MASTER

How is knowledge diffusion and learning taking place in the regional energy transition?
framework development and case study analysis of two energy regions in Noord-Brabant

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How is knowledge diffusion and learning taking place in the regional energy transition?

Framework development and case study analysis of two energy regions in Noord-Brabant

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Executive summary

Our current energy system based on fossil fuels is in need of change. This change entails a complex, socio-technical process which involves many different actors and covers a long time span. This need of change is recognised in climate agreements on different scales. In the Netherlands, the national government has decided to allocate the responsibility regarding the implementation of this transition to lower levels. This is expressed in the Regional Energy Strategies (RES), in which 30 regions have been defined within the Netherlands to design region-specific energy strategies. To develop these strategies, provinces, municipalities, distribution system operators (DSO) and regional water authorities work together in the RES. This task requires new knowledge and competencies from the local-regional actors involved. Earlier research has shown that this distribution of knowledge can be challenging, resulting in slower transition processes.

The aim of this thesis is to increase the understanding of knowledge diffusion and learning in the Dutch regional energy transition, to provide suggestions for improvement. This is done by first, conceptualising knowledge diffusion and learning in socio-technical transitions. Second, using this conceptualisation to study the processes of knowledge diffusion and learning in the Dutch regional energy transition, and third, using these findings to provide suggestions for improvement.

The research is embedded in a MARET/ORAKLE project initiated by the province of Noord-Brabant. The project is a collaboration between the TU/e, Tilburg University, Enpuls and the province of Noord-Brabant. The aim of the project is to develop a knowledge agenda and a platform for the regional energy transition in Noord-Brabant.

Research design

The research uses a qualitative approach to adhere to the complexity of the topic studied. The research design consists of the following steps. First, a systematic literature review is performed to develop an analytical framework to study knowledge diffusion and learning in socio-technical transitions, in an aim to answer to the need of conceptualisation in the field of learning in transitions. Second, a comparative case study is performed. The embedding of the research in the ORAKLE project motivates a focus on the RES regions in Noord-Brabant. Two RES regions are selected based on dissimilar characteristics, West-Brabant and Noordoost Brabant. The processes of knowledge diffusion and learning in these two RES regions are studied through the developed analytical framework. This involves in-depth interviews with the regional governing bodies involved in these regions, including provincial actors, municipal actors, representatives from the regional water authorities and actors monitoring the RES process. Besides in-depth interviews, the data is validated through grey literature, such as policy documents and government websites, and ORAKLE meetings. The empirical data is analysed through bottom-up coding and presented in light of the proposed analytical framework. To enable insights in the practices within the region and provide feedback on the framework. Last, the findings are used to provide suggestions for improvement.

Theory and framework development

The thesis focuses on two theoretical streams. The regional focus of the thesis is supported by findings from the geography of transitions literature. This literature recognises that transitions are spatially sensitive and should thus be studied as such. A distinction is to be made between the

traditional approach based on geographical proximity and the relational perspective which focuses on socially constructed spaces. Recently, an increased focus on the region is recognised in practice, while the literature still focuses relatively little on the region, but instead on the national or global level. The emergence of the region and new demands from the actors involved makes it especially relevant to study knowledge diffusion and learning in a regional perspective.

More prominently, the literature on knowledge diffusion and learning in socio-technical transitions is employed. This literature is explored through a systemic literature review and enables framework development. Five components to study learning in transitions are identified: the who, what, how, results and dynamics of learning. The categorisation is based on earlier suggestions of authors to conceptualise learning in transitions. These components include a number of sub-components to guide the study of knowledge diffusion and learning in transitions. *Who* includes the type of collective actors and role of actors, *what* consists of knowledge types, *how* consists of type, mode and organisation of learning. Further, *results* consists of outcome and impact of learning, and last, *dynamics* includes the MLP levels and learning, order of learning, timeframe and the interactions between other components. The division of the subcomponents among the components could be debated, however it provides a lens for studying knowledge diffusion and learning, for this thesis in the context of the regional energy transition of Noord-Brabant.

Empirical findings

The empirical findings show that knowledge diffusion and learning in transitions is dependent on a variety of factors. Recognising the role of actors in a transition is crucial for identifying the correct knowledge and learning needs, even within a seemingly similar actor group such as the governing bodies. The relations between these actors also influence the knowledge sharing activities, mainly based on feelings of trust. An important finding relates to the need of educating citizens in the regional energy transition. Their opinion greatly influences the execution of the RES plans and a lack of knowledge among citizens possibly obstructs the governing bodies from expressing their learning results in practice.

The need of educating citizens shows the importance of creating the capacity for all actors in the network to learn. However, not all actors need to learn the same things and to the same extent. The governing bodies express the need for practical, actionable knowledge and prefer learning from others' progress through interactive learning. A main distinction made between local actors involved in the process and their knowledge needs, is the one between civil servants and aldermen. Civil servants and experts should focus on the detailed knowledge, while the aldermen need the relevant information for making well-considered decisions.

Besides the type of (collective) actor considered, the timeframe of the process and the governance scale considered are both factors that influence the learning needs and processes. The governing bodies express a higher need for collaboration and sharing of experiences as the process progresses and the problems get more complex. Regarding the scale of learning, they emphasize that lessons learned in one context are not always easily transferred to another.

Secondary to the answer of how knowledge diffusion and learning is happening in the regional energy transition in Noord-Brabant, the findings also provide additions to the proposed framework. More specifically, the findings suggest the additions of *conditions* and *scales* of learning to be important.

Last, the empirical findings identify a set of improvements for the knowledge diffusion and learning activities in the regions. These include recognising the value of optimism, by presenting positive messages and not overburdening actors with bureaucracy, and the importance of a clear message, mainly coming from higher, provincial or national, governance levels. Further, the search for relevant information should be optimised, to make it easier for actors to accumulate knowledge. Lastly, transparency towards citizens should improve, as well as the possibilities for citizen involvement and learning.

Implications

By creating a framework to study knowledge diffusion and learning processes in transitions, the thesis provides conceptual clarity and contributes to the understanding of these processes. The resulting empirical findings guided by the framework offer several policy implications.

First, the role of a facilitating body in learning processes should be considered. Such an intermediary can address differences in power, knowledge and resources among actors and nurture feelings of trust, as well as keep track or create awareness of the progress of different localities and regions and thereby improve knowledge sharing among contexts. A facilitating body should ideally have a neutral role in the overall transition process. Second, the scales of learning should be considered properly in the knowledge offer. Municipalities still lean closely on their local role, as this is where the execution of plans need to happen. This makes it important to adapt the knowledge offer to local needs. On higher levels, a trade-off should be made between enabling bottom-up knowledge gathering and providing clear guidelines and demarcations for learning. The first can enable local actors to gain a lot of knowledge very fast, but the second can prevent the overburdening of already busy actors. Finally, the available knowledge should spread better across the network of actors, making the evaluation of citizen involvement particularly important.

The increased understanding and consideration of these policy implications could greatly benefit the processes of knowledge diffusion and learning within the regional energy transition.

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Chapter 1 - Introduction

The energy transition away from fossil fuels to renewable energy sources is a complex, socio-technical process, involving many different actors and covering a long time span. It requires a fundamental change based on radical social as well as technological innovations. The importance of this transition, and the negative impact the current energy production and consumption patterns have on the environment, is recognised on different levels. On a global scale, the Paris Climate agreement of 2015 has yielded guidelines and global, binding agreements to limit global temperature increase to 1.5 degrees (European Commission, 2015). On the national scale, The Netherlands has adopted a Dutch Climate Agreement to reduce national greenhouse gas emissions with 49% by 2030 relative to 1990, and by 2050 even a decrease of 95% (Dutch Ministry of Economic Affairs and Climate, 2019).

As part of the national agreement, the responsibility and decision-making regarding factual implementation of the energy transition is allocated to the lower, regional level, and is expressed in the so-called Regional Energy Strategies (RES). 30 regions are defined in the Netherlands within which provinces, municipalities, distribution system operators (DSO) and the regional water authorities work together to define their new region-specific energy strategies. This local-regional approach acknowledges the different challenges and capabilities that the various regions have, and offers the regions flexibility in developing their own tailor-made regional strategy. The main goals of the RES include: the definition of the regional energy targets, support in organisation of spatial integration, and stimulation of long-term cooperation between regional parties (Dutch Ministry of Economic Affairs and Climate, 2019).

The allocation of the decision-making regarding implementation of the energy transition to the regional level, on the one hand creates ample opportunities for bottom-up experimentation and meaningful involvement of citizens, but on the other, proves a daunting task regarding the organisation of the regional collaboration. Specifically, the RES implementation and the regional transition as such, proves to require a different, more networked and polycentric approach to the governance than the currently known and used hierarchical system, organised around municipal, provincial and state decision making (van Dijk, 2020). In this new approach, the local-regional governing bodies are not only faced with new, unknown roles and responsibilities, but also with the need to participate and implement processes that are different to anything they have done so far and where they have limited knowledge, skills or experiences of. This implies a large demand for a different type of knowledge base and development of entirely new competencies.

This necessary knowledge base about and for transitions, is not 'non-existent'. Significant know-how around the topic of energy transition has by now been accumulated in two important forms. The first is a more tangible and articulated form created by the academic field of sustainability transitions. That has developed over the past 20 years into an established epistemological community (Köhler et al., 2019) with its own journal: Environmental Innovations and Sustainability Transitions, and an annual conference. The second is a more tacit, practical knowledge, which is often embedded in the very many experimental, often bottom-up projects, local practices or minds of their initiators (van Doren et al., 2020). Where the problem lies, is that this knowledge, regardless of its form, seems to be difficult for the regional actors to access, comprehend and utilise. Often, these actors do not even know what they do not know or what they need to know to run the regional energy transition (RET) (Scholten, 2019). Earlier research shows that as a result, local actors often 'reinvent the wheel' and struggle with the organisation of the regional process in a way that makes reaching the targets, set in the Paris and

national agreements, more difficult (Matthijsen et al., 2021; Planbureau voor de Leefomgeving, 2019).

Another aspect that the RES developments in the Netherlands reveal is an increasingly important role of the regional level in implementation and governance of the energy transition and thereby also sharing knowledge. 'Regional' here is defined at the level of the currently operating RES (close to municipality level) system, which positions 30 RES regions in the small territory of the Netherlands. These regions have different boundaries than the traditional governance levels focusing on the municipal or provincial jurisdictions, or the official European NUTS system, which aims to harmonise European regional statistics.

In that view, the Province of Noord-Brabant, has begun a collaboration with TU/e in the context of a MARET/ORAKLE program on organising knowledge and learning for the regional energy transition. Funding of this program is a signal that the Province considers knowledge diffusion and learning not happening sufficiently in the region and that they need support in defining what causes this deficiency and how to remedy it for the sake of implementing the regional energy transition.

From the scientific perspective, learning and knowledge diffusion are of key importance for transition processes (Geels & Raven, 2006; Kamp et al., 2004; Wals, 2007). Specifically, learning is considered a crucial step in the transfer of experience and lessons within and between local projects and from local projects to a more generic level (Raven et al., 2008; van den Bosch, 2010). The generic level is considered an important step in institutionalisation of alternative practices. These practices embody more sustainable 'ways of doing' that are necessary to empower alternatives based on path-breaking innovations (Smith & Raven, 2012) and to destabilise the unsustainable status quo – two processes crucial to enable a transition (Wieczorek & Berkhout, 2009).

The literature however suggests that effective learning in transitions is dependent on a great number of factors: the type of knowledge being shared, the actors involved and their capacities, and a plethora of contextual factors (Coenen et al., 2012). This heterogeneity and complexity of actors, factors and contexts should be taken into account when unpacking knowledge and learning in transitions (Bos et al., 2013) As difficult as it seems, opening up of the black box of learning in transitions is important because it can aid understanding of how to improve these processes, or which policy measures to take (Smit et al., 2007).

Regarding the regional scale, spatial embeddedness is also recognized in this literature as important for understanding the way radical change unfolds and how it should be governed. Hansen & Coenen (2015) argue that sustainability transitions unfold in a geographically uneven way because the differences in space result in heterogeneity and asymmetry in socio-technical systems. In relation to knowledge diffusion and learning, (Coenen et al., 2012) conclude that these processes therefore require different circumstances at different scales because aggregation of local lessons into generic knowledge requires shared cognitive rules and structures.

Borghei & Magnusson (2018) further demonstrate that experiences and lessons taken out of context may lose their local connotations. At the regional level, research performed on behalf of Noord-Brabant confirms this by acknowledging the differences in progress and capacity for the energy transition in various regional contexts (Panteia, 2018; van Dijk, 2020). However, the specific mechanisms for knowledge diffusion and learning in socio-technical transitions, in the context of the

region still remain understudied and undefined (Hoppe & Miedema, 2020). That makes it difficult to inform practice regarding the best organisation of knowledge sharing and learning in the province.

In that context, this thesis is going to address the following research question:

How is knowledge diffusion and learning for the regional energy transition taking place in Noord-Brabant and how can it be improved to better facilitate the transition?

To address this question, three issues need to be clarified. First, it is important to theoretically clarify the concepts of knowledge diffusion and learning in the context of transitions and how to study these. For this purpose, the thesis develops an analytical framework based on existing literature. Second, these findings can be used to understand the current practices regarding learning and knowledge diffusion at the regional level of Noord-Brabant, with a focus on the governing bodies' perspective. Finally, the findings are used to discuss improvements for a better organisation of learning in the regional energy transition of Noord-Brabant and on a more general level.

These issues are addressed in the following three sub-questions:
1. *How can knowledge diffusion and learning be conceptualised in relation to socio-technical transitions?*
2. *How is knowledge diffusion and learning for the regional energy transition taking place from the perspective of the governing bodies in Noord-Brabant?*
3. *How to improve the processes of knowledge diffusion and learning in the regional energy transition of Noord-Brabant?*

The thesis is embedded in the ORAKLE project. The ORAKLE project is a collaboration between Eindhoven University of Technology, Tilburg University, Enpuls and the province of Noord-Brabant. In this project, that started on September 1st, 2020, the Noord-Brabant Province has expressed the need for an improved knowledge and learning infrastructure in support of the regional energy transition and specifically in developing and implementing the Regional Energy Strategies (RESs). The aim of the ORAKLE project is to develop a knowledge agenda and a platform for the regional energy transition in Noord-Brabant.

The report continues as follows. Chapter 2 introduces the main theoretical concepts of socio-technical transitions and clarifies the regional aspects of radical change using insights from geography of transitions. Chapter 3 presents the research design of the thesis and methodology. Next, chapter 4, 5 and 6 accordingly provide answers to the first, second and third sub-question. Last, chapter 7 concludes the thesis with an answer to the main research question, limitations of the presented research and suggestions for future research.

Chapter 2 - Theoretical foundations

To provide a broad theoretical background for answering of the research questions, insights from sustainability transitions research are mobilised. Section 2.1. provides a generic introduction to the socio-technical transitions field and section 2.2. introduces the foundations of geography of transitions for studying the regional level. It is important to note that none of the frameworks presented in this chapter are explicitly used as a conceptual lens to study knowledge diffusion and learning, since it is not their aim to do that. The aim of these frameworks is to clarify how large-scale, socio-technical transitions unfold, with knowledge and learning being important, but only one of many aspects conditioning this process. The explanation of the transition frameworks, however, is necessary to discuss the specific insights on learning and knowledge in transitions emerging from the systematic literature as presented in chapter 4.

2.1. Socio-technical transitions

The transitions research field focuses on socio-technical system change and argues that the current challenges society is facing, major ones being climate change and social inequalities, require radical change in the basic systems providing societal needs. This change in the system is termed a transition, and encompasses both technical as well as social dimensions of change (Elzen & Wieczorek, 2005). The change, given its scale, implies that not one actor is responsible, but concerns all of society and therefore all societal groups have a task to fulfil (Farla et al., 2012; Penna & Geels, 2012). The various aspects of the dynamics of these processes of change are conceptualised and studied by different frameworks, including: the Multi-level perspective, Strategic Niche Management, Transition Management and Innovation Systems. All of which incorporate aspects of knowledge or learning (Markard et al., 2012).

The core model in studying transitions is the Multi-Level Perspective (MLP), which also connects other approaches within the field such as the Strategic Niche Management (SNM) framework and Transition Management (TM) approach (Geels, 2002; van Mierlo & Beers, 2020). The MLP is an analytical tool to understand how transitions unfold, using three distinguished levels: the niche, regime and landscape level. The regime consists of locked-in, path-dependent configurations of rules and routines which favour incremental innovation. This path dependency is sustained by several dimensions: regulative, cognitive and normative rules. That means change can be influenced by current regulations, but also common values and behaviours that are shared in the network. One of the dimensions in the regime also includes the existing knowledge base, which is embodied in the products, actors and institutions of regimes and contributes to the stability of the current regime.

The next level, landscape, consists of contextual factors that stabilize or put pressure on the regime. These are exogenous and autonomous trends beyond the direct influence of actors, like climate change, wars or crises (Geels, 2002). Lastly, the niche level reflects space where alternatives to the dominant practice are developed, and which have the potential to disrupt the regime. Niches provide space for incubation of radical novelty through experimentation, learning processes and network building (Kemp et al., 1998). If the regime is confronted with tensions and the linkages in this network loosen, radical innovations have a higher change to escape the niche-level and challenge the regime (Geels, 2002). System transformation is eventually the result of mutually reinforcing landscape pressure, regime destabilisation and the upscaling of niche innovations (Elzen &

Wieczorek, 2005; Wieczorek & Berkhout, 2009). Within MLP analyses, knowledge and learning are indeed found important, but are only one of many factors that contribute to the successful (de)stabilisation of a regime. Knowledge and learning are therefore usually not the main focus of the MLP type of analyses. In the literature on niche development, learning processes receive a more prominent role.

The development, empowerment and upscaling of niche innovations is studied using the Strategic Niche Management (SNM) lens. SNM is about explaining how a niche can emerge successfully, to become mainstream and challenge the regime. SNM argues that the processes of shielding, nurturing and empowering are preconditions to construction and upscaling of niches (Smith et al., 2014). Shielding concerns protection of a niche against regime selection pressures and can take a form of financial support or implementation in a favourable location (Verhees et al., 2013). Empowering means that the niche can sustain in the unchanged selection environment or has stretched the system enough to sustain in the changed environment (Smith & Raven, 2012). Last, the process of nurturing includes three key processes. These are the articulation of expectations and visions, the building of social networks and learning processes of various types (Verbong et al., 2008). The alignment of these learning processes contributes to a stable configuration of the niche and, in combination with the other processes, can help the niche in gaining momentum (Kemp et al., 1998; Schot & Geels, 2008).

As the Strategic Niche Management approach illustrates, niches play an important role in enabling transitions. Niches are important because they provide protected spaces for interactive learning processes and enable the creation of new knowledge and practices, both on technological and societal aspects (Kemp et al., 1998). The further dynamics of learning at niche level are discussed in chapter 4.

The Transition Management (TM) perspective focuses on the governance of socio-technical transitions. TM builds on MLP and SNM insights and argues that sustainability transitions cannot be governed in a traditional top-down way, but rather require an iterative, reflective and explorative approach. This approach aims for (social) learning, empowerment and an increased understanding of complexity or a shared narrative as core societal effects. Its essence lies in bringing together different (niche) actors to contribute to the development of alternative solutions (Loorbach, 2007; Schäpke et al., 2017).

The last framework which is increasingly used in transition studies, and which also incorporates aspects of knowledge and learning, is the innovation systems approach. The innovation system concept was developed at the end of the 1980s, originally not to understand socio-technical systems change but to study the innovative capacity of systems around specific innovations (Carlsson & Stankiewicz, 1991). The innovation system framework starts from the notion that innovation is a non-linear, interactive process dependent on multiple actors, ranging from firms to customers to research institutes (Wieczorek, Raven, et al., 2015; Wieczorek & Hekkert, 2012). Each actor contributes to the innovation process in a different way. These actors, and the relationships between them, form and determine the rules of the innovation system.

One of the important characteristics of the innovation system approach is the emphasis on interactive learning and transfer of knowledge between actors of the innovation system (Kamp et al., 2004). Originally, innovation system studies focused merely on innovative performance of firms and knowledge economies rather than socio-technical transitions (Wieczorek & Hekkert, 2012). The focus in the 1990s was on national and regional aspects of innovation systems (Asheim et al., 2011; Morgan, 2004). The concept of technological innovation systems emerged later to explain the nature

and pace of technological change and has a strong focus on knowledge and competence flows within the system (Carlsson & Stankiewicz, 1991). In more recent literature there has been a focus on activities which could contribute to the establishment of such a technological innovation system. Among these activities are knowledge development and the exchange and diffusion of knowledge through networks (Bergek et al., 2018; Hekkert et al., 2007).

2.2. The regional aspects of transitions

As mentioned in the introduction, the focus of this thesis is on the regional level, as defined by the Dutch approach for the energy transition. In the transition literature, the regional aspect has been considered as part of the geography of transitions topic.

In its first research agenda, the sustainability transitions research network argues that transition theory so far had paid too little attention to the spatiality of transitions and thus devoted a chapter to the geography of transitions. It specifically emphasised that the geographical context has too often been treated as a passive background and that there has been a lack of or problematic usage of scale in analyses (STRN, 2010). Transition analyses were then said to have overlooked the importance of exploring where transitions take place (Coenen et al., 2012) and that they ignored the fact that sustainability problems and the necessary transitions, encompass geographical diversity and international actor networks (Truffer et al., 2015). The neglect of the role of physical places left an important blind spot for governing such transition processes while unpacking the spatiality of transitions can allow to better understand the underlying processes (Hansen & Coenen, 2015) and better inform governance. A geographical turn has been called for to improve the conceptualisation of space in transitions (Fastenrath & Braun, 2018). The argument was that this understanding can provide genuine insights into the places, spatiality and multi-scalar embeddedness of transitions and to make more explicit why certain transitions have succeeded or failed (Coenen et al., 2012; Wolfram et al., 2017).

In recent years, the crucial influence of geography in the field of transitions has become more widely recognized and it materialised in a growing body of literature on the topic (Hansen & Coenen, 2015; Truffer et al., 2015)Notable contributions are by Coenen et al. (2012); Hansen & Coenen, (2015); Raven et al. (2012); Truffer et al. (2015) and Truffer & Coenen (2012). Hansen & Coenen (2015) and Truffer et al. (2015) provide an overview of the literature and contributions on the topic, while the others have tried to make conceptual additions. The major issue discussed is the integration of spatial aspects in the MLP (Hansen & Coenen, 2015). Frequently, empirical studies related the niche level to subnational, local and regional processes; the regime level to the national scale and the landscape level to events of supranational scale (Hoppe & Miedema, 2020). However, the MLP reflects levels of structuration and processes with different temporal dimensions, not geographical scales (Raven et al., 2012). While variance can be expected across space, the original MLP lacked attention for the geographical dimensions of the levels' dynamics (Hansen & Coenen, 2015)The commonly used notion of a socio-technical regime conveyed a certain level of homogeneity and consistency, while there is also considerable variation of regime structures at regional and local levels, which provide a place for spatial variations (Späth & Rohracher, 2010, 2012; Wieczorek, 2018). Similarly, niches are described as having less extensive and less stable social networks, but those networks do not need to be local, they could also exist on the national or international scale (Raven et al., 2012), thus, supporting a recognition of variances in spatial scale. Hansen & Coenen (2015) summarise that while a higher sensitivity concerning the importance of place-specificity has emerged, with some exceptions

(see e.g. Wieczorek et al. (2015) and contributions in a special issue by Coenen & Truffer, 2012)) it is still biased towards findings from single case studies or specific places. This results in a consensus that place-specificity matters but there is little generalisable knowledge yet about how it matters.

