Uncovering Ordering Principles

Finding Structure in (Energy) Transitions

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by

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Preface

The thesis you are currently reading was written as the final assessment for the master program Complex Systems Engineering & Management from the faculty of Technology, Policy and Management at the Technical University of Delft. Having studied at this faculty for almost five years now, transitions - and the energy transition in particular - have been a recurring theme within my studies. The systemic perspective is one characteristic of my faculty - and the influences of all the courses, lecturers and literature is clearly visible. However, especially leading up to the start of my master's thesis, I became more and more intrigued by the mismatch I observed between literature and reality. My observations and my need to investigate and explore another approach to transitions have been the starting point of this thesis process.

I would very much like to thank my first supervisor - Mark de Bruijne - for supporting me in this exploration. Being quite vague, general and chaotic at the start of this process, I greatly appreciate the confidence he had that I would end up somewhere worthwhile. Moreover, I would like to thank him for supporting me when the explorative nature of this research caused my stress levels to rise. Secondly, I want to thank Aad Correljé, my second supervisor and chair. Although we did not have many meetings, the feedback provided was always able to provide a new perspective. Third, I want to thank Igor Nikolic, for aiding me in finding the right words to describe what I wanted to research.

Finally, I want to thank all the people who responded to my request for interviews. Using this method of research creates a major dependency on the enthusiasm of others to collaborate, and I greatly appreciate the time and energy you have given me.

Everything changes and nothing stands still - Heraclitus

M.J. van Kesteren
Delft, August 2023

Executive Summary

The energy transition involves a complex societal transformation encompassing changes in production, distribution, consumption, and behaviour. It necessitates collaboration among private and public stakeholders as well as the adoption of technical and non-technical innovations to combat climate change. While new technologies are being developed, progress towards a low-carbon energy system is slow due to technological, economic, and political barriers. The energy transition affects all systems interconnected with energy, such as transportation, housing, and spatial planning. Stakeholder involvement is crucial to connect these systems in policy but coordination and consensus are lacking, leading to paralysis and a lack of progress. Existing literature, focusing on innovation and technological barriers, lacks a comprehensive systems perspective. Traditional frameworks for change and transition in such complex systems often assume a rational and manageable system, overlooking the interconnectedness and interdependence of individual elements and their influence on the overall system, as well as the thorough interconnection with the political domain. They are built on the assumption that there is a (sub)system subject to transition and there is consensus on what the goal is. In the energy transition, neither is often the case and thus these traditional approaches to governing transitions have resulted in incoherent policy.

This thesis utilises an abductive approach to identify design principles for transitions and their overarching themes to guide the energy transition. This method is exploratory in nature and uses empirical data in the form of case studies to develop new theoretical insights.

First, an overview of prior knowledge was made as a starting point for exploration. The Multiple Streams Framework (MSF) and several sustainability transition approaches - such as the Multi-Level Perspective and Transition Management - were discussed. The ordering principles of integration and collaboration emerged as central themes in this review. Integration of innovations is conceptualised to occur when there is a window created, either by pressure from the external landscape level, or through the coupling of problems, politics, and policy solutions. Collaboration is visible in the creation of this window, where intermediaries are noted as crucial links between various streams or levels in both the MSF and sustainable transition methods.

In the following research phase, successful transitional projects in the domains of water management and transport management were investigated to extract the design principles that made these transitions successful. These domains were chosen due to their recent completion of successful transitional projects - with the underlying assumption made that transitions consist of or are initialised by these transitional projects. Transitional projects in water management appeared to be more radical and resulting from the crisis, while transport transitions were more adaptive and incremental in nature. The key design principles observed in these transitions include the presence of senior facilitators, the coupling of multiple goals, and the upward spiral or momentum generated to achieve the adoption of innovation. The principles of collaboration and integration were clearly visible in these transitions, though clearly different from what the theory suggested. The transitional projects showed that transitions are rarely technology-driven, and transitions are not all radical.

These empirical observations were input for the exploration of other fields of literature, which consisted of a synthesis of the literature on complexity science and innovation science. This literature nuances the concepts of collaboration and integration, and added the ordering principle of connection - which is based on network theory - to address the coevolution of systems in transition.

The principles of integration, collaboration and connection are also found to be essential in the energy domain. Policies in these transitions build upon existing networks and emphasize collaboration, knowledge sharing, and hassle-limiting approaches, allowing frontrunners to take the lead. The integration of goals across the affected systems and domains is evident, although barriers such as the lack of visible senior facilitators, turnover in government entities, and language barriers among experts persist. Despite challenges, efforts are being made to address hesitations and improve communication. During this phase, the principle of alignment emerged in addition to the previous principles, because there is a noticeable interaction between different levels of policy-making and execution.

The ordering principles of connection, alignment, collaboration, and integration serve as guiding principles for successful transitions. The principle of connection highlights the need to connect different perspectives and goals to achieve mutually beneficial solutions. This principle emphasises the intangible process of development of ideas and innovations - before they become concrete plans. The principle of alignment underscores the need for alignment between the scope of goals and the specificity of policy actions to attain successful guidance. In order for ideas to become widely adopted, an entrance for new approaches or technologies needs to be created by setting goals - with which the level of concreteness is increased. The third ordering principle highlights the importance of collaboration and cooperation among stakeholders. This is the principle where the action is taken and ideas are developed into actual plans. This is the stage where collaboration is necessary to link problems to solutions. Finally, integration recognizes the practical challenges of integrating innovations into existing systems and the importance of incremental change. These ordering principles provide valuable insights into the factors that contribute to successful transitional projects. Although all of them coexist simultaneously and co-develop, a hierarchical relationship can be observed in which the 'previous' principle needs to be advanced sufficiently before the 'next' principle can develop further.

To bring these principles more clearly together and display the effect they have on the operational system, a framework was introduced that includes top-down and bottom-up integration of innovations and views, recognizing the complexity of operational systems. This combines the insights from previous literature, with sustainability transitions focusing mostly on top-down transitions that are almost entirely the endeavour of government guidance and complexity science focussing mostly on bottom-up transitions caused by the joined efforts of individuals. The framework distinguishes between rapid, turbulent and slow, adaptive change and acknowledges the nonlinear nature of innovation adaptation.

This comprehensive framework challenges reductionist approaches and offers insights into the complexity of change and transition in complex systems, emphasizing the interactions, adaptation, and evolution of system elements. The outcomes of this transdisciplinary research provide a unique combination of insights from literature and practice that is especially beneficial in the study of energy transitions, in which many domains and disciplines are involved. Much more research is required to elaborate and investigate this theory expansion and consequently, suggestions for further research were elaborated upon. This encompassed amongst others a more extensive literature review, broader case studies and an investigation into the effects of human behaviour on transitions.

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1 Introduction

The energy transition is a complex and diverse process that involves a fundamental transformation over the whole width of society. Not only production and distribution of energy is involved - the transition requires a change in consumption and behaviour as well. It is a monumental undertaking that requires significant alterations in the way we live, work, and interact with the environment (United Nations, 2021). New technologies are being (commercially) developed and implemented which promise to contribute to a more sustainable future. At the same time, both private as well as public stakeholders seem ready to participate in a wide range of collaborations to coordinate the actions of private and public bodies to realize the national ambitions regarding combatting climate change. The necessity to act seems widely agreed upon but also appears quite difficult to organise and materialise. The scale – local, regional, national or international – seems to affect the perceived difficulties. Despite growing awareness of the consequences of inaction, progress towards a low-carbon energy system is slow – hindered by many barriers with technological, economic, and political aspects.

The energy transition requires a broad change in society, affecting many different systems (OECD, 2020). Not only the electricity system itself but also other domains like transport and mobility, housing and spatial planning are affected. This is why stakeholder and public involvement has become a crucial component of environmental planning, decision-making, and research programs that seek to produce reliable, policy-relevant knowledge. Processes undertaken in the past to facilitate broad endorsement of policy have not yet resulted in sought-after changes. Governments, commercial parties, citizens, and academia all seem to be pointing towards one another to take the first steps – whether this is regarding technical aspects, role divisions, or responsibilities. In other words, there is no optimal solution, which makes this endeavour a typical wicked problem (Rittel & Webber, 1973) This leads to widescale paralysis – preventing actions needed to limit climate change – and an increase in polarisation, resulting in a general lack of advancement.

Yet, it is important to recognize that - from a systems perspective - the absence of a clear path forward, consensus on the to-be-reached goals and a clear definition of responsibilities does not necessarily paralyze. One example of natural growth can be seen when looking at a city. Cities are dynamic socio-technical systems that grow and develop in response to changing social, economic, and environmental conditions. As a city grows, it requires infrastructure to support its development, including transportation networks, water and waste management systems, and energy systems. Regardless, the growth and development of a city is not just about physical infrastructure. It also involves changes in behaviour and attitudes towards different aspects - transport, architecture and recreation amongst others. Cities are continuously changing, developing, and adjusting. Not to say this is always (or ever) without struggle, yet despite the many systems affected and the many stakeholders involved, the city develops or evolves. The world of planning has thus far mostly focussed on a static world (de Roo, 2018). In reality, however, everything is always in flux. While the energy transition is often framed as having a clear 'start' and 'end', the analogy between the energy transition and how a city grows and develops provides useful insight for understanding the challenges and opportunities of the energy transition. Just as a city evolves and grows organically, adapting to shifting circumstances and embracing diverse perspectives, it could substantially aid the energy transition to step away from the linear path that is often assumed and instead embrace a non-linear and adaptive method of approach and analysis.

1.1. Scientific Foundation

In order to guide transitions, several fields of literature have been developed, such as Transition Management (Loorbach, 2010) and Strategic Niche Management (Kemp, Schot, & Hoogma, 1998). This literature is mostly focused on (technological) innovations and their role in transitions, which is strongly related to the multi-level model (Rip & Kemp, 1998) and multi-level perspective (Geels & Schot, 2007).

However, none of these branches of academic research provides a full grasp of transitions or a general, easy-to-implement set of solutions. The literature seems to focus primarily on the (barriers towards) technological innovations in the system (Gielen et al., 2019), thus disregarding interaction and dynamics between systems, actors and measures (Meadowcroft, 2009; Shove & Walker, 2007). Whether this is a focus on the internal dynamics of niche innovations or a focus on the economic incentives – past literature strongly seems to miss a systems perspective. This focus on the development of innovations as drivers for transition has resulted in the development of many promising new technologies, that have not yet been integrated into society. Recent insights have led to an increased awareness of system embeddedness and a realisation that (technological) innovation in itself is not carrying the energy transition as thought (Meadowcroft, 2009). This is why additional field research with a focus on the nonlinearity of the process of transition is necessary. By learning from past transitional projects in sectors such as water management or transport, I aim to contribute to and reflect on the current existing theories on transitions.

1.2. Core Concepts

Many different interpretations and definitions of the energy transition circulate, such as a large-scale transformation in (sub) systems of society (Rotmans et al., 2001) or a transformation of the global energy sector from fossil-based to zero-carbon sources (International Renewable Energy Agency (IRENA), n.d.) or a fundamental change in structure, culture, or practice (Loorbach, 2010). This definition merges the various definitions regarding change but does not restrict the system that is affected by the change or the nature of the change itself. In other words, it is much broader than the definition of a technical change in a subsystem. In this research, a transition is defined as follows:

A transition is understood as all adaptations of something new - like technologies, but also ways of thinking or framing - that require an alteration to the existing infrastructure and institutional frameworks in place.

It is assumed that a transition is characterised by transitional ”projects”, in which a project is a process of development, adaptation and integration of the aforementioned new thing. It is assumed that the realisation of these transitional projects contributes to the desired process of transition and as such, studying the transitional projects provides insight into the process of the transition. Although the selection of the cases was placed with the experts, the goal is to identify transitional projects on a meso level. This is because the interest of this study is to uncover the missing middle. When taking the multi-level perspective into account, the niche innovations are at the micro-level. As explained in the previous paragraph and will be discussed in more detail in chapter 3, much has been written about the stimulation and development of (technological) niche innovations. The macro-level in this framework is the grand, high-level developments. The transition is described as taking place within the meso-level - the regime level (Geels & Schot, 2007). When looking at a more spatial interpretation of macro, meso and micro levels, the macro level would be on a European or (inter)national scale and is characterised by relatively vague and far-away goals as well as by ”cockpit-ism” - the illusion that governments and intergovernmental organizations can steer the transition with top-down governance (Hajer et al., 2015). The micro level - on the scale of municipalities or neighbourhoods - on the other hand, fails to translate these macro-level goals into micro-level actions. Regarding the energy transition, many attempts to start projects or collaborations on a regional scale are in progress - such as the RES and Charging Pole Infrastructure. Since these projects appear to be the missing link between micro-innovation and large-scale change, they form the key interest group of this thesis. That is why the transitional projects chosen for case study analysis in this thesis are at this meso-level.

Because this research is focused on the identification of how a transition takes place, the main focus is the identification of the process followed to accomplish a transition, rather than on the technological or institutional aspects. It is assumed that when multiple transitions / transitional projects are considered, the process that brought them about can be decomposed into several blocks. These blocks are henceforth addressed as *design principles*. Following the identification of design principles - the building blocks for transitions as it were - it is valuable to see if and how they can be sorted into overarching themes or *ordering principles*. This sorting will aid in the identification of the main themes within transitions so that their manifestation within the energy transition can be identified.

1.3. Main Research Question and Approach

The main goal of this thesis is to develop a starting point for a shared language of ordering principles to guide the energy transition, by synthesising and extracting the design principles in transitions and sorting them into ordering principles. This leads to the main research question of this thesis as follows:

What ordering principles can guide the energy transition?

This research consists of two main phases – which both utilize literature/desk research and multiple case studies. Multiple case studies are necessary since one of the main gaps in the preceding literature was the question of whether their findings from single case studies could be generalized. According to Crowe et al. (2011), a case study approach is used to explain, describe or explore. They emphasise the suitability of the 'how', 'what' and 'why' questions. In the first phase, the focus will be on transitions that have taken place in different domains. These will be analysed to identify the ordering principles in these transitional projects. Following this initial and explorative research phase, more in-depth research into the energy domain will show if and how these principles are applicable and what other conditions are present. The abductive research process is explained in more detail in chapter 2.

1.4. Relation to CoSEM masters programme

This thesis is written to complete the Master of Complex Systems Engineering and Management (CoSEM) at the Faculty of Technology Policy and Management of the Technical University of Delft. A CoSEM master thesis aims to design solutions for significant and complicated socio-technical challenges that characterise today's society. Technical, institutional, economic, and social knowledge is combined to successfully cope with technological complexity and the management of stakeholders with wildly differing interests. This is done through the application of methods, tools, and techniques for constructing and assessing the impact of technical solutions that contain both effective management strategies and system engineering approaches in the systems that make up our society. This particular thesis was written as part of the Energy domain that can be chosen within the Master. Focussing on the conditions for change in the energy transition involves a standing knowledge of the technological aspects of the current energy system, as well as insight into the many stakeholders involved and the complexity of their interactions. By first identifying the design space in depth, an initial set of transformative conditions in both the slow and sudden stages of change is formulated.

1.5. Structure

The next chapter of this thesis will explain the abductive research approach in more depth. The chapter following - chapter 3 - is dedicated to the current body of academic literature regarding Transition Management, the Multiple Streams Framework and Innovation management. Following the theoretical embeddedness, the subsequent chapter 4 presents the case studies - and their results - in the domains of water management and transport management. Building on the findings in this first research phase, chapter 5 presents a literature exploration in the light of theory matching that is essential to the abductive research process. Chapter 6 is dedicated to the case studies in the energy domain and the results there. Building on the results of the two phases of case studies, the synthesis of ordering principles and their translation into a novel framework is presented in chapter 7. This thesis will be concluded in chapter 8.

2
Methodology

This chapter presents the methodology of this master's thesis to address the research objectives and answer the research question. The research methodology consists of an abductive research approach that utilizes a literature synthesis and two phases of case studies - with one phase focussing on successful cases in other domains, while the second phase focuses on cases in the energy transition. The chapter begins by providing an overview of the research design and justifies the choice of an abductive method. It then describes the two phases of case studies and explains their purpose and sequence.

2.1. Research Design and Approach

The research design of this study is abductive in nature. The abductive research process is shown in figure 2.1. As opposed to grounded theory - in which the analytical framework is proposed prior to empirical research - the abductive research method uses empirical data and observations to construct new theoretical insights (Timmermans & Tavory, 2012). Whereas inductive research strengthens or problematises existing theory and deductive research starts with a hypothesis, an abductive research method allows for a more creative research process because it creates the space to move away from preconceived notions and therefore is regarded as very suitable for theory construction (Tavory & Timmermans, 2014).

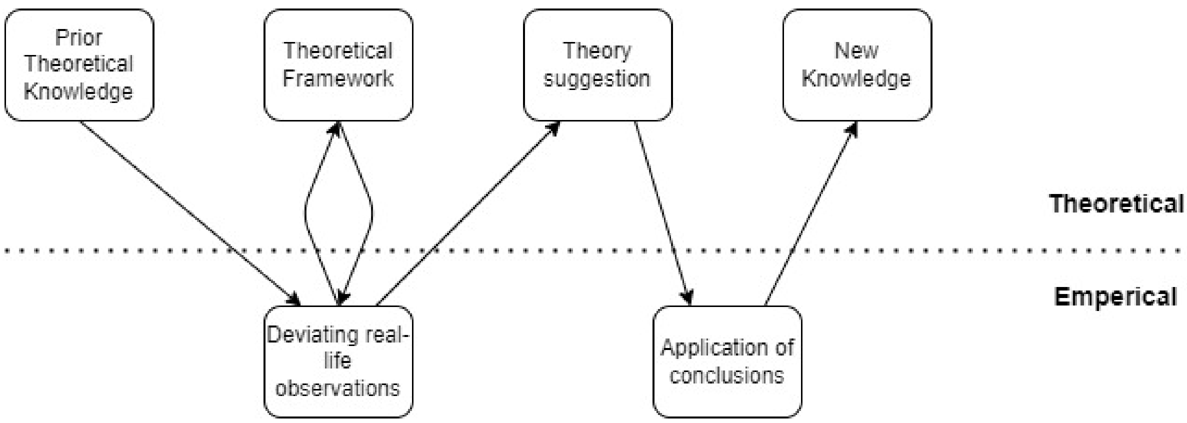

Figure 2.1: Abductive Research method, adapted (Timmermans & Tavory, 2012)

By employing an exploratory method, this study intends to uncover design principles of transitions and sort them into ordering principles. The main goal of this work is to serve as a stepping stone to future research in the field of managing, stimulating and facilitating transitions by adding to the development of theory. The research flow diagram of this research, including corresponding chapters, outcomes and actions is displayed in figure 2.2.

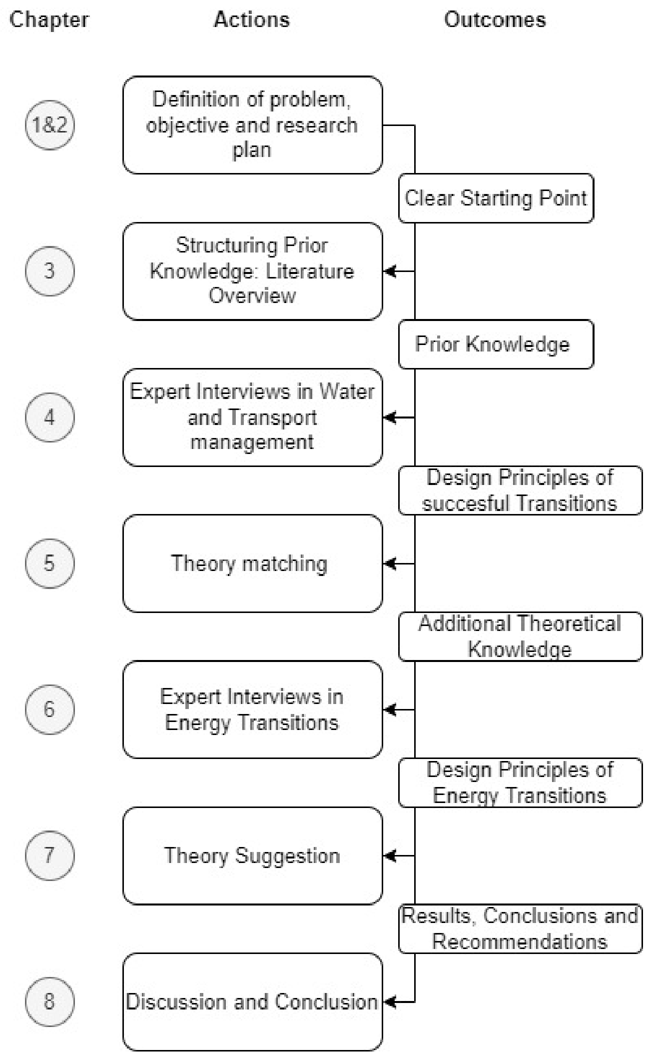

Figure 2.2: Research Flow Diagram

2.2. Prior Knowledge

The starting point of exploration - the observed problem - has been introduced in chapter 1. This chapter is dedicated to the presentation of the objective and research plan. Abductive research starts from a basis of prior knowledge. Since this research is carried out by means of writing a master's thesis, most prior knowledge originates from the educated theories within my studies. However, it is important to construct a clear overview. In order to do so, a semi-systematic literature review is carried out, since this type of literature review is most suitable to create an overview of a research area and specifically its development over time (Snyder, 2019). This review approach can be used to identify theoretical perspectives within a specific research discipline, without the need to conduct an all-encompassing review (Ward, House, & Hamer, 2017). The two primary research fields that are at the basis of the prior knowledge are the schools of the Multiple Streams Framework (King, 1985) and Transition Management (Loorbach, 2010). The literature review is carried out in the database scopus.com and based on the assumption that the most cited articles are the most foundational within a school, the 100 most cited articles are selected, screened and reviewed according to the PRISMA method - in which all reports are scanned and included or excluded according to predefined criteria, after which the findings are synthesised (Moher, Liberati, Tetzlaff, & Altman, 2009). The exact PRISMA diagram is shown in Figure 2.3. During this process, articles that are not considered in either of the two fields of research are disregarded, but a note of their field is made. This allows for the identification of theories that could be useful during the theory matching that follows the case studies. The literature review will conclude with the identification of one or more ordering principles as observed in the articles. This list is presumed incomplete but will allow for a starting point of exploration within the case study.

