audio is essential, so participants are free to keep their cameras closed during the recording.

Consent Form

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐

3. I understand that taking part in the study involves: · An online interview in which the audio will be recorded · The audio of the interview will be then transcribed as text · The recording of the interview will be destroyed after the research ends · The transcribed text will be anonymized and stored for up to 10 years in the 4TU.ResearchData that is of public access Note: In case participants have their cameras open, the video will also be recorded. However, the video is not essential in this research so the cameras can be closed.	☐	☐
4. I understand that I will **NOT** be compensated for my participation by sharing the research results with you at the end of the research project.	☐	☐
5. I understand that the study will end in August 2022.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study does **NOT** involve the following risk: · *physical or mental discomfort; risks for participants in a surbordinate position to the researcher*	☐	☐
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) such as full name and email address and associated personally identifiable research data (PIRD) such as the field of expertise, place of work and job position with the potential risk of my identity being revealed.	☐	☐
8. I understand that the PIRD collected is **NOT** considered as sensitive data within GDPR legislation. Sensitive data include: · *Religion and ethnic origin* · *Political views* · *Data concerning criminal activities* · *Etc.*	☐	☐

9. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: · During the research, data storage (including contact information, the recordings and transcript of interviews) will only be found on the OneDrive that is linked to the TU Delft email address · Only the research team, including the researcher and research supervisors, will have access to the data collected · The audio transcript will be anonymized (names and email addresses and job position, and other personally Identifiable Information will be removed from the transcript) · After the research ends, the audio-recording will be deleted while the anonymized transcript will be stored.	☐	☐
10. I understand that personal information collected about me that can identify me, such as [*e.g. my name and where I work*], will not be shared beyond the study team.	☐	☐
11. I understand that the (identifiable) personal data I provide will be destroyed once the research ends and the thesis is defended in August 2022	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
12. I understand that after the research study the de-identified information I provide will be (potentially) used for a scientific publication.	☐	☐
13. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐
14. I agree that my real name can be used for quotes in research outputs	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS, AND REUSE		
16. I give permission for the de-identified information (anonymized interview transcripts) shared during the interview that I provide to be archived in 4TU.ResearchData repository so it can be used for future research and learning.	☐	☐
17. I understand that access to this repository is open and unrestricted	☐	☐

Signatures

____________________________ ___________________________ _________

Name of participant [printed] Signature Date

[Add legal representative, and/or amend text for assent where participants cannot give consent as applicable]

I, as legal representative, have witnessed the accurate reading of the consent form with the potential participant and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

____________________________ _________________________ __________

Name of witness [printed] Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

__________________________ ____________________ _________

Researcher name [printed] Signature Date

Study contact details for further information: [*Rima Arab, 0638724240, rimaarab@live.com*]

Appendix 3: Interview Questions

Opening Questions

- Could you briefly tell me about your role in the firm?
- How long have you been working at the company?

A.Industry related questions:

General Questions

- In general, why do you think the Netherlands is transitioning to electric cars?
- Why did your firm decide to support the transition to electric cars?
- How does your firm contribute to the transition to electric cars?

Question related to past developments:

- What role did your firm (in the past) play in the transition to electric cars?
- What local and/ or global factors (technical, social, environmental, etc.) influenced the decision of the firm to start working on helping the transition?
- What local and/ or global events influenced the decision of the firm to start working on helping the transition?
- Which policies helped you throughout the process?
- Which main actors played a role in stimulating the transition to electric cars?
- What kind of difficulties (technical, policy-related, social, financial, etc.) did you face throughout the years while working on the transition?
- How did you collaborate with other actors in the network to help the transition?

Questions related to the technology:

- What technological improvements helped the transition?
- Which technical players were or are actively involved in developing the technology?
- What shielded these technologies from phasing out?
- What empowered these technologies to further develop?
- What are your expectations about market developments?

B. Policy related questions:

Policy Window questions:

- What are major global or local events you think helped the transition to electric cars?
- Are there also indirect reasons for such stimulation? (e.g., reducing oil dependency?)

Problem Stream:

- Were there sudden events that increased the interest in electric cars?
- Were there certain indicators that the government wanted to address by transitioning to electric cars?

- Could these indicators not be addressed in another way? Like stimulating public transportation?
- Were there other failed policy-related issues that had to be addressed by initiating the transition to electric cars?

Policy Stream:

- What kind of policy, financial and legal tools did the government use to speed up adoption?
- What were key changes that happened based on the policies?
- How did non-governmental actors help the government formulate stimulating policies?
- How did policies on electric vehicles make use of developments in the electric mobility sector?
- How did the Netherlands learn from their counterparts around the world, to move to mass electric vehicle adoption?

Political Stream:

- How did you know that the public was ready for such a transition? (Polls are usually a sample of the population, did you take that into account)
- Which interest groups played a role in addressing the need to transition?
- Why were these interest groups interested and how did they address their interests?
- Which political party played a role in this transition? How did they contribute?
- Which government officials were pioneers in supporting this transition?
- To what extent were local governments receptive to the national calls for a transition to electric cars?