Several of these studies on geography of transitions e.g. Coenen et al. (2012)and Hansen & Coenen, (2015), borrow from the economic geography field and specifically from its three streams: geographies of innovation, environmental economic geography and evolutionary economic geography (Fastenrath & Braun, 2018). The studies in the field of transitions, according to Hansen & Coenen (2015), generally distinguish between stressing geographical proximity, a more traditional approach, and taking a more novel, relational perspective on geography which focuses on socially constructed spaces. An example of the latter is e.g. the study of knowledge flows between socio-spatially constructed locations through actor networks (as in Wieczorek, Hekkert, et al., (2015); Wieczorek, Raven, et al. (2015)). The relational perspective as argued by Raven et al. (2012) implies: *"Analysis should also look at the imagined spaces, the struggles and conflicts in establishing specific spatial relationships and the resulting regimes and institutions, and implied reorganisations of spatial relationships."* (p. 69) Relating these findings to studying learning in transitions, means taking into consideration the spatial relations and networks through which knowledge sharing and learning is established, but also considering which socially constructed spaces are present for learning.

This distinction between geographical and relational proximity is especially interesting considering that there seems to be a simultaneous process of globalisation and decentralisation occurring in current research. Some argue for the urgency of geographical proximity while others claim, as a result of digitalization processes, that 'geography is dead' (Isaksen & Trippl, 2017). A similar trend occurs in governance, where globalisation and Europeanisation match regionalisation and decentralisation. The lower levels are increasingly being used to execute what is decided higher up, and how these lower levels are defined is dependent on the problem statement (Groenleer, 2016). This trend of globalisation versus decentralisation is also recognised by Schot & Kanger (2018) in their research on deep transitions. While the First Deep Transition is focused on trends of globalisation, industrialisation and mass production, the second could counter this directionality through renewable energy, local production and renewed services.

This sensitivity to space and scale, whether considered geographically or relationally, is also relevant when considering the energy transition, which covers several geographical and governance levels. The energy transition is not bound by the municipal or national borders, as is increasingly reflected in the new governance approaches. The traditional, hierarchical governance levels (type I multi-level governance) are increasingly complemented by more fluid network-type governance arrangements, with a more heterogenous set of actors (type II multi-level governance) (Späth & Rohracher, 2012; van Dijk, 2020). Within a decentralized, type II, approach like the RES, local actors are required to work together and be more innovative to find unique solutions for their local context (van Dijk, 2020). Such an approach should lead to opportunities for learning across scales (Goldthau, 2014). The geographical lens to sustainability transitions should enable identification of conditions to transfer lessons from successful cases from one region to another, and preferably across different scales (Truffer & Coenen, 2012). These new arrangements do not make traditional actors, like the province, obsolete, but rather it requires new roles from them, e.g. a more stimulating role, to connect and push for action and collaboration. More often the region is becoming the place where these new collaborations between different scales and levels are being manifested, as in the Dutch energy strategy (Groenleer, 2016).

Although the regional level is gaining more focus and responsibilities in policy, also in the energy transition, it receives relatively little attention in academic publications. As found by Raven et al. (2012), the large majority of transition studies with a geographical delineation, have focused on the national level, implicitly suggesting that the national is the right geographical level to study sustainability transitions. Meanwhile, several authors have provided argumentation for the importance of the region. As Späth & Rohracher (2012) argue, the regional level provides a good place for the implementation of alternatives to the dominant regime. Despite of perhaps limited principal constraints, such as lack of control over important actors (Späth & Rohracher, 2010), the region can be used as an influential demonstration setting. The implementation of alternatives can demonstrate the feasibility and consequently accumulate credibility, which can result in changing or strengthening actor networks and institutions on higher levels. If these changes result in new social norms, they will also impact the regime via the landscape level (Späth & Rohracher, 2012). Thus, not using the region as a breeding ground for niches, but rather as a model or inspiration for other regions. Guiding visions from a regional level can turn abstract visions of a sustainable future into more concrete requirements and opportunities. Which naturally differ and must be adapted for transfer to other contexts but can nevertheless provide a model (Späth & Rohracher, 2010). Additionally, transitions have proven to unfold in a geographically uneven way, with urban and regional policies regarding sustainability issues often preceding national and supranational regulations. On the one hand, the region is closer to the involved actors and local conditions, while on the other, the increasing complexity of transitions governance implies a diminishing control for regions and a lack of sufficient funds/resources. Making the study of processes at this regional level very relevant (Hansen & Coenen, 2015).

The definition of the region can, however, differ, according to who you ask and in which context. In relation to the MLP, Späth & Rohracher (2012) state the region has to be located across the levels of niche, regime and landscape since a region can be part of the energy regime but also a place where partial transformations happen, through inconsistencies and variations of the regime. Relating to the traditional governance scales, the region can be regarded as a sub-level to the provincial level and super-level to the local level. Regions can also be determined geographically, e.g. a city-region, or in functional terms, e.g. where municipalities have specific collaborations (Hoppe & Miedema, 2020). The approach for the regional energy transition studied in this thesis, is based on the execution of the Dutch energy transition, as expressed in the definition of 30 RES regions across the Netherlands that do not correspond to any above definitions.

In summary, what defines the region is not set in stone, and therefore often a point of discussion (Groenleer, 2016). Regardless of that, however, and given that many existing studies have focused on the national or global context, with much emergent interest for the region in practice, it becomes necessary to study transitions from a regional perspective. The rise of the region stresses the changes in governance and roles of actors, resulting in the need for new skills and knowledge.

Chapter 3 - Research design and methodology

3.1. Research design and worldview

The thesis as a whole takes a qualitative research approach, thereby honouring the complexity of the topic, leaving space to collect open-ended data and flexibility in interpreting the findings (Creswell, 2014). The qualitative approach is a common approach in transition studies and motivated by the constructivist worldview embraced in this thesis. The constructivist worldview is suitable given the complex and socio-technically constructed topic under research. Constructivists, and more specifically social constructivists, use a broad research approach and seek to understand the complexity of views in a problem statement. This is indicated by the 'how' in the main research question: "*How is knowledge diffusion and learning for the regional energy transition currently taking place in Noord-Brabant and how can it be improved to better facilitate the transition?*" The approach leaves space to explore the variety of views and answers rather than narrowing it down to the confirmation of a predefined theory (Creswell, 2014).

The research question is answered in several steps. First, a preliminary literature review, including academic and grey literature, provides direction to perform an elaborate literature review on knowledge and learning in transitions. As the conceptualisation of knowledge diffusion and learning in transitions is still insufficient, the findings are used develop an analytical framework. Second, this analytical framework is verified by, and guides in, the gathering of empirical data in the form of a case study, which is further explained below. Last, the empirical findings from the province of Noord-Brabant, put into perspective through the analytical framework, provide suggestions as to how the situation can be improved.

Thereby, the research design answers the main research question, by providing an answer to each of the sub-questions. These are:
1. *How can knowledge diffusion and learning be conceptualised in relation to socio-technical transitions?*
2. *How is knowledge diffusion and learning for the regional energy transition taking place in Noord-Brabant?*
3. *How to improve the processes of knowledge diffusion and learning in the regional energy transition of Noord-Brabant?*

The case study design is common for constructivist research and helps to understand the context in which the topic is embedded (Creswell, 2014). As stated by Yin (2017), a case study: "*investigates a contemporary phenomenon (the "case") in depth and within its real-world context (...)*" (p. 45). Thus, it is a suitable approach to better understand the dynamics of the (real-world) regional energy transition in Noord-Brabant. More specifically, a case study is fitting to answer questions related to 'how' and 'why' problem statements, providing suitable information to answer the second and third sub question. In the scope of this thesis, the case study serves as a representation of the situation in Noord-Brabant. However, doing a longitudinal study of one or comparing more cases is too complex and time consuming. Therefore, two cases with dissimilar characteristics are selected to give an indication of the situation. The criteria for case selection are described in section 3.2. Additionally, using two cases instead of one allows for analysis within and between cases (Yin, 2017).

Finally, the combination of theory development and comparative case study helps in generalizing the findings from the case study. The execution of the above described case study allows to shed light on empirical findings within the theoretical concept. This process is called analytic generalization (Yin, 2017). Thereby, the research design is also helpful to, foremost, generalize the findings to the province of Noord-Brabant and provide useful insights to improve knowledge sharing and learning in the regional energy transition in general. Thus, providing an answer to the third sub question.

3.2. Case selection and description

In view of the plurality of definitions of the region in the literature, but given the developments in the Netherlands, for this thesis the RES level is taken as the region. It demonstrates the level of implementation of the regional energy transition for the Netherlands and allows to study the implications for knowledge diffusion and learning. Furthermore, given the embeddedness of this research in the ORAKLE project (see introduction), two RES regions from the province of Noord-Brabant are selected. Noord-Brabant has a total of four defined RES regions, being: West-Brabant, Hart van Brabant, Noordoost Brabant and Metropoolregio Eindhoven. Figure 1 shows an overview of the 4 regions on the map (together with all RES regions), adapted from Rijksoverheid, IPO & Unie van Waterschappen (2018). RES number 1 represents West-Brabant with 16 municipalities, 2 - Hart van Brabant with 9 municipalities, 3 - Noordoost Brabant with 16 municipalities and 4 - Metropoolregio Eindhoven with 21 municipalities (Kooistra & van der Steen, 2019; Metropoolregio Eindhoven, 2019; regio Noordoost Brabant, 2019; Regio West-Brabant, 2018).

Figure 1: (Highlighted) RES regions of Noord-Brabant. Nr. 1 – West-Brabant, nr. 2 – Hart van Brabant, nr. 3 – Noordoost Brabant, nr. 4 – Metropoolregio Eindhoven

Keeping the scope of this thesis in mind and for indicative purposes, the number of cases is limited to two RESs: West-Brabant (1) and Noordoost Brabant (3). These two have been selected based on the information from the administrative starting notes ('startnotitie') for each RES and information from the Province of Noord-Brabant. This choice is driven by the different approaches that the two RES regions took regarding the division of their RES-related responsibilities. West-Brabant took a more

regional, integral approach from the start and deliberately left opportunities open for cross-municipality projects. Noordoost Brabant initially divided the responsibilities more locally, with goals per municipality (regio Noordoost Brabant, 2019; Regio West-Brabant, 2018). Given that the division of responsibilities might have an impact on learning processes, as indicated by the theory presented in chapter 2, studying these two RESs provides a varied representation and interesting starting point to understand learning and knowledge diffusion in the regional energy transition of Noord-Brabant and perhaps opens up new, future research directions.

3.3. Methods

The main research question, and related sub questions, are answered based on various sources of data and different methods for data collection and analysis are used. The methods are described below per data source. Within each section, the relation to the sub-questions is explained and the chapter concludes with an overview of the methodology per sub-question.

Academic literature

Before zooming in on the situation in Noord-Brabant, the related academic field is researched through a systematic literature review with the aim of developing a tailored analytical framework. A systematic review aims to identify, appraise and synthesize all relevant studies within a field in a comprehensible way, while remaining transparent and unbiased in how this literature is gathered and analysed (Briner & Denyer, 2012). This approach relates to the first sub question, to identify and summarize the current findings from the relevant fields and conceptualise learning and knowledge diffusion in relation to socio-technical transitions. The purpose of the first sub-question fits with one of the reasons for doing a systemic review as pointed out by Petticrew & Roberts (2006): *"When a general overall picture of the evidence in a topic area is needed to direct future research efforts."(p.21).* The efforts of the systematic literature review provide the understanding needed to answer the first sub question and provides direction for the following research steps.
Based on Petticrew & Roberts (2006), the systematic literature review, includes the following steps:
1. Defining of the question to be answered
2. Deciding on inclusion/exclusion criteria of literature
3. Carrying out the literature search
4. Screening and including/excluding results of the literature search according to established criteria
5. Summarizing, analysing and comparing findings of the included literature

Defining the question
Steps 1-4 relate to the data collection phase. The first step, defining of the question, is expressed in sub question 1 and 3: *"1. How can knowledge diffusion and learning be defined in socio-technical transitions?"* & *"3. How to improve knowledge sharing/learning in the regional energy transition of Noord-Brabant?"* The identification of the sub-questions is described in the introduction, chapter 1. Consequently, based mainly on sub question 1, inclusion/exclusion criteria for the literature review are decided upon.

Deciding on inclusion/exclusion criteria and carrying out the literature search
The second and third step of the process are carried out intertwined. Determination of the search query and inclusion criteria are described below.

To ensure the quality of included literature, the literature review is performed via Scopus. To delimitate the search to socio-technical transitions, keywords as 'sustainability/sociotechnical transition' are used. However, from the exploratory literature review and usual suspects found through exploratory snowball reading, it showed that e.g. Geels & Raven (2006) do not use the term transition to refer to sociotechnical system innovation processes. Instead they refer to the specific framework used in the studies. According to the most recent special issue on learning in transitions by van Mierlo et al. (2020) studies on learning in the transitions field often put the study in the frame of a specific approach used, the most common ones being: strategic niche management, transition management and the functions of innovation systems approach. Therefore, these approaches are used as substitutes for transitions keywords in the literature search.

Since sub-question one relates to knowledge diffusion and learning, both terms are included in the search query. Additionally, to prevent finding articles where knowledge diffusion and learning are just one of the many aspects of a transition process rather than a core feature of interest, the search is limited to title, abstract and keywords in Scopus. This search term results in 1,032 documents from the complete Scopus database. After exclusion of irrelevant subject areas, e.g. 'nursing' and 'veterinary', this results in 968 documents. Since the research discusses the energy transition specifically, a search limited to the energy subject is saved separately, including 139 documents, to enable further selection. The overview is presented in Table 1.

Table 1: Scopus search on learning in transitions

Search entry	Search fields	Number of documents
1. *("Knowledge diffusion" OR "learning") AND ("sustainab* transition" OR "socio-technical transition" OR "sociotechnical transition" OR "strategic niche management" OR "transition management" OR "innovation systems")*	Title, Abstract, Keywords	1,032
1.1. *Exclusion of irrelevant subject areas*	Title, Abstract, Keywords	968
1.2. *Limited to "energy" subject area*	Title, Abstract, Keywords	139

Screening and including/excluding results
Consequently, the titles and abstracts of the 968 articles are scanned. A level of relevance is assigned, 3-2-1, from no relevance to must read, based on the role knowledge diffusion/learning seems to have in the article. A score of 3 is based on a number of factors, including 1) articles describing learning from cases of sustainability transitions rather than learning within such a transition, 2) articles focusing on a very different (geographical) context or empirical field, which does not seem to have generalizable findings, and 3) articles in which learning is just one of the many characteristics in the process, rather than the subject of analysis.

Accordingly, all articles assigned a 3 are deleted from the sample, leaving 753 articles. Besides, 145 articles are assigned a 2, and 70 a 1. Of these remaining articles, 19 of the articles assigned relevance level 1 are within the energy subject area, and 23 of the articles assigned relevance level 2. It is

decided to further investigate all 70 articles assigned a 1 and the 23 articles assigned a 2 that are within the energy domain.

These 93 articles are further categorized based on the reading of abstracts. If clear, the scale of focus and the analytical framework used in the paper are assigned. Next to the type of learning, type of knowledge and the location under study, e.g. a specific city, country or continent. Additionally, key words are added to enable faster referencing for step five of the systematic literature review, e.g. is the article about who is learning, what they are learning or how they are learning. This more elaborate filtering results in the exclusion of 11 more articles.

Additional to the Scopus search and selection, some articles are included through snowball reading. From the special issue on learning in transitions by van Mierlo et al. (2020) and references from the ORAKLE project proposal. A total of 5 articles is included through this process. An overview of the final included sample of articles, the Scopus articles and snowball articles, a total of 87, can be found in Appendix A.

Summarising, analysing and comparing findings
This final sample of 91 papers is read fully, with exceptions for specific case descriptions/studies. Reading is done while keeping in mind the related sub-questions: "1. *How can knowledge diffusion and learning be defined in relation to socio-technical transitions?*" & "*3. How to improve knowledge sharing/learning in the regional energy transition of Noord-Brabant?* While reading the articles questions are identified to categorise relevant findings. These initially are:
- What is learning in transitions and why is it regarded important?
- Which types of learning (theories) are mentioned and how are those defined?
- Which types of knowledge and information are mentioned and how are those defined?
- Where is learning taking place or in which setting is learning described?
- What is said about learning in relation to different actors?
- What is said about the regional scale and learning?
- What is known/suggested relating to the organisation of learning?

The findings are categorised and summarised based on these questions. For the development of a more conceptual approach and to answer SQ2, a thematic analysis of the findings is performed using post-it notes. The purpose is to identify recurring categories used while studying learning in transitions. The findings of this process constitute the base for the analytical framework presented and discussed in chapter 4.

Grey literature

Grey literature concerns the organisation of Dutch energy transition and specifics of the Noord-Brabant context. The grey literature mainly consists of policy documents and websites, like the guidelines for the national RES program and provincial energy strategy. To answer SQ2, the documents are scanned for sections mentioning 'knowledge' and 'learning'. This information is mainly used for triangulation of the findings from the interviews, see next section, which are the main sources of information. An elaborate analysis is not performed on this literature, however, the information from the grey literature can still confirm or add to findings from the interviews. An overview of the used literature is provided in Table 2. The table also mentions which aspect of the research design or which sub-question it relates to.

Document	Use
Startnotitie RES Metropoolregio Eindhoven	Case selection
Concept REKS Hart van Brabant	Case selection
Bestuursopdracht-startnotitie RES2030 West-Brabant	Case selection
Bestuurlijk startdocument Noordoost-Brabant	Case selection
Concept-RES regio Noordoost-Brabant	SQ2
Concept RES West-Brabant	SQ2
Nationaal Programma RES – Handreiking	SQ2
Nationaal Programma RES – Handreiking 1.1	SQ2
Energieagenda 2019-2030 Provincie Noord-Brabant	SQ2
Uitvoeringsprogramma energie 2020-2030 – Provincie Noord-Brabant	SQ2
Energiewerkplaats Brabant	SQ2

Interviews

Since so little is known and researched on learning specifically at the regional level, this thesis utilizes a bottom-up approach to understand the regional situation in Noord-Brabant. Empirical findings are used to identify aspects of knowledge sharing and learning in transitions at the regional Dutch level. Information on learning in specific Noord-Brabant regions is collected by talking to actors involved with the two RES regions included in the case selection, see section 3.2. This is done through semi-structured interviews. Semi-structured interviews are interviews guided by a predetermined set of questions, but the direction may deviate and be influenced by both the interviewee and interviewer throughout the interview. Providing the possibility to adapt the questions throughout the interview, making it suitable to explore emergent topics and gain a more elaborate understanding of the interviewee's position (Longhurst, 2013).

The final set of interview questions is based on the results of sub-question 1, the outcome of the grey literature review and validated through ORAKLE project meetings. For sub-question 3, the semi-structured interviews are designed to ask about possible improvement points. To make the flow of the interview as natural as possible, the questions are grouped in similar subjects (Hermanowicz, 2002). The interview guide is enclosed in appendix B.

The actors of interest are those involved as governing bodies in the decision-making process of the RES in Noord-Brabant. Especially important because they are the ones having to organise and execute this new organisation of the regional energy transition. In this case, these are regarded as all actors having decision-making powers in the RES process. These can include responsible persons of municipalities, the province, and the water authorities.

The target group is verified, and interviews are set up through provincial actors involved in the ORAKLE project, after which the snowballing method is used to target more people. Unfortunately, quite a delay took place in receiving contacts and the researcher had to adapt to this pace. The use of the snowballing method also results in a slightly narrower group of interviewees than initially intended. The share of municipal stakeholders, aldermen, is eventually quite high in the sample. However, because of the large number of interviews, 14 in total, and comparative case study design, it still provides rich and sufficient indicative information. The final list of interviewees can be found in Table 3.

Table 3: List of interviewees

No. interviewee	Role of interviewee in RES process	Governance body/organisation	RES region
1	Project leader	Independent consultant	NOB
2	Initiator ORAKLE project	Province/consultant	/
3	Member of steering group	Municipality	NOB
4	Member/vice-chairman of steering group	Municipality	NOB
5	Process director	Water authority	WB
6	Member of steering & leading group	Municipality	WB
7	Member of steering group	Municipality	NOB
8	Process director	Province	/
9	Member of steering & leading group	Municipality	WB
10	Member of steering group	Municipality	NOB
11	Process director	Independent consultant	NOB
12	Member of steering group	Municipality	WB
13	Member of steering & leading group	Municipality	WB
14	Member of steering group	Water authority	NOB

Because of circumstances regarding the covid-19 pandemic, all interviews are conducted online. Before the interviews take place, each separate participant digitally receives an informed consent form, asking to sign it before the interview takes place (Appendix A). The program to meet online that is Microsoft Teams, the interviewees are sent a meeting link before the interview. The interviews are recorded using the recording function in Microsoft Teams and as a back-up with the audio recorder of an Android phone. This means the interviews are both audio and video recorded, if possible. Additionally, handwritten notes are taken during the interview. To analyse the interviews and for future use in the ORAKLE project, the interviews are transcribed manually.

For the answering of the second and third sub-question, the interviews are coded using the software of NVivo. The thematic analysis of the transcripts entails an iterative process. First, codes are assigned to each recurring subject which could be of potential interest, after which many codes have emerged. Later, the codes are inspected for underlying patterns and relationships that emerge (Yin, 2017). This process provides an answer to what constitutes knowledge diffusion and learning in the region, answering sub-question 2. In the answering of sub-question two the empirical findings are presented in relation to the developed framework (in sub-question one). Enabling identification of learning factors both through an expert-based approach, the systematic literature review, and through a participatory, empirical, method. Combining the two methods is most rigorous, as it can show conformity between some of the factors but can also bring new factors to light in either one of the approaches (Halbe & Pahl-Wostl, 2019). Regarding sub-question 3, the categorisation of codes is based on possible points of improvement and the current processes are compared to the theoretical findings, to identify specific opportunities for improvement.

ORAKLE project meetings

Additionally, meetings of the ORAKLE project are utilised to better understand the current situation in Noord-Brabant. The researcher attends several meetings related to the project. During these meetings active participation is taken when appropriate. Meanwhile the researcher observes and takes notes relating to validation of the problem statement and research approach. Additionally, during some of the meetings, intermediary results are presented and discussed, which also influence the ORAKLE process. Including a preliminary presentation of the literature review results and a discussion of the proposed interview questions, after which the ORAKLE actors provide input and the interview questions are adapted accordingly. An overview of the attended meetings and use of the meetings is provided in Table 4.