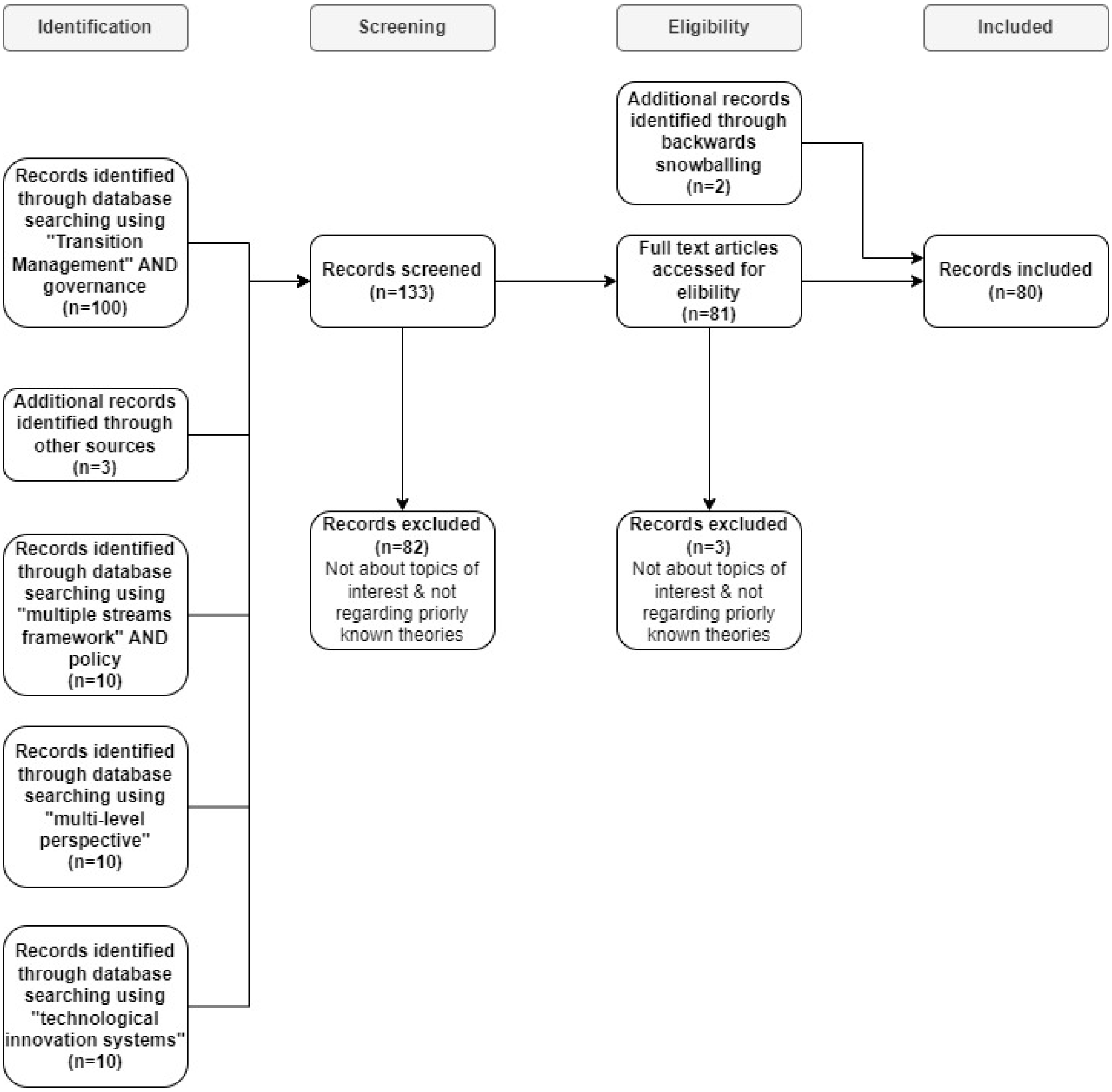

Figure 2.3: PRISMA Flow Diagram of the selection of Prior Knowledge literature

2.3. Case Studies Round 1

The first round of case studies involves the selection of cases in domains in which transitions have taken place. Important domains that have been subject to transition relatively recently are ICT, transport and water management - for example, the project of Ruimte voor de Rivier (Room for the River) was completed in 2019, or the widescale adaptation of electric vehicles in the past decade. In this initial exploratory phase, the domains of water and transport were chosen over ICT because many articles in the prior knowledge literature review mentioned these domains alongside energy as having been subject to transitions (Van Der Brugge, Rotmans, & Loorbach, 2005; Loorbach & Rotmans, 2010; Markard, Raven, & Truffer, 2012; Steinhilber, Wells, & Thankappan, 2013).

For this thesis, the choice is made to interview a small set of experts within the transport and water domains and have them appoint succesful cases of transitional projects. The choice was made to focus solely on successful transitional projects because it is thought these projects completed the full process from idea development to execution. The selection of these projects was placed with the experts because the experts were chosen based on their experience in the field and thus presumably know many projects and it was important to let them define when they considered a project or transition successful. Although a general idea of some transitional projects is present beforehand due to the cases mentioned in the articles of prior knowledge, this method allows the most freedom for the experts to uncover the design principles of projects they regarded as having been successful. Experts are considered to be individuals who are particularly knowledgeable on a specific subject, possibly due to their position within a community or their status (Döringer, 2020). The experts central to this thesis were selected based on their overall expertise and experience in the field - as opposed to their current job. This entails that although an attempt was made to select experts from various organisations - public, private and semi-public - most experts have experience with all three organisation forms due to their experience within the field.

Data collection is centred around a set of exploratory interviews, supported by desk and literature research. The exploratory approach to the interviews means that the sample size is not necessarily relevant. Open interviews - otherwise known as unstructured interviews - were conducted with three experts involved in the selected cases to gather rich qualitative data (Döringer, 2020). Two of these experts were involved and employed in water management, and one expert was involved in the transport sector. All three were Dutch. An open interview method was chosen, rather than semi-structured because the exploratory nature of this research makes it impossible to have a predefined set of questions. Rather, several themes have been thought out. The interview protocol is shown in Appendix A. Note that this interview protocol, as well as the corresponding information, is provided in Dutch because all interviews were conducted in Dutch since they involved Dutch experts. The limitations this creates for the applicability of this research outside of the Netherlands will be discussed in chapter 8. During and following these interviews, observations of the leading design principles were carried out to capture contextual information and identify any patterns or trends, resulting in a set of design principles. The data was coded and categorized to identify recurring themes and patterns within and across the cases. The method for coding employed during the case study is identical in this first phase as in the second phase and is explained in detail in section 2.5.1. The ordering principles uncovered during the prior knowledge literature review will guide the identification of ordering principles within the case study, in such a way that they serve as a starting point. The main focus will consequently be on the design principles that emerge during the interviews, and whether or not they match the previously defined ordering principles. The design principles that cannot be matched are in turn the access point for the further theory exploration of the next research phase.

2.4. Theory Matching

Following the first round of case study and identification of design principles in water and transport management, the fourth phase and thus the fifth chapter of this thesis is dedicated to theory matching. The literature review of the prior knowledge already uncovered some possible fields of literature for theory matching, but furthermore, the expertise of the supervisors was used to identify the literature that matches the design principles that were uncovered. The choice is made to focus on complexity science literature. This literature was reviewed in the same manner as the literature of prior knowledge, with the most cited articles as starting points. The PRISMA flow diagram in figure 2.4 displays the selection process. This phase concludes with an expansion of the list of ordering principles, which will serve as input for the second round of case studies within the energy domain.

2.5. Case Studies Round 2

The second phase of the case studies is centred around cases in the currently unfolding energy transition. The cases selected here involve - similarly to the cases in phase 1 - transitional projects that involve a multitude of stakeholders and take place at the meso level. The projects selected are the Regional Energy Strategy (RES) of the metropole region Rotterdam Den Haag, the Charging Pole Infrastructure in the Netherlands and the development of the National Plan Energysystem (NPE). The RES and Charging Pole Infrastructure were selected because of their regional scope. There seems to be a thus far unseen role for the region or province within the energy transition - with a focus on municipal collaboration and an integrated approach. This integrated approach is central to the development of the NPE - which is developed during the duration of this research and therefore an interesting case to study, although this project is on a national rather than regional scale.

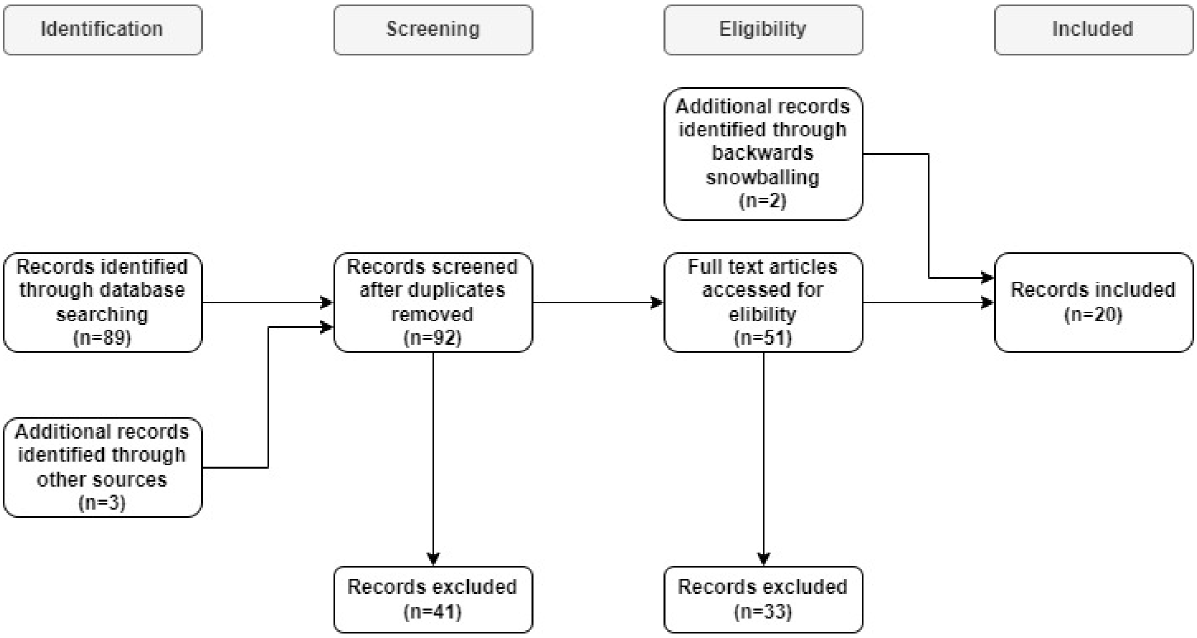

Figure 2.4: PRISMA Flow Diagram of selection of Complexity Science literature

Data collection in this phase is also centred around open interviews with experts, of which a total of nine were conducted. These experts were involved in the projects on behalf of governments, consultants and network operators. It is important to note that - similarly to the experts within water and transport management - the interviews took place with regard to the expertise of the person themselves, not the organisation. Many experts were involved in or had knowledge of multiple projects. The information brought forth within the interviews was then supported and expanded with desk research into the scientific literature, grey literature and other sources as secondary data, as well as the governmental reports and documents as primary data.

The same analysis method was deployed as in phase 1 - in which the interview transcripts were coded into design principles, which in turn were sorted into ordering principles. In these interviews, however, the focus shifted from entirely general to a more defined focus on two or three of the previously found design principles in order to estimate their visibility and applicability in the energy transition. This choice was made due to the time available for this thesis, and further research could investigate all design principles found - see also chapter 8.

2.5.1. Method of Coding

The interviews are transcribed in Microsoft Word - using the recordings - in order to allow coding in Atlas.ti. The coding is done in three successive parts. First, each transcript was intuitively (or open) and inductively coded. Inductive coding entails the assigning of a label to a small part of the transcript (Chandra & Shang, 2019). This label best represents the text and is usually a small number of words - such as SupportiveSupervisor. Because the coding is done intuitively or open, a large amount of labels is created. The second action is therefore to combine all labels that essentially mean the same thing. This results in a set of labels that have entries in different transcripts and therefore allows comparison between interviews regarding the same subject, thus allowing identification of concepts (Huq Khandkar, n.d.). These labels are then separated into two categories, one being the design principles that make transitions, the other being ”other”. This second category contains all statements made about, for example, the background of experts. These design principles emerged from the intuitive coding allowed for axial coding - in which core themes were broken down (Kelle, 2005). These themes are presented as the ordering principles of transitions. Axial coding enables refining and elaborating on core categories, establishing their relationships, and creating a coherent theoretical model (Williams, Kennedy, Philipp, & Whiteman, 2017). Through axial coding, a more comprehensive understanding of the phenomena can be found. The incrementally established list of ordering principles will serve as a starting point, but whether or not these themes also emerge from the axial coding of the empirical data is the core result of this research.

2.6. Framework Development

In the final section of this thesis, the resulting design and ordering principles from the case studies will be used as input to develop a novel theoretical framework. First, the ordering principles will be compared and their relation towards one another will be investigated. The aim of this is to identify commonalities, differences, and emerging themes across the different domains, which will contribute to a deeper understanding of the ordering principles that guide, hinder and/or facilitate the energy transition. This comparison combined with the theoretical backgrounds presented in both the prior knowledge of chapter 3 and the theory matching of chapter 5 allows for combining the results into a novel, adapted framework to contribute to the theory on how transitions take place.

2.7. Ethical Considerations

Throughout the research process, ethical considerations will be adhered to - as discussed with and approved by the Human Research Ethics and Consent application of the TU Delft. Informed consent will be obtained from all participants, and their confidentiality and privacy will be protected. No direct quotes from participants will be used. The data collection - consisting of recordings and transcripts - will be stored on the TU Delft OneDrive and deleted for a maximum of 2 years after the completion of this thesis.

3

Prior Theoretical Knowledge

In this chapter, a synthesis of the literature as described in chapter 2 will be presented in order to give the reader a grasp of the prior knowledge at the basis of the abductive research process. This chapter presents several theoretical models that regard governance in chronological order - starting with the multiple streams framework that was developed in 1984 (Kingdon, 1984) - but includes recent revisions. Although this literature review does not include all the literature that has been written in this field since then, it provides a general overview of the developments taking place regarding the angles and approaches that these frameworks present. This synthesis focuses on the underlying assumptions of the governance approaches or theories, and their implications when used to create policy to govern sustainability transitions.

3.1. Multiple Streams Framework (MSF)

Prior to the rise of Transition Management, a conceptualisation of the formation of policy was made by Kingdon (1984). This framework never aimed to aid transitions, but was directed at the paradigm of the creation of policy and policy changes and theorizes the process of policy formation on a systemic level (Zahariadis, 2019). It can be seen as an analytical lens to capture the effects of interactions between institutions and agencies in the policy creation process.

The Multiple Streams Framework conceptualises three streams: (1) a problem stream, (2) a policies stream and (3) a politics stream. The problem stream within the framework reflects the perspectives of individuals on public problems - problems that the government is required to act on. These usually come up for discussion through crises or other situations that somehow receive public attention. Meanwhile, the policy stream involves the generation of various policy options as ideas undergo a process of ”mutations” and ”recombinations” similar to natural selection - which are the output of experts and analysts. The political stream consists of factors such as public sentiment, party ideologies, and interest groups that influence the government’s readiness and capacity to take action on a particular issue (Béland & Howlett, 2016). When the three streams are combined, a window of opportunity is created in which new policies can be formed and decisions can be made. The creation of a window can also be triggered by focusing events - like a crisis - or the presence of a policy entrepreneur. The framework was first developed to analyse the agenda-setting process (Herweg & Zahariadis, 2018) and has been used to analyse agenda-setting processes on many different scales in different parts of the world, such as European level (Copeland & James, 2014), local level in the US (Liu, Lindquist, Vedlitz, & Vincent, 2010) and - although in extended form - on an African state (Ridde, 2009).

Rather than focussing on the development of technological solutions, this conceptualisation acknowledges the parts that chance and coincidence play in system formation more than transition management literature does. The fundamental presumptions of the MSF deal with - amongst others - time restraints, problematic preferences, stream independence (Ackrill, Kay, & Zahariadis, 2013) and ambiguous technology (Herweg & Zahariadis, 2018). Time restraint refers to the practice that policymakers are often under such time pressure that they cannot choose the problems they solve, but rather are forced to address those that arise outside their control. Problematic preferences, as well as ambiguous technology, articulate the assumption that the preferences of actors are ill-defined and organisational technology cannot be fully comprehended. In other words, the process is susceptible to political interference that is biased in favour of those who produce information, manage access to decision-making spaces, and coordinate or take advantage of timetables. Finally, perhaps the main assumption of the framework lies within the conceptualisation of the three streams as being relatively independent of one another. To further refine the independence of the three streams, several theory expansions have been suggested, such as the inclusion of a problem broker to further conceptualise agency in the problem stream (Knaggård, 2015) or further analysis of the role of party politics and political networks within the politics stream (Herweg, Huß, & Zohlnhöfer, 2015).

Moreover, several expansions of the MSF have been made. Though in turn a critical evaluation of the assumption that decision-making is a fully rational process, Mukherjee and Howlett (2015) adapted the MSF into a five streams framework by dissecting the policy steam into three separate streams consisting of a policy solution, a policy program and a policy process. Goyal et al. (2020) combines this extended framework with the technological aspects by conceptualising six streams, as shown in figure 3.1. This extension of the initial Multiple Streams Framework provides a broader conceptualisation of change because the high-level conceptualisation is slightly more specified with regard to the role of technology or innovation within the creation of policy. Not only does this framework acknowledge the part that technology plays in the development of new policy, but the separation of the policy stream into solutions, programs and processes presents more impressable and manufacturable components. Solutions can be sought after, programs can be forged and processes can be designed. This conceptualisation allows for a slightly more definable window of influence for policymakers than the 3-streams conceptualisation appears to do.

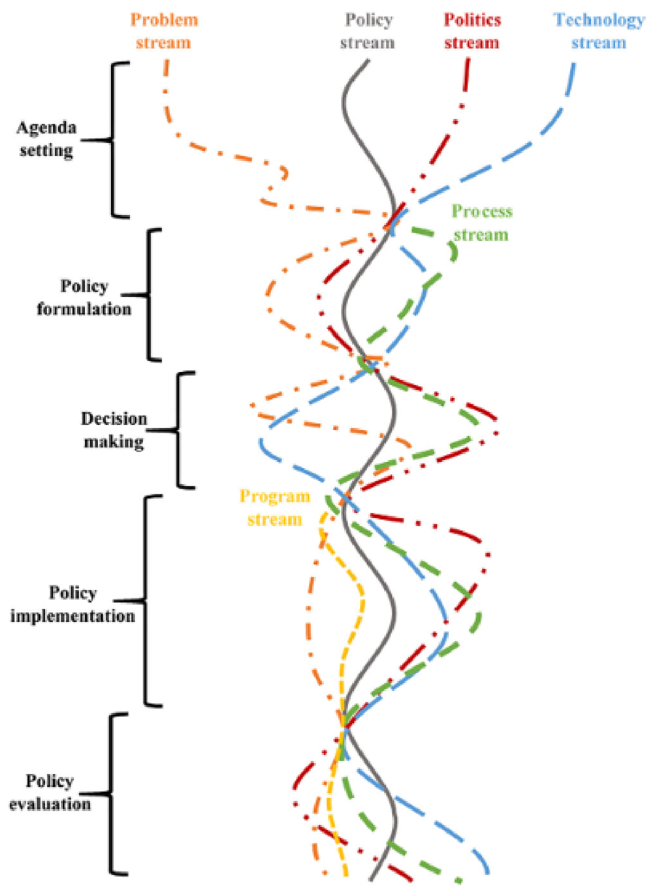

Figure 3.1: Six-stream variant of the Multiple Steams Framework (Goyal et al., 2020)

3.1.1. Underlying Assumptions and Drawbacks

The Multiple Streams Framework acknowledges to a certain extent that development is non-linear and a certain chance component is involved. This framework, however, is abstract and focuses primarily on the creation of policy - thus assuming that it is the policy that drives a transition in society. This is a very policy-centric approach to transitions, which seems to rely on (national) governments for plotting the path. In addition, the conceptualisation of independent streams neglects the differentiation of the components that make up the streams and assumes there is one party that is the full problem owner - the government in most cases. Moreover, the responsibility of the coupling of the multiple streams rests entirely with the policy entrepreneur, thus disregarding the many different actors involved in many processes (Ackrill et al., 2013).

This framework fails to take the complexity of multiple problem owners, the variety of policies, the lack of coherence and the many different scales into account that are characteristics of the energy transition. Within this conceptualisation, there is much attribution to a seemingly unpredictable factor of coincidence - which provides little guidance in the formulation of recommendations or trajectories. The use of this framework in literature seems to be to trace back how policy was created and thus offers little guidance beforehand - and is insufficient to fully understand the process (Brunner, 2008). Finally and consequentially, there is little consideration for the supposed effectiveness of the policy after the streams have been combined and thus little attention to the fact that not all policy reaches the goals set out.

3.2. Sustainability Transition Approaches

At the beginning of this century, several (related) conceptualisations of transitions arose. The four main frameworks include the Multi-Level Perspective (MLP) on socio-technical transitions, Transition Management (TM), Strategic Niche Management (SNM) and Technological Innovation Systems (TIS) (Markard et al., 2012). These frameworks are all aimed at promoting and governing a transition. Below, a short overview of the core of these frameworks will be discussed, as well as how they relate to one another.