Policy Entrepreneurs:

- Which actors were important in initiating and driving this transition? And Why?
- Were there actors opposing this change?

Appendix 4 External Validation Interview Questions

The focus of the validation interviews was to answer the following questions:

- How do you think policy change and socio-technical change co-evolve together?
- How do you think exogenous challenges affect policy change?
- How do you think the exogenous opportunities affect policy change?
- How do you think small incremental policy changes (i.e, tax changes, granting subsidies, forming agreements) affect bigger policy changes?
- How do you think regime actors (i.e, actors of the system) influence policy change?
- How do niche developments infleunce policy change?
- How does policy change (an adopted policy) affect niche developments?
- How does policy change (an adopted policy) affect the strucutre of an established system?

Appendix 5 Governance System in the Netherlands

In order to give context to the case study, especially in relation to the MSF analysis, it is essential to understand the Dutch governance system. To begin with, the Netherlands is a parliamentary democracy meaning that Dutch citizens have the right to elect their representatives. Their representatives are the Lower House of Parliament (Second Chamber), the provincial councils, the municipal councils and the Dutch delegation in the European Parliament. The King's position is also laid down in the constitution making the Netherlands a constitutional monarchy. There are three powers in the Netherlands; the legislative, executive and judicial branches. The constitutions of these branches will be explained below.

The Legislative Branch

The legislative branch is the Government (King and Ministers) and the States General (First and Second Chamber). As shown in Figure 26, the legislation process in the Netherlands goes through several steps. The process usually starts off with warning signs of all kinds of problems in society. These signs are sent from social organisations, citizens, or the media. This step however is not shown in the figure yet constitutes part of the law-making process according to the House of Representatives (n.d.). Such information constitutes grounds for members of parliament to ask the government to come up with new legislation. Once a minister wishes to introduce a law, he or she asks his or her civil servants to draft a text (the bill). The Council of Ministers then discusses this draft with an "explanatory memorandum". The explanatory memorandum entails a detailed explanation why the new law is deemed necessary and what its contents are.

Next, the Council of State, the highest advisory body in the government, receives it and forwards it along with recommendations to the Council of Ministers. The monarch then receives the bill and writes a note. The bill is then sent to the Second Chamber along with the recommendations, and the "Royal Message" from the king. A committee reviews the proposed legislation, compiles a report on its findings, and then sends it back to the minister. The minister writes a "reply memorandum" in response to the report.

Afterwards, the chamber committee draws up a final report and the bill is debated in the Second Chamber and voted upon. If the Second Chamber votes for this bill, it goes to the First Chamber where it is again discussed in a committee. A report is drawn up, a reply memorandum is written and the final report goes back to the First Chamber to be voted upon. If the bill is again passed there, the king signs it, after which the involved minister countersigns it. Finally, it goes to the Minister of Justice so that it can get announced in the *Staatsblad* (Bulletin of Acts and Decrees). Only then the bill becomes a law (Instituut voor Publiek en Politiek, 2008).