Table 4: ORAKLE meetings

Date	Meeting type	Purpose for current research
24-08-2020	1st ORAKLE consortium meeting	Validation of problem statement
13-10-2020	ORAKLE brainstorm session with TU/e and Tilburg university actors	Presentation and discussion of initial framework findings
10-11-2020	ORAKLE update session with TU/e and Tilburg university actors	Further discussion of framework proposal and interview planning
11-11-2020	ORAKLE meeting with actors from TU/e and province	Validation of interview questions and approach

This process is also considered within action research, where the researcher is more closely involved with the actors of a team and through a reflective approach aims to provide not only generalizable explanations, but also solutions for the specific context (Stringer, 2007).

An overview of the data sources and methods used for collection and analysis is provided in Figure 2, aligned across the relation to each sub question.
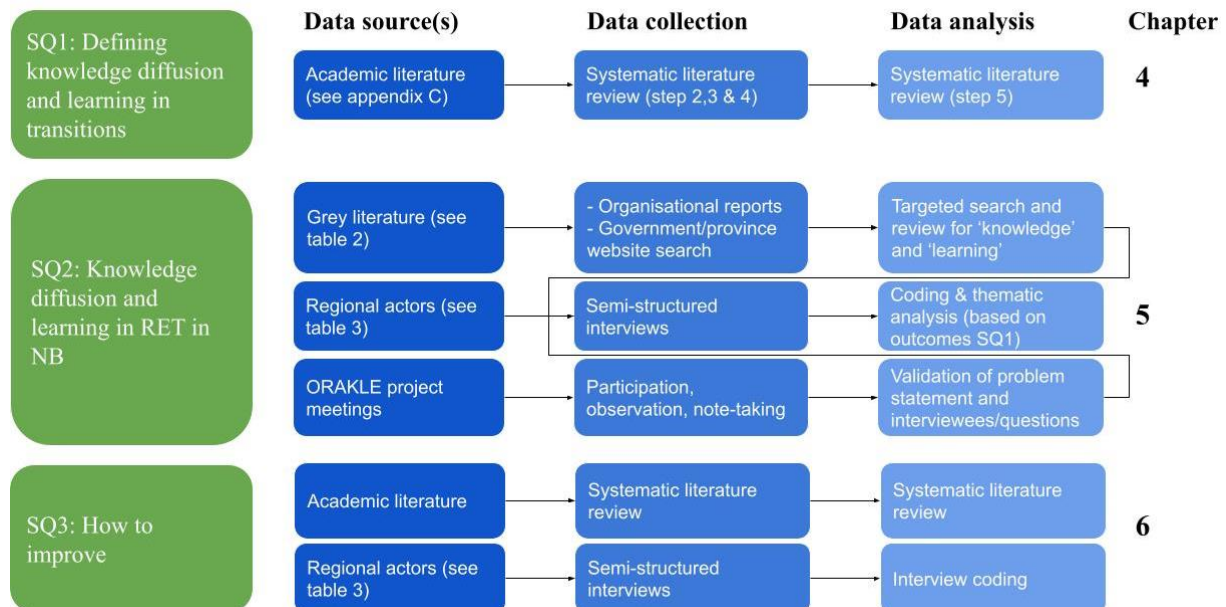
Figure 1: Sub-questions and corresponding methods

Chapter 4 - Defining knowledge diffusion and learning for socio-technical transitions

This chapter aims to answer the first sub-question:

"How can knowledge diffusion and learning be conceptualised in relation to socio-technical transitions?"

The question is answered by means of a systematic literature review of 91 articles on knowledge diffusion and learning in transitions.

The initial guiding questions for this systematic literature review are: *What is learning in transitions? What type of knowledge/information flows are identified? Which types of learning (theories) are distinguished and how are they defined/utilized? Who is learning and what are they learning? Where does learning take place? What is said about the regional scale and learning? How should learning for sustainability transitions be organized?* The questions are based on exploratory snowball reading and an exploratory literature review of 20 articles on the same topic by Van Poeck et al. (2020). Together with the findings from the systematic literature review, they provide the basis for developing an analytical framework on knowledge and learning in transitions. Several authors have called for conceptual clarity in studying learning in transitions and for a suitable analytical framework (Beers et al., 2016; Van Poeck et al., 2020). This chapter proposes such a framework.

In the reviewed literature, the findings on the regional aspects of knowledge diffusion and learning are rather scarce. Instead, the local or municipal level is discussed in a more generic way. This thesis therefore addresses the regional setting in chapter 6 on occasion of discussing regional organisation of knowledge sharing and learning.

The chapter is structured as follows. Section 4.1 provides an overview of the reviewed literature and identifies emergent elements of the framework. In section 4.2.-4.6. the elements are discussed individually in separate sub-sections, and lastly, in section 4.7. the analytical framework is presented.

4.1. Overview of the reviewed literature and framework elements

Transition studies often emphasize the importance of knowledge sharing and learning as a basic condition for effective systemic change towards sustainability (Smith & Stirling, 2010; Wolfram et al., 2017). Understanding how these concepts are important for transitions provides leverage to facilitate, trigger and strengthen transitions (van Mierlo & Beers, 2020). However, currently, learning is often a topic of interest rather than a topic of analysis. Learning is just assumed to take place (van Mierlo et al., 2020) and conceptualization of these processes is still scarce (Beers et al., 2016; Sol et al., 2018; Van Poeck et al., 2020).

Some transition authors attempt to provide an answer to what learning is in light of socio-technical transitions. Van de Kerkhof & Wieczorek (2005) propose a general conceptualisation of learning as undergoing a change in knowledge and/or action, resulting in an improvement of this knowledge and/or action. However, others argue that learning is more than the gathering of knowledge by also including remembering and unlearning (Malecki, 2010). Van Mierlo et al. (2010) argue learning happens when a change in perception about a topic takes place. This can include perceived social pressure, aspirations, belief in own capacities and an increased perception of risk and own responsibility. A broad definition of learning therefore includes changes in knowledge, action and perceptions, implying that it can occur through processes of acquiring new knowledge, but also through conversation and interaction between stakeholders (Beers et al., 2014). Similarly, van Mierlo et al. (2020) argue that learning in transitions is a process of acquiring and generating new knowledge, and of meaning-making of experiences through interaction.

Besides defining learning, there are also attempts in the literature to explain what constitutes learning and which elements or concepts are part of its definition. These contributions to the conceptualisation of learning are important starting points for the development of an analytical framework on knowledge diffusion and learning. According to van de Kerkhof & Wieczorek (2005) learning has four elements: the subjects (who learn), objects (what), results (to what effect) and process (how) of learning. Beers et al. (2016) distinguish between three elements: process, outcome and impact of learning. Quist & Tukker (2013) identify three central concepts in learning: Difference between tacit and explicit knowledge, first and second order learning, and the level of learning, which can be at the individual, organisational or societal level. Van Mierlo & Beers (2020) highlight four key characteristics of learning in sustainability transitions. They look at how those theories take into account: actor diversity and interaction, social levels, timeframe and direction of change. Similarly, Beers et al. (2019) use three boundary concepts to relate transitions to the negotiation of meaning approach, being actor diversity, process and outcomes. Implying that these three are components of learning in transitions. Last, Schäpke et al. (2017) review the use of social learning theory by looking at what constitutes it, who it considers and how it contributes to sustainability transitions.

All aspects of learning mentioned above are compared and presented in Table 5 below. Some of the elements in table 5 clearly overlap and could be considered jointly, while others are more ambiguous. Synthesizing these elements provides a starting point for the development of an analytical framework. Recurring components are the: who, what, how and results of learning. The *who* is also referred to as subjects, among whom exists a certain actor diversity. Second, is the *what* component, also termed the object of learning, which can consist of different types of knowledge. Third, the *how* component, also referred to as process, consists of how learning is happening. Fourth, is the *results* component, which according to van de Kerkhof & Wieczorek (2005) refers to what effect the learning is contributing to. However, outcome, impact and direction of change as mentioned by Beers et al. (2016) and van Mierlo et al. (2020) can also be considered in relation to this component, as they describe results of the learning process. There is discussion on the distinction between outcome, impact and process in the literature, which is discussed in section 5.6. However, to simplify the categorisation, in this thesis both outcome and impact are included in the results of learning.

Table 5: Elements of learning in transitions

	Kerkhof & Wieczorek (2015)	Beers et al. (2016)	Quist & Tukker (2013)	Van Mierlo & Beers (2020)	Beers et al. (2019)	Schäpke et al. (2017)	Suggested grouping
Subject/Who	X					X	*Who*
Object/What	X					X	*What*
Results/To what effect	X						*Results*
Process/How	X	X			X		*How*
Outcome		X			X		*Results*
Impact		X					*Results*
Knowledge type			X				*What*
Order of learning			X				*Dynamics*
Level of learning			X	X			*Dynamics*
Actor diversity & interaction				X	X		*Who*
Timeframe				X			*Dynamics*
Direction of change				X			*Results*

The order of learning, level of learning and timeframe can together be termed as the *dynamics* of learning. Answering to the call of complexity of studying learning in transitions, interactions recognised between the components are also discussed in the dynamics component.

Table 6 provides an overview of the emergent framework components and their specification. The following sections elaborate on the separate components and the corresponding literature review findings.

Table 6: Framework components including specification and the section where they are discussed in detail

Framework component	Suggested elements	Section
Who	• Subjects/Who • Actor diversity and interaction	4.2.
What	• Object/What • Knowledge type	4.3.
How	• Process/How	4.4.
Results	• Results/To what effect • Outcome • Impact • Direction of change	4.5.
Dynamics	• Order of learning • Level of learning • Timeframe • Interactions	4.6.

4.2. The 'who' of learning in transitions

The first component of interest is 'who', which concerns the actors learning in transitions and the interactions among them. Transitions are multi-actor processes and the actors involved often only meet rarely, and through indirect contact (van Mierlo & Beers, 2020). In this heterogenous and scattered group actors fulfil different roles with differing knowledge needs (Bos et al., 2013).

This makes it important to correctly identify the type of actors and their knowledge/learning needs. In the reviewed literature there are three groups of actors, which specifically receive attention in relation to learning in transitions. These are: facilitating actors, researchers and local authorities.

Several studies call for an independent organisation or government to act as a process facilitator in transition arenas and for the transfer of lessons between experiments (Brown et al., 2003; van de Kerkhof & Wieczorek, 2005). Domènech et al. (2015) even explicitly call for the involvement of a supralocal government body, at the regional and national level to fulfil this function. Governance experimentation should guide and support learning processes among the variety of interdependent actors (Bos et al., 2013). The facilitating institution should address differences in power, knowledge, resources and learning needs among these actors (Bos et al., 2013; van Mierlo & Beers, 2020). For the purpose of social and/or transformative learning, the facilitating body should also be devoted to nurture and build up feelings of trust (van Mierlo et al., 2013).

Further, there is a request for a reformed involvement of researchers. Fazey et al. (2018) state that researchers have a role to play in making research about energy transitions, transformations and climate change more actionable. Researchers could enable this through different roles, for example the role of a knowledge broker or learning expert, to help other actors better design their learning processes. Wittmayer et al. (2014) identify five ideal roles for researchers in processes of societal learning: the role of reflexive scientist, process facilitator, knowledge broker, change agent or self-reflexive scientist. Scholz (2017) argues for three possible roles of researchers: activists, catalysts or facilitators of efficient knowledge use and reflection. All three authors seem to distinguish between researchers taking an active role in providing knowledge or taking a more facilitating role and assisting others in the search for knowledge.

The role of local authorities and government actors has received attention from several authors. Von Malmborg (2007) underlines the importance of understanding the role of local authorities in regional sustainability innovation networks. Through empirical studies he finds two roles that local authorities can fulfil, the 'teacher', or the 'tutor'. The teacher is an active actor in the knowledge transfer process and holds the main body of knowledge itself, while the tutor helps companies to find suitable external sources. The tutor has a more open approach to external knowledge input, while the teacher has clear opinions and pushes these forward. Von Malmborg (2007) argues that initially taking a teacher role can provide the fundament for prolonged confidence and interaction among the actors, since it educates the actors and provides common ground. The study thereby presents interesting findings for the governance of learning processes.

The most common type of local authority operating at a lower governance scale is the municipality. Schreuer et al. (2010) recognize three roles that the municipality might have in technology learning processes: an early user, an early promotor and a funding body, or a policy maker providing long-term strategies and new legislation. Despite municipalities having prominent roles in learning processes, the authors argue that they also have limited space for manoeuvre and therefore must collaborate with various other governance levels. Heiskanen et al. (2015) discuss the role of municipalities in relation to their function of keeping people on board when it comes to learning in transitions. Especially, the

authors lift the importance of municipalities showcasing local successes and thereby inspiring and convincing other actors to take further steps in the transition processes.

Based on these insights, three groups of actors can be identified as particularly relevant for knowledge sharing and learning in transitions: facilitating actors, researchers and local authorities (most prominently municipalities). While more active and more assisting types are identified also within the categories of researchers and local authorities, the group facilitating actors refers to independent organisations or government with the pure purpose of facilitating learning processes.

Clearly, different actors might fulfil different roles in learning. This makes it important not only to identify the type of actor, as discussed above, but also the role and function of the actor.

A recent contribution by Goyal & Howlett (2020) has grouped different actors into networks, according to their primary role in the transition process. These networks are termed collective actor networks and each connect to a learning type. Goyal & Howlett (2020) identify four collective actor networks: the technology constituency, the epistemic community, the instrument constituency and the advocacy coalitions. The networks correspond to different types of learning: *"technology constituencies engage in technological learning, epistemic communities facilitate sustainability problem learning, instrument constituencies foster policy instrumental learning, and advocacy coalitions undertake political learning."* (p. 318)

Actors in the technology constituency have a *"shared interest in increasing the penetration of a technology, or a socio-technical configuration, regardless of its specific application or purpose."* (p. 313) These can be engineers, but also e.g. users and lobby groups. Members of an epistemic community are connected by their *"common interpretation of science for public policy"* (p. 314). This network of professional expertise can include scientists, academic experts and public sector officials. The instrument constituency consists of actors who facilitate new policy instruments. These are created during the invention of new policy instruments and usually last because of a shared interest in nurturing and diffusion of the policy instruments. Actors can include academia, but also business and civil society. The advocacy coalitions are *"glued together by a shared understanding of a sustainability problem as well as preference over the solution in a given policy area (policy core beliefs), even as their values or worldviews (normative core beliefs) and their positions on implementation specifics (secondary aspects) might diverge."* (p. 314) This collective actor includes mainly politically engaged actors, which also means that the core beliefs of the actors are relatively stable over time (Goyal & Howlett, 2020). While different types of actors (researchers or local authorities or civil society) can be considered part of the different actor networks, the categorization by Goyal & Howlett (2020) emphasizes that networks are not determined by the type of actor, but by their role in the transition process, which in turn defines their learning type.

The categorisation by Goyal & Howlett (2020) is however not broad enough to encompass the role fulfilled by facilitating actors which is to assist the learning processes of others with reflexive (systemic) type of learning as their objective (Manders et al., 2020). Therefore, the four collective actor networks defined by Goyal & Howlett (2020) are used as a basis for the categorisation of who learns in transitions, but expanded by adding a new collective actor network, termed the 'intermediary constituency'. Table 7 gives an overview of the five collective actor networks as concluded based on the findings in this section.

Table 7: Collective actor networks and their roles and learning types in transition processes

Collective actor networks	Role	Types of learning
Technology constituency	Technology development and diffusion	Technological learning
Epistemic community	Sustainability problem definition and framing	Sustainability problem learning
Instrument constituency	Policy instrument creation and diffusion	Policy instrumental learning
Advocacy coalitions	Problem and solution matching and implementation	Political learning
Intermediary constituency	Facilitation of required learning processes	Reflexive (systemic) learning

As argued in the beginning of this section, a correct identification of the 'who' in transition processes is essential for understanding their knowledge and learning needs but also enables an understanding for different actors' roles. The categorisation presented in Table 6 can facilitate both, and thereby increase the understanding for the knowledge and learning needs of the diverse group of actors in transition processes.

4.3. The 'what' of learning in transitions

Referring to different types of knowledge as the 'what' in transitions, authors on the one hand identify different distinctions in the categorisation of knowledge, and on the other hand, which type of knowledge is needed for the successful facilitation of a socio-technical transition.

A main distinction in the literature is between tacit and explicit knowledge. Explicit knowledge is knowledge that is written down and readily accessible, while tacit knowledge is the knowledge that is inherent in individuals. Tacit knowledge is local, sticky, context-dependent and has to be acquired through interactive learning (Morgan, 2004). It also consists of the values, worldviews and other mental models that guide behaviour and value statements. Sometimes these are guiding without individuals being explicitly aware of it. Therefore, Quist & Tukker (2013) argue that tacit knowledge has clear relations with the landscape level of the multi-level perspective in transition studies, as these are guiding principles and reinforced by the regime. This tacit knowledge cannot be easily captured in language and symbols, making it difficult to transfer.

However, it is not just tacit knowledge that requires effort to take in. Jensen et al. (2007) argue that knowledge transfer is never effortless and that explicit knowledge (for instance written down) also requires some understanding of the language to take in the knowledge. Codified knowledge that stands alone is in principle not useful without the capacity to understand it. This means, even for explicit knowledge, education and training might be necessary to enable transfer.

Besides the distinction between tacit and explicit knowledge, there is some discussion on which different types of knowledge are needed in transitions. Hjerpe et al. (2017) define systems, target, experiencing/experimenting and process knowledge as important within the Transition Management approach. In this approach, knowledge is assumed to be created bottom-up, by stakeholders creating a vision and jointly working towards it. Experiments are designed to overcome local bottlenecks and

provide time for learning, reflection and development of alternatives. Process knowledge is vital because transition management includes a transition team, responsible for guiding. Knowledge is even said to be the motor of transition management. By using SNM process characteristics, Verbong et al. (2008), analyse four renewable energies in The Netherlands. They conclude that societal, legal and commercial aspects should receive more attention, rather than purely technological learning.

In the context of transition experiments, Luederitz et al. (2017) argue that transitions should produce actionable knowledge; scientific output and context specific transition pathways to identify actions for transformational change, implying more guidance towards practical implication. This focus on normative and transformational knowledge is acknowledged by several transition scholars.

A shift has taken place in the aim of knowledge production within experiments, from a focus on system knowledge to target knowledge and transformation knowledge, to understand and transform the system to the desired state (Weiland et al., 2017). In their design for a conceptual model on local governance and up-scaling, Hoppe et al. (2015) distinguish between instrumental and transformative knowledge. Instrumental knowledge allows for horizontal upscaling, the transfer of lessons to new projects, while transformative knowledge enables vertical upscaling, which leads to changes in institutional environment. Last, van de Kerkhof & Wieczorek (2005) also support the normative focus, arguing that actors do not change their understanding if just presented with factual information, but rather that a change in insights on normative aspects is needed.

The wide range of knowledge types presented in the literature shows that there are different ways of interpreting the 'what' in learning for transitions. However, based on this overview, a more generic typology of knowledge can be identified: tacit versus explicit, social versus technical, system versus target/transformation, instrumental versus actionable/transformative, factual versus normative. The literature on transitions calls for specific focus on social, actionable, transformative and normative knowledge. For the governing bodies, especially transformative knowledge is viewed as necessary, as it could help transform the institutional environment for the sake of facilitating broader transition processes.

4.4. The 'how' of learning in transitions

The 'how' of learning relates to the learning process. The learning process can be analysed by looking at the *types* of learning, the *modes* of learning and the *organisation* through design.

In the sample of reviewed articles, four types of learning are frequently mentioned: social learning, organisational learning, interactive learning and policy learning. These most frequently mentioned types are briefly discussed below. A complete overview of the types of learning mentioned in the reviewed sample is provided in Appendix D.

Social learning is an outcome of interaction between a diverse, heterogenous set of actors. It results in a shared knowledge base and understanding, creating the foundation for joint future action (Beers et al., 2016; Bos et al., 2013; Domènech et al., 2015). According to several authors, social learning offers a promising starting point for conceptualisation of learning in transitions since social learning takes into account the diversity and complexity of actors and contexts which is inherent in a transition (Sol et al., 2018; van Mierlo & Beers, 2020). However, there is also some critique on its usefulness for studying learning in transitions. Van Mierlo & Beers (2020) argue that perhaps social learning dynamics do not provide many new insights to transition studies, because it is conceptually too

closely related to the transitions field. Moreover, several authors argue that the focus of social learning on joint future action can obstruct the development of more radical ideas for sustainability and learning through conflict (Dewulf et al., 2009; Schäpke et al., 2017; van Mierlo & Beers, 2020).

In contrast to social learning, the organisational leaning type focuses on a homogenous group of actors, with a common identity and shared practices. This is generally not the case for transitions, in which actors do not have a strong shared identity and the collaborations are of shorter duration (Beers et al., 2019).

Interactive learning is mainly discussed within the innovation systems perspective (Kamp, 2007). However, also transition scholars have used the concept to develop ideas on the geographical aspects of transitions (Coenen et al., 2012; van Mierlo & Beers, 2020) since interactive learning requires a sense of proximity and mainly concerns the transfer of tacit information through face-to-face contact. Especially in complex processes, interactive learning is relevant because one actor, whether a firm or local authority cannot have all required knowledge and skills in-house. The information has to come from different actors, which, especially in the case of tacit knowledge, makes interactive learning important (Kamp et al., 2004). Interactive learning is thereby closely related to the social type of learning.

Despite often being mentioned, authors hardly provide a definition of policy learning. The study by Borrás (2011) is the only exception in that regard but the definition of policy learning is not developed in the context of transitions (system innovation) but rather within the traditional notion of innovation (product, process innovation) and innovation policy: *"Policy learning refers to the specific process in which knowledge is used in the concrete development of policy formulation and implementation."* (p. 727) More intuitively, one could say that policy learning is any type of learning which results in a change of policy.

Next to these specific types of learning, Bos et al. (2013) argue that learning needs to be broad, reflexive and social. They define broad as creating a systemic understanding of the societal issue, reflexive as questioning the status quo of doing, thinking and organising societal issues, and social as the process of interaction and through this the development of alternative practices. Broad and reflexive learning could also be considered as additional types of learning.

In addition to the different *types* of learning, transition scholars also emphasize different *modes* of learning. Within the innovation systems perspective four modes of learning are usually mentioned: learning by searching, by doing, by using and by interacting (Cooke & Uranga, 1997; Kamp et al., 2004). The main focus is on learning by interacting, which is seen as a crucial process when it comes to learning (Cooke & Uranga, 1997). If learning and innovation is hindered, and the innovation system is slowed down, this is called a system failure (van Mierlo et al., 2013). Within the transition management approach, learning is viewed as a precondition to change.

The last part of the 'how' component, is the *organisation* of learning processes, including how to design and stimulate the desired learning processes, for which specific capacities are needed.