3.2.1. Multi-Level Perspective

Transition Management, Strategic Niche Management and Technological Innovation Systems are the basis built on the multiphase model (Rip & Kemp, 1998), which is adapted into the Multilevel Perspective of Geels (2002a) shown in figure 3.2. This framework is focused on technological transitions and conceptualises three layers at a macro, meso and micro level - the landscape, the socio-technical regime and technological niches. The landscape level encompasses all things outside the regime and niche level, such as global trends. The other two levels hardly influence this level but this level does have a major influence on the lower two levels (Geels & Schot, 2007; Lachman, 2013). The socio-technical regime consists of three elements: (1) actors in a network, (2) rules, both formal and informal, and (3) material and technical elements. This layer is defined as stable due to path dependence and lock-in (Geels, 2004). The final layer consists of small, separate niches - which are technological innovations that are developed in protective spaces. These niches start as technological niches, consequently, developing into market niches and then causing regime shifts (Schot & Geels, 2008).

Transitions in this system are conceptualised to occur when shifts in the landscape cause the links of the networks in the socio-technical regime to weaken so that a ”window of opportunity” is created (Geels, 2002b). This allows a niche - developed in a separate and defined environment - to enter the regime level. This niche will then overtake the existing practice and thus transition is presumed to occur. This is shown in figure 3.3

The MLP framework is based on an evolutionary perspective (Geels, 2002b), that presents itself in the way the niches compete with each other and thus variation and selection occur on the micro level. Innovation also takes place within the regime level, but this is incremental while radical innovations are developed in the niches. During a time of crisis, the links within the stable regime weaken and radical innovation can be included. Evolution within this process is visible in the cascade effect that the introduction of a niche in the regime can have on the regime.

When looking at the ten most cited articles regarding MLP, it is worth noticing that the authors of the framework developed, enriched and elaborated the perspective over time. The first article dates from 2002 and the latest within the results dates from 2014 and addresses some main critiques.

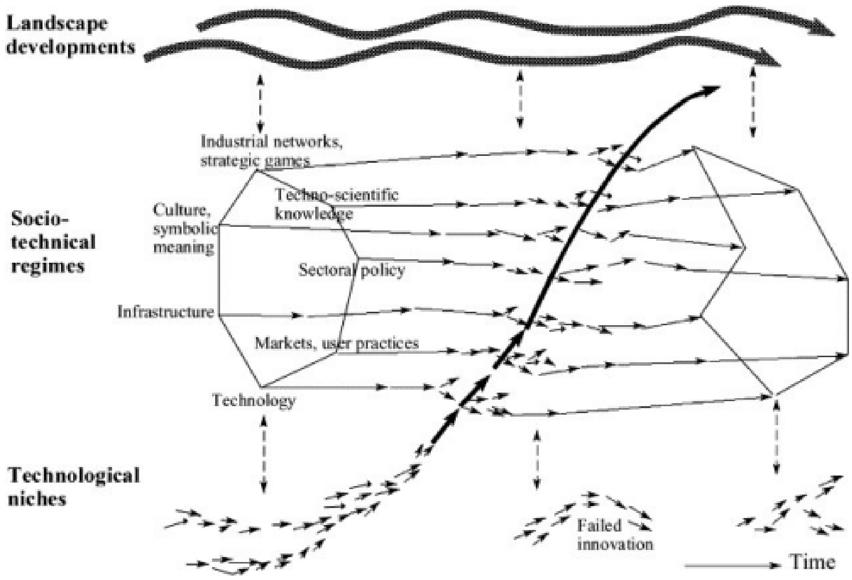

Figure 3.2: The Multi-Level Perspective (Geels & Schot, 2007)

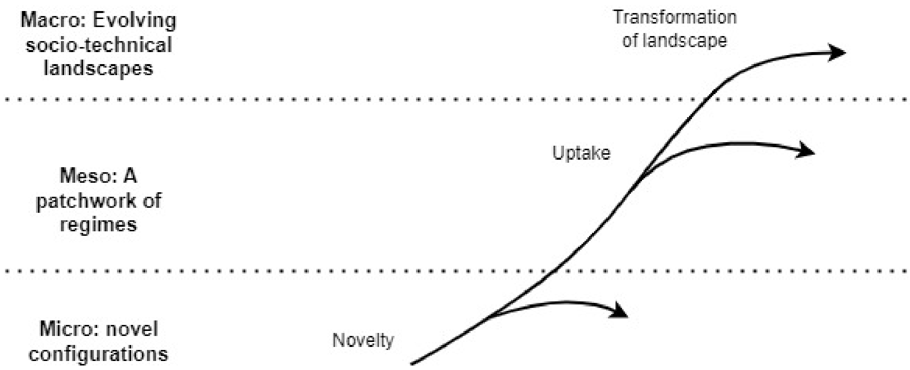

Figure 3.3: Dynamics of Socio-Technical Change (Geels, 2002b)

Smith et al. (2005) have a similar definition of the concept of the regime level, but provide a more nuanced view by stating that there are several empirical scales for regimes and that the term regime is used to describe a very complex and nested set of phenomena. They describe four different types of transitions - reorientation of trajectories, endogenous renewal, emergent transformation and purposive transition - depending on their resource locus being in or outside of the established regime and on their coordination being high or low. This is shown in figure 3.4.

Endogenous renewal is the consequence of regime actors using internal resources to make deliberate and planned efforts in response to external constraints. A shock, either from within or without the current regime, is followed by a response by regime actors employing internal resources, resulting in a reorientation of trajectories. Emergent transformation results from uncoordinated pressure that is exerted outside the regime and is frequently led by small and innovative businesses. Purposive transitions are planned transformation processes that come from outside the current regime and are coordinated. The focus on resource availability and transition origin causes the identification of several governance activities - such as the creation of new knowledge, supply of resources and formation of markets - for policymakers to guide transitions. This adds to the definition of the regime level.

In response to this definition of transitions, Geels and Schot (2007) identified five - different - transition pathways in the MLP, with the main critique being that transitions cannot be planned or coordinated. These five transition pathways are:

1. Reproduction process - When there is no pressure from the landscape, the regime remains dy-

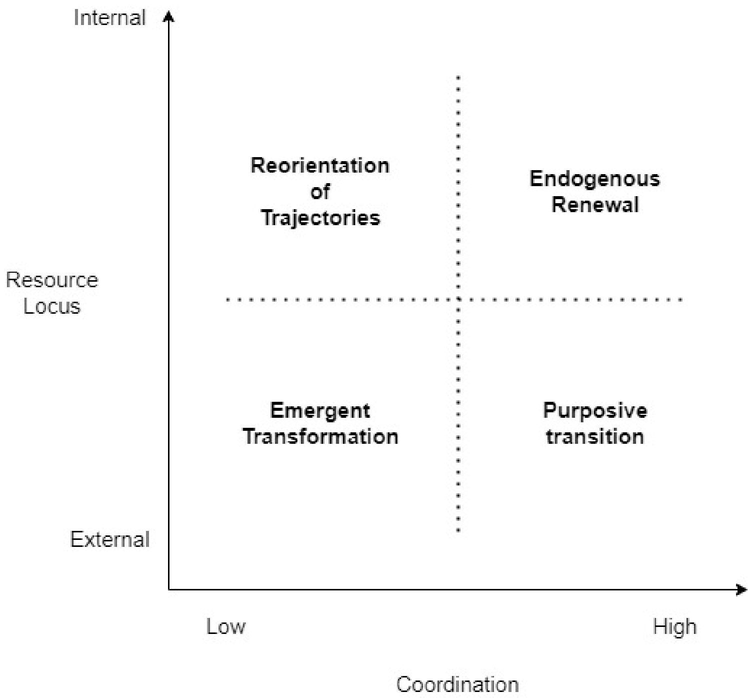

Figure 3.4: Transition Contexts, Adapted (Smith et al., 2005)

namically stable

2. Transformation path - limited pressure from the landscape triggers the regime to adjust to the direction of development paths and innovation activities

3. De-alignment and re-alignment - major pressure from the landscape creates de-alignment in the regime. Emerging niches will compete and one will become dominant.

4. Technological substitution - major pressure from the landscape combined with a well-developed niche causes a niche technology to take over

5. Reconfiguration - niche technologies are adopted at the regime level on small, local scales which causes growth and wider adaptation in the regime

The main critique on this model is the bias towards bottom-up change, the glorification of (green) niches and the absence of power and politics in the dynamics (Geels, 2011). Some of these criticisms have been addressed in follow-up articles (Geels, 2010, 2011), ultimately causing the initial author to expand the framework stating that the solution to change is not exclusively found in niches (Geels, 2014). In order to do this, the regime level is further unfolded. They state that it is important to recognise that the regime level resists fundamental change and therefore regime dynamics should be studied with similar gravity as niche dynamics, such as the relations on the regime level between firms and policymakers.

3.2.2. Innovation Management

Naturally, the focus of the MLP on the aspect of (technological) niche innovations has resulted in much interest in the stimulation of these niches. Much has been written on how to stimulate innovation from a centralized, policy perspective - such as innovation systems (IS), strategic niche management (SNM) and Transition Management (TM).

Innovation management primarily focuses on the internal processes, strategies, and practices within organisations to generate, develop, and implement innovations (Anderson, Potočnik, & Zhou, 2014). It involves managing the innovation process, fostering a culture of innovation, and aligning innovation efforts with business objectives. Innovation management research often examines topics such as idea generation, product development, innovation strategy, organisational culture, and performance measurement. One of the top results of the literature review considered open innovation, in which the organisation seeks collaboration with others - users or other businesses - in order to innovate more successfully. Many articles were written on innovation management, but because the main focus of this research is on the governance aspect of transitions, the development of the innovations themselves will not be explored further. However, there are conceptualisations on the adaptation of innovations in the broader system of society. The integration of innovations is often conceptualised as having four phases: (1) predevelopment, (2) take-off, (3) acceleration and (4) stabilization (Rotmans et al., 2001) - as is displayed in figure 3.5.

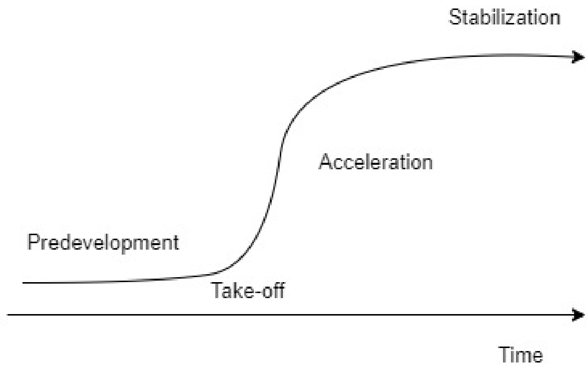

Figure 3.5: Uptake of innovations according to (Rotmans et al., 2001)

While innovation management primarily focuses on the internal dynamics of organisations - and conceptualises a rather linear uptake - strategic niche management, functions of innovation systems and transition management take a broader systems perspective, considering the external influences on innovation. These perspectives are built on the Multi-Level Perspective.

3.2.3. Functions of Innovation Systems

The Functions of Innovation System (FIS) refers to the broader societal and systemic factors that influence innovation at the national, regional, or industry levels (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007; Hekkert & Negro, 2009). This framework explores the interconnected components and actors that shape the innovation ecosystem, including universities, research institutions, government policies, funding mechanisms, industry clusters, and knowledge transfer mechanisms. It examines how these elements interact to facilitate or hinder innovation activities and economic growth. Suurs and Hekkert (2009), define 7 functions in order for an innovation to be successful: entrepreneurial activities, knowledge development, knowledge diffusion, the guidance of the search, market formation, mobilization of resources and creation of legitimacy.

3.2.4. Strategic Niche Management

Strategic niche management is an approach that focuses on the creation and development of niche markets as a means to promote and accelerate sustainable innovation (Schot & Geels, 2008). It is presented as a perspective on the ways to facilitate a transition into a new regime by uptake of a radical niche innovation (Kemp et al., 1998). It is based on the understanding that radical innovations often face barriers in the existing dominant market and can thrive better in specialized and protected niches. Three key niche processes are identified:

1. Learning process - the maturing of niche innovations in protected spaces by means of experimentation, adaptation and accumulation of knowledge
2. Network Formation - the establishment and growth of collaborative relationships among various actors within the niche space to stimulate the sharing of knowledge, resources and support
3. Coupling of expectations - alignment of perspectives and ideas of the various actors within the niche to achieve a shared vision of the potential and place of the niche innovation

SNM involves creating protected spaces for experimentation, learning, and development, and strategically navigating dynamics between niche innovations and the existing dominant regime - with a major role for intermediaries. They act as bridges between the shielded space of niche innovations and the broader socio-technical regime, facilitating the interaction, diffusion, and potential integration of these niches. Intermediaries can be organisations or individuals and take up several roles. Geels and Deuten (2006) identify three roles for intermediaries: combining knowledge from several local projects, creating an institutional framework for the niche, and organizing and defining local project activity. Hargreaves, Hielscher, Seyfang, and Smith (2013) add the role of brokering and managing partnerships with actors outside the niche. They also criticise the SNM by stating there needs to be more attention to the complexity of niches with respect to the often various internal objectives and ideologies.

These niches - in articles often referred to as grassroots innovation - have been the centre of various case studies in the UK which have expanded the SNM literature. Seyfang, Hielscher, Hargreaves, Martiskainen, and Smith (2014) conclude that intermediary organisations and networking can effectively disseminate some types of learning required for innovation diffusion, but it is insufficient since tacit knowledge, trust, and confidence are also crucial aspects. Kivimaa, Boon, Hyysalo, and Klerkx (2019) distinguish five types of intermediaries in transitions: systemic, regime-based, niche, process and user. Seyfang and Haxeltine (2012) analyse not a technical innovation, but a civil-society-based niche of the Transition Towns movement and conclude SNM is valuable for the analysis of these types of niches as well.

3.2.5. Transition Management

Finally, Transition Management is the largest body of literature within this prior knowledge synthesis. Developed and implemented in the Netherlands over the past decade, TM provides a framework for understanding the way in which sustainable transitions can be governed. A transition is regarded as a process of structural change in societal (sub)systems (Loorbach, 2010) and often concerns multiple transitions or system innovations (Kemp, Loorbach, & Rotmans, 2007). TM is based on the multilevel model and the multiphase model of innovation adoption that is shown in figure 3.5. Similarly to MLP, transition management conceptualises transitions to occur when the dominant structures in the regime are under pressure by external factors of society as well as by innovations of the system itself. The framework has roots in the complexity theory with a focus on selection, emergence, coevolution and self-organisation (Rotmans & Loorbach, 2009). Several principles are foundational for TM: creating space for niches, focusing on frontrunners, guided variation and selection, radical change in incremental steps and empowering niches. These principles are translated into a cycle of 6 steps: (1) Stimulating niche development, (2) Developing visions at the macro level to guide niches, (3) stimulating the formation of niche regimes, (4) creating a diversity of niches, (5) selection of the most promising innovations and (6) adjust visions to further stimulate coevolution of macro and micro levels.

Kemp et al. (2007) argue that sustainable development requires a radical change in not only the current functional system but also with regards to governance. They define three levels of execution: (1) strategic level, (2) tactical level and (3) operational level. The strategic level encompasses all entrepreneurial activities, the tactical level focuses on the transition agenda by aligning the regime with the long-term goal and the operational level evolves around experimentation to stimulate learning and development. Loorbach and Rotmans (2010) adds another governance activity to this list by stating reflexive actions of monitoring and evaluating are essential to the learning process of transitions. This final step creates the aforementioned cycle of transition management again.

As stated previously, the practice of TM has been widely adopted in the Netherlands to support the framework with empirical data (Loorbach & Rotmans, 2010), for example with experiments in urban transition labs (Nevens, Frantzeskaki, Gorissen, & Loorbach, 2013) or an exploration of the guiding visions (Späth & Rohracher, 2010). This has resulted in many additions to the framework, such as in the development of the adaptation development cycle by Park et al. (2012).

3.2.6. Mutual relations, underlying assumptions and drawbacks

As stated previously, the sustainability approaches are strongly interconnected, as is also shown by Chappin and Dijkema (2008) and Markard et al. (2012). There appear to be a few key and collaborating authors - predominantly Dutch - that form the core of this field of literature. Transition Management and Strategic Niche Management seem to be very strongly linked together, as there are several articles implementing both (Steinhilber et al., 2013; Kivimaa et al., 2019; Nill & Kemp, 2009). Technological

Innovation Systems are also aimed at niche development but take a more analytical than practical approach. They are both highly complementary with TM, with SNM and TIS focussing on the development of the niche and TM focussing on the larger governance framework surrounding this. The Multi-Level Perspective seems to be more foundational to these frameworks and thus presents a more theoretical and high-over view.

However, despite the application of these theories in the Netherlands, the transition to a carbon-neutral energy system is slow and subject to many social-technical and institutional barriers. Meadowcroft (2009) describes two main reasons for transition management's current lack of results. Transition Management first assumes a general consensus about the goal of the transition, but it is unclear who decides what the 'right' direction is Shove and Walker (2007). Secondly, the assumption is made that there is a clearly defined system that will undergo a clearly defined transition. In other words, there is an A and B in a subsystem of society – and all parties agree on what B will be. This might not be as straightforward as the Transition Management literature suggests. Voß and Bornemann (2011) and (Smith & Stirling, 2010) also argue for the integration of power and politics within the design of reflexive governance and a larger attention to the spatial aspect - because politics are usually spatially bound due to the jurisdiction areas and multilevel processes of politics and governance (Smith & Stirling, 2010).

Society is constantly changing and many changes are unintended, autonomous and surprising (de Roo, 2018). Conceptualising transitions as clearly defined as has been done, results in the notion that the transition can be guided and governed using a normative, top-down principle – using amongst others subsidies to promote innovation adaption. This normative approach addresses the multi-stakeholder setting – that is always present – inadequately. Consequently, it leads to the idea that there is a uniform solution that can address the whole system – whereas the reality is much messier - and much less linear. This approach assumes top-down governance of transitions and their management, whereas the system is actually a lot more networked and fragmented and thus unable to be completely directed. Instead, it might be possible that the system can be governed at best.

In addition, it is important to note that events take place in a wider context as well, which may influence the possibility of 'steering' or reduce the impact of the 'steering'. One thing that is evident and widely agreed upon, is that collaboration and innovation are essential in order to achieve change. However, the focus on innovation causes an emphasis on the technical system (Shove & Walker, 2007). Moreover, Kern and Smith (2008) applied the framework to the energy transition policy of the Netherlands and concluded that the dominance of the regime actors results in the formalising of selection criteria that are most beneficial to the regime actors themselves, thus resulting in too little space for radical niches to enter the regime level. Kern and Howlett (2009) conclude that the implementation of TM for the Dutch energy sector has resulted in incoherent and inconsistent policy combinations that result in disruption of initial transition management efforts.

3.3. Change and Ordering Principles

There are several observations that stand out with regard to the literature that is discussed above. When looking at the literature synthesis, it can be concluded that change is often conceptualised as a development over time - entering a more or less stagnant system. From the multi-level perspective, these are the regime and landscape levels. The entire model of Kingdon would supposedly take place within this regime level, with the problem stream perhaps in the landscape.

These frameworks all seem to be built upon the same underlying assumptions. First, they assume a relatively rational and thus manageable system - with clear relationships and roles between actors - that allows for a determined change or transition. This also means that there is an external manager or government that can influence the system without being an inherent part of it (Shove & Walker, 2007). Second, the frameworks conceptualise subsystems as separate and independent systems, thus disregarding the effects one system has on the other. And third - although they conceptualise time as a factor within the system - they assume the system itself is quite constant. The landscape level is only capable of very slow change, while the regime level is conceptualised to change radically when niches enter this level.

Despite the many reservations and comments that can be made regarding these frameworks, there are two main ordering principles that clearly come forth. The first principle is that of *integration*. There is a connection between (niche) innovation and the space there is for integration of this innovation within the operational system. Whether this space is created through pressure from the landscape level as depicted in the MLP or through the coupling of problems, politics and policy solutions, there seems to be consensus on the fact that changes come mostly in the form of innovations and a window of some sorts is necessary for these innovations to be implemented.

This brings forth the second ordering principle of *collaboration*. In both the MSF as well as the sustainability transition approaches, intermediaries are mentioned as essential connections between separate streams or levels. These intermediaries can be within the regime or outside of it, regardless of their origin, they are presented as sharp thinkers who observe the opportunity for change and consequently have the means and drive to act.

4

Design Principles Past Transitions

This chapter is dedicated to the first phase of case studies - which focuses on cases in the domains of water and transport.

4.1. Watermanagement Introduction

Water management has been an integrated aspect of Dutch society for centuries due to the fact that 50% of the Netherlands' surface area is below sea level and the largest European rivers flow into the sea in the river-delta of the Netherlands. This has resulted in long-standing efforts to control, influence and contain the water (Rijkswaterstaat, n.d.-d).

The earliest organized efforts to control water in the Netherlands date back as far as the Middle Ages. Due to the delta region formed by the Rhine, Meuse, and Scheldt rivers, constructing dykes, canals and drainage systems has been necessary to prevent flooding. This need was combined with the need to claim more land when the Zuiderzeewerken were realised in the first half of the twentieth century - with which the Afsluitdijk was built and the whole province of Flevoland was reclaimed (Watersnoodmuseum, n.d.).

One of the most significant events in water management history was the devastating North Sea flood of 1953. This catastrophic event claimed the lives of thousands and led to widespread destruction. It prompted the Dutch government to launch the Delta Works project, a massive engineering endeavour aimed at protecting vulnerable coastal regions from future flooding (Rijkswaterstaat, n.d.-a). The Delta Works, completed in 1997, consists of an intricate system of dams, barriers, and storm surge barriers, including the iconic Oosterscheldekering and Maeslantkering.

4.2. Ruimte voor de Rivier - Room for the River

4.2.1. Case Description

The Room for the River project - "Ruimte voor de Rivier" in Dutch - is a groundbreaking initiative to manage and mitigate the risks of flooding in the Netherlands. In 1993 and 1995, large amounts of rain and meltwater caused very high water levels in the rivers. In many places, the dykes were not strong enough, which meant they might collapse. This caught the Dutch Department of Public Works - Rijkswaterstaat - by surprise and many people had to be evacuated (NRC, 1993). About 8% of the province of Limburg was underwater in 1993, flooding amongst others the villages of Borgharen and Itteren - which were unprotected by dykes (NRC, 1994). These villages were also badly affected in 1995 when in the province of Gelderland, 250,000 people and 1 million animals were evacuated as a precautionary measure (Mijn Gelderland, n.d.). After these high waters, the Room for River project was initiated.