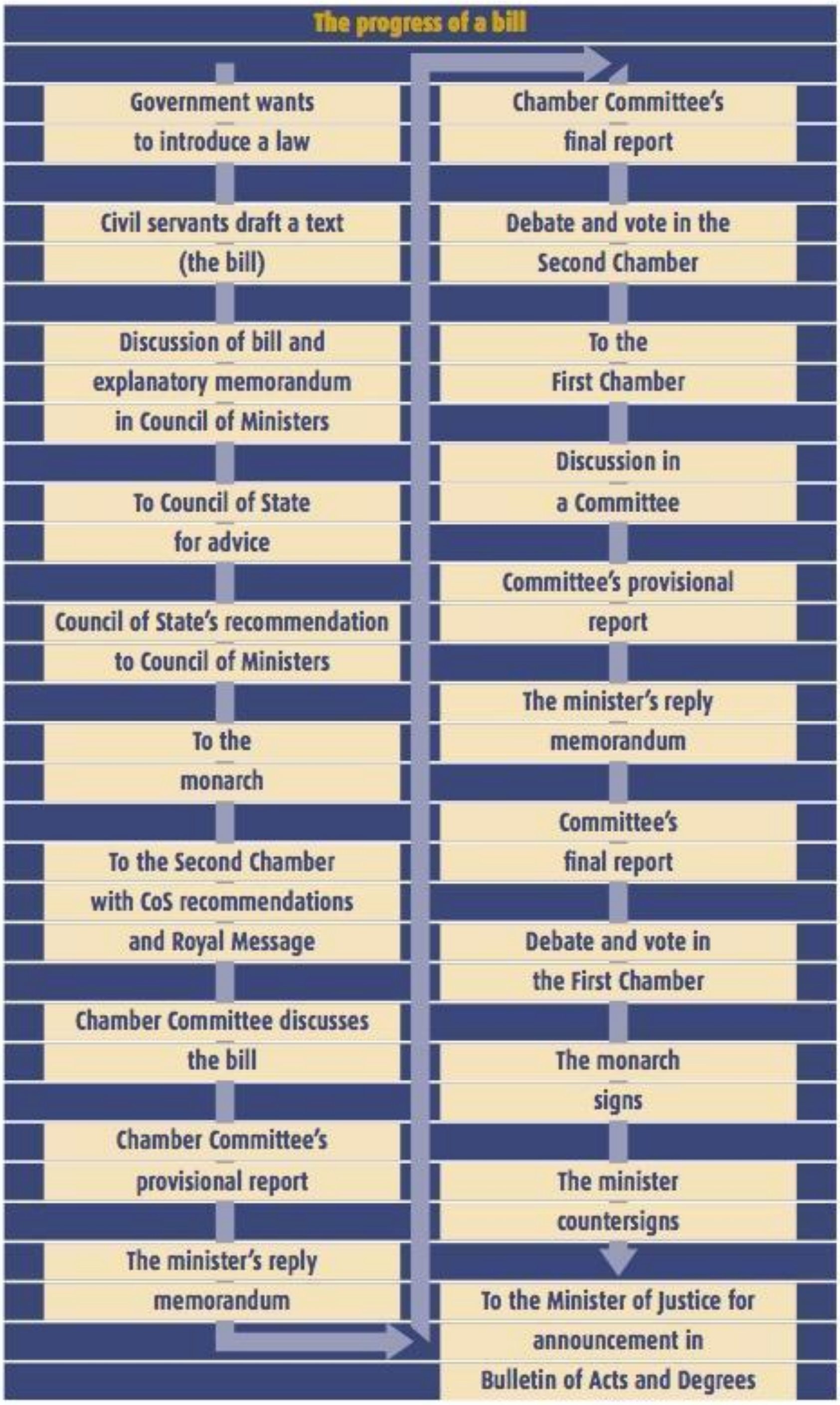

Figure 26 *Law- making process in the Netherlands (Instituut voor Publiek en Politiek, 2008)*

Executive branch

The cabinet of the Netherlands, composed of the ministers and state secretaries, is the principal executive body in the country. As explained in the “Legislative Branch”, the government shares these legislative tasks with the States General. Thus, in the Netherlands, the executive power is not strictly separated from the legislative power, because the government also has legislative tasks (Nederlandse Grondwet, n.d.).

Besides making laws in collaboration with the two chambers of parliament, the government also signs international treaties, lays down foreign and defence policies and appoints mayors, provincial governors and members of the judiciary (Instituut voor Publiek en Politiek, 2008). Nevertheless, the power of the government is not unlimited. As executive power, the government performs the duties laid down in the Constitution under the supervision of the parliament and is controlled by the judiciary (Nederlandse Grondwet, n.d.). Although the parliament cannot reverse government decisions in these areas, it can let the government know it disapproves (Instituut voor Publiek en Politiek, 2008).

The Judicial Branch

The judicial branch in the Netherlands consists of courts, tribunals, and the Supreme Court. The court system in the Netherlands comprises different areas of law and a variety of bodies. Judges are independent and cannot be dismissed by the Minister of Justice and Security. Areas of law include: civil law (also known as private law) for civil disputes, administrative law for the rules that public authorities must keep in their decision-making relations between government and citizens, and lastly criminal law for offences ranging from minor infringements to serious offences such as drug trafficking, theft and murder.

The organisational structure of the courts in the Netherlands is divided into 11 district courts, 4 courts of appeal and 1 Supreme Court. District courts are where most cases start. Each district court includes a limited jurisdiction division that considers cases. Additionally, cases involving infractions of the law are heard in this area. The case may be sent to an appeals court if one of the parties disagrees with the court's ruling, and then, through an appeal in cassation, to the Supreme Court (Ministry of Justice and Security, 2018).

Appendix 6 Coding Scheme

Table 8 *Coding scheme used in the application of the MLP and MS. Source own compilation*

Code	Element	Definition
sc-LANDSCAPE	Landscape development	All developments happening outside the Netherlands including technological developments, exogenous problems, policies at EU and international level etc
sc-REGIME	Socio-technical regime	Established technology, infrastructure, knowledge, culture, policy, networks, markets and user practices.
sc-NICHE	Technological niche	All governmental and non-governmental developments that were driving the transition and industry initiatives
sc-WINDOW OF OPPORTUNITY	Window of opportunity	Destabilisation of the regime due to internal tension or pressure from the landscape.
sc-PROBLEM	Problem stream	Conditions identified as problematic and for which action needs to be taken.
sc-POLICY	Policy stream	Collection of proposals, ideas and alternatives available in policy communities.

sc-POLITICAL	Political stream	Institutional setting, public opinion and political motivation directing the focus of policy-makers.
sc-POLICY WINDOW	Policy window	Coupling of the streams through focusing events or by the policy entrepreneur.
sc-POLICY ENTREPRENEUR	Policy entrepreneur	Key actors trying to influence policy outcomes in their favor.

sc = selective coding