Bos et al. (2013) provide several design features to create social learning situations: a shared learning agenda among key participants, focus projects, an open network, distributed roles and responsibilities, multi-organisational peer groups and multi-functional learning platforms. Other scholars also support that an informal societal network should be in place to allow for social learning. Transitions should

aim at creating this network if their lessons wish to be further diffused (Bos & Brown, 2012). Based on the analysis of 20 development projects, Herrero et al. (2019) argue for three other criteria in stimulating social learning situations: *"openness of the co-construction of the research question, clarification of the normative background and balancing the power distribution"* (p. 763). Moreover, a reflexive evaluation approach is needed to support ongoing learning processes and diffusion (Schäpke et al., 2017). A last, general thing to note on these organisational conditions is that creating these favourable settings might be beneficial to learning, but that it is not a guarantee for success (Beers et al., 2014). Both bottom-up and top-down directed policies can be crucial in creating (local) learning processes (Fastenrath & Braun, 2018)

Facilitating learning processes also requires certain capacities from the facilitator and the system of actors. According to van de Kerkhof & Wieczorek (2005), the process manager has four important aspects to be aware of: commitment, fairness, transparency and competence. Besides, the system should have procedures in place that allow for learning at all levels. A diffused organisational capacity is needed in which a varied set of actors has the necessary reflective skills and the ability to communicate and create a shared understanding (for the aim of social learning) (Borrás, 2011). There is a strong need of analysing sociotechnical transitions from a systemic perspective, as sustainable innovation can only be realised through mutual learning and collaboration in the network. Improvements for learning are rarely individual, making shared leadership in transitions and the consideration of the variety of actors, to enable learning across the system, crucial (Halbe & Pahl-Wostl, 2019). Quist & Tukker (2013) argue that these networks are often particularly strong at the regional level. Making the region crucial to enable a systemic perspective and accomplish collaboration, education and effective governance of learning processes.

The findings regarding the organisation of learning for socio-technical transitions show that correctly designing learning processes can be quite complex. The facilitating institution but also the system learning should feature the right capacities across all levels. In the literature, many suggestions for the organisation of learning focus on social learning. However, besides the optimalisation for social learning processes, the reviewed literature emphasizes the general need for a systemic perspective on learning in transitions. Enabling to look at the diverse network of actors involved in transitions.

Overall, based on this review, the 'how' of learning can be studied by looking at a number of elements, including:
-   Types of learning: social, organisational, interactive, policy, broad and reflexive learning.
-   Modes of learning: learning by searching, by doing, by using, by interacting.
-   Organisation of learning: design and capacities

All these elements are strongly related and dependent on each other. The type and mode refer to how learning is taking place or should take place, while the organisation of the learning processes can enable the desired types and modes of learning to take place. Since the type social learning is very present in the studies on learning, the suggestions for successful organisation are often related to enabling social learning.

4.5. The 'results' of learning in transitions

The 'results' of learning in transitions are about the outcome and impacts of learning. Most of the findings in that area relate to the field of social learning.

Beers et al. (2014) define social learning as: *"as a process in which people align, share and discuss their ideas together, with the outcome that they develop new shared mental models, form new relationships, and develop the capacity to take collective action and manage their environment."* (p. 6) According to this definition, an outcome of social learning is the development of shared mental models, relationships and capacity to take action. Beers et al. (2016) and Bos et al. (2013) argue that social learning creates a shared understanding which enables joint future action.

There is discussion in the literature on how to draw the line between conditions, process, outcome and impacts of learning. Social learning can be seen as both a process with a desired outcome, as described above, but also as an outcome itself, through the change it achieves. While the creation of social networks and trust among stakeholders might be considered outcomes of learning processes, some authors argue that these elements are conditions for social learning to even take place (N. Schäpke et al., 2017)Actor diversity is another element that is considered both a learning process and an outcome (van Mierlo & Beers, 2020). The literature suggests that outcomes may be of different kind.

One important distinction when it comes to results is the one between soft and hard outcomes. Soft outcomes are for instance involvement and trust, while hard outcomes refer to relations and actions. Another distinction is between conceptual and relational outcomes, as used in natural resource management theory. Conceptual outcomes are about the knowledge content of social learning such as new insights and innovative solutions. Relational outcomes refer to social networks that are formed as a result of the learning process, or trust among stakeholders (Beers et al., 2016; van Mierlo & Beers, 2020). These soft and hard, or conceptual and relational outcomes link well to the definition of learning in transitions as defined in section 5.1., learning being not only about change in knowledge and action, but also in perception (Beers et al., 2014).

The literature provides no clear distinction between the terms outcome and impact. Hoppe et al. (2015) argue that outcomes of learning can also include lessons that are used to guide future conduct and decision-making, while impact is suggested to be whether a desired goal has actually been reached. However, Scholz & Methner (2020) define impact as increased capacity, commitment, and creation of momentum to put actions into practice. Both definitions show that outcome and impact are not just about obvious or measurable results, but also about what happens on the way towards the end goal.

Social learning is the most prominent field when it comes to the findings on the results of learning. Nevertheless, other fields also provide some important insights on the matter. Several of the learning modes in the innovation systems approach are discussed in relation to their outcomes. Learning by searching is said to result in new, formalised knowledge, often written in research reports and articles (Kamp, 2007; Kamp et al., 2004). The learning by doing strategy results in 'know-how', meaning tacit knowledge available in individuals, routines or practices. These kinds of skills are accumulated over time. Lastly, learning by using is also said to create 'know-how' (Kamp et al., 2004).

Based on these insights the results of learning can be identified as:
- Outcomes: soft versus hard, conceptual versus relational, actor diversity, trust
- Impacts: successful action versus capacity to take action

However, the discussion in this section has also shown that there is a lot of ambiguity between process, outcome and impacts of learning. Especially in relation to social learning these

elements are hard to distinguish, as what might be a condition for one learning process, might be an outcome for another. Actor diversity, trust and the creation of societal networks are examples of aspects which could serve as conditions for but also outcomes of learning.

Further possible outcomes include changes in relations, actions and knowledge. Importantly, results of learning, whether outcome or impact, are not just about the most obvious results, but might include all consequences that learning processes bring. As Beers et al. (2014) argue, learning is not only about change in knowledge. Learning processes might also impact the involved actors to change their views and perceptions, as well as increase capacity and commitment, becoming important conditions for future learning. To conclude, results might be of various kind and the desired results of learning are highly context dependent.

4.6. The 'dynamics' of learning in transitions

As described in section 5.1., the 'dynamics' component consists of several elements. These are the *level* of learning, *timeframe*, the *order* of learning, and the *interactions* with the other components.

Regarding the level of learning, the literature shows a diversity in findings. Most relate to the MLP levels, which are considered as the levels of learning in this analysis. Timeframe is rarely mentioned as a separate element of learning in the literature and is thus not elaborated on here. However, the element is considered in the empirical data collection, as it impacts the learning dynamics. When it comes to the order of learning, it is usually divided into three steps, which are discussed below. Interactions of other components refers to the interactions between the learning components of previous sections. While understanding the interactions fully seems to be a rather impossible task, this section discusses some obvious interaction patterns that are guiding for the empirical analysis.

When it comes to the MLP *levels* and learning, a blind spot when it comes to literature on learning beyond the niche level is identified. The reviewed sample shows a large focus on learning within niches. van Mierlo & Beers (2020) find that there is a narrow focus mainly on learning in the early phases of transitions, in and around the niche level. Beers et al. (2019)define four different loci for learning in transitions based on previous work by Raven & Geels (2010) and Raven et al. (2008): 1) the level within a local niche, 2) between local niches, 3) within the global nice, and 4) between global and local niches. An explanation of the different niche levels is provided in chapter 2.1. At the local niche level, the actors have shared values and activities and learning results in furthering of the local technology/practice. Between local niches, lessons are exchanged to create mutual learning opportunities, since the actors have different knowledge and constituencies to exchange but still share similar values. Within the global niche, actors have more varied knowledge, values and interests. At this level learning can aid in creating future visions and identifying promising new experiments. Between the global and local niche level, the actors fulfil different roles and the most promising experiments are selected which further future actions (Beers et al., 2019; Raven & Geels, 2010; Raven et al., 2008).

Especially the defined locus 4, on niche to global niche level, is argued to be rather complex (Beers et al., 2019). Here one can study how lessons learnt at the niche level are aggregated to develop the global niche (Raven et al., 2008; Seyfang et al., 2014). As introduced in the theory section, local projects can add up to shape a technological trajectory at the global niche level. However, local lessons require aggregation activities, like standardization and codification, to become generic lessons and rules and be transferred to the global niche level. These generic rules again need to be translated

back for the use in local projects, this can be done through for example conferences, workshops and journals (Geels & Deuten, 2006; Geels & Raven, 2006). These processes regarding the local and global niche, and the different loci for learning identified are represented together in Figure 3.
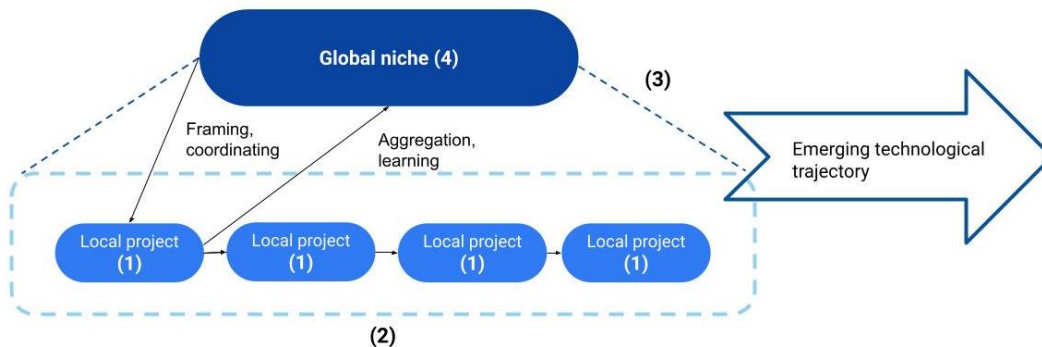
Figure 3: Learning activities between and within the local and global niche, based on Geels & Raven (2006) and Beers et al. (2019)

In literature specifically focusing on niche upscaling, the learning processes require to be broad and reflexive. Enabling learning to take place on several dimensions and learning about underlying assumptions and values creates potential for changing the frame of reference and vision towards problems and solutions (Naber et al., 2017). Hoppe et al. (2015) design a conceptual model to study how local governments can learn from low carbon initiatives for up-scaling. They provide three points of advice for local governments to improve learning processes for up-scaling: to ensure that learning practices use both instrumental and transformative knowledge (for horizontal (among niches) and vertical (niche-regime) learning), to enhance articulation of knowledge through structural project and programme evaluation, program coordinators and the creation of networks, and lastly, to value strong local political leadership with the mandate to experiment with sufficient resources.

These findings on the learning in niches are part of SNM considerations. The SNM approach looks at the content and character of learning and how this is influenced by social dimensions (Verbong et al., 2008). Borghei & Magnusson (2018) conclude that the literature on Strategic Niche Management regards aggregation as niche projects facilitating learning through knowledge sharing between different actors and organizations. Knowledge sharing is an interactive learning process that enables knowledge diffusion in a broader community. Niche aggregation is a process of cumulative learning within organizations and interactive learning between organizations. Both learning processes are important and mutually reinforcing. Thus, both aggregation activities within organizations, and networks to enable learning detached from the local space, are supportive of niche aggregation into global-niche structuration.

Moving on to the *order* of learning, a vast number of articles assumes a general distinction between 1st and 2nd order learning. Some exceptional studies even refer to 3rd order learning (Bos et al., 2013). First-order learning, also called technical, adaptive, single loop or lower-order learning, consists of searching for new solutions within the same problem definition and procedures (Brown et al., 2003). This learning can take place without a change in the underlying values, changing the perception regarding the causes of a problem, but not questioning the problem definition itself (Sol et al., 2018; van Mierlo et al., 2010).

Second-order learning, also referred to as generative, higher-order, or double loop learning (Brown et al., 2003), implies adjusting the problem definition and strategies. It involves changes in the norms, values and goals that govern decision-making and the evaluation of problems and solutions. Second-order learning is a more reflexive process, also compared to transformative learning (Pellicer-Sifres et al., 2018), which is generally agreed to be required for sustainability transitions (Naber et al., 2017; Sol et al., 2018; van Mierlo et al., 2010). Second-order learning is stressed as important, but how to achieve it remains vague. However, some studies have identified factors which could possibly influence second-order learning, most prominently broad and heterogenous social networks, where the inclusion of outsiders could stimulate second-order learning (Ceschin, 2013; Schot & Geels, 2008). Generally, people dismiss or ignore information that is not in line with their understanding. This could be overcome through exchanges with practitioners with different perspectives who contribute new and counter-intuitive information (van Mierlo & Beers, 2020). Indicators of second order learning are a shared learning agenda and dedicated points of reflection (Luederitz et al., 2017).

Third-order learning is about when the assumptions and protocols of governance become the subjects of learning. This learning should enable a change in institutional context and governing conditions (Bos et al., 2013).

These descriptions imply that the different orders of learning are important for different types of actors. While the 1st order learning might be sufficient for, for instance, installers of a new technology, it is not enough for the organizers of the transition. The network as a whole requires 2nd order learning to make a lasting and worthy impact. Last, 3rd order learning, even though only scarcely mentioned, seems especially important for the governing bodies of a transition.

Studying the dynamics of learning in transitions is a complex task. The components identified for this analytical framework aim to provide conceptual clarity but likely also have many underlying connections, which influence and relate to each other. To expand on and investigate all these interactions is beyond the scope of this research. However, several obvious *interactions* between the components can be identified for the purpose of facilitating and guiding the empirical work.

A first interaction seems to be between the 'who' and 'what' components, where the type of actor or collective actor involved in learning has a great impact on what needs to be learned. Moreover, the type of actor influences how learning needs to take place and which role this actor should take in the learning process and organisation of the learning process, an interaction between the 'who' and 'how' component. Third, the 'who' component influences the order of learning required, as 3rd order learning e.g. relates to policymakers or governing bodies, suggesting an interaction between 'who' and 'dynamics' of learning. Last, the different learning processes identified in the section on levels of learning show that up-scaling of a niche needs interactive learning, while other levels require different learning processes, thus relating to the 'how' component of learning. While some interactions might seem obvious, further research on the matter will increase the understanding not only for if interactions take place, but also why, and how.

Based on these insights, the following specification of the dynamics of learning in socio-technical transitions can be proposed:
- Level at which learning takes place: (local-global) niche, niche-regime, regime
- Order of learning: 1st, 2nd, 3rd
- Interactions between components, especially between 'who', 'what' and 'how'

4.7. Conclusions on SQ1 and analytical framework

This literature review answers the first sub-question:

"How can knowledge diffusion and learning be conceptualised in relation to socio-technical transitions?"

The answer is a proposal of a framework to study knowledge diffusion and learning in the context of transitions, bringing together a number of emergent components: who is learning, what is learned, how is learning taking place, what are the dynamics of learning and what are the results of learning.

The framework and its components are presented in Table 8, with several corresponding sub-categories. As the dynamic section implies, there are likely many underlying connections between these components that could still be unpacked. However, based on the reviewed literature, the presented analytical components capture the most important elements of learning in socio-technical transitions, making the framework a facilitating guiding tool for analysing learning processes.

Moreover, the table summarizes the specifications this chapter has identified for each sub-component. For the empirical research and answering of the main research question, however, the focus lies on the main components and sub-components.

Table 8: Analytical components, sub-components and specifications

Analytical Component	Sub-components	Specification
Who	Type of (collective) actors	Technology constituency
		Epistemic community
		Instrument constituency
		Advocacy coalitions
		Intermediary constituency
	Role of actors	Technology development and diffusion
		Sustainability problem definition and framing
		Policy instrument creation and diffusion
		Problem and solution matching and implementation
		Facilitation of required learning processes
What	Knowledge type	Tacit vs explicit
		Social vs technical
		System vs targeted
		Instrumental vs actionable (transformative)
How	Type of learning	Social
		Organisational
		Interactive
		Policy
		Broad
		Reflexive
	Mode of learning	By searching
		Dy doing
		By interacting
		By using
	Organisation of learning	Design

		Capacities
Results	Outcome	Hard vs soft Conceptual vs relational
	Impact	Action vs capacity to take action
Dynamics	MLP levels	(Local-global) niche Regime
	Order of learning	First Second Third
	Timeframe	Not specified
	Interactions (between components)	What – who – how

Chapter 5 - Knowledge diffusion and learning in the RET in Noord-Brabant

This chapter aims to provide an answer to the second sub-question:

How is knowledge diffusion and learning for the regional energy transition taking place from the perspective of the governing bodies in Noord-Brabant?

The question is explored through the components of the framework developed in chapter 5. Specifically, the framework is used to formulate interview questions. However, the findings of the interviews are not a one-on-one answer to the framework elements. There are a number of emerging themes identified based on a bottom-up coding process of the interviews' transcripts, using NVivo software, and information from the grey literature, presented in chapter 4.

The emergent categories are grouped and compared with the elements of the analytical framework. The framework therefore serves as a tool to make sense of the emerging themes while the emerging themes help verify the theoretical findings encompassed by the framework. Thus, while the primary objective of this chapter is to present the empirical findings on knowledge and learning processes in the region, the insights also provide theoretical feedback on the framework. During the bottom-up coding process a few new categories emerged, which were not identified as part of the framework, but are of relevance for the answer to the second sub-question. These additional observations are discussed in section 5.7.

As mentioned in chapter 3 and 4, the target group for the interviews consists of governing bodies active in the RES regions Noord-Oost Brabant and West-Brabant. The list of interviewees can be found in Table 3.

The chapter is structured as follows. Section 5.1. presents general information on the RET in the Netherlands. Section 5.2.-5.6. discuss the empirical findings relating to the separate framework components. In each section short feedback on the framework is provided. Section 5.7. discusses the additional observations, and finally, section 5.8. provides a summary of how this chapter has answered the second sub-question.

5.1. The regional energy transition in the Netherlands

As described shortly in the introduction, the Netherlands has developed a unique organization for the Dutch energy transition. In 2019, the Netherlands initiated the Regional Energy Strategy (RES) programme, which transcends the traditional governance levels. Within this programme, 30 regions have been defined in the Netherlands (Figure 3) which are each expected to develop a unique energy strategy. These strategies give shape to the agreements related to the electricity and built environment domains. The RES regions are responsible for researching where sustainable electricity, through wind or solar energy, can be generated and look at options for heating. The RES serves three functions: 1) it is an instrument to organize the spatial integration of the energy transition with societal engagement, 2) it is a way to ensure prolonged collaboration between all regional parties and 3) it is also a product, a final document has to be delivered in which each RES region describes their energy targets and planning (Nationaal Programma Regionale Energiestrategie, 2019). The process of the RES has had

and will have several stages. It was initiated in 2019 as part of the Dutch Climate agreement and the first, final version of the RES, RES 1.0 must be delivered by 1st of July 2021. After this a calibration moment of the document is planned in 2023 and 2025.

Regarding organisation, the RES covers different governance bodies and includes a variety of actors. As mentioned, the Dutch municipalities and provinces have been divided into 30 regions. Sometimes the province is the region, but a province can also consist of several regions. However, a region never crosses provincial boundaries. Even though the actors of the RES cross different scales, the decision-making is now located at the scale of the RES. However, responsibility for execution lies with the traditional governance levels. Regarding its organisation, a RES has three minimal requirements:

1. A RES steering group, which serves as the main organisational body of each region. The steering group consists of representatives of the municipalities, the responsible water authorities and the DSO.
2. Administrative commitment ('bestuurlijk commitment') from the provincial executive (GS), the municipal executive (B&W) and the district water boards to participate in the process.
3. A participation process to include society and business.

At the national level, the National Programme RES (NP-RES) has been created to support the separate RES regions, this organ monitors but is not responsible for the separate RESses. The NP-RES also serves as the link between the Dutch Climate agreement and the region (Dutch Ministry of Economic Affairs and Climate, 2019). This NP-RES has expressed that these regional, custom, strategies are necessary to reach the national target of a 49% CO_2 reduction by 2030 (Nationaal Programma Regionale Energiestrategie, 2019). Thus, emphasizing that according to the Dutch approach, the RES level is the most suitable for achieving regional, and eventually national, progress.

A simplified image of the organisation of the energy transition is depicted in Figure 4.
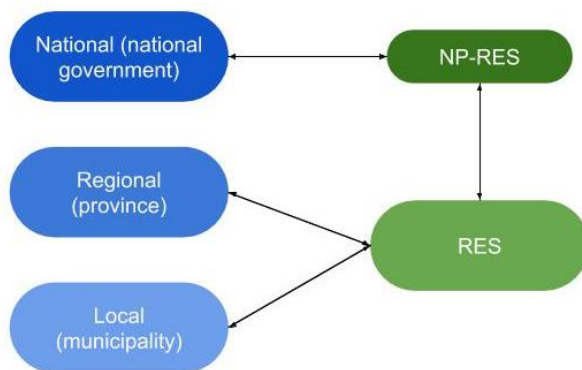
Figure 4: Dutch energy transition organisation, based on van Dijk (2020) and Nationaal Programma Regionale Energiestrategie (2019)

Within this organisation, the actors of interest are the regional/local governing bodies.

5.2. Who is learning? Perspective of local/regional governing bodies

The 'who' of learning in the analytical framework discusses the type actors in transitions, their roles and their learning needs. Five collective actor networks are identified based on the different actors' roles and needs: the technology constituency, the epistemic community, the instrument constituency, the advocacy coalitions and the intermediary constituency.

Given the focus of this research, a specific type of actor is interviewed, namely governing bodies. The results presented are based on the perspective of these actors in the regional energy transition.

Three emergent themes are identified based on the interviews. First are the tasks and responsibilities of the actors and which role they fulfil in the process. This, in turn, indicates which collective network they are part of. Second, the interviewees express the need for educating citizen councils, a type of actor which has not received attention in the analytical framework. Third, the feelings of trust among actors appears as key to learning and knowledge sharing. Trust does not receive explicit attention in the analytical framework, however it can aid the understanding of the relations between the actors. The three themes are discussed below.

Tasks and responsibilities of governing bodies

This theme discusses the tasks and responsibilities of the actors within the RES program. Since the roles and responsibilities differ depending on the interviewee in focus, four groups of actors are identified based on which actors fulfil similar roles. Within the interview sample these are: steering group members from the municipalities, the water authorities, actors from the province and process directors/project leader of a RES region. These groups in turn are identified as part of a collective actor networks based on the 'who' component of the analytical framework.

First, a reminder of the responsibilities of all those involved in the RES process. As interviewee **4** summarises it: *"(…) we are doing the RES because we signed that Climate Agreement, and to that belong a number of obligations, and within that we execute the RES. And one of those things is that two energy sources should be further developed, being solar and wind."* The RES setup has been developed to bring the decision-making closer to lower levels, which makes including municipalities, water authorities and the province a logical step to unanimously create a strategy together **(interview 4, 8)**. However, the regions as determined in the RES process do not have any authorised supervision. *"(…) we can only facilitate and make suggestions upwards, to the province and central government and downwards, to the local level. They have to really safeguard it and implement and enforce it as the competent authority."* **(interview 1)**

Regarding the municipal actors in the steering group, these are the municipality aldermen with the topic of energy in their portfolio. These actors are mainly responsible for representing, informing and educating their councils. They represent this following with a mandate in the RES steering group. *"A steering group does decide, but every responsible person within that, first has flanked that with his/her own administrative supporters of course. (…) It's not like you are able to go left, if you know that everyone behind us wants to go right."* **(interview 4)** Regarding the specifics of the task division in these steering groups, the region of West-Brabant has taken a different approach. Within the steering group it has identified a leading group, which several of the interviewed municipality actors are a part of. The actors involved in this leading group have a couple of responsibilities: *"Eventually it's officially prepared, but the leading group is supposed to, well, be able to discuss the political sensitivities beforehand and indicate where the emphasis should be and what the other administrators will find important. Before it is submitted to the steering group for the decision. And additionally, it's about keeping everyone involved (…). So, on the one hand it's preparation of decision-making and on the other it's also maintaining support from all municipalities."* **(interview 6)** In other words, this leading group seems to be taking some work away from the steering group and enables decisions on practicalities in a smaller setting.