Implemented between 2007 and 2015, the Room for the River project employed a unique approach that moved away from traditional flood defence methods - which primarily focused on raising and strengthening dykes (Rijkswaterstaat, n.d.-c). The key concept behind the Room for the River project was the idea of "giving rivers more space." This involved a series of measures, including the excavation of secondary channels, the creation of floodplains, the construction of bypasses, and the relocation of dykes farther inland. These interventions effectively increased the river's capacity to handle excessive amounts of water when necessary, reducing the risk of floods and thus protecting the surrounding areas.

More space for rivers, however, also means a different layout of the river area. The project provides not only increased safety but is a demonstration of an integrated approach to water management by achieving a multitude of objectives in the river system's safety and social, ecological and economic aspects (Rijkswaterstaat, n.d.-c). It reduced the probability of high water levels downstream, prevented erosion of riverbanks, restored natural habitats, and created additional recreational areas for the local communities - thus an attractive living environment for people and animals. This was an important part of the project due to the decreased ecological state of many of the rivers and riverbeds (ARK Natuurontwikkeling et al., n.d.). Next to these benefits, there were some significant obstacles and downsides to providing the rivers with more space. When reclaiming land or moving dykes, for instance, people and businesses had to move in order to create the space necessary. Due to the integrated approach, many different stakeholders were involved in the realisation of the project - such as water authorities, provinces, municipalities, wildlife organisations and citizens (Van Alphen, 2019).

The success of the Room for the River project has been widely acknowledged, both nationally and internationally and initiated a transition in water management style from a technical, scientific orientation towards an integrated and participatory style (Van Der Brugge et al., 2005).

4.2.2. Results

The respondents indicated that the project was characterised as a transition due to the new approach to managing large amounts of water - in which the rivers were widened rather than the dykes heightened. This was not necessarily a technological innovation, since the techniques used during the execution of the project were not new, but it was a transition of approach. This approach broke through what is referred to as the Levy effect - which is the spiral of heightening dykes when the land behind it is more valuable, while the land behind the dykes becomes more valuable when investments are made due to the safety perceived by the height of the dykes.

One respondent emphasises that this transition was a transition within the government, with the government as the most important actor. Rijkswaterstaat was the sole responsible party on a national level, whereas the water boards carried responsibility for their districts. This made responsibility - and thus ownership of the problem - relatively straightforward.

Another important aspect of this transition is that it took quite long. The principle of the Levy effect was known for a long time - 70 or 80 years. The idea for the alternative approach is mentioned as dating back to 1980-1985, whereas one of the respondents states the implementation was in 2015. This is a total of 35 years between idea and execution, and even more time between identification of the problem and formulation of a solution. Room for the River consisted of a total of 36 projects - with a budget of 4.2 billion - so the actual physical execution of the project took a significant amount of time as well.

Finally, there is some doubt about whether this transition is definite. One of the respondents notes that there is a major risk of falling back into old habits, where increasing the dyke heights is the go-to measure to take with rising water levels. Recently, new flood protection standards initiated the need to strengthen the dykes, but votes came in to heighten the dykes as well since the dykes needed work anyway.

When asked to describe the process, it is characterised as starting small and growing slowly. The high waters of 1993 and 1995 were stated as being extremely helpful in the consideration of alternatives that reduced the risk of lives and material lost when there would be high water again that would break the dyke. This trigger was useful in this sense because the plan for widening the rivers, broadening flood plains and moving the dykes backwards was already thought out and ready.

What followed is stated as 'someone who dares'. A large part of the success of the implementation is given to the senior policymaker. Both respondents mention Melanie Schultz-van Haegen by name as being the minister who made the final decision to widen the rivers in 36 projects. Both also mention several CEOs who allowed for small research projects that proved foundational for the development of innovation. These small research projects resulted in a cascade effect, of increasingly larger research projects until a project plan was developed and the approach was widespread.

One of the main barriers that was brought forward in the interviews, was the expansion of the responsibilities of Rijkswaterstaat, with which they would get involved in decision-making behind the dykes as well as in between them. There is a difference noted within the organisation as well, with the department in the southwest of the Netherlands being more receptive to the ideas than other departments. This illustrates the diffusion of the idea not only between organisations but also within organisations.

The main driver that came forth in the interviews was the dual objective of the project. This was initiated by a director, in which the safety aspect of the project - which was the main goal but rather elusive and high-over for most involved and affected parties - was coupled with the aspect of spatial quality. This dual objective ensured that it became a project that was also attractive and had direct benefits for the local population in the form of a recreational area. To each of the parties affected, there was added value in the project besides providing more security from floods.

Finally, one of the main success factors mentioned is the way in which was dealt with resistance. One respondent mentions that resistance was reduced because there was enough money to reasonably compensate those affected - for example, because they had to move. However, the administrative correctness of the process combined with frontrunners in government allowed for a legally correct procedure that ensured the project could continue. Interestingly, it is also mentioned that although there was much protest to the plans originally, there is much appreciation for the projects at the moment. This also indicates that perhaps changes are resisted, but once they occur, people find a way to live with them and even appreciate them.

4.3. Zandmotor - Sand Motor or Building with Nature

4.3.1. Case Description

The Sandmotor - Zandmotor in Dutch - is another example of a major innovative engineering project in the Netherlands. This coastal engineering initiative is implemented along the coast of South Holland. Launched in 2011, the project aimed to address coastal erosion, enhance coastal protection, and stimulate natural coastal processes using a unique approach known as ”Building with Nature.” (De Zandmotor, n.d.)

The Zandmotor is a large artificial peninsula created by depositing millions of cubic meters of sand along the coastline. Stretching over 21 hectares and located near the town of Ter Heijde, it serves as a ”mega-nourishment” that acts as a natural buffer against the forces of the sea (Rijkswaterstaat, n.d.-e). The concept behind the project is to allow nature to shape and redistribute the sand, promoting the natural growth and maintenance of the coastline over time. By harnessing the power of wind, waves, and tides, the Zandmotor creates a dynamic coastal environment. As waves interact with the sand, they gradually erode and transport the sediment along the coast, replenishing nearby beaches and dunes. The process helps to mitigate erosion, maintain coastal profiles, and provide long-term coastal protection.

One of the key advantages of the Zandmotor project is its sustainable and cost-effective nature. Instead of periodic and expensive beach nourishment projects, where sand is replenished regularly, the Zandmotor provides a single nourishment that lasts for approximately 20 years. This significantly reduces the need for frequent maintenance interventions and minimizes the ecological impact on marine ecosystems (van Donk & Wijsman, 2020).

The Zandmotor project has gained international recognition as a pioneering example of the ”Building with Nature” approach to coastal management (Luijendijk & van Oudenhoven, 2019). It demonstrates a shift from traditional hard engineering solutions towards more nature-based and sustainable alternatives. The project also serves as a living laboratory for researchers and scientists, who monitor and study the ecological and morphological changes occurring in the area.

Since its implementation, the Zandmotor has proven to be successful in its objectives. It has contributed to coastal protection, stimulated natural coastal processes, and created new habitats for marine flora and fauna. In addition, recreational areas have been made more attractive as well as safer (Rijkswaterstaat, EcoShape, & Kansen voor West, 2014).

4.3.2. Results

The Sand Motor is indicated as a transitional project due to the different approach. During high tides, the sea takes the sand on beaches away from the coast - even more so during storm surges and spring tides. The strength of dunes depends on the amount of sand present, so every once in a while, sand replenishments were done to keep the protection from the sea sufficient. However, this approach was structurally different when the Sand Motor project was initiated.

When asked to describe the process that led to this, the first thing that is mentioned is the necessity for a different approach. Climate change affected the sustainability of the bit-by-bit approach. Because there were solid figures - numerical evidence - to support the claims that sea levels were rising, the resistance of climate deniers was reduced. Namely, the origin of the problem was not incredibly relevant, and thus the urgency to address the issue rose.

When asked to state why the project was successful, the respondent stated that many different problems were combined and consequently addressed with the Sand Motor project. These reasons were safety-related, but also economical, and ecological and interestingly, an aspect of prestige came into play as well. The project was additionally presented as a learning opportunity that could make the Netherlands a global leader in large-scale coastal projects and thus provide an economic opportunity. A coalition was formed when Rijkswaterstaat backed the plans and sand suppletion companies and dredgers saw potential in the plans as well.

Various much more radical innovative ideas were rejected ahead of realisation and the Sand Motor was developed and investigated. For example, there was a plan to build an entire island in front of the coast - the Watermanplan - or the ”haakse zeedijk” (Butlijn & van den Haak, n.d.), or even an airport in the sea - Flyland. These plans were never realised due to protests from climate activists, ecologists and inhabitants of the coastal regions and the regulation regarding the Natura 2000 areas. One of the success factors mentioned is the correctness of the participatory process that was followed. Moreover, the respondent also mentioned Lenie Dwarshuis - who was a member of the college of deputy state of South Holland - who took the lead and acted as a pioneer for the development of the Sand Motor.

4.4. Interpretation of Watertransitions

The results of both cases lead to the reconstruction of water transitions as displayed in figure 4.1 since both processes share many characteristics.

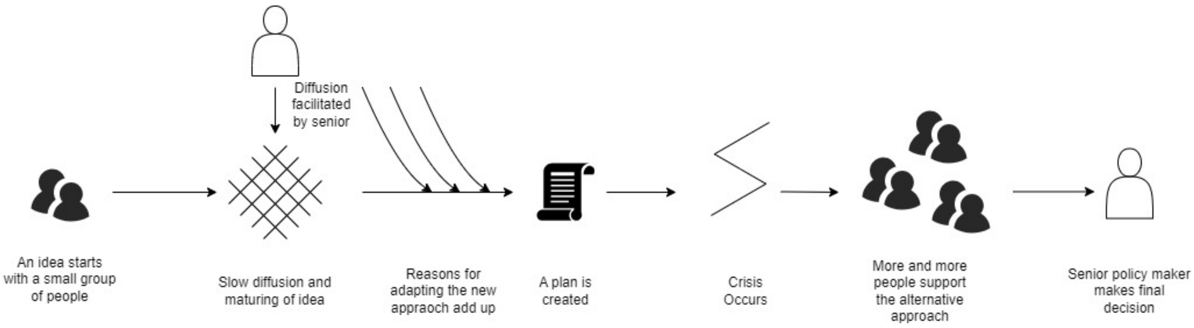

Figure 4.1: Process of Transition in Watercases

The experts indicated that the processes both followed more or less the same path of transition. Initially, there was a large variety of plans. With regard to the Sand Motor, the initial plans were far more extreme than the core of the plan that was eventually implemented. This initial development is quite chaotic, but through consultation with other actors and for example experiments, selection takes place and the most extreme ideas are abandoned. After the leading idea was developed - to widen rivers rather than heighten dykes or to build with nature instead of against it - it first entered a stage of slow diffusion through the network. These ideas often originated within academia but found an audience within other organisations through personal contact and individual transfer. This first phase of diffusion was facilitated by a senior authority by means of small pinprick research endeavours. The idea/innovation grows and spreads and reaches a state of full development.

Then, a crisis occurs. In the case of Room for River, these were the high waters, whereas the increasing sea level and more and more rapidly eroding coastline gave cause for the Sandmotor project. When the idea is mature enough, and the plans developed enough, one senior policy person takes charge and decides to switch to the new approach. Within this choice, prestige often plays a significant role. As stated in the introduction, water management is one of the Netherlands’ major expertise and in order to maintain this leading position, bold choices need sometimes be made. This choice then results in the availability of funding.

The following step is an interesting one - in the concretising of the plans, a coupling with other, seemingly rather unrelated issues, is made. In this step, a systems approach is taken to establish the intersections with other systems - and their issues. In the Room for River project, this meant coupling the safety of water with increased ecological prosperity and recreational areas for citizens. This coupling with ecological benefits was also made. In addition, the projects - naturally - were more economically attractive than their alternatives. A multipurpose endeavour is created due to this integrated approach. This causes partners in unexpected and unusual areas, like wildlife and nature organisations.

Finally, these projects are characterised by their effective coping with protest. In the Room for River project, many municipalities were affected and many citizens had to relocate in order to create the necessary room for the river. Although there was a protest, the civilians were properly compensated and a tool was created - the blokkendoos - that allowed for an insight into alternatives that were available for addressing the problems. This online programme gave the user the task of protecting living areas against increasing water volumes. This could be achieved by a multitude of measures - including widening the river, heightening the dykes and relocating people - that all had their corresponding costs. This allowed the user to get a feeling for the costs of the different available alternatives, within a short amount of time. This significantly added to the understanding of participants and affected municipalities. In the Sandmotor project, the original plan was significantly more far-reaching than the eventual execution, with plans for a whole island in the sea that could be used for housing. After consultation with several parties, this plan was deradicalised in order to achieve broad support. Finally, both projects still faced protest, but due to the institutionally correct path of development and the senior policymaker that pulled the cart, they endured and were realised. In other words, there was sufficient time and space to 'optimize' the solution so that it would resist the forms of protest.

4.4.1. Ordering Principles

The ordering principles of integration and collaboration can both clearly be traced and expanded by means of the cases. The Room for River project shows that radical innovations or approaches can be integrated abruptly when there is a clear, direct cause to do so. The Sand Motor project shows, however, that when the crisis is less pressing, there is much less space for radical innovations. The development of both innovations takes a long path from initial idea to implementation. Collaboration is key in this process, with major roles for catalytic policy-makers as well as seniors within the organisations themselves. This collaboration can be expanded with respect to the definition in the previous chapter since one of the main success factors of these projects is stated to be the multipurpose approach. There seems to be not only collaboration between the innovator and intermediary but also between problem owners. Both projects addressed the for many people intangible aspect of safety by also addressing the ecological state of the coast or river bank, as well as recreational purposes for the inhabitants surrounding the projects. This coupling of problems to be addressed with the same solution is a type of connection that is evidently sought after in these large transitional projects.

4.5. Transport management Introduction

Transport management is the second domain which is interesting for analysis in light of transitions. With the Netherlands having an excellent score on the European Transport Scoreboard, the Dutch mobility infrastructure is a unique one - with no other country in the world being so characterised by the use of bicycles. The average Dutch person makes 4.4 bike rides per week (CBS, 2022). Since the documentation of travel time, the time a Dutch person spends per day travelling hasn't changed - staying constant at about 70 minutes per day (Hilbers, Ristema van Eck, & Snellen, 2004). The distance covered in this time, however, has significantly increased over time. Although technological developments have increased the possible speed of different modes of transport, the average Dutch person is always faced with more or less the same possibilities: bike, car, bus, tram, metro or train.

The qualification of one of the most extensive mobility networks is not without costs, however. On average, the government invests €12 billion per year on traffic and transport, of which more than half is spent on expanding and improving the road infrastructure (Rienstra, 2022). In doing so, the choice is made to develop those places where the positive effects on the economy are greatest, but also regional accessibility is well funded.

The main responsibility for transport is divided across many different parties, with Rijkswaterstaat being responsible on a national level and provinces and municipalities on a more decentralised level (Rijkswaterstaat, n.d.-b).

4.6. Binnensteden zijn anders - City Centres are different

4.6.1. Case Description

About half of the outdoor space in the Netherlands is taken up by traffic and transport (van Ketwich, 2022). With increasing pressure on spatial planning due to an intensification of land use, mobility in city centres is changing. The most significant urban regions experience additional travel time of 20% or more due to congestion (Arnoldus, Arts, Knipping, & van der Wal, 2022). This use of cars in cities doesn't only cause inconvenience for users but also increases air pollution and traffic accidents. In the past 50 years, congestion has been responded to by expanding the road network, but within two years of road expansion, the amount of congestion is back to its old level or even worse.

The Dutch government has consistently supported and invested in cycling infrastructure and policies that encourage cycling as a preferred mode of transport. Initiatives such as ”Fietsplan” (Bicycle Plan) (Nationale fiets projecten, n.d.) and ”Fiets van de Zaak” (Company Bicycle Scheme) (Rijksoverheid, n.d.-a) have incentivized employers and individuals to choose cycling, resulting in increased bicycle usage and a reduction in car dependency. This commitment to cycling not only promotes a healthier lifestyle but also alleviates traffic congestion, improves traffic flow and reduces carbon emissions and other types of air pollution (TNO, 2023).

Cycling infrastructure in the city of Rotterdam is extensive and well-developed, comprising a comprehensive network of dedicated bicycle lanes, paths, and bridges. The infrastructure is carefully integrated with other modes of transportation, including public transit, to provide seamless and efficient multi-modal connectivity. The design of cycling infrastructure prioritizes safety, convenience, and comfort, making cycling an attractive option for daily commuting, leisure activities, and short-distance trips. This was not always the case, but since 2010, the municipality actively encourages and enables cycling (Gemeente Rotterdam, n.d.).

4.6.2. Results

This is categorised as a transition due to visible and statistical changes. The respondent shows images of the Coolsingel in Rotterdam from last year, which shows an extensive cycling lane both ways - full of cyclists. This is a major change as opposed to before 2010 when there was more emphasis on facilitating cars within the city. Statistics also show that many more people use bicycles as a mode of transport within the city than previously. This is supported by Gemeente Rotterdam (n.d.) who state that the amount of cyclists in the city has doubled since 2010. The respondent notes, however, that there was no technical innovation at the basis of this transition since the transport modes existed for a long time.

The process that leads to this transition, is a combination of many different causes. According to (Verkeerskunde, 2022), traffic jams and parking issues are the main frustrations of travellers and this has caused 23% of car drivers to seek other modes of transport. During the interview, the train cyclists - ”treinfietser” - are mentioned as being almost a new mode of transport. This is stated to be caused by the improvements in public transport, the train in particular. The example of ”Perron nul” is mentioned as typical for this change from dodgy, bad end of town, to one of the most prominent railway stations in the country. The respondent indicates that this transition to cycling was initiated by the behaviour of travellers, but enhanced with cycling enabling policy. This is typed as an interaction between users and enabling - for which there are many different reasons. Parking costs of €4 per hour in the city centre and traffic jams cause people to opt for different transport modes. This in turn is taken as an opportunity by the municipality, which views cycling not only as a solution for the increased pressure on mobility infrastructure but also as an opportunity to increase sustainability and promote a healthier lifestyle (Gemeente Rotterdam, 2019).

During the interview, it was mentioned that this change in policy was quite remarkable since there was a rather conservative city council. There was a lot of support for the measures, however, because the issues were identifiable and real for many people - and the policy followed a trend. The number of cyclists in the city increased by 60% in ten years (Gemeente Rotterdam, 2019).

4.7. Shared Mobility

4.7.1. Case Description

Another major change in transport in recent years has been the rise of shared mobility. Shared mobility refers to the concept of using vehicles or modes of transport on a shared basis rather than individual ownership. It encompasses various forms, including car-sharing, bike-sharing, ride-sharing, and scooter-sharing, among others. These shared mobility services aim to provide convenient, flexible, and cost-effective alternatives to traditional modes of transportation while reducing congestion, pollution, and the overall carbon footprint (Kamargianni, Li, Matyas, & Schäfer, 2016). The OV bike has existed since 2000, but its widespread use has been quite recent (van Gestel, 2021). Also, private parties that offer shared mobility are popping up everywhere - Greenwheels for electric cars, Go Sharing, Felyx and Check for electric scooters, to name a few.

Shared mobility has witnessed remarkable growth and acceptance, mainly due to the development of ICT infrastructure to support sharing in the form of easy-to-use apps (Kamargianni et al., 2016). Major cities such as Amsterdam, Rotterdam, and Utrecht have embraced shared mobility as an integral part of their transportation ecosystem. Bike-sharing programs have gained immense popularity, with fleets of bicycles available for rent at numerous docking stations throughout urban areas (Jorritsma, Witte, Alsono González, & Hamersma, 2021). This encourages residents and visitors alike to opt for sustainable and healthy modes of transport, reducing reliance on private cars. Car-sharing services have also gained momentum, offering users the opportunity to rent vehicles for short periods, allowing for easy access to transportation without the hassle of ownership and parking. Furthermore, ride-sharing platforms have provided an alternative to traditional taxis, facilitating cost-sharing and efficient use of vehicles. By promoting accessibility, sustainability, convenience, and affordability, shared mobility has become an essential component of the transportation system in a relatively short amount of time - encouraging a shift towards more efficient and sustainable mobility. According to ANWB (2022) andHollard (2023), 66% of business owners expect to transfer to sharing mobility, rather than owning the vehicles themselves. This indicates a major shift in perspective towards and use of vehicles.

4.7.2. Results

This transition from individual ownership of vehicles to shared ownership is gradually taking place. It is not possible yet to state whether this transition will be in full or partial, but it is clear that this type of use is currently co-existing.

This transition is reported as being much more technology-driven than the transition to cycling because shared mobility is strongly enabled by the use of a technology that enables allocation. This is for example an application on a mobile phone that allows for reservation of a shared vehicle. This is presumed to be the reason behind the recent success and uptake of this concept, whereas the concept itself is rather old. The OV bike, for example, dates back to 2000 and the city of Amsterdam already attempted to introduce shared bicycles in the 1960s. These ended up mostly in the canals and the plan is mainly regarded as unsuccessful. The interview brought forward that this is suspected to be due to the lack of ownership back then, whereas the use of the ICT applications now makes it possible to trace back who was using an item when.

One of the main drivers to support shared mobility is pragmatic and related to the pressure on the housing market. The respondent states that the old solutions are simply no longer tenable because it is simply impossible to develop large residential areas close to bottleneck parts of the highways. This has caused 6 million of the 7.5 million divided by Hugo de Jonge for accessibility of new homes to be invested in public transport and bikes. In addition, financial reasons play a major role for the individual. Sharing a vehicle is much cheaper than owning one. The respondent does indicate that there is much more hassle in using a shared vehicle, and especially when children are born new parents do tend to buy a car. With regard to the increased use of scooters in cities - which are directed at a different, slightly younger target group - the aspect of status is mentioned as a driver since the use of such a scooter is presumable more expensive than that of a bike. Although shared cars are more of a hassle, shared scooters are also thought to be attractive because they are actually easy to use and much quicker than a bike or public transport. For many car users, shared use is a combined solution to address costs, parking issues near home and climate change.