Besides this regional choice, both regions have chosen to make the municipalities contribute to the RES goals proportionally. Especially in the region of Noordoost Brabant, where each municipality should satisfy its own renewable energy needs, this division of responsibilities is a recurring topic. *"(...) every municipality has gotten a result obligation."* **(interview 1)**. *"We have made the choice, and that's not the same in every region, but with us it is, that the local autonomy, so actually every municipality's own right of decision comes first. And that means in practice that you don't have something shared. (...) that RES is, if you want to see it in a negative light, is just the sum of everything that's decided in the municipalities."* **(interview 11)**

As interviewee 11 expresses it, the choice of letting municipalities contribute proportionally to the RES goals has a lot to do with the importance of autonomy for those municipalities. This results in actors participating primarily as local actors in the RES process, making the regional aspect become less obvious. *"From the assignment, (...) everyone picks his/her own assignment, that's not very regionally thought. So that's still going less well."* **(interview 10)** Even though this sense of autonomy seems more strongly expressed in the region of Noordoost Brabant, it is also present in West-Brabant. *"To dare to observe, in my municipality a bit less, but in my municipality a bit more and that's logical, because we have to do that for the others. To have… that deal, that cross-boundary thinking, well we are not that far yet."* **(interview 5)** So according to some, there are still some steps to be made in bringing the local and regional responsibilities closer together.

Only two members of the water authorities were interviewed, one of whom also fulfils the role of process leader. The other actor states to have more of a side-line function, as the official assignment of the RES is for the municipalities. *"We have our own role but that is different than the municipalities' role, the municipalities got the assignment to generate a certain amount of energy in renewables. That's a municipal obligation, and they are together with the RES municipalities jointly responsible to achieve this target. (...) we are at the table but the obligation rests upon the municipalities and not on the water authorities."* **(interview 14)** The water authorities are, however, present in the discussions and open to collaborate. Especially to safeguard the water systems and create mutual profits from new plans, by introducing favourable technological options **(interview 14)**. Besides, the responsibilities of the water authorities are not limited to one RES region. Usually water authorities are involved in several RES regions, because the boundaries of the RES regions are based on municipal boundaries, not on river basins **(interview 5, 14)**.

The process directors/project leader have a bigger role in guiding the RES process. The process directors are more specifically focused on the managerial process and the project leader is responsible for guiding and facilitating the process of finalising the RES document. *"(...) next to project leader we also have a process director, whom in particular, monitors that administrative process even more."* **(interview 1)** Moreover, the process director is more in-crowd, while the project leaders come from external organisations. *"(...) I'm from the government of course, so from one of the partners responsible (...). Because a project leader we equip from outside and… there are also other things, take e.g. a connection to climate adaptation, or labour market or schooling, that's also relevant. Well that plays at other tables again, and there you have, as an actor within the region, much better insight into that."* **(interview 5)**

The role of a process director differs from the one of a project leader, however, in most regions the two naturally work together and accordingly divide incoming tasks. These tasks also seem to include responsibilities for communication outside the RES region. This counts for both regional activities and (learning) activities offered by NP-RES. Other interviewed actors note that certain activities are

mainly directed to the process leader and project leader. *"Because the process supervisors, such as [name], I would think, let them collect that knowledge across regions, if there is something special (…)."* **(interview 7)**

Last, the role of the province in the RES process seems to be rather complicated, since it has two responsibilities. On the one hand, the province is a part of creating the RES strategy. On the other, it has legal authority. *"So those three parties work together in the region to come to a strategy. (…) The province also has, from her tasks a legal role considering the environment. And safeguarding this environment and taking care of some… mutual coordination."* **(interview 8)** Thus, on the one hand the province participates in the process, but on the other also has the authority to interrupt the process. The difficulty of balancing these two roles is noted by interview **1**: *"The province is also just the competent authority, also has her responsibilities, and at the same time she is a partner in a regional process, so that's super complicated, that's two hats. (…) Now they're taking more control again, so then as a partner in a regional process, you're putting on your hat of province to take control."*

It seems that the juggling of the two roles can create tension if the province does not employ the right approach and does not manage to set clear expectations. Apparently, the province is inconsistent and uncertain about the role she wants to fulfil. *"Well that caused some discussion now and then, like are you a part of the RES or are you above the RES?"* **(interview 6)** This confusion also results in some actors seeing the province as a barrier in this process and makes them doubt their usefulness. *"Yes, we are actually quite bothered by the province in this topic, I think. (…) Well at least the coordination is very lousy."* **(interview 9)** *"What I am not so satisfied about is the role of the province, Brabant, now and then. In which they set up additional rules and obstacles to bring about the energy transition."* **(interview 7)**

The inconsistency in role-taking can be appointed to a lack of coordination and transparency, but it is also partly related to political changes in Noord-Brabant. *"But I think that mainly has to do with which political colour is in the board of Brabant, and so how important you find the energy transition or not."* **(interview 6)** With a change in political management, there is naturally a change in beliefs. This inconsistency and resulting frustration are often expressed in relation to the topic of solar energy. *"You see for example in the province of Noord-Brabant that they say now, yes maybe we should hand in a motion, first on the roofs, so a little half-heartedly (…)"* **(interview 4)** This refers to first putting solar panels on roofs, rather than on fields, even though this has already proven to be too little to satisfy the energy goals. This change in policy is awarded to a change in political management by interview **9**: *"So there is a lot of discomfort. And of course, another commissioner has come, well with Forum, this debate has of course also started in a different way."* Also referring to the regional energy transition, and more specifically the production of solar energy. To conclude, the role of the province is two-sided and seems difficult to balance in this regional process, especially within the changing political dynamics.

In addition to the separate roles for each group of actors, the interviews present a call for dividing and managing actors 'different responsibilities well in the process, and thereby making use of each actors 'skills and capacities in the correct way. *"(…) that you make agreements about how you will tackle this task together and the necessary skills and tools and such, that you divide those among each other, that you don't make it a competition, but that you use each other's strengths."* **(interview 2)** Interview **5** makes a similar point about using each other's strengths, but then regarding the spatial division of renewable energies and in a way criticising the proportional division of responsibilities that has been taken within the regions. *"(…) because the power of a RES is that you see, no we have*

to… use those aspects where, let's say 'use your talents', but then in the physical domain. And that's a difficult conversation to have." (**interview 5**)

In summary, the municipal actors mainly have a representative and decision-making role. The actors from the water authorities are positioned on the side-line as the RES is a municipal assignment. They do however provide expertise and try to find synergies in possible solutions. The process directors and project leader have more of a guiding and facilitating responsibility in the process. Last, the province has a two-sided role, it is a partner in creating the RES strategy but also has legal authority to overrule decisions and facilitate.

The differences in responsibilities for each of the actor groups defined show that, even within a seemingly similar group of actors, they still fulfil a variety of roles. These are important to distinguish to understand how they function in the learning processes. As suggested in chapter five, actors in learning can be grouped in five main collective actor networks, differing by their roles and their learning objects.

In this sample, the municipality actors come from political backgrounds and are focused on problem and solution matching, which corresponds to the collective actor network type advocacy coalition. The role of the water authorities is less present and only seems to be relevant when collaborating with municipalities in their territory and for the promoting of certain technological innovations. This actor could therefore be defined as technology constituency, however it is also a provider of expertise. The process directors and project leader in the sample seem to be a part of the advocacy coalition, but also seem capable to fulfil the role of an intermediary in the learning process. The province can decide which role to take, but seems indecisive, while first having taken on a role more related to a guiding intermediary, later taking a step back, becoming a part of the advocacy coalition.

The table below summarizes the actors within the RES program, their main role and their corresponding collective actor type. While some actors seem to have clearer roles than others based on the interviews, defining their different purposes and responsibilities, not only in theory but also in practice, seems desirable. Especially the changing role of the province seems to create potential tension according to some of the interviewees. The identification of actors' different roles, as done in this section, is an important starting point in learning processes aiming for clearer responsibility division. Future research could use these suggested collective actors to identify actors with common roles and based on this make clearer distinctions in who needs to learn what, and even how.

Table 9: Grouping of interviewees' actor groups

Actor groups (present in interviews)	Roles (as described in interviews)	Identified collective actor (from analytical framework)
Municipality	Representation and decision-making	Advocacy coalitions
Water authority	Provide expertise and look for collaboration	Technology constituency
Process director/Project leader	Guide and facilitate the RES process and products	Advocacy coalitions/intermediary

Province	Partner in RES process and legal authority of environment	Intermediary > advocacy coalitions

Educating citizen councils

Despite of a focus on the governing bodies in the interviews, a recurring type of actor that is mentioned for which knowledge diffusion and learning should improve, is the general population and mainly representatives of citizen councils. *"Support from citizens, companies, but also council members, mostly. (…) Yes, but council members are the most important I think. Because that is basically the representation of the citizens, in municipalities."* **(interview 2)** Currently too much knowledge and information are said to be concentrated in one place, while it should flow more towards citizens. This information is needed for making well-considered choices. *"Well what I think helps a lot more is if we… this knowledge and what we're doing right now in these considerations, much more towards residents. I think they need it much more, so how do you get as much as possible on the same knowledge level… yes consideration level so to say, instead of it all being with us."* **(interview 10)**

The whole system of actors must learn and understand what is happening, so it is also stressed that council members should be at a similar knowledge level to make these complex choices **(interview 1)**. Whether things are approved or not is eventually up to the municipal council members. *"(…) the municipal council has the decision-making power to make the correct spatial assessment, and that is not the region, because the region is nothing in this case. And it also doesn't have a formal mandate to be able to take decisions in this regard."* **(interview 6)** Thus, rightfully many of the interviewees **(interview 1, 3, 8, 9, 12, 13)** seem to worry about these differences in knowledge levels and how those affect the decisions of the councils. *"But the big challenge we face is, how do we ensure that there is sufficient support? How do we ensure that we include everyone, and that we also know how to share that urgency and knowledge and that we are able to share it sufficiently, with people who are not yet directly involved or confronted by this."* **(interview 3)** *"(…) if I look at members of parliament and councillors, who are ultimately the supreme boss of this whole story, and I see how little knowledge they have, and they do have to make the decisions later."* **(interview 8)**

Overall, a big step is to be made in informing municipal councils well to convince them of the urgency of the energy transition. Seemingly, teaching municipal councils well also forces the managers to gather more knowledge as one of their main responsibilities is informing the municipal council. Thus, if the councils ask more questions, it also results in a bigger learning curve for the manager. This is exemplified by a statement of **interview 9:** *"(…) and my role is of course to discuss this with my council and explain it to them. So, I just have to know a little bit more than my council and then it's okay."*

In relation to the actors identified in the theory, citizens and specifically citizen councils, seem to be a new category. They do not seem to correspond with any of the identified collective actor networks, probably because they have a less prominent role in the overall transition process. However, it is important to also consider the learning needs of those confronted with a socio-technical transition, especially since their decisions have a big impact on the execution of the plans. This could be considered a new specification within the 'who' of learning.

Trust and learning

Another important theme to discuss in relation to the 'who' of learning, to understand the relations among these actors, is the feelings of trust. Feelings of trust also seem to be an important indicator for good collaboration among actors. Within the intermediary constituency role, as defined in section 4.2., one of the tasks is to build feeling of trust among actors.

The local actors often mention that there is at least a mutual understanding for each other's situation. *"(…) just being open, transparent and willing to help each other, then you'll get there. And that's what I also said in the beginning, a positive thing is the collegiality, everyone can understand everyone's situation. That helps."* **(interview 10)** However, understanding does not seem to be enough to create trust yet. Regarding the divisions of responsibilities, as discussed in the 'tasks and responsibilities' theme, interview **1** relates the proportional, local division of the RES task to feelings of distrust among the local actors. *"The… between brackets, distrust of each other, like will everyone do something, or will there soon be 1 or 2 municipalities that have to fix the whole shit for the region."* Him/her continues: *"You don't have to trust each other through and through, I mean, if we're talking about illusion. (…) But we shouldn't have distrust, when we have that we start to catch each other, or use it as an excuse to do less ourselves… we don't feel comfortable in that, then it becomes very difficult. So, we have to eliminate the distrust."* **(interview 1)**

Some actors note that creating feelings of trust can be done over time, that through collaboration and discussion trust can grow. *"So, we should also use these 10 years to gain more trust in each other, that we can solve it honestly together, that we will help each other in that. (…) if joint projects are running, if those run well that also creates trust for a future solution that doesn't have to be on the boundary of a municipality."* **(interview 3)** Acknowledging that for future challenges, the regional level could become more important, and act as a facilitator for trust-building and collaboration. Interview **7** addresses that trust can grow, if the actors can meet in facilitated settings: *"I also see a clear improvement in the connection to the water authorities and in the connection with Enexis. There are still a lot of steps to be made there, but I do see that you find each other much more easily because we are at the table together."*

A take-away from the interviews is that trust should ideally not be forced, but rather be allowed to grow over time through collaboration and interaction. Trust-building might however not always be easy, especially not between collective actor networks.

This section has illustrated that it is important not to oversimplify the categorisation of actors within a sample, since their roles and responsibilities are not always consistent with the ones of other actors in the same group. Identifying the different responsibilities of each actor and the position of this actor in the network is important for recognizing which role they could fulfil in the learning process. The interviews further show that some actor groups, citizens and citizen councils specifically, need to be added to the list of collective actors. These actors need to be further conceptualized in order to properly identify their role in learning. Additionally, the relations between actors can be further conceptualised, the aspect of trust could be a part of this.

5.3. What has to be learned?

The 'what' of learning, as expressed in the analytical framework, touches upon various types of knowledge: tacit or explicit, social or technical, system or target, instrumental or actionable/transformative, factual or normative. The knowledge needed for successful transitions is

considered to be social, actionable, transformative and normative. This section also addresses what has to be learnt by whom, relating to the 'who' component of learning.

The interviewees touched upon several broad topics when asked about which knowledge they were missing or which knowledge they thought they still needed. An overview of the expressed knowledge needs is presented in Table 10. The table also shows what type of knowledge it is according to the theoretical framework.

Table 10: Knowledge needs emerging from the interviews compared with the theoretically driven categories

Knowledge needed (emerging from interviews)	Knowledge type (identified in analytical framework)	Interviews
Process knowledge (from others)	Tacit, social, target, instrumental, factual	2, 3, 6, 7, 9
How to involve citizens and organise participation	Explicit, social, target, transformative, normative	11, 7, 3, 9
Basic technical knowledge	Explicit, technical, system, instrumental, factual	12, 4, 6, 5
Procedural knowledge	Tacit, social, target, instrumental, factual	3, 4, (7), 8
Managerial experience	Tacit, social, systems, instrumental, normative	11, 4, 5
Information on spatial planning and considerations	Explicit, technical, target, instrumental, factual	4, 6
Knowledge on concrete projects	Tacit, social, target, transformative, factual	6, 7
Insights into choices and consequences	Tacit, social, target, transformative, normative	10
Sharing experiences	Tacit, social, systems, instrumental, normative	3
Social costs and benefits analysis	Explicit, social, target, transformative, factual	5
Juridical	Explicit, social, system, instrumental, factual	5

As demonstrated in Table 10, the main topics of interest identified in the interviews are knowledge regarding process, procedures, how to organise citizen involvement and participation and the basics of relevant technology. Besides knowledge, also managerial experience and activity of sharing experiences is mentioned as important for these actors.

Sharing experiences could also be seen as a need for process knowledge: *"Yes, I think I mainly need to share experiences, so how did you approach this, gosh you're already this far, tell me, and what did you run into then. And then you look more at experiences on… managerial level or project leader level… and this is how we did this, and this is what we would have done differently in hindsight."*

(interview 3) It seems the use of sharing experiences is to gather insights into the other's process. In general, the actors requesting knowledge on process and procedures want to receive this from other actors who are in a similar stage, or preferably further. *"Actually, I have a lot of contact with the alderman in Oss, because they are further in the planning… and for example I have less contact with [name] because they… in Vught are less far than here [laughs]. So there, yes he could call me, but that doesn't help me because he's still a phase back (…)."* **(interview 7)**

Additionally, learning from the progress of others could provide new insights and inspiration for their own progress. As some of the interviewees also recognise it is difficult to know what you don't know. *"Yes, it's always good to… to know where others are at (…), sometimes you don't know what information you are missing. So that's the point, the things you miss yourself, that you actively look for yourself, but the things that could be useful and that you don't think about, you don't look for that, you also don't take the time to go through that."* **(interview 5)** This proves a challenge for the organisation of knowledge and learning.

Overall, the knowledge needs that are signalled are quite practical. The actors want to know how certain processes work and which steps to take when. Further, they want to understand the technology and spatial planning considerations well enough to make well-informed decisions. However, the knowledge does not seem to be actionable/transformative as defined in section 5.3. Their aim is not to transform the system, but rather they require instrumental knowledge, which enables the transfer of lessons between projects. This also means that the definition of 'actionable' knowledge as identified in the framework needs discussion. Based on the interviews, a suggestion is to split up the term actionable from transformative, where transformative could imply the original meaning of transforming the system and actionable could refer to practical knowledge, including process, procedural and 'how-to' knowledge. Overall, these findings stress the need for a distinction of who needs which type of knowledge, instead of identifying knowledge types that are generally important in transitions. Interestingly, also technical knowledge is mentioned as important, however not for the purpose of understanding the technology fully, but to make balanced considerations.

The interviews highlight the importance of identifying what has to be learnt by whom. Not all actors in learning processes need to learn the same things. A clear distinction is made between what civil servants within a municipality should learn and what is relevant for the administrators, the actors of interest in the interviews. Additionally, they distinguish between the knowledge needed and present within different governance levels and between governing and technical actors.

The administrators in the interview sample state that they should be careful not to learn too much. This is dependent on time and interest, but mainly on their role. *"And I also think that administrators should also primarily focus on what interests I weigh in, and we are not civil servants who have to be knowledge experts on all kinds of themes."* **(interview 10)** Although there is an interest to understand the processes relating to the energy transition, they should be careful not to take in too much information. Although they should be well-informed of the decisions and thus have a general understanding of the field, the level of detail to which civil servants must be informed compared to administrators is much higher. This counts for the general governance of these topics. *"The substantive information must, in principle, largely land and be known with the civil servants. So, when I have a research question, I sometimes have the tendency to go after it myself, but in principle, I can put that question with the civil servants."* **(interview 3)** The administrators need sufficient information on all aspects to make a decision instead of deepening their knowledge on one aspect in great detail.

Additional to the distinction made between civil servants and administrators, different governance actors have and require different knowledge. Since the municipalities should eventually execute the plans in the RES, they should have knowledge on the implementation. *"On the execution, we've said: the municipality is the first tier of government when it comes to realising the task. So, then you need the implementation knowledge of 'How do I do that smartly?', you have to develop within the municipalities."* **(interview 8)** This should not be embodied in a specific person, such as the administrators or civil servants but within the organisation of the municipality. Moreover, in general, very content-specific expertise should be left in the right places. E.g. the technical information on the capacity of the energy network should be taken from the DSO actors. *"I don't need to know everything, (…) and we often get bogged down in technical discussion about the network, for example, while you should actually say, 'Yes, Tenet, Enexis, you know about that' (…) That we leave everyone's expertise much more in its value."* **(interview 3)**

The answers by the interviews show that not only is it important to identify who needs to know what, but also which people that *do not* need certain knowledge. For example, overburdening the administrators with very specific knowledge is not beneficial. Identifying the desirable types of knowledge, and in turn who needs it to bring the learning processes forward, seem to be central steps of enabling successful learning in transitions.

5.4. How is learning taking place?

As described in section 4.4., the 'how' of learning focuses on its process. In this component the different types of learning, modes of learning and the organisation of the learning process are considered. Several types of learning are common in studying learning in the transitions field, the most common are: social, organisational, interactive, policy, broad and reflexive learning. The modes of learning refer to: learning-by-doing, by-using, by-searching, by-interacting. The organisation of these learning processes included: design, capacities and circumstances. It can be a complex task, as top-down steering is not a guarantee for success, and it is dependent on the type of learning that aims to be achieved. Moreover, certain capacities are required from the facilitator and the system that is learning.

The findings relating to the 'how' of learning are discussed here in two themes. The first elaborates on how the sample of actors usually learns, which type or mode of learning they employ. The second theme is based mainly on grey literature and provides the organisation of learning as described by the province of Brabant and the two RES regions in focus.

How are the local/regional governing bodies learning?

The interviews provide some general trends on how learning and the gathering and exchange of knowledge is taking place. First, the members of the steering group seem to learn through simple exposure to the topic, they are being confronted with new information on a topic that before was not familiar to them, foremost during meetings. *"And definitely if you're working on it every 2 weeks, like us in the leading group, and you see numerous reports and the like. Yes, then you also have the necessary knowledge yourself at a certain point."* **(interview 13)** Especially members of the leading group in West-Brabant acknowledge this **(interview 9, 13)**. Spending more time on a topic and being presented with more information expands your knowledge base. This can explain the differences in knowledge levels between these actors and citizens, since citizens are less often confronted with this

information. *"Yes, I think that is inherent, unfortunately, to this profession, because I do it full time and councillors do it on the side, so I deal with it almost every day."* **(interview 10)**

Instead of simply being confronted with information, through meetings and presentations, the actors also look for information themselves. These findings provide a better impression of how they would like to learn. The preferred approach for retrieving information seems to be through interaction. *"(...) what works much better for me is knowing the right people and being able to call and ask, gosh I have this problem right now, tell me."* **(interview 8)** Picking up the phone to call someone you know can help, but also the interaction in meetings provides opportunities to learn. *"Yes, I think especially the conversation with each other, so the conversation in the leading group, I learned a lot from that. Because what other councillors brought in and what they encountered, and then to look at it together, that has brought me a lot."* **(interview 9)**

This interaction is also enabled through their network. Often, people with a certain proximity to the actor are approached for questions. This proximity can be organisational proximity, but often also relates to geographical proximity. *"And that doesn't always feel like one region, because there is quite a big distance in between. So, there is a lot more connection with our sub-region and to Den Bosch of course, with which we simply have a lot more contacts."* **(interview 3)**

The bordering municipalities are often in contact in general **(interview 9)**. The organisational proximity refers to their civil servants, if applicable to their role, and other actors in the steering group, mainly the process director or leader, as they are also seen as responsible for the gathering of information. *"My first step is often to approach the civil servant, yes. Civil servant and fellow administrators. I have learned that you often achieve more with talking than with reading a lot of pieces."* **(interview 7)** Indeed, several interviews agree that their lines for getting information either go via fellow-administrators, their civil servants or working groups which consist of civil servants. *"We have a club of people of course, called the programme team I believe, and there we can ask all our questions, and then they figure out who they should go to, to get the right information on the table."* **(interview 6)**

A last order of proximity that seems to be discussed is political proximity. Both interview **7** and **9** state that they also engage in activities for learning through their political network. *"I also from my own party, they organise webinars and such too of course, that I also join then."* **(interview 9)** These are more general activities, but interview **7** also refers to sharing experiences with this network. *"Myself I'm from the political colour, [name], so we also have a group of [name] aldermen in Brabant, with whom we regularly exchange thoughts. About the problems and what we encounter… yes what we learned from and what we would do differently a next time."* **(interview 7)**

Besides interaction, other types of learning also take place, e.g. information is gathered through reading and listening. *"Yes, you also have the site of course. From the RES region and such, there I also retrieve information yes."* **(interview 7)** *"A lot of things I run into automatically, for example, the reports that are now also appearing nationally about the RES, I already pick those out myself and then I start reading them."* **(interview 10)**

Interview **9** states that in the beginning of the process he/she also participated in more activities related to the RET, however as time passes you also make choices on how much information you want to get and can comprehend. You could argue that in the broad, more introductory start learning can be done through presentations and reading. However, as the process progresses, the interviewees

require much more actionable knowledge, as expressed in section 5.2., which they prefer to retrieve through interactive learning. As they also develop their network over time, this becomes more doable as well. As interview **6** summarises it, to know each other is crucial in knowledge exchange: *"If you know which employees of a municipality are working on sustainability, then it's a lot easier to pick up the phone and ask : 'hey, we're working on this energy project, I think you did something similar, how does it work with you, how did you take on that process?' That stands or falls simply with 'knowing each other'."*

Organisational ambitions of province and the RES regions

The province of Noord-Brabant describes itself as an important intermediary between the national government and municipalities, by translating national ambitions to Brabant's fashion and supporting municipalities and district water authorities in the transformation of the energy system. Relating to the RES, the province aims to aid in mutual coordination of the strategies (Provincie Noord-Brabant, 2018). Province positions itself as an equal partner in the process of the creation of the RES documents. Providing substantive knowledge and expertise to make well-informed decisions, and organising the knowledge sharing within and between the 4 RES regions of Noord-Brabant. Additionally, taking responsibility for the organization of knowledge sharing between the RES, the national government and NP-RES (Provincie Noord-Brabant, 2019).

The exact steps taken by the province are not elaborated on, but the mentioned points suggest the importance of five knowledge flows for the province of Noord-Brabant. 1) The flow of factual knowledge and expertise from the province to requesting RES regions, 2) this flow from DSO to requesting RES regions, 3) knowledge-sharing within a RES region, 4) knowledge sharing between RES regions (of Noord-Brabant) and, 5) knowledge sharing between a RES region and national government and NP-RES.

The latest RES document version of Noordoost Brabant states a number of issues relating to knowledge and learning. First, it recognises that the actors in the region can learn from each other, by exchanging knowledge, data and space. Second, they recognise the need for an equal knowledge level within the RES, first of all within the organisation. Afterwards this can be communicated clearly to outside actors (RES Noordoost-Brabant, 2020). However, how these processes are organised is not elaborated on. The latest RES concept of West-Brabant also recognises the need for knowledge and knowledge sharing in two places. First, it is said that council meetings have been organised to achieve an equal knowledge level among the councils. Second, for the future collaboration in the region, they want to emphasize the sharing of knowledge and experiences between municipalities and with different stakeholders. Last, the learning experiences from (innovative) pilots are closely monitored and a focus on 'learning in practice' is expressed, especially for the heating transition. Which seems similar to the 'learning-by-doing' mode of learning recognised in the analytical framework.

As emphasized in chapter 5.4., creating the right circumstances for learning processes can be quite complex. The interviews show that a combination of learning types and modes take place and that these different, complementary, ways of learning are all important for successful learning processes.

The organisation and design of the learning processes, such as the strategy in Noordoost Brabant, can enable the desired types and modes of learning to take place. By focusing on, among other things, creating equal capacities for all actors by equalising knowledge levels. However, a strategy is no guarantee for success. The interviews show that there are still points of improvement when it comes

to interactions and knowledge exchange that might considerably aid learning processes. The 'how' of learning is clearly dependent on a lot more than the provided plan or design. The findings even suggest an additional element of how. Based on the knowledge flows recognised by the province of Noord-Brabant and the RES regions, channels for knowledge communication are an additional element recognised in the organisation of learning processes.

5.5. What are the results of learning?

The 'results' of learning component described in the analytical framework focuses on the outcomes and impact of learning, hereafter referred to as simply 'outcomes'. As discussed, there is ambiguity, especially in the social learning field, between what might be a condition for learning or an outcome of the learning process. Additionally, outcomes of learning not only involve changes in knowledge and action, but can also relate to changes in views, perceptions, increased capacity and commitment.

In the interviews it becomes clear that some outcomes of learning are more obvious than others. Knowledge is widely considered the most logical result of learning and is something that actors can control themselves. To gather and process knowledge lies at the heart of learning processes and most interviews hint at changes in knowledge as the main result of learning in their respective cases.

Outcomes relating to changes in perception are also visible. Several interviews note that through the collaboration and interaction in the RES, their vision and feelings of urgency regarding the problem have changed. *"We mainly noticed that in the beginning, when we just started with that regional energy strategy, when everyone was still searching a bit, like what is this actually, the climate agreement was not signed yet then. (…) And only during the ride I think everyone realised, oh this is really an important task (…)."* **(interview 6)** The actors in the steering groups have realised the urgency of the problem and are motivated to resolve it. This is also acknowledged by interview **14**: *"You just notice that among the managers, initially they were like: it's mandated by law and we have to do it. But now you see more and more that people also have the drive themselves to do it… to tackle it, and also aware of it."* This outcome of perception change is considered 2nd order learning, as discussed in the dynamics section. However, the mutual drive and ambition to work towards a shared goal is also considered an outcome of social learning.

At the same time, the space for change in action seems to be more limited. The governing bodies are mostly 'representatives of the population', meaning that they cannot decide on changes individually. *"Yes, well, if it's really about the decision-making, it's of course not one on one, a steering group decides, but every responsible person of course first discusses with his own administrative support. (…) It's not like you can turn left, when you know everyone behind us wants to go right."* **(interview 4)** Despite of changes in knowledge and perception having taken place among these actors, it might not have impact if the citizen councils, their support, do not agree. However, the RES organisation has also created impact in municipalities which did not have any sustainability goals. *"So, I really think that is the great added value, also in Noordoost Brabant, that a lot of municipalities, I think a majority of the municipalities, were hardly or not at all involved in this and now they are."* **(interview 10)**

Additionally, an outcome of learning in one actor group might be a stimulus for learning in other groups. *"Or the general shift that everyone considers the energy transition to be an increasingly important aspect. (…) So, I think you also just see a shift in the image forming in society, that it is a very important theme. And that also makes it more urgent, also for municipalities and*

administrators.” **(interview 6)** Societal learning outcomes, a feeling of urgency, seem to stimulate governing actors to act. This relates to the element of commitment. Realising the urgency of a matter by witnessing how other actors take it seriously might increase the commitment to act.

A conclusion to be drawn from the interviews is that while change in knowledge is an obvious result of learning, change in perceptions happens, but presumably not as visibly. As discussed in chapter 4, the results of learning processes are however not only about the most obvious or measurable results. As the interviews emphasize, learning processes can bring realisations about the importance of certain issues. Such realisations might be crucial for enabling further learning. Connecting back to the discussion regarding the difference between conditions for learning and results of learning, change in knowledge and perception can clearly be both. As interview **11** and **14** highlight, the collaboration and interaction in the RES has led to new realisations and awareness. It is rather intuitive that these changes also facilitate further collaboration and interaction, thus constituting conditions for further learning.

Changes in knowledge and perception could also be argued as connecting to increased capacity and commitment. New knowledge increases the intellectual capacity of actors to act. Change in perceptions in a positive direction might have a convincing power, increasing the commitment of actors. When it comes to change in action, the interviews show that the results are generally more limited. The mandates of different actors limit the possibilities of changing their actions when new knowledge is accumulated, even if the actors in question would wish to act.

5.6. What are the dynamics of the learning processes?

The 'dynamics' of learning in the analytical framework encompasses several elements: the levels of learning, timeframe, the order of learning and interactions between other components.

The levels of learning concern the MLP levels. Since the MLP is not used to analyse the current topic, the learning processes are not discussed in relation to the MLP here. The most prominent findings in the interviews concerning the dynamics of learning relate to timeframe and growth. The findings relating to this are discussed in this section.

The timeframe is clearly an important aspect in relation to learning needs. Different phases of the RES require different types of knowledge and information from the participants. *“And what's useful, and… yes at this moment, but that's, it's about when you happen to talk to someone.”* **(interview 5)** What might pop up as a relevant topic also depends on when you ask someone this question, as the needs are dynamic. Figuring out who needs which knowledge when can be rather complex and getting the right information to people at the right time seems important. *“(…) there is quite some knowledge, but you also have to get it to the right spot at the right time.”* **(interview 5)** In this earlier phase of the RES, there seems to be a smaller need for collaboration, as people are still busy figuring out their own organisation. *“(…) you start with a process in which you are very much in your local… setting or your regional setting, a lot of things are left to be figured out. How do you work together? How do you arrange things for example? (…) And yes, for that you don't need the other as much. (…) But now in this phase you come closer together and you can also start to learn more from each other.”* **(interview 8)** More practical questions are still to be figured out, so there is more focus on their own process rather than already looking what there is to learn from others.

One of the interviewees notes that in early phases of the RES, one of the main goals is to let everyone understand the urgency of the problem **(interview 5)**. However, in later phases, mainly the execution phase of the RES, the actors seem keener on collaborating and learning from each other. *"Well what is good is that we intend to, with the RES 2.0 as it's called, and the RES after 2030 as horizon, that then we want to take it up in a more regional way than we did now. So, that conviction lives with everyone, but I'm also thinking: First see, then believe."* **(interview 10)** When approaching this execution phase, it is expected that the actors realise the necessity for this cooperation more. These intentions of collaborating more closely in a later stage is also noted by interview **5**: *"(...) on the one hand there are different learning questions, so there is a need to learn, but there is also a real difference on several points, where the... where you have your biggest learning need. (...) I also think it helps when, well when every RES has finished its documentation and decision-making, then you have reached a point again that we're all at the same stage. Perhaps."* This emphasizes that tackling certain issues together can be complicated when regions are at different stages in the process. At later stages, however, collaboration and answering questions jointly might become more useful.

Another part of the time element relates to the feeling of urgency. *"You just notice that among the managers there was, initially they were like; it is mandated by law and we have to do it. But now you're also starting to see more that people themselves have the drive to... take it on and is also more aware of it (...)."* **(interview 14)** Simply spending time and being confronted with the issue seems to raise awareness. Moreover, time influences cohesion. As people work together longer, their collaboration naturally also grows. *"(...) if new people join, both civil servants and administrators, then you suddenly notice at what altitude we are together. And how that has grown in the past 2 years."* **(interview 1)** Regarding the time spent on the transition and how it increases cohesion and collaboration, it is good to note that regions have had different starting points for this transition. *"If you compare it to other regions in Brabant, we are, they were 1. Already much more regionally organised, and there was already a pilot project RES, so they were already working on this process for one and a half year together. So that's a big difference of course, in that respect we really started from 0."* **(interview 1)** Thus, the concept of time and its results cannot be considered in an absolute matter. *"It's also dependent on how far you're already used to working together, what you have already done."* **(interview 5)** When considering knowledge needs over different regions in time, it is important to compare these relatively and not base it solely on how long the RES process has been taking place, as previous collaborations also have an impact on this progress.

Last, the different RES phases also impact the proper timing of evaluation. It seems that it is currently too early for third-order learning, in which the assumptions and protocols of governance are the subject of learning, as outlined in table 8. When asked about whether the RES organisation is the correct structure for organising the regional energy transition, several interviewees expressed that is too early to judge this. *"I would say it's really too early to, to say, because then you would change course halfway through."* **(interview 5)** They argue that this evaluation could and should happen in a later stadium. *"(...) but in the end, there you should dare to evaluate, with about one and a half year you should dare to say; is this the correct route?"* **(interview 4)**

Interview **6** even specifically mentions that it would be good to evaluate before a next phase of the RES process is entered. *"(...) and maybe the determining of the RES 1.0 is a good time to do so. Because then also the turnaround comes from, okay now we go to ... monitoring and the programming table and again in 2 years to recalibration. I think then we would nicely, we could use that tipping point for that."* This suggests that with each phase some lessons could be learned.

Going from third- to second-order learning, this does seem to have taken place, at least among the municipality members of the RES steering groups. Second-order learning is defined as learning in which the norms, values and operating procedures that guide decision-making and actions are changed (Brown et al., 2003; van Mierlo et al., 2010). While noticing this change could be difficult in the designed study, as these norms, values and operating procedures change over time, interview **14** does make an interesting comment on this. When a political change occurred in the board of the province, the municipal actors protested this change in course. *"I thought that was a striking development, that at a certain moment together ... the people turned against [name]'s position. So that did mean that something had happened in their heads, because if he had come up with it 2 years earlier, he probably would have, some had embraced him."* Clearly, the perceptions on what is necessary in the RES process changed, as a result of time and close collaboration.

The timeframe element shows that the original element of the dynamics component relating to timeframe is actually very important to study learning in transitions, even though it is not elaborately discussed in the framework section 5.5. The timeframe of transitions shows that knowledge and learning needs are dynamic and change over time. The current phase of the process therefore has a big impact on which needs are recognised. Moreover, it has an impact on other components of the framework, such as the 'what', 'how' and the orders of learning.

Overall, this section has elaborated on findings related to the dynamics of learning, with a focus on how learning needs are impacted by the timeframe of learning. The interviews clearly confirm that learning processes are, as the component name suggests, highly dynamic. As stated in chapter 4, scrutinizing the dynamics of learning is a complex task. Nevertheless, the interviews provide with some clear patterns when it comes to the impact of timeframe on learning, highlighting that learning needs are not only determined by the role of an actor, but also by time in terms of RES phases.

5.7. Other relations to knowledge diffusion and learning in the RET

Through the bottom-up approach of the thematic analysis also several relationships/themes emerged that do not seem to relate to the components identified in the framework. However, these themes are also of interest and thus are presented here separately. They can give direction in how to evaluate the proposed framework, but this is further discussed in chapter 7. Three additional themes are discussed: the relationship between (governance) scales and learning, conditions for learning and the tools and activities offered for learning.

(Governance) scales and learning

An emerging theme from the interviews and not captured by the theoretical part, is the relation between scales and learning, mostly in relation to existing governance scales. Several topics occur within this theme. Foremost, there is a distinction considering which types of knowledge and learning needs are required at different scales, which can be explained by a variety of factors. Second, the influence of the RES organisation on learning activities can be positioned in two ways. It can serve as a useful connection between the local scale, but it also rules out connections on different scales.

One of the interviews mentions that today, perhaps the scale of providing information does not matter so much anymore. *"In the past you would say, yes, that must all be fairly limited, so not on a too large scale. I tend to think that in these times, that that scale level is not so relevant, but that it is mainly about: what is the quality and accessibility."* **(interview 8)** Indeed the knowledge should be

weighed on quality and accessibility, however, many of the interviewees do seem to stress the distinction of scales in relation to providing information and learning from each other. In total, five scales are identified: The national, the provincial, the regional (RES), the sub-regional and the municipal.

Starting on the highest level, the knowledge offer of the NP-RES is discussed, with which the interviewees are generally quite satisfied. They can provide theoretical and general information of high quality. *"That could be done nationwide, yes, yes. (...) That you can go to Den Bosch and then go to a really good lecture, I can see that. Especially if that would be about involvement and involving citizens."* **(interview 9)** However, it is useful for regional actors to also engage in discussion with those national actors, to prevent the input they provide from becoming too theoretical, with no insight on what is happening in practice **(interview 5)**.

Below the national, is the provincial level. The provincial level is viewed as closer to the ground than the national, but for some topics still considered too far away. *"The great thing is that the province has also been very active in ... setting out various tracks. So also, the ... issue of people with a small grant, energy poverty, through the 'energy for everyone' project. (...) So, we could also take advantage of that. And that is nice, especially so that ... to have that on a provincial scale. And not on a national scale."* **(interview 5)** In addition, interview **13** would find it useful to share lessons from innovative projects on a provincial level. At the same time, the province is seen as far away from the people, making the region, as defined in the RES, relatively close. *"But I do think that regional level is necessary. If we also recognize it together, because the provincial level is too far away for a lot of people. The region is already a long way away, but there is still a bit more togetherness and a connection between municipalities."* **(interview 1)**

Following the statement by interview **1**, the regional level (RES) should be more comprehensible and closely connected. However, as also discussed in the 'who' of learning, the responsibilities are often divided even lower than on the RES level. This is also acknowledged in relation to learning and knowledge creation and sharing, where a sub-regional level is often stressed. *"But if you want to get to know each other better and want to reach other when necessary, then maybe a smaller setting is convenient. (...) Yes, so I see less added value in that, then it becomes too much of a 'far from my bed' show. It always sounds very nice, but I think in practice it works better if you organise that in a smaller setting. And maybe even smaller than our region."* **(interview 6)** In response to the question of whether knowledge and learning should take place at a higher, provincial level, the actor was clearly sceptical and stressed that even the regional level is quite far away. Other actors acknowledge that in a sub-regional setting the feelings of proximity and willingness to collaborate are higher. *"And we also have a very big region, about knowledge, that's also a thing about knowledge. (...) They don't know what it looks like there. And that ... is quite difficult. It is easier to work together with your own neighbouring municipalities, because then you can comprehend it better, you also meet those people everywhere. But yes ... someone who lives on the other side of the province, yes that is more difficult."* **(interview 11)**

On the local level, the municipal level is considered. The municipal level is still seen as the main level where implementation of the plans should occur. *"So, I think that especially the preparatory work, and that keeping each other to agreements and holding each other accountable for agreements, that it is perfectly possible to do this on this scale. Ultimately, however, the municipalities themselves or in collaboration will have to implement those agreements."* **(interview 6)** Therefore, also knowledge on

the implementation processes should be focussed here. *"And next, a part of that knowledge will just have to land within the individual municipalities, to actually execute it."* **(interview 3)**

This desire for the creation of implementation knowledge on lower levels can be explained by a complexity across contexts. It is not always easy to transfer lessons between different municipalities, since they have very different preconditions. *"I think we can certainly learn from each other ... but I also think that every municipality has its own challenges and problems, in other words, Boekel, the smallest municipality, has completely different problems than Den Bosch. (...) so what can we really learn from each other? That's ... not that much."* **(interview 10)** This comment shows that very specific lessons learnt cannot easily be copied into other situations, even though they operate at a similar governance level.

The RES regions force actors to cooperate at a level they perhaps would not have deemed interesting themselves for knowledge sharing and learning, since it brings together actors from different settings. *"And that has to do with indeed geographic composition, so indeed the size of the cities, with that similar problems. And the smaller agricultural municipalities that are of course working on completely different tasks. The great thing about this energy transition is that they come together and that they also see and know that they need each other."* **(interview 1)** This setting widens their network for interaction and learning opportunities. If the municipalities indeed feel this realisation and urgency to collaborate, it could provide greater efficiency in for instance shared knowledge creation. However, currently the question remains whether the RES is employed 'regionally' enough, since responsibilities are still divided. *"You notice that every move that you try to make regionally, that it is a bottleneck. Because then it's constantly the question of: Everyone would just do their own thing, so why should we pick up X or Y regionally now?"* **(interview 10)**

At the same time, the RES region assumes all actors should be involved regionally, which sometimes causes a missing, or weaker, link to the national level. *"That's just the shakiness of when is the region the right scale. Because you are close to the implementation practice, but you miss the links there with the matters that are at national level, with Tenet and Rijkswaterstaat.(...) there is quite some knowledge, but you also have to get it to the right place, at the right time."* **(interview 5)**

Conditions for learning

Besides the above-mentioned elaborations on how learning is looked at from different components, there are also certain conditions which influence whether actors engage in knowledge sharing and learning activities. These relate to the willingness and experienced necessity for the actor to engage in knowledge sharing and learning and the availability of time.

The willingness to learn is dependent on a variety of factors. A main necessity and drive to be informed relates to the responsibilities of these actors. Since they need to inform their councils, it is important they have the right knowledge to do so. *"Eventually I need to have the debate in the municipality council, yes then a bit of knowledge is welcome. I cannot say every time to the municipality council; you have to be with the civil servants for that! It doesn't work like that."* **(interview 13)** This is an external drive for them to learn and gather information. A similar drive comes from the obligatory nature of the RES assignment. *"But also know that, talking about knowledge, also know that this is a part of the climate agreement and the agreement of Paris and that every municipality has a number of tasks, they all know that."* **(interview 11)**

However, the individual and intrinsic interest and drive felt for this energy transition, also seems to be an important indicator for the willingness to learn. *"I see it more in the, people intrinsically feel... I have to share knowledge. You have those people who are sharing everything, and those that always keep everything to themselves. I think that could be a somewhat stronger factor than whether you feel the sense of urgency or less."* **(interview 8)** Regarding the specific topics, this however could overlap with their responsibilities. Interview **9** notes that he/she finds the information on participation more interesting. *"I do read all the pieces on participation, I just find that interesting, but if I get a piece about technics, I won't read it. I don't have the time and I won't remember it anyway."* These individual interests could also intersect with the responsibilities of the aldermen, in this case.

Another influence on the necessity to learn depends on whether the person finds it useful or not. One interview clearly notes that having more and more knowledge is not a solution to the problems and decisions ahead. *"That may also have to do with the fact that I feel a little ... we must not create the illusion that the lack of knowledge, or more knowledge, will not lead to more support or better, stronger decisions etc."* **(interview 10)** Despite that knowledge on specific topics can be useful, knowledge and learning does not seem to have a value in itself. Also noted by interview **8**: *"And there is just a huge challenge I think, because what you see is that ... they find the knowledge and information very important, but that it has no value."*

Another condition for learning is the available time to spend on it. Many of the interviews express a lack of time in their work and therefore it becomes difficult to filter and find the right information. *"I run into the same problem as those aldermen and others I think run into, there is a lot of information, but it is very difficult to filter in there. You have to be able to see the trees through the forest, and you should actually have a little more time for that, yes and most people don't have that."* **(interview 11)** This doesn't only count for the governing bodies. A lack of time is also recognised among the citizen representatives of the councils. *"Well within the RES there are also a number of meetings organized for council members, but then you see that very little use is made of it by council members, sometimes there are only 1 or 2 council members from 1 municipality who go. (...) they also have to divide their time and they also have several subjects that they have to think about."* **(interview 12)**

Clearly, time pressure is felt across the organisation of the RES. It is not only felt on a daily basis, but also in the bigger picture. *"So that is an important step forward, but we now have ... 4-5 years to arrange that those places are there, that permits have been arranged, because that permit must be completed by 2025-2030. (...) Yes, it all seems very far away, 2030, but in these types of trajectories ... it is not."* **(interview 3)**

The sense of necessity to learn and enable knowledge diffusion in combination with the time pressure, results in trade-offs. *"We have to make choices daily; we will do this, we will not do this. So... let alone that people think; I'm going to sit down and look for a moment, even though that may ultimately save a lot of time, because I'm convinced of that too. But it does require a huge pre-investment without the chance of ... success. That you also find something that will help you."* **(interview 10)** The interviewee describes the balancing of what the time invest might result in and that with the search for knowledge, there is not a guarantee that the invested time also brings you something. This can mean that the active participation in knowledge diffusion and learning is not always a priority. *"Sometimes it's also very straightforward, sometimes you have a seminar and then you see in your agenda that you also have 3 other appointments that are also important. Yes, then you have to make choices."* **(interview 12)** When learning is weighed off against completing more explicit goals, likely the explicit goals receive priority. As also suspected by interview **8**: *"If you say, yeah I don't have time*

for that, because I still have to bring knowledge somewhere else, then I can imagine that a manager says: Yes nice that you do that, but first fix this, then I support that you start working with knowledge." Especially in smaller municipalities with less personnel capacity, this trade-off might have to be made.