4.8. Interpretation of Transporttransitions

Whereas the transitions in water management can be categorised as taking place in the transformative transition part of the framework, the transitions in transport are of a more adaptive or incremental nature. This transition path as reconstructed broadly speaking, is visually displayed in figure 4.2.

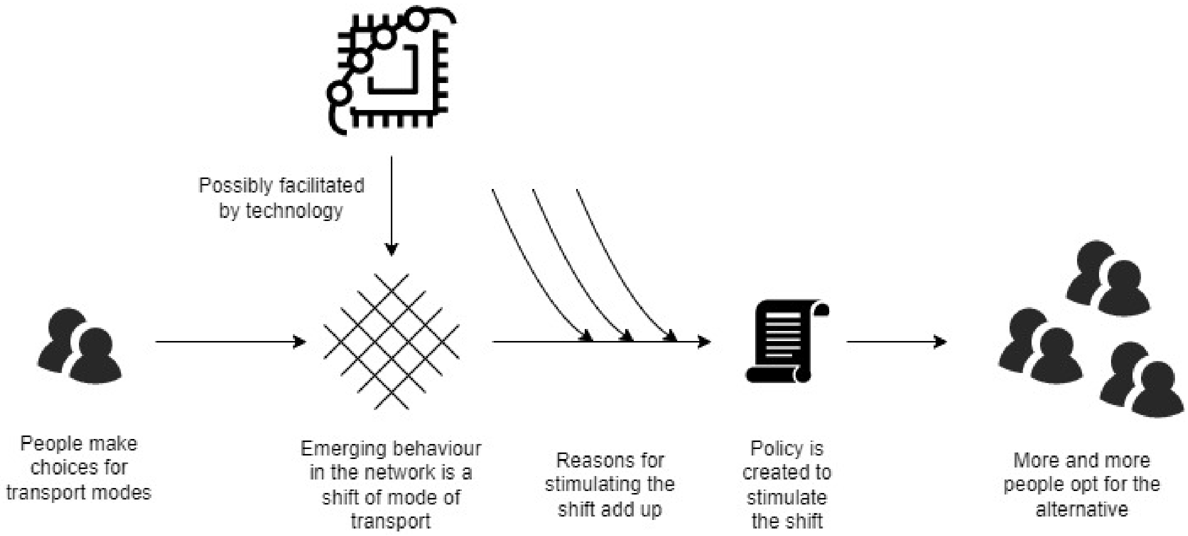

Figure 4.2: Proces of Transitions in Transport

The transition that has taken place in the city centre of Rotterdam has been a typical bottom-up transition and an almost ideal case of adaptive management to stimulate a trend. The transitions observed are user-driven rather than policy-driven. Due to the increased travel time experienced when travelling by car - due to traffic jams - people opted more and more often for travel by bike. Although it may not be a system-wide crisis, this can be seen as a trigger on an individual level. As a result, the demand for better cycling paths grew and the municipality increased the accessibility of the city centre for cyclists. This in turn resulted in the bike option being even more attractive than the car option and thus the trend was enhanced. This transition was reported as being rather practical in nature - people did not want to be stuck in traffic in the city centre - but other factors contributed to the decision to enhance the cycling trend. The same coupling of issues as was seen in water transitions can be observed here as well. By stimulating cycling and decreasing cars, the city centre's air quality would improve. Moreover, the increased accessibility of the city centre would attract economic opportunities for the settlement of large companies. All in all, there were so many reasons to develop the cycling lanes, that the municipality could simply not afford to not do it.

The transition towards shared mobility appears to be of the same nature, with several scale levels to consider. The smaller-scale behavioural changes are enhanced by the larger-scale policy. On both scales, the reasons for this change are multiple - like with cycling. Financial reasons, convenience, travelling time, climate, pollution and limited space create a combined immense cause to change the mode of transport.

4.8.1. Ordering Principles

The ordering principles of integration and collaboration are visible in these transport transitions as well, but they take a vastly different form. Collaboration appears to be much less searched and more found - it is much more pragmatic in nature. It almost seems as though policymakers are presented with a change in behaviour, realise the immense benefits more of that behaviour could bring and then enhance it with policy. This collaboration is thus less directed and more organic in nature. Moreover, integration of these alternatives also seems to happen organic and incremental. None of the innovations can be regarded as technological innovations and none of them have thus far repressed the "old" technology. This makes the integration a very incremental process, in which an upward spiral - or momentum - is visible. This incrementality of change is perhaps also the reason there appears to be little conflict. The behaviour is already there, then the policy is created.

4.9. Outcomes

In conclusion in this first phase of cases, the one thing that stands out most is the diversity of types of transitions taking place. Whereas in water management the transition was rather radical, the transition in transport was of a more incremental nature. They have in common that there is a clearly identifiable trigger. Apparently, when there is a crisis on a national level, the integration of radical innovation is possible, whereas a smaller trigger causes a more gradual change over time.

Another noteworthy takeaway from these cases is that none of them were actually technology-driven. The most technological innovation to be introduced is perhaps the use of technology to support shared mobility - with an emphasis on support. This leads away from the perspective of technology-driven innovation and suggests a transition as an emerging consequence of behaviour. Moreover, the uptake of these innovations is far from linear. In transport, the transition was gradual and for example, the shared mobility took several tries, fails and alterations before there was actual adaptation. With regard to the Room for River project, there is doubt on whether the radical change in approach will be sustained since policymakers are quick to reconsider the ”old” approach. This raises the question of whether radical transitions might be less stable than incremental transitions.

The principle of collaboration - and the aforementioned role of intermediaries - is clearly visible in all cases, with major roles for government officials in daring to make the final decision in water, or drawing up the policy in transport. This principle is strongly connected to the integration of innovation, as collaboration is often foundational for the development of innovations and plans - like in the Sand Motor, where the initial radical plans were abandoned when the participatory process drew out protest. This protest - or conflict - also seems to be an inherent part of collaboration and progress in radical changes (Correljé, Pesch, & Cuppen, 2022; Cuppen, Pesch, Remmerswaal, & Taanman, 2019). Due to conflict, plans are altered in such a way there is a majority in favour and they can continue. In the more incremental change paths of transport, on the other hand, there is a much smaller role for conflict and the change appears to be regarded as the only logical solution to address the variety of issues, which is due to the bottom-up nature of the change. There might still be some protests from within the regime - such as the automotive lobby advocating larger investments in the road network - but this is less significantly visible.

Finally, a very interesting aspect of collaboration - or perhaps a different ordering principle altogether - is the interaction or multi/dual purpose of these projects. None of them sought to address solely one issue. In the Room for River project, the goal of safety was coupled with financial, ecological and recreational goals. The Sand Motor project also coupled safety with ecology and learning opportunities. The transition to cycling in Rotterdam is additionally to mobility aiming to contribute to health and climate goals. Shared mobility is not only cheaper but makes parking much less of an issue and decreases pollution and travelling time. This principle is strongly related to the previous two principles because these multipurpose projects are created through collaboration and increase the chance of integration.

5

Theory Matching

In the first round of cases in water and transport, the ordering principles of integration and collaboration could be traced and elaborated upon. However, several design principles brought forth during the interviews could not be explained with these two ordering principles or required further investigation for a more precise definition - which is especially necessary when the principles need to be used to analyse the cases within the energy domain. These design principles are mostly related to the integrated approach - the systems-of-systems theory - and the already described shortcomings of Transition Management with regard to power and politics in networks and the distinction between radical, innovation-centred change and incremental change. That is why this theory-matching chapter is dedicated to the application of complexity science literature to the energy domain. This application to energy is relatively recent, but emerging (Bale, Varga, & Foxon, 2015).

Although Transition Management is related to complexity science, complexity science is the generic term for a field of studies that focuses on complex systems and sets out to understand how simple interactions between individual components can give rise to emergent phenomena and patterns at a larger scale. Complexity science focuses on the necessity to consider the whole system and the interactions between its components - thus challenging the reductionist approach on which the previously introduced frameworks are built. Complex Systems are characterised by networks, emergent patterns, self-organisation, co-evolution, path dependency, adaptation & evolution (Bale et al., 2015). Branches of complexity science include network theory and chaos theory (de Roo, 2018).

5.1. Cities and Urban & Spatial Development

The first thing that stands out from this literature review is the number of articles emerging that concern the development of (smart) cities (Gebhardt, 2017; Schiller, 2016; Moroni, 2015). This is especially interesting since the analogy in chapter 1 showed that cities are a core example of dynamic growth and development that seems unhindered by paralysis in the absence of a clear goal. Evidently, complexity science has already been shown to be much more applied in this domain. One of the main issues facing the social sciences is modelling the dynamics and evolution of cities (Dearden & Wilson, 2015). Bibri (2018b) states that cities are too complex to address with only one discipline because there are many underlying subsystems that are connected by a web of relationships that cause emergent behaviour (Bibri, 2018a). Wilson (2010) argues that the rapid advancement of urban models in the context of complexity science presents an excellent opportunity to apply this knowledge to the problem of climate change.

5.2. Coevolution of systems

A complex system is adaptive or evolutionary and influenced by social, political and physical processes (Bale et al., 2015). These complex systems are often highly interdependent, connected systems (Williams et al., 2017), that coevolve. Coevolution is an aspect of complexity science that focuses on the dynamic interactions between entities. The evolution or change of one entity is influenced by and influences the evolution of the other interconnected entities. Coevolution recognizes that entities in a system are not isolated or independent, but rather, they interact and exert selective pressures on each other over time. These interactions can lead to mutual adaptation, where changes in one entity drive adaptations in others, creating a feedback loop of continuous evolution. Coevolutionary dynamics often involve nonlinear and emergent properties, where small changes or interactions can lead to significant shifts or cascading effects within the system. These dynamics are incredibly difficult to study since they involve many different parameters in the connected systems (Marshall & Green, 2021). Many social systems are naturally unpredictable as a result of these dynamics, especially when structural change - like transitions - is present. This has implications for policymakers when their focus is too narrow (Jager & Edmonds, 2015). A new, more accommodating policy narrative is outlined by the concept of complexity, which regards society as a complex, dynamic system that is difficult to control but can be influenced (Colander & Kupers, 2014).

5.3. Rapid and Slow Change

When departing from the idea of a static world and accepting a world in flow, de Roo (2018) describes two types of flow: slow and sudden. When the contextual environment is relatively stable, contingent transformative conditions prevail. When there is turbulence, however - and the system is pushed off track - adaptive transformative conditions take over. This is also conceptualised by Anderson et al. (2014) who distinguishes incremental and discontinuous change and notes that managing incremental change is fundamentally different from managing discontinuous change. These two types of transformation are displayed in figure 5.1.

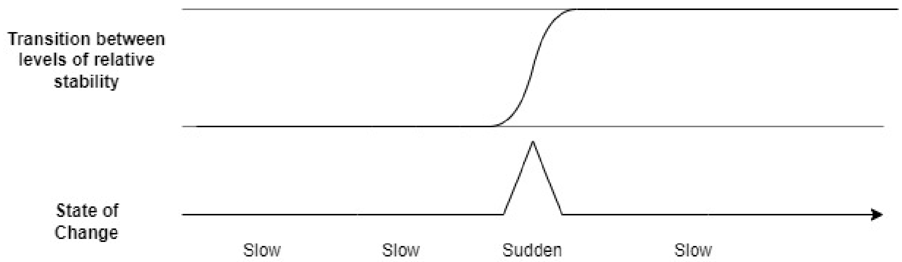

Figure 5.1: Slow and Sudden Transformation - adapted from (de Roo, 2018)

This reasoning addresses the notion that although change requires direction, one cannot easily plan for - or govern - a transition. First, because our world is constantly changing from one state to another – so it is too simple to state there is 'a transition'. Second, many different aspects come into play that are unintended, unexpected and unpredictable: innovation development, or geographical conflicts for example. Governance and decision-making cannot directly address the shortcomings perceived in the energy transition, but instead, need to consider the conditions under which the system transforms.

de Roo (2018) argue that insight into these conditions allows for the definition of a window of influence - a design space - to enhance the positive effects of transformation or minimize negative impacts. In other words, in order to guide the energy transition, it is necessary to know the current trajectory as well as the points of influence.

During the relatively stable phase, the system and its components slowly evolve and transform over time due to small, low-level adjustments. These contingent conditions are replaced by adaptive conditions when the environment changes from stable to turbulent - generating enabling and constraining conditions for system response. This theory revolves around the idea of bifurcation and differentiation, which is shown in figure 5.2.

Bifurcation and differentiation offer alternative ways of displaying the role of innovation within transformations. Rather than innovation development, uptake and replacement of previous technologies, the illustration in figure 5.2 shows the coexistence of different technologies within society. During periods of slow change, innovations are fostered and developed - sometimes in isolated environments such as living labs, sometimes directly within society. These innovations cause bifurcation and differentiation within the operational system. The figure illustrates the difference between differentiation - the addition of a new technology or innovation - and bifurcation - a split in a previously uniform technology. For example, within the domain of transport, the automobile can be regarded as a differentiation with respect to the use of horse and cart, while the development of the electric car is a bifurcation of the car into fossil-fueled and electric fueled. Rather than designing the whole transition, there are only two

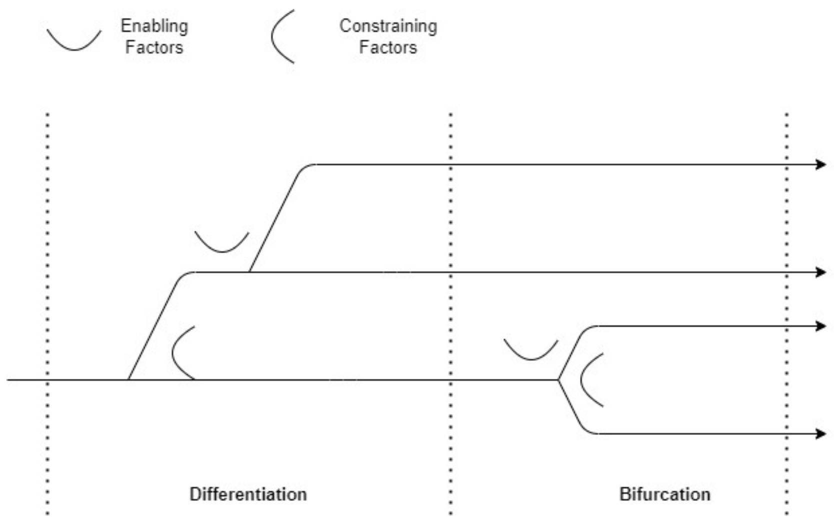

Figure 5.2: Bifurcation and Differentiation adapted from (de Roo, 2018)

places of influence defined - constraining and enabling factors. Bredikhin (2020) states that bifurcations are slowly changing parameters that eventually reach a critical condition and cause crisis. Although bifurcations initially do not cause crisis, they state that all bifurcations will become a crisis at a certain point.

By acknowledging the continually ongoing processes of (technological) change in a system and the limited design space available, (de Roo, 2018) argues that trends in society need to be identified, assessed and consequently constrained or enabled according to their desirability. In order to identify the space for enabling or constraining, it is important to know the ordering principles of the system for change in both the slow and fast phases. Ordering principles in spatial-economic transitions for the spatial planning domain are presented by de Roo (2018) and include cohesion, compatibility, complementarity and competition.

5.4. Innovations

As came forth in the first phase of case studies, innovations play a major role in change - but their adaption is much less linear or radical than is often depicted. Innovations might find uptake when there is space for them in the system - but this typically takes several tries before it is successful. This was conceptualised by Roland Ortt (2010), as shown in figure 5.3.

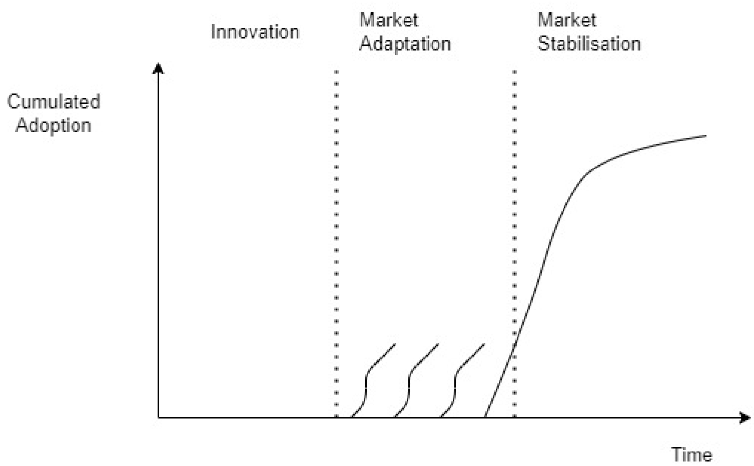

Figure 5.3: Uptake of Innovations, adapted from Roland Ortt (2010)

This visualisation of the uptake of innovation shows a much more incremental development path,

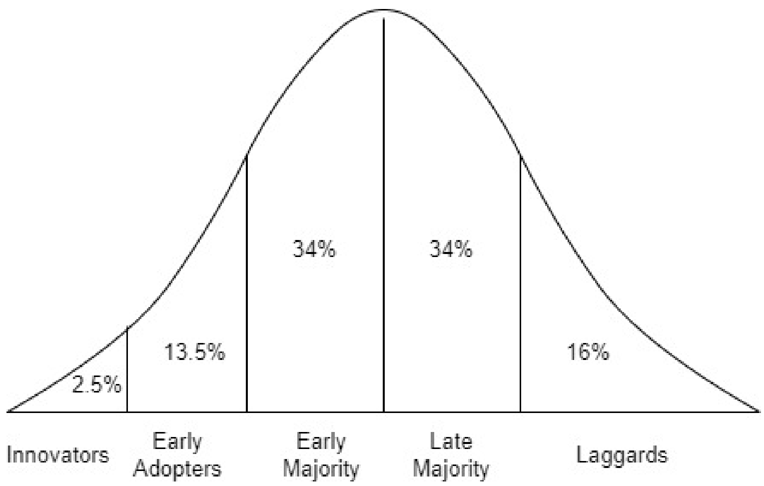

Figure 5.4: Diffusion of Innovation, adapted from (Rogers, 2003)

with several attempts to take an innovation to market, failing, adjusting and trying again. This nuances the view of innovation development in separate, isolated niches and shows much more interaction between niche and regime levels than is often suggested by the Multi-Level perspective (Geels, 2004). Although this figure is aimed at the development of technological innovation and consequently its introduction and stabilization in the market, innovations can be more than solely technological. Changes in approach, thinking, framing or defining systems - for example, the Room for River project - are also significant innovations.

The theory of disruptive innovation, conceptualized by Christensen, McDonald, Altman, and Palmer (2018), describes how emerging technologies or products can initiate significant industry transformations. This theory distinguishes two key types of innovation: sustaining - which involves refining existing offerings for current customers - and disruptive - which seeks to serve underserved markets of new customers with more radical innovations. Disruptive innovations embark on a trajectory of gradual enhancement, initially addressing niche markets that regime-level companies tend to overlook. These innovations are often embraced by early adopters and gradually move across the technology adoption curve shown in figure 5.4, eventually challenging established products in mainstream markets (Reinhardt & Gurtner, 2015). This transformative process can force regime-level companies into an "Innovator's Dilemma," compelling them to decide whether to invest in technologies that may seem inferior in the short term. By recognizing the dynamics of disruptive innovation and the diffusion of innovation model, businesses can strategically navigate industry shifts and remain competitive amidst changing landscapes.

5.4.1. Ordering principles

The literature above offers more insight into the development and uptake of innovations, and nuances in the view of the isolated niche that enters the regime level to cause a transition within a system. Integration of innovation in one system strongly influences other systems, leading to a cascade effect that eventually drives a transition. This is reflected by the incremental adaptation and uptake of innovation as conceptualised in the theory of disruptive innovation. Collaboration is essential to facilitate this integration, but a new ordering principle of *connection* emerges as well. Whereas collaboration focuses on the practical stimulation of innovation and is thus necessary for integration, a connection is aimed at the identification of the networked systems-of-systems and the integrated approach to address problems in these complex systems on a much more abstract level - with much more regard to the intangible interactions taking place before there is actual practical implementation.

6

Design Principles in the Energy Transition

6.1. Introduction to Climate Policy in the Netherlands

Before the cases within the Energy domain can be introduced, it is necessary to have some idea of the background of energy policy in the Netherlands because the climate policy is affected by many different events, changes and documents - of which it is difficult to keep an overview. Moreover, climate policy is characterised by a high degree of institutionalisation in policy documents and regulations. This has a major effect on the projects with regard to the design space available to seek solutions. That is why it is important to map this regulation.

Climate policy in the Netherlands dates back to the 1970s - although the main motivation for legislation then was not climate change. The 1973 oil crisis and growing concerns about pollution and energy security led to increased awareness of the value of energy resources. In the 1990s, the Dutch government took initial steps towards climate policy. In 1992, the Netherlands signed the United Nations Framework Convention on Climate Change (UNFCCC). Subsequently, various policy measures were introduced to reduce greenhouse gas emissions, increase energy efficiency, and promote renewable energy (Boot, 2020). The Netherlands ratified the Kyoto Protocol in 2002, committing to reduce its greenhouse gas emissions by 6% compared to 1990 levels between 2008 and 2012 (UNFCCC, n.d.). Several policy measures were implemented, including promoting renewable energy and energy efficiency. Ambitious targets were set in the 2010s. In 2013, the Energy Agreement for Sustainable Growth was established, aiming for a 14% renewable energy share by 2020. Additionally, the Dutch government pledged to reduce greenhouse gas emissions by 20% by 2020 compared to 1990 levels (Rijksoverheid, n.d.-b).

From the beginning, climate policy has almost always been linked to the economic opportunities that it would provide, but this shifted recently (Boot, 2020). From 2015 onwards, everything climate-related gained momentum after the signing of the Paris Agreement and a more integrated approach to climate policy was adopted when interaction with spatial planning was recognised. Its main goal is to combat climate change by limiting global warming to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius (van Santen, aan de Brugh, & van der Walle, 2020). The overview of national Dutch legislation from this moment on is shown in figure 6.1.

Later that year, a landmark climate lawsuit was filed by the Urgenda Foundation against the Dutch government, arguing that it had a legal duty to protect its citizens from climate change (Urgenda, n.d.; van Santen, 2018). Following these events, the Dutch government presented an energy report - Energie Rapport - and an energy agenda - Energie Agenda - in 2016. The Dutch Climate Act - Klimaatwet - was written in 2018 and sets legally binding targets for greenhouse gas emissions reduction in the Netherlands. Although it was proposed in 2018, it was formally adopted in 2019. The law sets a long-term target of reducing greenhouse gas emissions in the Netherlands by at least 95% by 2050 compared to 1990 levels. It also establishes shorter-term milestones, including a reduction target of 49% by 2030 (Rijksoverheid, n.d.-b). In addition, the Dutch government is required to develop five-year

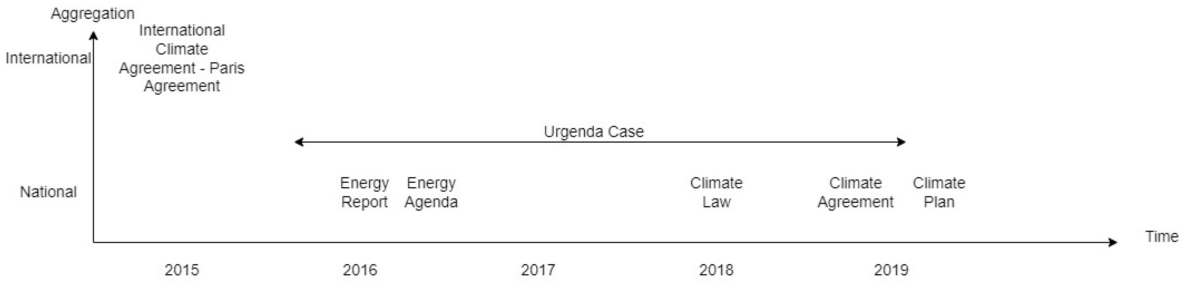

Figure 6.1: Development of Climate Regulation in the Netherlands since the Climate Agreement, adapted from (Rijksoverheid, n.d.-b)

climate plans outlining the policies, measures, and targets to achieve the emissions reduction goals. These plans are to be submitted to the Dutch Parliament and provide transparency and accountability in climate action. The Climate Act establishes an independent advisory body called the Climate Authority (Klimaatautoriteit). The authority monitors and assesses the government's progress toward meeting the emission reduction targets, provides recommendations, and reports to the Parliament and the public. The Climate Act also introduces the concept of a "climate budget" and "carbon budget." The climate budget specifies the total amount of greenhouse gases the Netherlands can emit until 2050. Carbon budgets are five-year targets within the climate budget, outlining the allowable emissions for each period. Finally, the Climate Act requires the government to base its climate policy on the National Climate Agreement - Klimaatakkoord - which was developed in 2019, outlining policies and measures to achieve its long-term climate goals (Klimaatakkoord.nl, n.d.). The agreement aims to reduce greenhouse gas emissions by 49% by 2030 compared to 1990 levels and achieve carbon neutrality by 2050. Also in 2019, the Dutch Supreme Court ruled in favour of Urgenda, ordering the government to reduce greenhouse gas emissions by at least 25% by the end of 2020 compared to 1990 levels.

As a consequence and part of all the agreements above, many different policy documents have been established since. It is quite difficult to keep an overview in this maze of policy documents, because they interact with, interfere with and complement each other. An overview of (some of) the policy documents is presented in figure 6.2.

The image is divided into three levels: national, regional and local. Many of the documents contain plans aimed at a single sector affected by the climate goals - agriculture, mobility, heat, energy or industry. Recently, however, there has been a commendable shift towards comprehensive planning that acknowledges the interconnections among various sectors impacted by climate goals, recognizing the imperative for holistic and integrated approaches rather than solely focusing on individual sectors. This resulted in the current development of the National Plan Energy Systems. In this research, three programmes are at the centre of attention. These are highlighted in figure 6.2.

6.2. Charging Pole Infrastructure

6.2.1. Case Description

The National Charging Infrastructure Agenda - National Agenda Laadpaalinfrastructuur - is part of the Climate Agreement (Nationale Agenda Laadinfrastructuur, n.d.). It contains agreements for a comprehensive charging network for electric transport in the Netherlands. It takes into account the strong growth in electric passenger cars, public transport and freight transport - aimed at accelerating the development and deployment of electric vehicle (EV) charging infrastructure throughout the country. The outlook by ElaadNL (n.d.) suggest that 10.6 TWh of electricity will be needed for passenger transport in 2035, and the combined required amount of electricity for all transport accumulates to 22.2 TWh. The national agenda is part of the Dutch government's efforts to support this task, by collaboration with local governments, businesses and network operators. The agenda has 4 key objectives (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.):

- A sufficiently covering charging infrastructure - significantly increasing the number of public and private charging points across the Netherlands to meet the growing demand for EVs. This involves the installation of charging infrastructure in residential areas, commercial buildings, public parking lots, highways, and other strategic locations.

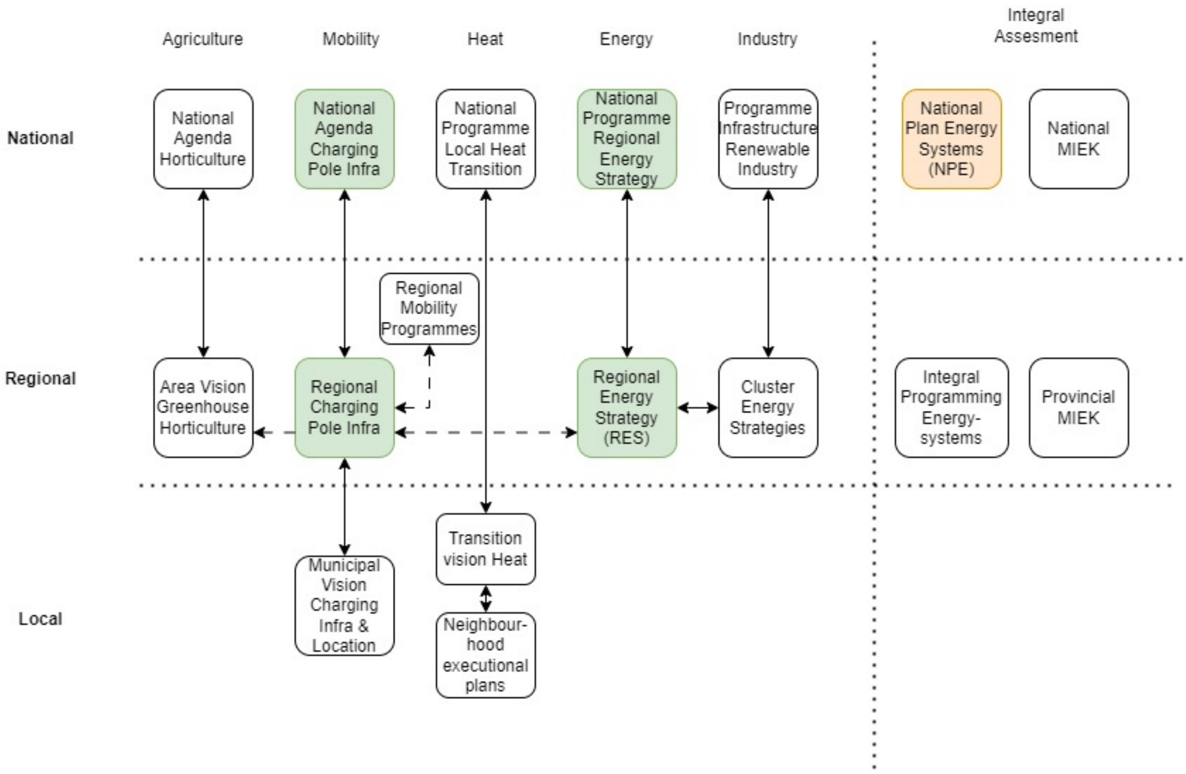

Figure 6.2: The institutional context of climate programmes Adapted from Provincie Zuid Holland 2023

- Reduced times needed for planning and strategic placement of charging infrastructure even before demand arises - emphasizing the importance of standardization and interoperability of charging infrastructure. This involves establishing common technical standards, protocols, and payment systems.
- User Convenience - user-friendly and convenient charging. This includes providing clear and reliable information about charging locations, availability, and pricing, as well as ensuring ease of payment and accessibility for all EV users.
- Smart Charging - implementation of smart charging solutions that optimize the use of renewable energy sources and manage the load on the electrical grid.

Each municipality must adopt an integrated vision for charging infrastructure by 2020. In that vision, municipalities and provinces, together with market parties, also designate suitable locations for fast chargers. Municipalities and regions also agree with companies on the minimum number of charging points in business parks. Municipalities and regions secure the rollout of charging infrastructure in the Regional Energy Strategy (RES), the environmental vision and the environmental plan. To aid municipalities, the National Agenda appointed several regions - one of which is the Region Southwest West in which the provinces of South Holland and Zeeland collaborate (Nationale Agenda Laadpaalinfrastructuur, n.d.). In this approach, the tasks per municipality are embedded in policy and implementation. The regional approach provides step-by-step insight into the size of the task - like the amount of electricity needed - and the effort needed to realise a smart, comprehensive, accessible and affordable charging network in all municipalities of Zuid-Holland and Zeeland, in the form of an agreement between provinces, the Ministry of Infrastructure and Water Management (I&W) and association Netbeheer Nederland (van Riet & Vredebregt, 2022).

6.2.2. Results

When asked about the coming of the national agenda for charging pole infrastructure, the respondents explained the emergence of electric vehicles that led to the creation of the plan. One of the respondents defined the start with former prime minister Ruud Lubbers, who had a passion for electric vehicles and was one of the frontrunners in its uptake. Being one of the first owners of an electric vehicle, his public image gave him an opportunity to charge his vehicle when necessary, just by asking people. Noticing that this was of course not available for anyone else, he strongly encouraged and advanced the creation of the e-charging grid (Luyendijk, 2009). Mandemaker (2018) wrote that he was the man who was always looking for solutions - and for a charging station for his electric car. Another respondent noted that the ideas for a charging infrastructure started very small, with a senior manager supporting the idea of electric charging infrastructure and an opportunity to develop the ideas for this. The necessity of the grid operators to be future-proof was coupled with a perceived opportunity from the Ministry of Economic Affairs to be a global leader in charging infrastructures. This led to an initial investment and the realisation of 10,000 charging poles (ElaadNL, n.d.). This was catalytic in the gaining of momentum and increase of the use of e-vehicles. The national agenda was created as part of the climate agreement, but one of the respondents explains this was only possible because there had previously been consultations about fuel - ”brandstofoverleg” - in which there had already been a vision on fuels. They also indicated that this led to frustration among many of those involved because the agreements made here could not be implemented before there were already other agreements pushed forward. Also, the existence of the Formule-E team aided the development of the agenda.

All three respondents indicate the presence of quite some resistance. One respondent mentions there was initial reluctance to invest in charging poles because government officials regarded this as being outside the task of grid operators. The initial investments were done by grid operators, but later on in the development of the infrastructure, the charging stations had to be tendered. Another respondent states that there were many meetings with legal representatives because there was resistance from the oil industry, but the conflict with their own legal representatives was resolved because they could get the point across that this charging pole infrastructure was necessary to battle climate change.

When the original charging poles were built, respondents mentioned several success factors. First, there was a strong focus on the municipalities that were enthusiastic. The idea was that this would add to the momentum, and other municipalities would follow. Another respondent indicates that this is still the focus of the NAL, and provides the example of the city of Leiden - where was already a recurring mobility consultation. This pre-existing consultation made an easy access point for the tools provided by the Province to support the development of a charging pole infrastructure because the municipality was already working on this. The presence of a frontrunner is mentioned again, this time the mayor of Den Bosch Rombouts. The respondent indicates that his involvement and the way in which he engaged with municipal councils and boards was an important part of the puzzle to create sufficient support and test grounds for further development.

The success of the NAL itself is according to the interviews due to the clear demarcation - for example, there was no hydrogen discussed - and focus on supporting. This support meant the use of various planning models and assistance in participatory processes. This is indicated to be especially necessary for smaller municipalities, in which there is often limited manpower to address an immensely wide variety of issues. For example, whereas larger municipalities might have a department for mobility, smaller municipalities might have only a few people dedicated to mobility, transport and logistics. This difference between the appointing of goals on a high-level, that are to be realised on local levels is stated to be a point of friction. Another barrier that is mentioned is the quick turnover in the political field. The respondent states that this takes a lot of time because especially in smaller municipalities officials have a lot of issues in their portfolio and much time is lost when they need to familiarise themselves with this.

The ordering principle of connection is regarded very visible by the respondents, who indicate that the development of the charging pole infrastructure had never been a solely climate-driven venture. The network operators coupled their need to be future-proof in terms of congestion management, with the desire of the government to be frontrunners and found interest in major cities that saw opportunities to reduce air pollution caused by fossil fuels.

6.3. Regional Energy Strategy (RES)

6.3.1. Case Description

In Regional Energy Strategies (RES), many national agreements from the Climate Agreement are organised into practical execution - in a nationwide programme of 30 regions (Nationaal Programma Regionale Energie Strategie, n.d.). The Metropole Region Rotterdam - Den Haag is one of these 30 regions. In the RES, governments are collaborating with social partners, grid operators (for gas, electricity and heat), industry and where possible residents, to shape the regionally supported choices with regard to energy related policy. Lelieveldt and Schram (2023) report that the latter - participation with citizens - is currently lacking and citizens are often merely informed of the plans. The RES consists of three elements: the generation of sustainable electricity (35 TWh), the heat transition in the built environment (from fossil to sustainable sources) and the storage and energy infrastructure required for this. These choices are translated into areas, projects and the implementation and execution of those projects. The focus of the RES is on the two tasks of the implementation of the heat transition for the Built Environment and the generation of electricity on land. With this, the RES has three main functions:

1. To describe the energy goals and in which time frame they will be achieved
2. To serve as an instrument to organise spatial integration with societal participation
3. To enable the organisation of long-term collaboration between all parties within the region

6.3.2. RES Metropole Region Rotterdam - Den Haag

Each of the regions has been asked to make an estimation of the amount of renewable electricity and heat that can be generated, and what can be saved in terms of energy. One of these RES regions is the metropole region Rotterdam - Den Haag. This region consists of 21 municipalities, four water boards and the province of South Holland (Energiestrategie regio Rotterdam Den Haag, n.d.). Around 2.4 million people live within the region's area, which consists of two major cities and a port of global importance. It is also the most densely populated region of the Netherlands, with 34% of the surface covered by buildings and 31% by agriculture - including greenhouses (RES Rotterdam Den Haag, 2021). The translation of the national objectives for the region Rotterdam Den Haag has a main goal of being ambitious while being realistic and achievable. The chosen regional solutions, through which the region contributes to reducing CO2 emissions by stimulating savings and through sustainable energy production, are designed to fit the landscape, the inhabitants, the companies and the regional qualities. This is regarded as necessary to create large support for the measures. Energiestrategie regio Rotterdam Den Haag (2023) report, however, that the region is not on track yet to achieve the goals of the RES 1.0 due to financial, technological and political obstacles.

6.3.3. Results

The first thing that stands out is that respondents don't necessarily qualify the plans themselves as a (successful) transition, but the type of collaboration. This is reported as one of the first collaborations of this type and is regarded as a stepping stone for future projects and development. The RES 1.0 was reported to be built on previously existing collaborations regarding mobility and economic business climate. This was a formal, but not very powerful collaboration. When the RES regions had to be determined following the climate agreement, the decision was made to collaborate in the metropole region Rotterdam The Hague because of this pre-existing collaboration, but also because the affected infrastructures of (residential) heat and electricity are very interconnected in this area. In other words, collaboration was essentially practical.

Onshore Generation
Following this, the decision was made to allow for the onshore generation - one of the two goals of the RES - to be the product of bottom-up initiatives. There were no decisions made on which municipality had to generate what amount because this would allow municipalities and areas to investigate what was possible in their jurisdiction. Respondents do report, however, that this has not resulted in the advancements that were hoped for.

Heat Transition
With regard to the heat transition, respondents are more positive. One respondent explains how EBN (Energiebeheer Nederland) was involved in the exploration of the use of geothermal energy. Previously, their role was to coordinate with regard to gas. This knowledge of the Dutch soil had led to early ideas for the exploration of geothermal energy, but although these were supported by the director's strategy and technology, these efforts were put on hold in 2013 due to the limited authority of the semi-public business. In 2015, these efforts were taken up again, when there was more freedom to expand

tasks due to changes in political opinion. As shown in the introduction, 2015 was the year the Paris Agreement was signed and a more integrated approach to climate policy was adopted. This resulted in an increased need to find innovative solutions that would aid the realisation of the climate goals. This need to explore geothermal energy was mostly practically driven, with a need to be future-proof. This reason for the change is also reported to be the main driver behind the realisation of the heat network in the Westland. Here, there is large support for this heat transition due to the many reasons and limited hassle involved. The municipality is stated to have taken up most of the initial research, after which many horticulturists supported the plans. Private companies coupled the need to be future-proof with finances and even saw opportunities to market themselves as sustainable companies.

Many different barriers are mentioned in the execution of the agreements of the RES. One of them is the large turnaround within the political field that was also mentioned during the NAL case. Network operators and consultants experience delays in development when trust-building processes start anew after every election. Moreover, the RES attempted to integrate many different fields - such as spatial planning with electricity grid operators. These experts all speak a different language and this is reported as being time-consuming since different interpretations of the agreements need to be resolved. Moreover, respondents indicate that the agreements are often perceived as an encroachment on the autonomy of local authorities, which makes them reluctant to participate. Smaller municipalities are mentioned as being susceptible to this because they often don't feel like the conversation with for example energy corporations is on equal terms.

6.4. National Plan Energysystems - Nationaal Plan Energiesysteem

6.4.1. Case Description

As stated in chapter 1, criticism came from various quarters about the lack of vision, unity and alignment in the Dutch government's approach to battling climate change. To take action on this, the National Plan Energy system has been initiated in February 2023, which will describe how the Netherlands is developing an energy system suitable for a climate-neutral society (RVO, 2023; Heijne, 2023). This vision document has three main goals:

1. Outlook - An image of the energy system of the Netherlands in 2050
2. Plan - A coherent and long-term energy policy
3. Consistency - coherent (policy) choices for a good match between energy supply and demand (generation and use) at different levels (from local and regional to national)

The outlook was prepared by an independent expert, which consisted of independent experts of various domains such as energy experts, economists, business experts and professors (Expertteam Energiesysteem 2050, n.d.). To create the outlook, existing scenarios and studies on bottlenecks as well as the actions required to take immediately to achieve the climate goals on time were used. The Outlook Energy System 2050 working group supported the expert team. This working group included people from the Netherlands Enterprise Agency (RVO) and the Netherlands Organisation for Applied Scientific Research (TNO).

The National Energy System Plan contains a long-term vision of the energy system in 2050, as well as a map of how to achieve this. The plan is designed to be updated every five years, thus allowing respondents to innovation and social developments. The plan also states what contribution the central government and other authorities (municipalities, provinces) have to make. And what this means for citizens and entrepreneurs so that they can decide their own trajectories. The development of the NPE takes place during the research of this thesis. The planning is displayed in figure 6.3.

In July 2023, the concept plan for the NPE was presented by Minister Rob Jetten (Ministerie van Economische Zaken en Klimaat, 2023). Within this plan, 5 leading choices are made: maximum supply (generation of a maximum supply of infrastructure for electricity, hydrogen, renewable carbon carriers and heat), energy savings, attribution of scarcity from a system perspective, international collaboration and joined piloting with civilians and businesses to create space for participation and initiative. The vision focuses on four systems: electricity, hydrogen, carbon and heat.

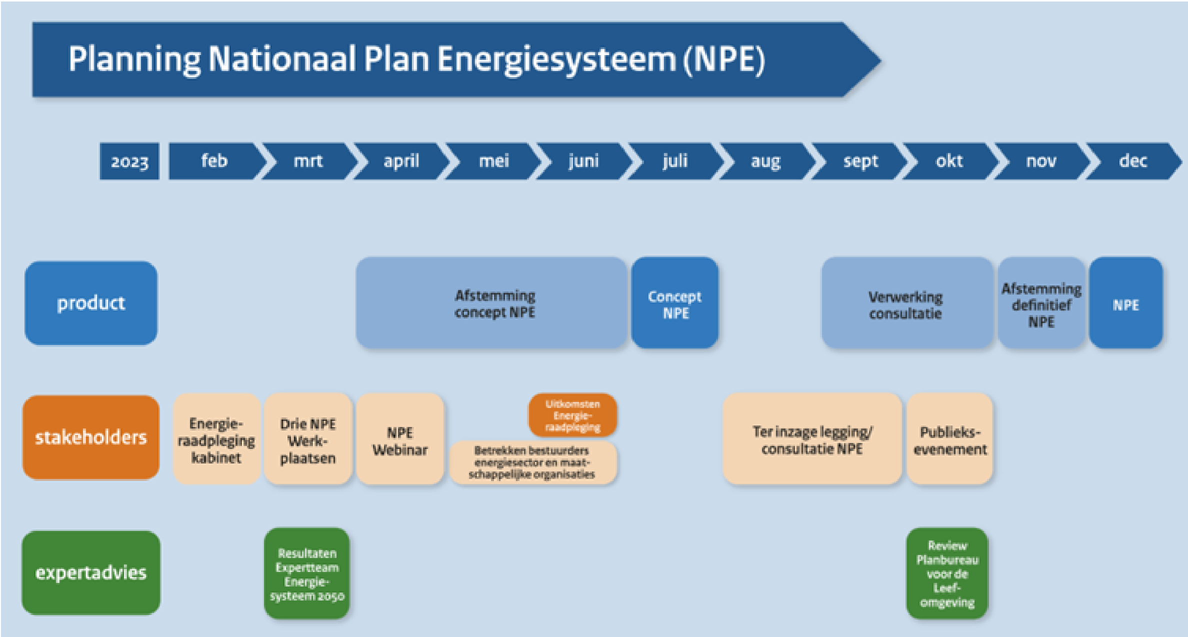

Figure 6.3: Planning Nationaal Plan Energiesysteem - (RVO, 2023)

6.4.2. Results

The NPE differs from the other two projects, not only because of the national scope but mostly because the NPE regards a vision document and not a (binding) policy. According to the experts, this allowed for more space to explore a new path. Unique for the creation of the NPE, is the participatory consultancy process that was used as input and the integrated, system-as-a-whole way this participation route was embedded. During the workshops - which were open for attendance to everyone (although it has to be noted that there was a large representation of higher-educated experts within the energy domain) - there was not only attention for electricity, hydrogen and heat, but also for questions regarding the safeguarding of justice, equality and accessibility within the energy system of the future. What stood out in particular during these workshops was the integrated approach that was taken in de development of this plan, as well as the core role of values and justice. The respondent also states that the usual 4 public values were expanded to 8 public values, to facilitate broader thinking about public values.