This theme has shown that it is not only important to look at whether learning is taking place, but also at why it is or is not taking place, as the involvement in learning is also dependent on a number of key conditions. In the interviews, mainly the perceived value of increased knowledge and the time to spare to accumulate knowledge influences this involvement.

Tools for learning and participation in learning activities

Knowledge offer/infrastructure
As the grey literature review has shown, both NP-RES and the province of Noord-Brabant provide a certain infrastructure and tools for knowledge exchange and learning. An overview of these is presented, followed by the mentioning and evaluation of these as expressed by the interviewees.

NP-RES
The NP RES offers three program lines for support and clarity. Program line one relates to learning and knowledge exchange and is named 'Knowledge and support'. This line offers a variety of services, products and meetings related to five knowledge themes: 1) process and organisation, 2) spatial design and spatial interest balancing, 3) potential, data and technology (monitoring, analysis), 4) system efficiency, and 5) information about the RES and Climate Agreement.

The products of NP-RES can be accessed via the RES website (*www.regionale-energiestrategie.nl*). Additionally, on the intranet, the regions can share knowledge, documents and expertise. The related services mainly consist of activities and meetings, which are announced via the website and newsletters. On the website a page has also been dedicated to examples from practice. These can be filtered per topic. The topics are: communication, community of practice, organisation and participation, participation, council meeting, use of space, spatial integration, system efficiency and citizen representatives.

Other support products and services related to learning and knowledge exchange in the NP RES, include an expert pool and 'Peer-reviews and Community of Practice'. The expert pool offers answers to content-related questions or short-term process support. This expert pool is accessible via the RES website. The other support, in the form of peer-reviews and 'Community of Practice', is set up to enable knowledge exchange between RES regions. The NP-RES emphasizes that sharing expertise and successes between regions is very important because local successes can also be relevant to other regions (Nationaal Programma Regionale Energiestrategie, 2019). This statement, however, seems trickier in practice than in theory, as described in the theme on scales and learning.

According to the guidelines published by NP-RES there seems to be particular focus on two types of knowledge flows. First, the providing of content and process-related expertise from the NP-RES to the regional level, if requested. Second, the flow of practice, expertise and knowledge between RES regions.

Noord-Brabant

Noord-Brabant has created an online platform for professionals involved in the energy transition, the Energiewerkplaats, which can be accessed via: *https://www.energiewerkplaatsbrabant.nl/over/default.aspx*. These professionals can be active at different levels: provincial, regional and local. Currently, professionals who are involved in the energy transition can join or create a relevant working group. Within these groups, information, documents and updates can be shared. To join a working group, you can register for an existing working group on the website. The administrator determines acceptance. In case a project does not fit the current working groups, a new working group can be requested of which the founder controls new member requests (Provincie Noord-Brabant, n.d.). The website also includes information about the RES organization and the possibility for each RES to work together privately. However, it seems only RES Noord-Oost Brabant and Metropoolregio Eindhoven have utilized this possibility. Additionally, the Energiewerkplaats does not seem to be embedded in the NP-RES website. When looking for the regional information, you are redirected to separate pages and there is no mention of the shared platform.

Evaluation of knowledge offer

When asked about the tools and activities offered for knowledge exchange and learning, most interviewees have an idea of what is offered. However, the extent to which it is used differs a lot. While everybody seems to be generally satisfied with the offer, not all people find it necessary to use it themselves. *"Oh, no, no, so far I have not, I see some coming by now and then but from that, no, I have not made any use of that."* **(interview 10)** This can be partly explained by their role in the process, as some have agreed that general administrators involved in the steering group do not have to join such activities, but those are the responsibility of the chairman and process directors. *"No, because we put that with the chairman. She goes to the NP-RES, but she did complain now I believe that she has to do all of that."* **(interview 9)** This might explain why not at all participants have joined such activities, instead of it being because of a lack of interest.

Focusing on the role of NP-RES, interviewees mention it in a rather positive light. Especially the process directors and project leader mention that they used several services of the NP-RES. This is mostly done through the contact person provided from NP-RES to the region, both Noordoost Brabant and West-Brabant find this a useful way to gain and share knowledge. *"Yes, I talk [laughs], we have, from NP-RES there are contact persons. For the region South and then I call [name] and I say, I need this and this, where can I find it?! (...) Yes... then they do help."* **(interview 11)** Additionally, West-Brabant has used the service of the expert pool for a technical calculation **(interview 5)**. Overall, the facilitating role fulfilled by the NP-RES seems to be appreciated. *"Spread of general knowledge, insights, is always important. And that can be facilitated, so I find the role that the NP-RES fulfils now, I find very admirable and valuable."*

Besides appreciation for the current offer, it is also noted that there are options to provide input and ask for additional information if needed. *"No, if themes are missing then you can of course raise your hand yourself and say, can we also organise something about this theme sometime? That space is there."* **(interview 12)** This appreciation is not so agreed upon for the offer from the province of Noord-Brabant, the Energiewerkplaats. West-Brabant has quit using it because it was not in line with their needs and because of the use of other systems. *"but the province was, in that aspect still behind, with designing a good working place. (...) Now we have... different clouds and methods to share pieces and... yes that works much more effectively now, so I'm not using the Energieplaats at all anymore."* **(interview 5)** This emphasizes that there is a need for a platform such as the

Energiewerkplaats, but that it must be effective in order to be useful. In general, the Energiewerkplaats was scarcely mentioned in the interviews as an important source of information.

5.8.   Summary of the findings

This chapter has discussed the findings relating to the second sub-question:

How is knowledge diffusion and learning taking place for the governing bodies of the RES in Noord-Brabant?

The findings are based on the interviews and are discussed in relation to the framework components as presented in chapter 4, essentially answering the questions: Who is learning? What has to be learned? How is learning taking place? What are the results of learning? What are the dynamics of the learning processes? The chapter also presents additional insights provided by the interviews, beyond the scope of the framework.

How learning and knowledge diffusion is taking place among the RES in Noord-Brabant is influenced and dependent on a variety of factors.

The actors involved in the RES, even within the target group of governing bodies, fulfil a variety of roles and therefore have different knowledge and learning needs. The municipality actors mainly fulfil a representative and decision-making role, counting them as part of the advocacy coalition. This means they should engage in political learning. The water authority actors have a passive role as general members in the RES process, because the municipalities are the ones obliged to complete the RES assignment. They are considered part of the technology constituency and should therefore engage in technological learning. The process directors and project leaders of the RES guide and facilitate the RES process, making them potential intermediaries in learning processes, however they are also a part of the advocacy coalition in their task to complete the RES document. Last, the province can also fulfil both roles, intermediary and advocacy coalition, because they are part of the RES process but also possess legal authority. The interviews show that the position of the province has changed from being more guiding to become passive in the process. The 'who' also shows that the feeling of trust among the involved actors differs and needs improvement, which could happen through guidance, but also through collaboration and interaction.

An important finding of how learning is happening in the RES is that it is not sufficiently happening for all actors involved. The citizen councils do not seem to be at an equal knowledge level regarding the transition. This obstructs progress to certain plans and makes it difficult for citizens to make well-informed decisions.

Regarding what has to be learned, the involved actors (governing bodies) require actionable knowledge, preferably through interactive learning. They also recognise that different actors have different knowledge needs. A main distinction is made between civil servants, who need much more detailed knowledge and the aldermen, who want to have a general picture to make balanced decisions.

However, what needs to be learned is not only dependent on the actor, whether individual or as a collective actor. It also seems to be dependent on the timeframe and the scales considered. Learning needs are dynamic over time. Regarding scales and learning, the interviews identify five scales of

importance when considering knowledge flows and learning around the RES. These are: the national, the provincial, the regional (RES), the sub-regional and the municipal.

There are a range of tools implemented to stimulate and coordinate learning and participation. However, while the organisation of these learning processes is present, it is dependent on more. As the 'conditions for learning' theme has shown, facilitating learning is not enough. The involved actors also need to be willing to learn and have time available. Especially the element of time seems tricky for the actors of interest. Further, the tools for learning and participation need to be perceived as effective in order to be used, which is something the interviews lift as an area for improvement.

Last, the results of all these learning processes vary. While changes in knowledge and perception are taking place among the interviewed actors, there is limited space for change in action because of the roles of the actors. However, the collaboration and interaction in the RES has led to important realisations and awareness of the urgency of the transition.

To conclude, the practices of knowledge diffusion and learning encompass many different forms, conditions and outcomes. The findings also provide useful information for the evaluation of the framework and offer possible improvement points regarding knowledge diffusion and learning in the region. These points for practical improvement are discussed in chapter 6. An evaluation of the framework is provided in chapter 7, as part of the conclusions and discussion.

Chapter 6 - Suggestions for improvement of knowledge diffusion and learning in the RET of Noord-Brabant

This chapter aims to provide an answer to the third sub-question:

"How to improve the processes of knowledge diffusion and learning in the regional energy transition of Noord-Brabant?"

However, first a key question should be asked: do the processes of knowledge diffusion and learning really need improvement? Interestingly, the interviewees mention worries more often regarding other topics such as citizen support, spatial planning and lack of electricity capacity, than in relation to topics such as shared vision, interaction and learning (see Appendix E). However, rather than questioning the importance of learning, it could be argued that this conclusion emphasizes the *role* of learning. Learning is taking place with the purpose of *facilitating* the work of the governing bodies in the RES. Successful learning that results in knowledge spread and awareness might in turn mitigate other worries.

With this clarification, the aim of this chapter is to provide practical points of improvement for the situation in Noord-Brabant. The suggested improvement points are identified in the coding process of the interviews. In the analysis, potentially relevant topics were coded as 'improvements', after which their relationship to other nodes was investigated. These improvements are discussed within five themes: the value of optimism, the importance of a clear message, decreasing the difficulty of finding relevant information, the right information in the right place, and transparency and involvement of citizens.

As the suggestions for improvement do not necessarily relate to specific learning components, but rather span over several, the structure of this chapter does not follow the framework components, as in chapter 5. However, the improvements are connected to, and complemented by, the findings from the analytical framework and the new emergent themes of chapter 5. These connections are identified within each section and summarized in table 9.

6.2. The value of optimism

Several interviewees mention the value of sharing successes and best practices with others, as this does not only spread knowledge, but also motivation. Interview **14** mentions the benefits of positive framing in spreading your message: *"Well I find one of the positive developments, (...) there they brought along a landscape architect for several evenings and he/she was mainly talking about 'the new landscape' and brought this positively, so he/she didn't go into the defence of... solar panels and windmills. (...) So that's also a way to get people on board, in the sense that they'll think, hey that's a development we can support."*

The example brought forward in interview 14 illustrates a simple way of providing people with information without scaring them off, by delivering the information in a positive light. On the

contrary, it seems like providing rules and motions has a tendency of demotivating participants. *"No, mostly aim for as little as possible tricky business, and with that I mean extra motions that the province still accepts, like sun on roof…"* and *"How do we take steps forward, that you as a resident become aware of the savings, that you are going to put those solar panels on your roof. That an entrepreneur is triggered to fill his entire roof with panels. Yes, that gives me more energy than a 20-page paper document."* **(interview 7)**.

In the interviews, examples as the ones above are recurring. Based on this, a simple guideline and point of improvement could be that decreasing bureaucratic hassle and improving the focus on positive results has a favourable impact on learning processes. Optimism seems to have a value, by making actors more open to new information as well as motivating future action.

The value of sharing positive results and successes connects to several of the components of learning, most prominently 'what' and 'how'. Positive messages could be categorised as spreading tacit and normative knowledge. In chapter 5, the sharing of normative knowledge is mentioned as particularly favourable for learning processes. Further, sharing knowledge is a form of interaction between actors, and thus of interactive learning. As part of the 'how' in chapter 5, interaction is highlighted as an important facilitator for successful learning.

6.2. The importance of a clear message

Several interviewees express the need of clearer communication from higher governance levels, mainly relating to the national and provincial scale. Some interviewees argue there is too much focus on input coming from the regions, which creates an exaggeration of the bottom-up process, and leaves directions from higher levels confusing and unambiguous. *"Yes… that's my point that it could be a bit more steering, towards the regions, because right now it is very bottom-up. And bottom-up is very good, but you can also exaggerate in that, I think that's happening a bit now."* **(interview 10)** Clearer guidelines on what is expected from the regions and where whose responsibilities lie is requested, also by interview **1**: *"Yes, so I am very much in favour of bottom-up, so really very much from the perspective of what is going on, but a number of conditions must be met top-down to really facilitate that well together."*

Practically this means that setting clearer demarcations of responsibilities and conditions to reach goals would be facilitating according to the interviewees, both from NP-RES and the (Noord-Brabant) province. NP-RES requests a certain contribution from the regions, but how the regions reach this target is up to them: *"We have, the RES process is of course a bottom-up process. And… that also means that every region is allowed to make its own process and actually has to make. So that means that… to exemplify, NP-RES has made of a number of suggestions, but if you pay attention, those guidelines are not very tightly arranged. (…) So how you do that in your own process to get there, the regions can decide themselves."* **(interview 8)**

By some this is experienced as an issue, as regions can make very diverse choices and nobody holds them accountable if the total, national target is reached: *"And third is… the frameworks and really providing context to the RES. The difficulty is, (…) that nationally the race is aimed at one goal, that's the national goal. And we, in the RES we make agreements, that has also been my question nationally and those talks will continue, but what if we don't make the regional goal? And what if the national goal is still achieved then, will you do something?"* **(interview 1)** Similar comments are made about the role of the province, who is not consistent and clear in their requests.

As also stated in chapter 5, the role of the province is generally tricky in the RES process. However, regarding demarcation, a first simple step would be clearly expressing what is meant by certain statements, rather than letting the regions figure that out for themselves. *"Also, the province can (...) They can also be much more steering than they are now. Look, municipalities are still kind of alone. The government says, this our task, municipalities you do it. And the province says, and then I'm talking about province of Noord-Brabant, they say; Fine as long as there is public support. (...) And meanwhile it's also not clear what the province understands by public support, so then they bother you more than they help you."* **(interview 10)**

A lack of steering also makes finding the relevant knowledge more difficult, since there is no demarcation for the search. Additional to practical guidelines, the importance of shared visions and ambitions is recognised. Similarly as regions should have a more unified expression, it would be good for higher levels to also express a similar sound, to avoid confusion and make the topic more understandable for lower governance levels and citizens. *"On a national level, then you would like a bit more frameworks and a little more the creation of one voice, that over all layers, the government, province, water authorities, municipalities, that they express one sound, a more unambiguous sound."* **(interview 1)** Even stating that this shared vision should be the source of all knowledge spread *"Well, it's also just about the overarching story and the cohesion, the interplay of what we're all doing together. I think that should be the… the core, the general source of knowledge dissemination."* **(interview 1)** Emphasizing the importance of a shared vision over the importance of giving everyone as much information as possible.

An actor from the province does express to be working on this. *"I'm the chair of such a meeting (...), for the synergy, coordination, to see if we can, with respect for the regional colour and regional individuality, also can end up on the same level a little bit, or the same way of looking at things."* **(interview 8)** Still, there seems to a need for a more unified message from the province itself.

Additionally, an unambiguous message could prevent opponents from finding grounds to interrupt the process. As interviewee **4** notes, an inconsistent message provides opportunities for resistance. *"Yeah that is grist to the meal for those who are against, they say 'Yes you see, they don't know themselves either'. (...) if you would oblige it, that would be so compulsive, but it does not help us in any way that we ... do not have an unambiguous policy in the Netherlands. So, then I also very well understand that resistance."* This is in line with how several of the interviewees also see the use of the RES program, in which they stress an opportunity for the RES to express a shared, convincing vision, among the actors and towards inhabitants. This is summarised by interview **14**: *"I think it has mainly worked well in the sense that people are now aware of… that it is necessary. And that also means in the communication, that a RES can fulfil a very good role, also towards the inhabitants and the council members (…). I think that the communication… convincing people that steps have to be taken, that that's the most important."*

The suggestion for a more convincing and unambiguous message relates to several of the components of the analytical framework. The need for a clearer division of tasks and responsibilities relates to the 'who' and 'how' of learning and is in agreeance with the theoretical findings. Well distributed roles and responsibilities as well as a shared learning agenda can facilitate social learning processes.

This theme also very clearly demonstrates that creating a setting for bottom-up learning processes is not a guarantee for success. Both bottom-up and top-down directed policies can be important for

stimulating learning processes at a local scale. Some top-down steering from the national, provincial or RES level can also stimulate progress across all municipalities, even if there exist capacity differences at a local scale. This diffused organisational capacity is important for learning in transitions.

6.3. Decrease difficulty of finding relevant information

A recurring struggle in the search for correct information and knowledge is the abundance of available knowledge. It is usually spread out across different scales, websites and people, and some experience this as an overload of information. *"Yes, I… it's so much. It's really a web"* **(interview 1)**, *"And that's the hardest. And so offering more and more information is not the solution, no, it is mainly about you, you want to be helped to find the information you need and you do not want to get lost in the amount of information, so that's the trick nowadays I think."* **(interview 11)** This problem statement in combination with the lack of time expressed by many of the interviewees, asks for a more efficient way of finding the information and expertise that is relevant to a specific question. The interviewees seem to offer three possible outlines of solutions to this.

First, perhaps not all knowledge has to be written out, rather the knowledge could be embodied in people and spread through people and participation. *"So… some sort of broker, of 'hey I see', maybe that will help the most. Instead of a kind of database, maybe better you could have a broker whom you could call: 'Hey do you know the sustainable polder?' Just to mention something, 'Do you know a municipality in Brabant, who ran into this and that, which I'm running into now, that I could call?' That would help, yes."* **(interview 10)** This makes another person responsible for the finding of the relevant information and connects the person with a question to the right person, taking away time for searching and reading. Another interviewee argues for a similar system of embodying knowledge in people, but does not specifically mention a broker. *"I would feel a lot more… for people who join us for a day with the civil servant in [region]; gosh we are in this phase, are we still missing something? Can we do anything better? Can you come assist as an experienced team for half a day? Because we are in this phase now, come and help us for half a day. (…) let's mostly invest in those concrete projects."* **(interview 7)** This emphasizes the need of focusing on help in concrete projects, with concrete questions on the spot, rather than providing an overload of general information.

Second, the interviewees argue for certain divisions in the knowledge offered. *"(…) at least make sure that it is presented in an orderly manner, that it is offered tailor-made. So that you can search very specifically and that the information is easily accessible, that you know… yes that you can easily find useful information."* **(interview 11)** However, deciding on which divisions this knowledge offer needs to adhere to seems more tricky, as certain roles and questions overlap, and people want to learn similar things but to a different abstraction level. *"(…) but that's not always easy to distinguish because when I look at… at my administrative practice, you also see that the, suppose you have a council meeting, yes, of course you will sometimes also receive questions from council members that are very general, but sometimes also very technical and … also level of detail varies."* **(interview 12)** This emphasizes that sometimes it is hard to know in advance how much you exactly need to know or understand.

Other interviewees do provide some suggestions for divisions in knowledge offer, being: different learning styles of participants **(interview 9)**, target group or practical use of the information **(interview 11, 8)** and knowledge or experience level of participant **(interview 3)**.

Providing an option to filter the knowledge offer on such divisions can also prevent mismatches between expectations and reality. *"I do argue that we should look carefully who to invite for what because there has also been a series of… yeah lectures I believe, that was also partly supported by the province and first I thought that was really aimed at administrators who were involved in the energy transitions, but then it was also, actually meant more for council members and… yeah then I didn't participate anymore."* **(interview 3)** It is important to communicate those kinds of intentions well beforehand to prevent that participants feel like their time was wasted in a session, that they could have rather done something else. *"(…) but it constantly the trade-off of, that's one or two hours, in this case behind my laptop listening, in which I maybe, and I am curious and interested in the material, but then I learned 2 new things and… 95% of what I heard, I already heard 5 times before."* **(interview 10)** There seems to be an important trade-off to be considered between wanting to update everyone, but also being careful not to overburden people in taking in information.

Last, the benefits of presenting information in a very short and clear manner are of interest. The examples of Q&A's (questions and answers) and fold-out options on websites are mentioned. *"Well what I always find convenient is if you have… Q&A's, so… that always provides some insight, if you… on certain themes just get those sorts of… structures. That you… well that people can ask questions, those are already formulated then and also the answer to it."* **(interview 12)** The structure of Q&A's is mentioned to prevent some unnecessary searching on websites and provide answers to frequently asked questions upfront. A similar structure for simplifying the knowledge infrastructure is mentioned by offering information in small bits and providing the option to read more if you want. *"Knowledge and knowledge is also something, does knowledge always have to be worked out in 4 decimal places or is it more; 'this is how you could do it, for more information see…'"* **(interview 8)** On websites/platforms for knowledge sharing these fold-out options are easy to implement and could prevent a feeling of overload.

This theme is very clearly related to the component of 'how' on the organisation of the learning process. Although not elaborately discussed in the analytical framework, a part of this organisation is online platforms. Which the theme of 'tools offered for knowledge exchange and learning' has discussed in chapter 5. The online availability of knowledge has made many things more accessible, however there is also a risk of excess, as emphasized here. This makes the tailoring of the knowledge offer important, a question that concerns many interactions between the discussed components, as it concerns figuring out who needs to learn what, but also how this knowledge should be presented and transferred.

6.4. The right information in the right place

This improvement relates to identifying the right locations and scales for the distribution of information. This is important for both the online environment and for offline knowledge sharing.

Regarding the online environment and creating a suitable system for this, a main message relates to preventing double work. The interviewees do see knowledge sharing and learning as important, but do not seem eager to contribute to setting up new systems to enable this. If changes are to be made to the online environment, the structures in place should be exploited and improved. The expansion of a knowledge platform on the provincial level, while a platform already exists at the national level, by NP-RES, does not seem like a popular idea. *"Yes, I wouldn't find that so useful from the province I think, to make a central library then, a central knowledge base. I think if you do that well nationally, just do it well. (…) No, then you also come out of your Brabant's bubble in our case, not wrong. I*

think that the structures that are there now, that those are interesting." **(interview 1)** If more platforms exist than necessary, it will add to the abundance of work and information. *"I don't think we should do that. Because that's just the further enhancement of those regions, while it should be in the execution."* **(interview 7)**

These findings also relate to the scales and learning theme, as identified in section 5.8. in which the divisions between knowledge needs at different (governance) scales are discussed. Regarding both the on- and offline knowledge offer, these distinctions show that there might be a need for setting out global guidelines, for knowledge creation and sharing, at a higher, national or provincial level. While the practical implications and implementation of those should be figured out closer to the ground, on a regional, sub-regional or even municipal level. An actor employed by the province provides this suggestion during the interview: *"A lot is already being organised, but still there is a need to do it a smaller level. RES region or even smaller, so maybe you should go to an organisation where nationally and provincially a lot of things are bundled, found, figured out, but that the dissemination happens smaller."* **(interview 2)** How this takes place and how detailed the information on a higher level can be, remains ambiguous.