During the interview, the respondent noted that this type of development is unique. The team that developed the initial outlook is reported to consist of relatively young people with not only technical backgrounds but also backgrounds in social sciences and spatial planning. This outlook was positively received due to its inclusion of justice as well as ecological planning - thus moving on from the previous technocratic view on energy systems towards a more integrated and societal approach. The creation of the policy document was initiated due to the climate crisis perceived in many layers of society, the Ukraine crisis and the overwhelming need to be prepared for the future.

During the interview, it was stated that this document is a vision document and not a policy document, which is presumably why more freedom was allowed in the creation of this. This vision document was initiated by Minister Rob Jetten of Climate and Energy. His design of the expert team as being interdisciplinary and interdepartmental addressed the difficulty that is often experienced due to the responsibility for the energy systems' components being scattered over ministries. For example, economic affairs is in charge of electricity, while heat belongs to domestic affairs and circularity and carbon is part of infrastructure and water.

When asked about the barriers of this document, the question emerges of whether this vision will break through the distribution issue of the available energy when scarcity occurs. Justice is one of the core values on which the NPE is built, which also means that questions with regard to who is most entitled to the limited production of hydrogen. Another respondent is rather sceptical about the inclusion of hydrogen in this vision and states that this is an unrealistic innovation solution due to the low convergence efficiency, as well as the public perception of hydrogen. They state that the integration of hydrogen is largely based on a predicted increase in efficiency - which is unreliable. In addition, many misperceptions regarding hydrogen are present, such as the notion that the current gas network could be used to distribute hydrogen when it would be used for residential heating - which is not the case.

Some of the same design principles as discussed in the previous cases in the Energy domain are found in the creation of this project. Starting with the Minister as the Senior Facilitator and the need for cross-organisational collaboration.

6.5. Interpretation of Energytransitions

The first thing that stands out, is that both policies are built on *previously existing structures*. The RES Metropole Region Rotterdam Den Haag was an existing inter-municipal consultation that addressed mobility & transport and economic-business climate. For the Charging Pole Infrastructure, there was a previously formed agreement regarding fuels. Secondly, the stimulating factors uncovered in the cases of water management are visible within these projects as well with regard to the principle of collaboration and integration. There is often a *senior facilitator* involved - either a politician or CEO - that takes the lead and has the courage as well as the authority to push through, even when the regulatory framework is not yet fully developed for the innovation. This lead usually creates an upward spiral - sometimes referred to as *momentum*. Notable is the focus within these projects of *'coalitions of the willing'*. Both within the RES and Charging Pole Infrastructure, there is little top-down enforced. There is a major focus on first aiding the actors such as municipalities that are motivated to contribute and implement the change. This leads to the next design principle within these policies, namely the focus on knowledge sharing and hassle-limiting. This *facilitative collaboration* seems to leave most of the figuring out how to approach projects in municipalities that have the manpower and enthusiasm for it and create a stepping stone for smaller entities by reducing the initial effort needed. This also results in the avoidance of conflict to a large extent, while conflict can be used to resolve issues and make progress. The main difference between the NAL and RES/NPE is the presence of conflict. In the development of the charging pole infrastructure, many conflicts between network operators and government, within governments and with industry were resolved regarding the legal authority to act. This resulted in progress in the sense of initial investment and development of the market for the installation of charging poles.

Finally, the ordering principle of connection is visible in the *coupling* of goals or drivers over systems and domains within these transitions as well. Regarding the charging pole infrastructure, the practical drive from network operators to be prepared for the effects of increased electric mobility was coupled with the need for the central government to become a global leader in charging pole infrastructure and the desire of major cities to improve air quality by reducing fossil-operated vehicles. As a consequence, integrated policy is becoming more standard. The connection with landscape planning is becoming more necessary and widely adopted because almost all energy-related projects require proper embedding within the landscape.

Within the interviews conducted, there was a larger role for the barriers encountered than was during the interviews of phase 1, and interestingly many of them had been mentioned in the cases of water and transport. The role of the senior facilitator - the one with the courage to push forward - was not always visible. Regarding the Charging Pole infrastructure, the foundation E-laadNL was an initiative coming from the network operators, with the main goal of creating knowledge regarding the trajectory of electric mobility. The main driver behind this foundation was the network operators' observation that the rise of electric vehicles would have major consequences on the electricity grid. This same drive was more difficult to find within the RES agreements, and the term ownership - and lack thereof - was quite often used. Although the RES aimed - within the goal of generation on land - to avoid things like the NIMBY effect by drawing up softer agreements, there is currently an impasse of inaction due to a lack of ownership of the goals.

The second major barrier that recurred was the large number of people passing through the governmental entities. Multiple experts expressed their concern regarding the loss of time due to the rapid replacement of the workforce - and the consequent time needed to build trust, explain past decisions and continue in the decided-upon direction. An additional barrier within this political field is the impairment of the autonomy of municipalities. Due to the facilitative collaboration, in which part of the goal-making and planning of projects is carried out by for example the Province, there was an increased suspicion coming from local entities about the trajectories chosen and whether these were beneficial for their municipalities. Much was won within both the RES as well as Charging Pole infrastructure, by addressing these hesitations through intensive contact and inclusive conversations. The fourth barrier that was encountered during the development of integrated policy also regarded conversations - specifically the difference of language used by experts of different domains. Several interviews brought forward the confusion that would arise due to this mismatch of jargon, but all that mentioned this barrier also stated that this is slowly improving over time.

7

Results and Synthesis of Theory Suggestion

7.1. Energy compared to Water and Transport in general

The first observation that can be made in the domain of energy, is that the governance seems far more complicated than that in the domains of water and transport. This is partly due to the amounts of systems that are affected by climate policies, and partly due to the amount of stakeholders involved. The respondents of the interviews in water and transport were all asked how they thought the principles in their succesful transitions could be applied to the energy transition. One respondent indicated that the transition in water was far less complex than in energy, due to the transition being mostly within the government. The observation was made that the energy transition is far broader and the stakeholders far more scattered. This observation was shared by the other respondents in the first round of case studies and supported by the difference in approach shown from the policy documents. Within the energy transition, a more integrated approach addressing many different domains is used - with the number of policy documents as shown in figure 6.2. Moreover, there appears to be less consensus on the need for climate change policies. Whereas in water management, climate change is not the issue in itself, but rising water levels are - and the statistics on this are clear. One of the respondents stated that even the most radical climate denier could not deny the statistical evidence of rising water levels. In addition, the trigger of the high waters increased the realisation of the need for water management. The same is the case for transport, in which the pragmatic need to address the issues of traffic jams is widely agreed upon. These causes are very tangible and palpable. Thus, relatively little debate was held on whether the policy was needed at all. In energy, on the other hand, the awareness of the need for climate action - and the form in which this is undertaken - is still more of a topic for debate. This is visible in the execution of the programs rather than the creation of the programs themselves. For example, the RES 1.0 of the metropole region Rotterdam Den Haag is not on track, partly due to a shortage of initiatives originating from municipalities. One of the respondents indicated that this might not be entirely due to the reluctance to combat climate change, but due to the loss of autonomy that is experienced by local governments when policy is created on higher hierarchical levels. This causes a strange misalignment, in which local governments are responsible for the execution of climate policy, but limitedly involved in the creation of it. This increased complexity of the involved stakeholders and different levels of scale cause the energy transition to be more complex than the transitions in water and transport.

Finally, what stood out during the expert interviews was the difference between domains with regard to the frame of reference. Water and transport management seemed to be referred to as means to an end, while energy sometimes appeared to be the goal itself. In water, the goal of safety was very clear, whereas in transport there is an undisputed need to travel from A to B. Slofstra (2021) also states that mobility is framed as a prerequisite rather than the end goal. The energy domain seems to be susceptible to less clear goals with regards to why we need the energy and thus energy seemed to be often framed as the goal - generation of 35 TWh for example, rather than the goal of having zero power outages in 2030.

7.2. Towards an Integrated Framework

All of the approaches, conceptualisations and frameworks that emerged from literature in previous chapters have their strengths and shortcomings. In order to reflect on the insights of these literature fields and combine them with the observations and results from the case study, an integrated visualisation is presented in figure 7.1.

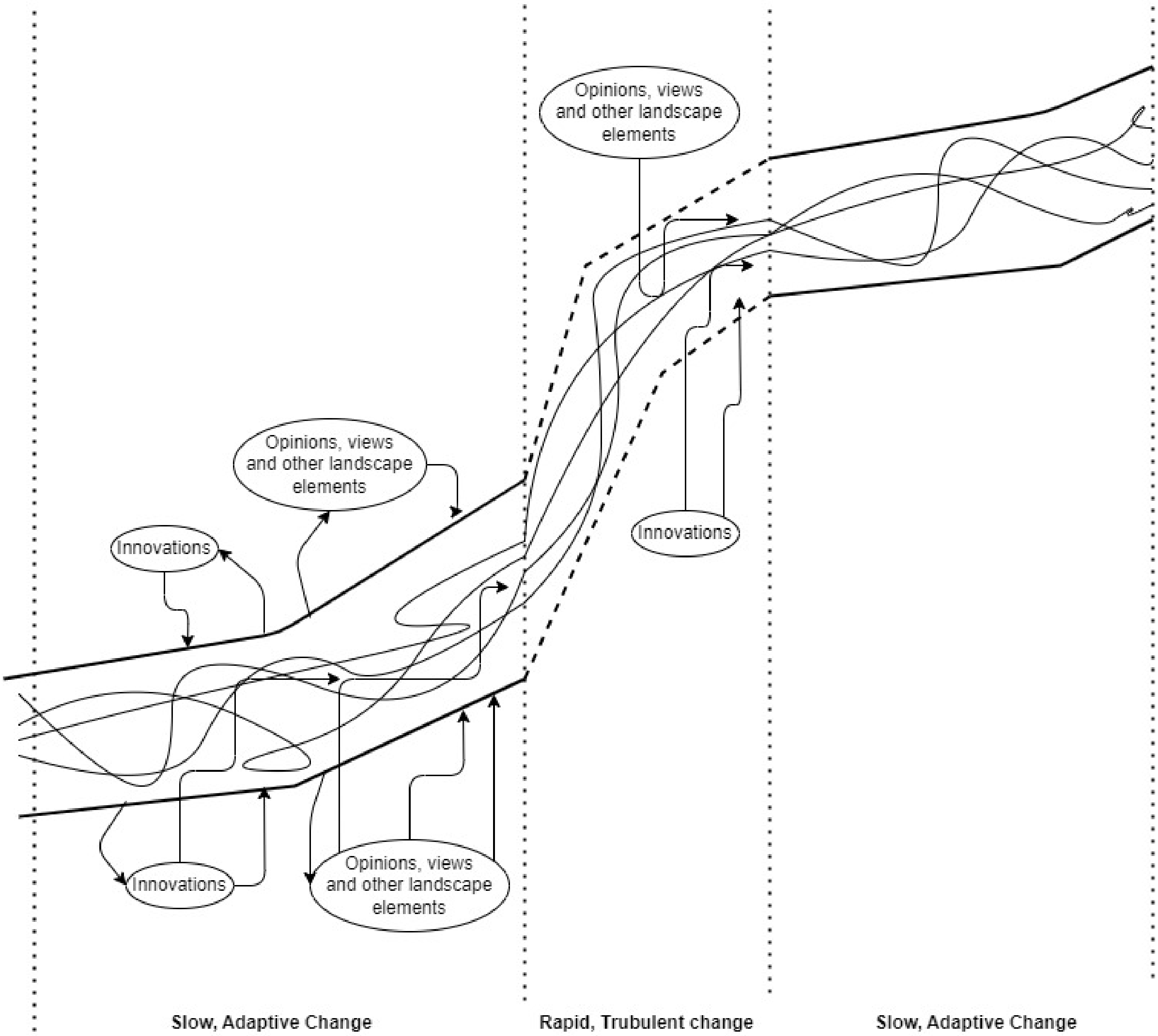

Figure 7.1: Integrated Framework

The conceptualisation of a regime level is persistent, which is visualised by the wider bar in the centre of the picture. This encompasses all actor networks, regulations and widely adopted technologies. To show the nonlinearity of the interactions within the regime level, several lines have been added that cross each other on occasion but can be identified as separate systems. The borders of this regime level are displayed by the thicker black lines through which innovations, as well as opinions and other landscape elements, interact with the regime level. These lines are solid because, in the stages of slow adaptive change, these external factors both from the top-down as well as from the bottom-up have difficulty integrating the regime level. However, it is important to recognise that during this stage there is an incremental change, which is why the regime level is not conceptualised as horizontal but as slightly increasing and slightly going upward. This shows that change does occur. Through small, low-level adjustments this interconnected system is improving and developing continually. This is influenced by innovations as well as opinions, views and other landscape elements that interact with the system from both top-down as well as bottom-up. These interactions shape the system and innovations and views in such a way that they coevolve and co-develop.

The second phase displayed in this framework is the stage of rapid and turbulent change. On occasion, a trigger causes the stage of incremental changes to transfer to rapid and turbulent change. During this phase, change occurs much quicker than in the previous change which is symbolised by the much steeper incline of the regime level. The 'walls' of the system become thinner - or permeable which is represented by the dashed line - and thus more space is created for radical innovations or opinions. This stage is of short duration, however, and uptake of radical change elements depends on a variety of factors including but not limited to a daring politician and a well-developed alternative.

This framework contains several complexities:

7.2.1. Fast and Slow Change

The operational system is conceptualised as always transforming and changing. These changes, however, are fast and slow. During periods of slow change, the system is perceived as relatively stable. The small scale and individual level adjustments add up, however, and over time a transition can be observed. During this stage of change, adaptive conditions for change are dominant, bifurcation and differentiation occur and trends can be observed in the system. The main policy instruments available during this stage are aimed at enabling or constraining the development of alternatives or shifting preference for one alternative. In other words, the policy window is aimed at fine-tuning, with a focus on win-win situations and the system has the space to be ambivalent on both individual as well as policy levels.

7.2.2. Crisis

When extreme external factors - such as weather circumstances or geographical conflicts - occur, the relatively stable system suddenly changes into a turbulent system. Crisis takes over and gives rise to rapid change. In this system, drastic conditions for change take over, and the influence of policymakers shifts from merely fine-tuning to actual and clear decision space with a zero-sum decision as opposed to a win-win. Rather than stimulating or discouraging individual choice in the differentiated and bifurcated system, there is now space to end one line completely and radically shift track. After a period of rapid change, the system returns to relative stability with slow change.

7.2.3. Top-down as well as Bottom-up

The Multi-Level Perspective defines three layers - landscape, regime and niches. What exactly separates regime from landscape and what defines either remains rather unidentified and open to interpretation. Complexity Science on the other hand doesn't define layers at all and characterises the entire system as one playing field. This framework combines these views into a conceptualisation of an operational system level - consisting of a complex interplay of networks, actors, institutions, rules, policies and technologies - that is influenced by and influences both top-down as well as bottom-up technological innovations, opinions, views and other landscape or environmental developments.

7.2.4. The Role of Innovation

As stated previously, innovations play a role in both phases of change. However, the adaptation of innovations is never conceptualised as linear. During the period of adaptive change, innovations might find uptake when there is space - but this typically takes several tries before it is successful. During periods of slow change, these innovations are fostered and developed - sometimes in isolated environments such as living labs, sometimes directly within society. These innovations cause bifurcation and differentiation within the operational system. When it comes to technologies or physical alternatives, they coexist and the choice for either can be encouraged or discouraged by policymakers. This is displayed in subfigure 1 of figure 7.2.

When it comes to ideas or approaches, these might coexist as well, but rather than a physical coexistence, the idea does not yet find practical execution - as shown in the second subfigure. When the first type of bifurcation has taken place, a crisis can have the consequence of preferring one alternative over the other thus causing a different alternative to becoming dominant - as indicated with the bolder line. In the second type of bifurcation, the crisis might have the effect of shifting tracks altogether.

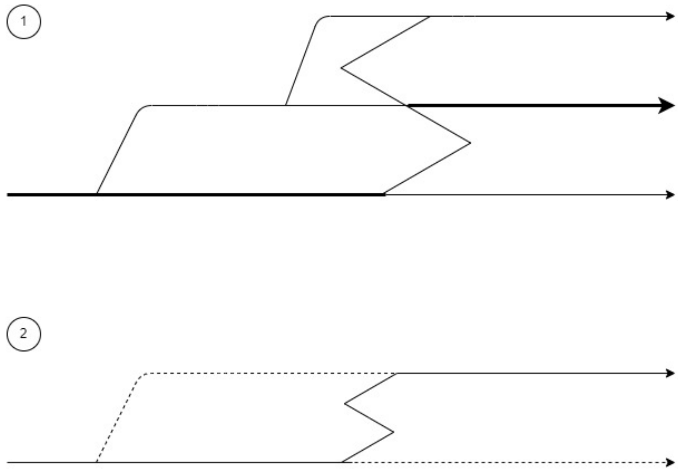

Figure 7.2: Differentiation of technologies versus ideas and the consequence of Crisis

7.3. Ordering Principles

The ordering principles of integration, collaboration and connection have been introduced in chapters 3 and 5. In the case study, these principles are visible, but they need to be nuanced and expanded. The design principles that emerged from the cases have been sorted into four ordering principles - shown in table 7.1. This sorting offers insight into which design principles can be grouped together under an overarching theme. Vise versa, the sorting shows what types of design principles belong to the ordering principle and in that way also what is represented by the ordering principle.

Table 7.1: Ordering Principles

Connection	Alignment	Collaboration	Integration
Senior Facilitator	Ownership/Autonomy	Multi-purpose projects	Innovation Window
Network diffusion of innovation	Facilitative Collaboration	Network diffusion of innovation	Coalition of the Willing
Momentum/Upward Spirals		Building on pre-existing structures	Prestige
		Cross-organisational Collaboration	Need to be Future-proof

7.3.1. Connection

The first principle that is evident in the transition studies, is the principle of connection. This principle recognizes that successful transitions are not isolated endeavours but instead involve the interplay and integration of various perspectives and goals. In successful transitional projects, individuals appear to naturally seek to connect their ideas, initiatives, and aspirations with the objectives and aspirations of others - the managerial culture is geared towards cooperation. By fostering these connections, transitions become a result of co-creation and coevolution, where individuals and groups collaborate to find mutually beneficial solutions. This connection signifies the ability to align different interests, demonstrating that transition initiatives can serve multiple goals simultaneously. This approach promotes synergy and cooperation, enabling stakeholders to find common ground and collectively contribute to the transformational process. Embracing the principle of connection and co-creation from a bottom-up perspective can empower individuals and communities to enhance the effectiveness and sustainability of their surroundings. From a top-down perspective, the acknowledgement of the need for connection is referred to as creating support - 'draagvlak creëren' in Dutch - and is often an integrated part of successful planning.

Throughout all cases, the need to collaborate with each other to achieve the desired change was not even a topic for discussion. There appears to be an overwhelming need to create a connection between one innovation with other causes. Some refer to this as the multipurpose business case, others use win-win situations and yet others call it integral planning. Regardless of the term to be used, there is an evident and cross-column connection of goals in successful transition projects.

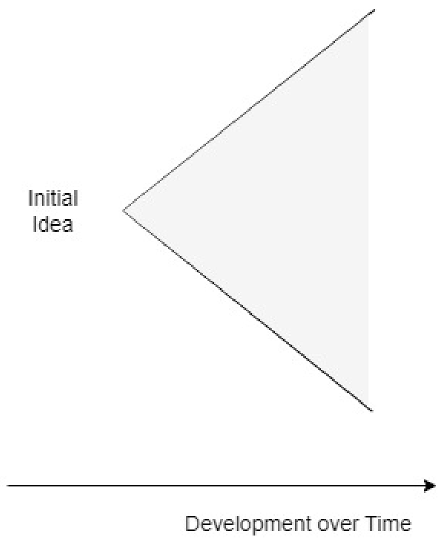

Figure 7.3: The process of connection. During this process, an initial idea is developed and grows due to the connection of this idea to problems and solutions within the same or in other fields. This idea starts small, but over time grows bigger and matures, with a wide variety of possible implementations as a result.

What happens during the process of finding this connection is shown in figure 7.3. The initial idea fundamental to the transition starts very small, presumably amongst one or a few people. The connection of the idea to other ideas and insights causes the innovation to grow and mature. This applies to both the idea itself and the number of people who are aware of the existence of this alternative. This is also the stage where the amount of ideas skyrockets and the most extreme innovations are entertained and considered. Many different applications as well as domains are coupled together in a variety of plans. There might also be some small-scale tests or research to facilitate this growth, but 'real' implementation is still quite far away at this stage.

What stood out in the cases, is that this process happened very organically, in which a usually very enthusiastic entrepreneur seeks a point of entry for their ideas.

One of the main barriers in the energy transition that was discussed was the lack of a systemic view, that allows for the connection between different domains. The need to create a supportive environment for this connection, however, has been observed and an attempt has been started to address this by means of creating the National Plan Energysystem, of which integral planning, the system perspective as a whole and participation pathways were fundamental.

7.3.2. Alignment

The second ordering principle that was observed in transitions entails the policy framework that governs the transition. This principle did not emerge as a central theme in the existing literature but is an important observation in the case study. In a successful transitional project, there is an alignment between policy and goals. For example, the Room for River project had a clear specific goal with appointed responsibilities - Rijkswaterstaat was responsible for providing safety from water.

This principle highlights the importance of ensuring a balanced interaction between the scope or specificity of the desired outcome (goal) and the extent or specificity of the actions and strategies employed to achieve it (policy) on the level of the governance involved. When both the goal and policy have a broad scope, they complement and reinforce each other, enabling a coherent and facilitative environment for advancement. Similarly, when both the goal and policy are clearly defined, their alignment creates a solid foundation for effective decision-making and implementation. However, misalignment arises when a broad goal is coupled with a narrow policy, or vice-versa. Such imbalance can impede progress and hinder the transition's success, as the limited actions prescribed by the policy may not adequately address the comprehensive nature of the overarching goal.

This is shown in the execution of the RES plans, where the specific goal of generation on land is not matched with a specific allocation of responsibility. Whereas the goal of heat transition is much less specified and thus aligns better with the responsibility of the local authorities. This alignment is strongly

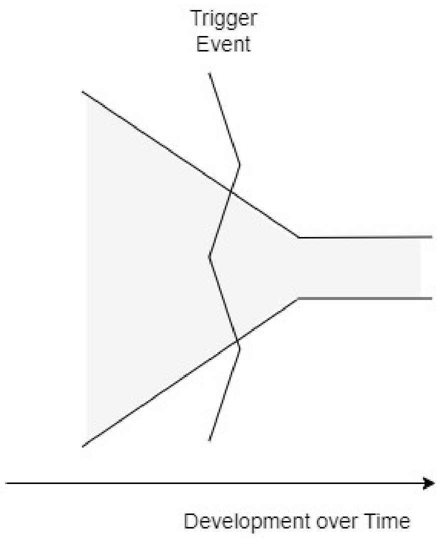

Figure 7.4: The process of alignment. During this, the wide variety of possible implementations for innovations that were the result of connection is significantly reduced through a natural selection process and the most extreme ideas are abandoned. The presence of a trigger event can cause this selection process to speed up. The result of this phase is concrete goals and a limited set of genuinely considered solutions.

linked to the perceived autonomy of decentralised authorities in the execution of central policy. When this autonomy is recognised in the overarching policy, the respondents stated it to be more successful.

The development of the ideas/innovations during the process of alignment is shown in figure 7.4. The wild variety of ideas is reduced - during which the most extreme ideas are disregarded - and possible solutions are coupled with problems. This is also the stage during which trigger events - big or small - cause for the setting of goals. In other words, the intangible variety of ideas becomes tangible when parties start to align themselves.

7.3.3. Collaboration

The third principle of collaboration emerged initially from prior knowledge and has been evident in all cases. Throughout the entire process of innovation, change and transition, there is a need for collaboration. This is not consistent with the perception of the lone innovator or entrepreneur that is suggested in much of the literature in chapter 3, who designs the technological innovation bringing about the transitions. This principle is strongly linked to the principle of connection but differs in practicality. While connection is characterised by the formation of ideas, collaboration becomes an important factor at a later stage in development and could be considered a transitional twist or turn as ideas are transformed into the taking of actions.

In the cases of water and transport, there was hardly any technological innovation involved and the cause of change was more found in the approach - the combination of (novel) or existing knowledge in new ways. Rather than a technological innovation, there is a clear collaboration between innovators, senior facilitators and other parties. This collaboration starts small - usually by pinprick research as shown in the Room for River project - in the form of trial and error, to grow larger and larger with promising results. This incremental collaboration with a large emphasis on giving space to innovative, new and out-of-the-box ideas to grow and develop suggests less of a linear path from innovation to adaptation and more of an upward spiral. This upward spiral is also visible in the energy domain, where the electric vehicles are taken up after a spiral of more charging stations causing more electric vehicles etcetera. The development of the innovation within this ordering principle is shown in figure 7.5. Due to the initial upward spiral, the ideas have grown bigger and are more widely endorsed. However, due to the action that is undertaken during this stage, the ideas also come together again - to form one concrete plan.

Regardless of their origin or nature, transitions are fundamentally shaped by collaboration. Whether they arise from top-down directives - as in the Room for River or Sandmotor projects - or emerge from bottom-up initiatives - such as the stimulation of cycling in the city centre of Rotterdam - the involvement

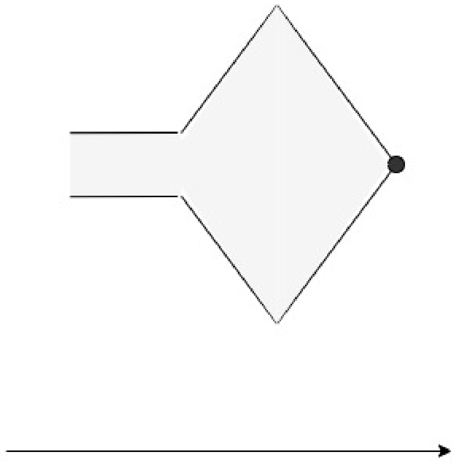

Figure 7.5: The process of collaboration. During this phase, the limited design space that resulted from the alignment is further developed, but not necessarily in width but rather in depth. The ideas become actual plans through cross-sector collaboration and this phase results in a concrete plan for implementation.

and cooperation of multiple stakeholders are necessary for their realization. In top-down transitions, collaboration occurs through the combined efforts of innovative managers, policymakers, and decision-makers who establish the plan and stand for it when the opportunity arises. Their ability to engage with and gain support from various stakeholders is vital to mobilising resources, enacting policies, and creating the widespread support needed for drastic change. Contrarily, bottom-up transitions - like in transport management - derive their strength from the collective actions and collaboration of individuals, communities, and grassroots movements. Through their (sometimes unaware) collaboration, they can raise awareness of policy-makers, integrate innovative solutions, and bring about change, requiring higher-level institutions to respond. Ultimately, successful transitions rely on the collaborative labours of both top-down and bottom-up approaches, as they collectively work towards transformative outcomes.

This collaboration is very often between individuals rather than between the organisations they represent, which was especially visible in the case of the charging pole infrastructure in which several key authority figures collaborated to get the first large projects going. The upward spiral of innovations and their consequent distribution through the network are the consequence of interpersonal contacts and trust. For example, the reported senior manager in the water domain allows space for the investigation of an idea because they see potential in it. One of the main barriers mentioned by many respondents within the energy transition is the relatively rapid turnaround in governments. Due to the elected period of merely four years, many experts indicated that they spend a lot of time building trust and support with ever-new people. This rapid turnaround used to be an issue in water management as well but was addressed when a delta-commissioner was installed after the adoption of the delta law. The respondents indicated that this appointment of a structurally responsible entity was a major improvement. Stability appears to be an important condition for collaboration to evolve.

7.3.4. Integration

The final ordering principle of transition is integration, which involves the incorporation of innovative ideas and practices into existing systems. This is the stage where plans become actual projects. Figure 7.6 shows that the original projects often give cause to yet another increase of ideas, with new applications, domains or audiences found.

While transitions are frequently perceived to necessitate radical or extreme innovations to address complex challenges, integrating such innovations into established systems is challenging. In times of crisis, the urgency and disruption caused by the crisis can create opportunities for more rapid integration, because crises can prompt a willingness to experiment, adapt, and adopt radical changes - as the status quo becomes untenable. However, outside of crisis situations, designing and implementing a completely new system is a seemingly impossible task. Established systems tend to be resilient, with embedded routines, regulations, and vested interests that resist radical change. The lack of a crisis

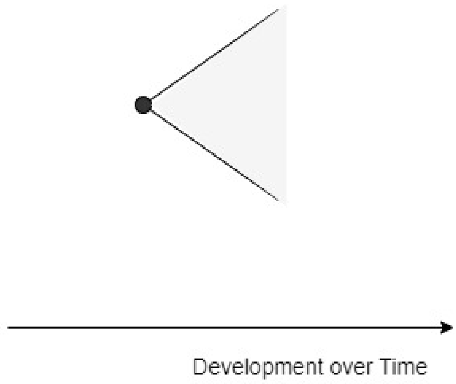

Figure 7.6: The process of integration. The concrete plan of the previous phase is executed. The implementation and integration of the innovation cause the innovation to grow again, when users find new adaptations, methods and applications for it.

can create inactivity and resistance to systemic transformation. Nonetheless, transitions can still occur by incrementally integrating innovations, learning from small-scale experiments, and gradually shifting the system towards desired outcomes. Recognizing the challenges of integrating extreme innovations and leveraging crisis situations for rapid change can inform strategies for navigating transitions, while the absence of a crisis calls for strategic and patient efforts to design and integrate changes into the system over time.

One of the interesting parts about the energy transition is that on the one hand, politicians and policymakers are repeatedly referring to the need to create enough support for measures, while on the other hand, they seem to be relying heavily on the development of a black swan technology and/or silver bullets - referred to as the 'refuge of innovation' by one of the experts - that will rise and allow a transition to a zero-carbon energy system without many changes in our behaviour. Either way, it is clear that innovations need to be developed enough to be actually adapted, as well as compatible enough with the current system. Most innovations require several trials before embedding within the system indefinitely. In other words, the alteration needs to be befitting the system, whether this is aimed at the technical system, or aimed at the behavioural system. In the energy transition specifically, hydrogen is regarded as one of the most promising innovations. In this research, however, respondents stated many times that the promise of hydrogen, but the not yet fully developed technology is one of the barriers towards implementation of the currently available options. Not only is the technology not as developed as it could be, but integration and embedding within the system is also difficult due to the perceptions towards hydrogen and the entirely new infrastructure needed to transport it.

7.3.5. Ordering Principles Combined

When looking back at the ordering principles, there is sequentially that can be observed. Their relationship is shown in figure 7.7.

The principle of connection describes the necessity of fusing various viewpoints and objectives to create win-win situations. The use of networks is very important during this stage, as a wider network increases the chances of finding a successful connection. During the alignment phase, the ideas become more concrete when parties start to make agreements, start to discuss resource availability and set goals. This phase is very 'political' and involves negotiations and trust building. The result of the completion of this phase is the agreement - or policy document. What follows is the actual action in the phase of collaboration, when parties start to act to create plans. These plans become a reality during the integration, where the actual adaptation into the operational system is realised. During the sequence of the ordering principles, selection takes place. During the first phase, the ideas increase, but these are reduced in a funnel effect over the other three phases in which ideas that do not find sufficient support or connection are abandoned.

As opposed to the figure shown, this process of development is far from linear. The development of concrete plans greatly assists during the alignment phase, clear goals aid in the development of ideas and implementation of projects generally gives cause to alter goals, and plans and even create new ideas. During the transitional projects studied, all of these ordering principles coexisted and were tremendously interconnected through feedback loops. The only linear observation that can be made is

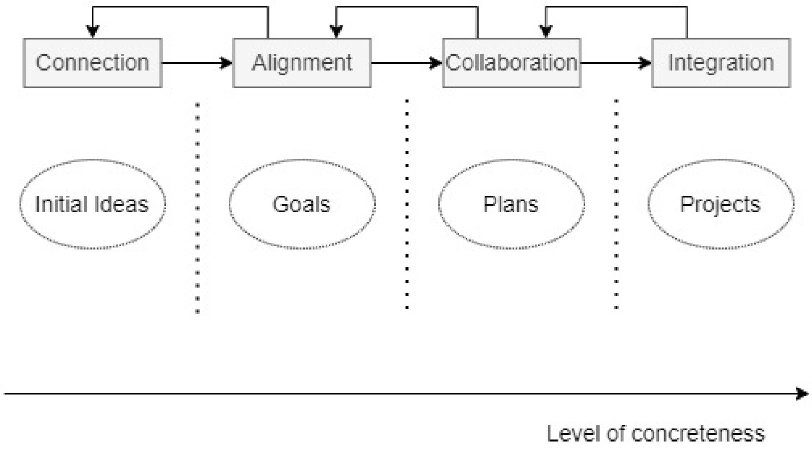

Figure 7.7: Ordering Principles related to each other

that the previous phase needs to be adequately developed before the following phase can successfully progress.

Additionally, the trigger event or crisis is symbolised in the phase of alignment, since the effect on this phase is observed to be largest. However, the crisis affects all phases. During the connection phase, a crisis would stimulate innovators to seek connection more vividly, whereas established regime actors could be more open to considering the innovators' ideas. In the phase of collaboration, a crisis also presents an urgency to the realisation of collaboration. The same is the case of integration, where crisis might allow for less resistance to the integration of innovation due to the regime levels' experienced need for change.

8

Discussion & Conclusion

8.1. Discussion

The research process behind the report of this thesis was a rather challenging and turbulent one. Due to the explorative nature of the research, the first set of interviews was conducted at the same time as the literature exploration. The design principles found in water and transport domains lead to the necessity to explore many different fields of literature. However, due to the limited number of case studies and experts interviewed, these design principles are presumably not exhaustive. Respondents within water and transport management proved to be rather difficult to find and although the expert interviews were combined with desk research to achieve triangulation, future studies could benefit from a wider sample within these domains.

In addition, the choice was made to select cases from water and transport that were examples of successful transitional projects. In order to get a broader view of the barriers faced in these domains, future research could include (thus far) unsuccessful transitions as well. The same is applicable to the choice made for the case studies within the energy domain. Other projects of interest included the National MIEK and provincial MIEK - Meerjarenprogramma Infrastructuur, Energie en Klimaat - but due to the limited time, this case was excluded.

Moreover, the selected cases were all within the Dutch regulatory framework. This resulted in limited empirical substantiation. In order to assess the theoretical framework's use for different societies - and consequently the role of Dutch national character or the influence of Dutch norms and values - further research could look at cross-border cases or cases in other parts of the world.

Additionally, this research adopted an exploratory and abductive method that coupled many different disciplines and fields of research. A more formalised method of pattern modelling could be an excellent way to add to the research's comprehensiveness by explicitly and methodologically looking at the multiple levels that might be driving the patterns of the processes (Grimm et al., 2005).

Finally, many interesting questions emerged from this research. As mentioned in 7.1, the perceptions within the energy domain seem to be different than those within water and transport. The way in which the transitional projects are framed proves an interesting angle for future research. Not only with respect to the types of goals set but also the underlying implication in energy that the transition needs to be collective - and thus there appears to be much more focus on widescale endorsement rather than a more optimisation-oriented approach.

Another interesting entry point for future research is the role that people and ICT play in transitions. This would include the role managers have in creating crises or whether transitions can be managed or governed at all.

Last but not least, in-depth research and verification of the introduced framework and observations are certainly very intriguing. This includes further exploration of the assumption that was made in this thesis that transitions are deployed by transitional projects, whether radical change is lasting change, what causes shifts between the phases of change and if the amount of resistance experienced in radical transitions differs from that in incremental transitions. In other words, further research could focus on the systemical patterns of transitions over a longer period of time and investigate the working mechanisms behind all of these systems' parts.

8.2. Conclusion

The main aim of this thesis was to introduce an expansion of the literature on transitions by developing a framework and exploring the use of ordering principles in the energy transition, supported by empirical data.

The initial exploration began by reviewing prior knowledge, where the Multiple Streams Framework and various sustainability transition methodologies were examined. The ordering principles of integration and collaboration emerged, highlighting how innovations merge through external pressures or problem-policy linkages and involve intermediaries crucially linking streams in both frameworks. Subsequently, successful transitional projects in water and transport management were studied for their design principles. Water projects deal with rapid changes, while transport projects seem more adaptive. Found principles include senior facilitator presence, aligning multiple goals, and fostering momentum for innovation adoption. The transitional projects underscore practical collaboration and integration, albeit sometimes deviating from theoretical expectations, revealing that transitions aren't solely technology-driven or entirely radical. Empirical findings informed theory matching, integrating complexity science literature, which introduces the concept of connection as an ordering principle based on network theory. This principle focuses less on practical execution than collaboration but describes the evolutionary process of innovative people developing their ideas by connecting them to other ideas and problems. This addition addresses the coevolution and co-development of transitioning systems. Applying these principles to the energy domain, transition policies leverage existing networks, stressing collaboration, knowledge sharing, and practical approaches.

Within the domains of water and transport management, the main conclusion to be drawn is that transitional projects within the water domain are often characterised as rapid turbulent transitions, while transitional projects within transport take place within adaptive systems. The design principles within these projects were the presence of a senior facilitator, the coupling of goals - economic, prestige, future-proof, comfort, climate and the upward spiral or momentum in adopting innovation. These design principles were essential for the case studies within the energy domain as well. These policies build upon existing networks and incorporate the principle of the coalitions of the willing. These policies prioritize collaboration, knowledge sharing, and hassle-limiting, allowing motivated municipalities to lead the way. The coupling of goals across systems and domains is evident, integrating practical concerns with broader objectives. However, barriers include the absence of a visible senior facilitator in some cases, a lack of ownership of goals, rapid turnover in governmental entities hindering trust-building, concerns over the autonomy of municipalities, and language barriers among experts from different domains. Despite these challenges, efforts are being made to address hesitations and improve communication.

Connection, alignment, collaboration and integration are the four ordering principles observed in successful transitional projects. Connection emphasizes the interplay and integration of various perspectives and goals, fostering co-development and the coupling of different interests, viewpoints and ideas. This organic process is essential for the growth of innovations. Alignment ensures a balanced interaction between the scope of goals and the specificity of actions and strategies, avoiding misalignment that may impede progress. This is where ideas become goals, and actors start making agreements with one another. Collaboration involves the cooperation between innovators, facilitators, and other parties, starting small and growing incrementally with successful results. This is where the innovation becomes practical. Finally, integration involves incorporating innovative ideas into existing systems, either through crisis-driven rapid changes or gradual shifts over time. Together, these principles characterise the way change occurs within the operational system.

A comprehensive framework was developed that integrates the concept that systems are always in transition with the distinction of two types of change - slow, adaptive change and rapid turbulent change. Within these two types, the same ordering principles for transitions prevail, although they need to be translated into two vastly different sets of transformative conditions. A framework was introduced, which combined aspects from several fields of literature, including the Multi-Level Perspective, Complexity Sciences and Innovation Management. A research agenda was developed to investigate this theory expansion further.

This research contributes to the academic literature and policy discussion around the energy transition in a number of ways. The developed framework and the 4 principles are a first attempt to identify what triggers transitions by mapping the whole process from beginning to end whereas previous literature focussed mostly on one of the steps in this process. The sustainability transitions literature focussed mostly on the final two ordering principles of collaboration and integration and thus on the rather practical side of (technological) innovations. Complexity science literature has very scarce application to the energy domain thus far, but the insights gathered through application in the domain of spatial planning are very useful since they integrate the role of individuals and the evolutionary nature of change. Additionally, these various theoretical fields were coupled with the insights from empirical data gathered in the case study. This integrated approach using concepts and insights from different disciplines provided a unique insight into the working mechanisms that cause transitions and is especially valuable with respect to energy transitions due to the number of domains and systems involved. Moreover, this research contributed to the clarification and nuance of the concepts central to the fields of literature involved. By uncovering the design principles, the working mechanisms behind transitions were given more substance due to the use of empirical data. It is therefore a stepping stone to investigate whether the pattern observed in these transitions is complete, just as to further research into these indicated phases.

Besides this academic embedding, this research also aims to contribute to the policy discussion, as it challenges both the notion that the system - and thus the transition - can be fully managed as well as the notion that it cannot be managed at all. This attempt to map out the entire process from the beginning - which starts with a scattergun approach - to the implementation of the innovation, provides an impetus for policymakers to identify the points in the process they can influence. This causes policymakers to have a clearer picture of how to address the problems caused by wickedness and of the opportunities available to encourage innovations and other approaches to problems as well as the moments to do so, which is something previous literature does not. This initial identification of the points that are crucial in achieving successful change provides insight for stakeholders that allows for more effective policy formulation.

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A

Appendix A - Interview Protocol

A.1. Informatie voor Respondenten

Dit interview is onderdeel van mijn master thesis project voor de master Complex Systems Engineering and Management aan de faculteit Techniek, Bestuur en Management van de Technische Universiteit Delft. In deze thesis probeer ik uit succesvolle transities uit het verleden ontwerpprincipes te destilleren die kunnen bijdragen aan het doorbreken van barrières in de huidige energietransitie. Hierbij focus ik niet per se op institutionele of technische barrières, maar richt ik me op de manier waarop we de transitie gaan waarmaken. De hoofdvraag van mijn onderzoek luidt: *What transformative conditions for change guide the energy transition?*

A.2. Vertrouwelijkheid van de via de interviews verkregen gegevens

De onderzoekers verzoeken de respondenten vriendelijk de opname van de interviews toe te staan. De aldus verkregen gegevens zijn voorbehouden aan de onderzoekers voor dit specifieke onderzoek. Op specifiek verzoek van de geïnterviewde kan een samenvatting van het interview aan de respondent worden toegestuurd. De interviews en alle gegevens en informatie die via de interviews worden verkregen blijven vertrouwelijk en worden niet gedeeld door de onderzoekers. De onderzoekers zullen de tijdens de interviews verkregen informatie decontextualiseren voor opname in het uiteindelijke onderzoeksrapport. Informatie zal niet worden toegeschreven aan afzonderlijke personen en/of organisaties. In gevallen waarin de onderzoekers van deze richtlijn afwijken, zullen de geïnterviewden hiervan op de hoogte worden gesteld en zullen de onderzoekers expliciet toestemming vragen voor het gebruik van een bepaalde tekst in het rapport.

A.3. Interview Thema's

Thema I Algemeen

- Wat was jouw rol binnen het project?
- Wat maakte dat dit project typeert als een transitie?

Thema II Proces

- Hoe is het project verlopen?
- Wie waren erbij betrokken?
- Was er weerstand?
- Hoe zijn jullie omgegaan met deze weerstand?
- Hoe zijn jullie omgegaan met andere barrières?

Thema III Succes en Toepasbaarheid

- Waarom is dit project nou zo succesvol geweest?
- Waar was er sprake van geluk?
- Welke bouwblokken denkt u dat universeel toepasbaar zijn?

Thema IV Bouwblokken

- Literatuur suggereert succesvolle transities met koppeling van doelen