However, interview **6** provides a more practical suggestion to organise this on an even lower scale. *"Or that you think, well this is all still new to us, let's put our heads together to think about those processes together. We can all do that as municipalities individually, but maybe there are 3 municipalities with the same task and then discuss with the three of you to see how you can best tackle this and then separate again and in your own municipality then roll it out. So, it can be learning from each other, but it can also help each other to go in the right directions."* **(interview 6)** Providing guidelines for problem statements together, but figuring out the implementation within the municipality. From the national to regional level, interview **5** emphasizes that the national level cannot fully grasp the regional situation. *"If they think about it from the national level, then it becomes a very theoretical story, and then they sometimes really miss the regional practice and considerations."* Thus, as suggested by interview **2** and **6**, a distinction should be made between providing generic, theoretical knowledge at a national level or provincial level and creating more actionable knowledge at lower levels.

This improvement provides motivation for identifying which information should be created and offered where, in which case the where can relate to an online environment, but also to a governance scale. In essence, this section highlights the importance of providing the right information in the right place. In relation to the components of learning, this suggestion of improvement relates to the 'what' and 'how', as well as the scales of learning.

6.5. Transparency and involvement of citizens

Relating to the worries about knowledge levels among citizens and councils, a more active involvement of this group seems to be necessary. *"Maybe we should have… first asked the population how they see it. Before we gave our opinion about the solutions."* **(interview 13)** Besides active participation in general, the interviewees plead for more transparency towards citizens and ways to involve them in the learning process. *"(…) is the call for more transparency. (…) and rightly so, very important and impactful decisions are made. For almost, I think, a million people. So, I think that's an improvement point, of how can we also, well knowledge sessions etc. can we open those up to… all inhabitants."* **(interview 10)**

Regarding transparency, the RES Noordoost Brabant recently already initiated more opportunities for councillors to provide input and objections. *"Now they came up with, and I think that's very nice, that municipality councillors can sign up for information evenings (...) so they can submit proposals there and if a proposal, I don't know how big the majority is, but for example, gets 2/3 majority, then the steering group has to do something with it. (...) That means that people get the feeling: Look we have a direct influence on the decision-making process."* **(interview 14)** Such systems for transparency can also aid in providing learning opportunities for (citizen) councillors. Providing them with insights into the regional process, so that their information becomes more diverse than just based on their own surroundings. *"Yes, and I think that that... local, political debate, there where it actually has to happen, that that is now controlled by, 1. The issues of the day, and 2. The loud voice of inhabitants. (...) And not in the public interest, and I think that the councils, especially the regional and national perspective, that too much, that they do not have that information, or at least have insufficient information and therefore cannot make a well-considered decision."* **(interview 1)**

Making people aware of the necessity of the transition and giving them reliable information to make a balanced decision is crucial. Providing them insights into the process and rewarding progress in this is identified as important for the transition. *"Keeping up the drive, because that's the only thing that eventually leads to actual change, that it's really... carried by the people. Not just support, like okay we'll settle for the windmill, no but that the people actually see that something has to happen and will work on it themselves. And then... (...) rewarding the forerunners. Then people will join, and at some point if that's 60%, well then you simply have political, always support, even though a different political party comes or a different alderman."* **(interview 14)** This point shows the importance of getting citizens involved and educating them, because their support is needed to make actual change happen and motivate everyone to contribute to that. Regarding knowledge diffusion and learning this means providing citizens, and not just governing bodies, with ample information.

The involvement of citizens as discussed above relates to the suggestion of considering citizens as a collective actor in learning, as mentioned in relation to 'who' in chapter 5. Further, the improvement suggestion of this section relates to the 'how' component of learning, by emphasizing the need of mutual learning processes and diffused capacity throughout networks.

6.6. Summary of suggestions for improvements

This chapter answers the third sub-question:

"How to improve the processes of knowledge diffusion and learning in the regional energy transition of Noord-Brabant?"

The answer is a set of suggestions for the improvement of knowledge sharing and learning in the regional energy transition of Noord-Brabant. The suggestions are based on the interviews and supported by theoretical findings from the analytical framework. Some of the suggestions also clearly link to the new themes relating to knowledge diffusion and learning that emerged from the interviews, as discussed in chapter 5.

The suggested improvements are summarized in Table 11. The connections to the framework components and emergent themes from the interviews are shown in the right column. These are the value of optimism, the importance of a clear message, decrease difficulty of finding relevant information, the right information in the right place, and transparency and involvement of citizens.

Table 11: Improvements in relation to the presented framework components and emergent themes from the interviews

Suggestions for improvement	Related component or emergent theme
The value of optimism	- What - How
The importance of a clear message	- Who - How - Scales and learning (new)
Decrease difficulty of finding relevant information	- How - Dynamics - Tools offered (new) - Conditions for learning (new)
The right information in the right place	- What - How - Scales and learning (new)
Transparency and involvement of citizens	- Who - How

Chapter 7 - Conclusions and discussion

The aim of this thesis is to increase the understanding for knowledge diffusion and learning processes in socio-technical transitions and specifically in the context of the regional energy transition in Noord-Brabant. A further demarcation is made by focusing on the governing bodies in this process. The main research question guiding this thesis is:

How is knowledge diffusion and learning for the regional energy transition currently taking place in Noord-Brabant and how can it be improved to better facilitate the transition?

This chapter summarizes and reflects on the findings of the separate sub-questions and through this provides an answer to the main research question, presented in section 7.1. The answer to the main research question includes practical implications for the situation in Noord-Brabant. General policy implications are discussed in section 7.2. The proposed analytical framework receives a separate evaluation in section 7.3. Finally, section 7.4. discuss the limitations of the current research and avenues for future research.

7.1. Answer to the main research question

The main research question is answered based on the three sub-questions:

1. *How can knowledge diffusion and learning be conceptualised in relation to socio-technical transitions?*
2. *How is knowledge diffusion and learning for the regional energy transition taking place from the perspective of the governing bodies in Noord-Brabant?*
3. *How to improve the processes of knowledge diffusion and learning in the regional energy transition of Noord-Brabant?*

The research identifies a gap in the conceptualisation of knowledge diffusion and learning in socio-technical transitions. Therefore, the answer to the first sub-question provides an analytical framework based on a literature review of learning and knowledge diffusion in socio-technical transitions. This framework identifies five components: the who, what, how, results and dynamics of learning, as well as several sub-components.

Based on these components and sub-components, empirical data is gathered in two energy regions of Noord-Brabant: Noordoost Brabant and West-Brabant. The second sub-question is answered using this framework and focuses on the governing bodies involved in the process. The empirical findings show that the analytical framework is a convenient tool to study and present the findings. However, the empirical data also provides new insights on learning and knowledge diffusion which are not encompassed in the analytical framework, the evaluation of which is discussed in section 7.3.

In addition to the identified components, the themes of 'scales and learning', 'conditions for learning' and 'tools offered for knowledge diffusion and learning' emerge, each of which provides additional insights into how learning and knowledge diffusion are taking place in the regional energy transition.

The scales and learning theme are especially interesting in relation to the theory on the geography and regional aspects of transitions, as discussed in chapter 2. It shows that the understanding for learning in transitions can be improved by paying attention to the spatiality of the processes (Coenen et al.,

2012; Hansen & Coenen, 2015). By focusing on the regional level, it has shown that local levels can provide a place for spatial variation. However, if the focus would have been on the national level, perhaps the region would have come up as the place for variation. Overall, it emphasizes that indeed transitions unfold in a geographically uneven way (Hansen & Coenen, 2015).

These spatial variations provide some of the biggest opportunities for learning. The interviews have shown that transferring lessons and knowledge between contexts can be challenging. Nevertheless, actors seem open to learn lessons from other contexts, preferably from those who have progressed further. This conclusion is in line with the findings by Späth & Rohracher (2012), emphasizing the use of the region as a model of inspiration for other regions. Especially in a new organisation such as the RES, demonstrations of success are crucial for motivating further learning.

As stated in the theoretical foundations, Truffer & Coenen (2012) argue that using the geographical lens to study transitions can aid in identifying conditions necessary for transferring lessons from one context to another. This thesis recognizes a number of scales along which lessons can be transferred. Whether knowledge exchange takes place depends on different forms of proximity. The importance of the sub-regional level as expressed in the interviews shows the need for geographical proximity to enable transfer of lessons, which seems to be preferred over the relational proximity created in the RES organisation. Thus, perhaps the spaces identified for learning within the RET are not the same as the spaces identified for the decision-making of the RET, illustrating a distinction between geographically focused spaces for learning and more socially constructed spaces.

Last, the third sub-question provides several practical suggestions on how to improve knowledge sharing and learning in the RET in Noord-Brabant. These include recognising the value of optimism, the importance of a clear message, decreasing the difficulty of finding relevant information, providing the right information in the right place and increasing transparency and involvement of citizens.

In conclusion, these separate findings of the sub-questions can together provide an answer to the main research question. The answer to how learning is taking place is multifaceted and contains several elements, confirming that effective learning in transitions is dependent on a great number of factors. The governing bodies are learning but are limited in the outcome of these learning activities since the council members obstruct them from expressing this in action. However, changes in knowledge and perception are taking place, resulting in second-order learning among most of the governing bodies.

As stressed in the theoretical section, learning requires a systemic approach. Capacities for learning should be diffused along the network and enable mutual learning. All actors are required to participate before the learning can have a more overwhelming impact. However, that mutual learning should take place does not mean that all actors involved should have the same types of knowledge. It is important to distinguish between who should know what.

Further, the main research question asks how knowledge diffusion and learning can be improved for better facilitation of the transitions. As knowledge diffusion and learning are crucial processes to enable a socio-technical transition, incorporating the suggestions made in chapter 6 will result in a better facilitation of the transition process. However, the worries on other subjects of the energy transition, as expressed in the empirical findings, also show that resolving these improvements in relation to knowledge and learning are not a guarantee for making the regional energy transition more successful. These other worries should be addressed as well, preferably simultaneously, to enable a successful regional energy transition.

7.2. Policy implications

The introduction section calls for opening up the black box of learning, so an increased understanding can lead to suggestions for improvements and policy measures (Smit et al., 2007). Indeed, opening up this black box in the regional energy transition in Noord-Brabant has provided great insight into how knowledge diffusion and learning is taking place, leading to a number of suggestions for improvement in Noord-Brabant, but potentially also beyond.

The improvements can be useful for policy makers aiming to optimize the knowledge diffusion and learning processes in the regional energy transition and better facilitate this transition. An important implication for policy is the appointment of a suitable facilitator of these learning process, termed intermediary constituency in this thesis. This intermediary should nurture feelings of trust and address differences in power, knowledge and resources among the actors (Bos et al., 2013; van Mierlo et al., 2013; van Mierlo & Beers, 2020). This makes it important that the facilitating actor has a favourable or neutral position in the network. Additionally, the facilitating actor should provide a platform to showcase successes from other contexts, both locally and regionally.

Next, it is important to be sensitive to the traditional governance scales playing in this RES organisation. The municipalities are still in charge of the execution of the plans and in most cases greatly value their autonomy. Although some wish to collaborate more on the regional scale, it often remains rather challenging. Therefore, also knowledge diffusion should not only happen at a regional scale, but should also be sensitive or adapted to the local context. On the local level, there still exists a great variety when it comes to progress and capacities.

Third, the activities regarding knowledge diffusion and learning should never seem to take too much time for an actor. The amount of time available is already constrained and other worries regarding the transition receive more priority. This makes it important to distinguish knowledge and learning needs on a variety of factors, foremost by identifying the role of the actor in the transition. Additionally, the role of the province and NP-RES should be evaluated, mainly in making a trade-off between allowing bottom-up processes and demarcating the process better. The first might enable the local actors to gain a lot of knowledge very fast (Matthijsen et al., 2021; van Dijk, 2020) however there is also the risk of overburdening the actors involved and decreasing their willingness to learn in later stages.

Finally, the opportunities for involvement and participation of citizens should be evaluated, mainly council members. Currently, a lot of knowledge seems to be concentrated within the organisers of the RES, while they need the citizen support to execute the plans. Therefore, the involvement of citizens should be reconsidered. However, also taking in mind the above implications regarding time constraints and correct demarcation of the knowledge offer for this actor.

7.3. Framework evaluation

A main contribution of this research is the development of an analytical framework to study knowledge diffusion and learning within socio-technical transitions. In guiding the empirical research, it has proven useful for collecting data on the processes of knowledge diffusion and learning in practice. While there are probably many underlying connections and ambiguities on what to position in which component, it does provide a lens for researching and studying learning. Moreover, if used more frequently, it could provide a starting point for the streamlining of the research.

Some notes should be made on the evaluation and possible improvements of the proposed framework. First, as mentioned, the positioning of the elements among the components can be debated, as also several interactions of the components are recognised. Second, the findings of chapter 5 suggest the addition of several components and sub-components to the framework. Table 12 provides an overview of the proposed framework, including the original sub-components and specifications. In green, a number of additions to the framework are proposed, as based on the empirical findings in chapter 5.

Foremost the incorporations are related to the other relations identified in section 5.7. These include governance or geographical scales in relation to learning and how conditions like the willingness and time constraints influence learning. The additional theme of tools offered could be more naturally grouped under the 'how' of learning, as this also incorporates organisational aspects.

Further, working through the table from top to bottom, within the 'who' component a specification of collective actors is added, namely the collective actor of citizen support. While the previous collective actors defined were actively involved in the transition process, through policy, political or technical motivation, the citizen support actors will usually be more external. However, educating them on the sustainability problem and decisions to be made is crucial for enabling the transition. Also, a new sub-component is suggested, termed 'relations between actors'. The actors do not operate in isolation and the relation to other actors impacts learning processes. In the empirical findings especially feelings of trust emerged as an important topic, which is therefore added as a specification.

Regarding the 'what', the empirical findings suggest an alteration in the knowledge type specifications. Initially, instrumental knowledge was put next to transformative/actionable knowledge. However, the empirical findings suggest that transformative and actionable knowledge should be split up. Here, transformative knowledge refers to knowledge which enables horizontal learning, between projects. Actionable learning, on the other hand, refers to practical knowledge, 'how-to' and knowledge which can immediately be applied to a new context. Therefore, actionable knowledge is the opposite of purely theoretical knowledge.

The 'how' of learning already encompassing a broad range of elements, only receives a small iteration. The tools offered for learning, for instance in the shape of an online platform, are added as a specification of the organisation. Additionally, the organisational ambitions of Noord-Brabant and the regions showed that specific knowledge flows are identified. These knowledge flows were identified as knowledge communication channels and added as an additional specification of the organisation of learning. The specification then refers to the recognised communication channels between actors which enable knowledge sharing.

The 'results' component does not receive a new iteration, leaving the ambiguity between process, outcomes and impact open. The empirical findings emphasized this overlap rather than clarifying it.

Within the 'dynamics' of learning, the sub-component of timeframe can be specified. The empirical findings brought a lot of attention to the timeframe of learning processes and especially how learning needs are dynamic and change over time. Studying the timeframe of learning can be done by looking at the specifications of phase and urgency.

The 'scales' of learning is a new component to the framework. Based on the empirical findings it is suggested to include governance scales, with the specification of the five levels identified in the

interviews. However, it is important to note that especially these findings might be context-dependent and not suitable for generalisation into the framework. The context of the RES is embedded in these governance scales, making it logical that these come up. However, other contexts might focus on geographical scales rather than governance scales. To make a general proposition on the matter, further research is needed.

Last, the 'conditions' for learning are added to the analytical framework as a separate component. The conditions, based on the empirical findings, include the sub-components of willingness and time to learn. The willingness sub-component also includes suggestions for specifications, however the aspect of time seems more intuitive and is therefore not further specified. However, it is important to note the distinction between 'time' and 'timeframe', as part of dynamics. Therefore, perhaps a better term would be 'time available'.

Table 12: Framework evaluation

Analytical Component	Sub-components	Specification
Who	Type of (collective) actors	Technology constituency Epistemic community Instrument constituency Advocacy coalitions Intermediary constituency Citizen support
	Role of actors	Technology development and diffusion Sustainability problem definition and framing Policy instrument creation and diffusion Problem and solution matching and implementation Facilitation of required learning processes
	Relations between actors	Feelings of trust
What	Knowledge type	Tacit vs explicit Social vs technical System vs targeted Instrumental vs transformative/~~actionable~~ Theoretical vs actionable
How	Type of learning	Social Organisational Interactive Policy Broad Reflexive
	Mode of learning	By searching Dy doing By interacting By using

	Organisation of learning	Design Capacities Enabling tools Knowledge communication channels
Results	Outcome	Hard vs soft Conceptual vs relational
	Impact	Action vs capacity to take action
Dynamics	MLP levels	(Local-global) niche Regime
	Order of learning	First Second Third
	Timeframe	Phase Urgency
	Interactions (between components)	What vs who vs how
Scales	Governance scales	National Provincial Regional Sub-regional Local
Conditions	Willingness	Feeling of necessity Personal motivation Perceived usefulness
	Time	n/s

The fact that the theory was not all encompassing could provide reason to assume that perhaps the conceptualisation of knowledge diffusion and learning in transitions should be approached differently. As the theory proves short on providing guidance, perhaps practice should be used a starting point for defining learning and knowledge diffusion in transitions instead. Such an approach would serve the complexity of the field.

Overall, these findings invite future research to use the proposed framework in new settings and provide further suggestions for optimisation.

7.4.   Limitations and future research

The research provides interesting and relevant findings on knowledge diffusion and learning in socio-technical transitions. However, some limitations to the research should be acknowledged and departure points for future research recognised. The limitations are discussed regarding the theoretical aspect and the empirical part. The framework evaluation is discussed above.

Regarding the theoretical limitations, a point of complication for this thesis has been the explorative nature of the research. Since the conceptualisation of learning was insufficient and even more limited information was available on learning in transitions in relation to the regional scale, a very broad

outlook was chosen to enable conceptualisation of knowledge diffusion and learning. This approach might have been too ambitious for the conceptualising of a field that is still in development. The final framework design shows the wide range of factors involved in learning in transitions. Even though there is a call in the existing literature on conceptualisation, there is also a call for the better defining and decreasing of ambiguity in studying learning in transitions. This could have been addressed by narrowing the research. For instance, an existing field of learning could have been used as a lens to study learning in the regional energy transition. Second, one of the transition-related frameworks could have been employed to provide more directives for the research, for example focusing on the functions of technological innovation systems or the MLP dynamics, as shortly discussed in the theoretical foundations chapter.

The regional delimitation of the research and how this has been employed also provides some limitations to the research in general. In this thesis, the regional setting is sketched and a framework for studying knowledge diffusion and learning in socio-technical transitions is proposed. However, the two paths do not intersect much. Rather, the framework is tested in a regional setting, as argued in the introduction and theory chapter. As a result, this thesis has slightly touched upon the emerging field of geography of transitions, however rather in an instrumental way to support the decision for focusing on the regional level rather than adding many new insights.

The emergent theme of scales and learning as found in the interviews provides an interesting starting point for researching knowledge diffusion and learning in relation to traditional and non-traditional governance scales. However, this finding can also be considered place specific. Future research could make an effort at combining these paths and perhaps incorporating this regional level better, since a risk of emphasizing singularities found in specific places is that differences are merely established but not unpacked (Hansen & Coenen, 2015). Moreover, conceptualising and studying the variations of the niche and regime at this regional level was out of scope as the focus was on contributing to the learning in transitions field. Future studies could elaborate on the use of a multi-scalar MLP perspective in studying the current energy transition and the process of knowledge diffusion and learning within this.

Several limitations should also be noted in relation to the empirical part of the research. First, the interviews focused on the governing bodies, based on their new positioning in the regional energy transition and a call from the ORAKLE project. However, as stressed in the 'how' of learning, a systemic approach for studying learning in transitions is crucial. In the scope and timeframe of this thesis, a decision has been made to focus on a specific group of actors. Expanding this scope to a more diverse set of actors could greatly benefit the findings. A first suggestion is the inclusion of citizen council members, to understand what knowledge and learning types they need to make well-informed decisions. Second, as this research focused on the more political, managerial side of the process, it would be interesting to expand this to also interviewing the people working more on the content. The civil servants are often referred to in the interviews.

The intended focus of the research was on regional actors, whom in this thesis are the actors involved in the RES decision-making process. However, in practice, because the goal was to talk to governing bodies, several of the actors the thesis ended up focussing on were also local actors, namely municipality representatives. Even though they were interviewed about their role in the regional, RES, process, their background is in the local sphere, making the regional aspect maybe less present than anticipated as they represent local needs within the regional process. In combination with the fact that many of the municipality representatives seem to lean strongly on their representative role in the

process, shows that perhaps the role these actors fulfil in the RES process is not so new to them as anticipated in the introduction. Instead of a limitation of the research, this could also indicate that the regional level as artificially created in the Netherlands through defining the RES regions, rather results in local actors participating in a regional process than creating regional actors.

Focusing on the research design of the empirical aspect, a comparative case study was performed. Two cases were identified which were said to have dissimilar characteristics to enable a varied representation of the Noord-Brabant region and enable between-case analysis. However, in the presentation of the empirical findings these differences were not treated as elaborately. Mostly because the regions ultimately did not show great differences in their approach. If differences occurred these were noted, but it did not lead to an elaborate between-case analysis as anticipated in the methods section.

As also recognised in the timeframe element in chapter 5, the learning needs of these actors are dynamic over time and several of the learning processes bring results across time. Therefore, the results aspects of learning are slightly hard to measure. Changes are hard to identify if there is no baseline to compare. A longitudinal study would be more appropriate for that.

Last, in relation to the empirical aspect, the qualitative nature of the research provides some limitations as it is subject to interpretation by the researcher. This counts foremost for the interview findings, in which both the researcher and interviewee guide the discussion and the interpretation of the findings is also greatly influenced by the researcher. However, this is partly compensated by triangulation of the findings based on ORAKLE meetings and grey literature.

There also some suggestions on further research to be made in relation to the analytical framework, which has received an evaluation in section 7.3. An interesting path could be to further research the complex role of the intermediary in learning processes. Additionally, the intersections of the geography of transitions and learning can use further research.

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Methods.

Appendices

Appendix A: Informed consent form

Researcher	Mieke van de Veerdonk
Organisation	Eindhoven University of Technology
Project	Master thesis Innovation Sciences
E-mail	m.m.a.v.d.veerdonk@student.tue.nl
Telephone	0642060990

Thank you for agreeing to participate in this study. This form details the purpose of this study and your rights as a participant. This interview will be used for the research that I am doing to write my master thesis and obtain my master's degree, in the study Innovation Sciences at the Eindhoven University of Technology. I am writing my master thesis on knowledge diffusion and learning in the (Dutch) regional energy transition. You have kindly been requested to participate in this study due to your position in the organisation of the regional energy transition in Noord-Brabant.

The purpose of this study is:
- To gain an understanding of the organisation of the energy transition in Noord-Brabant at the RES level
- To explore the activities regarding knowledge sharing and learning at this level
- And, to possibly provide suggestions for improvement of the organisation of knowledge sharing and learning in the regional energy transition

Regarding data collection and voluntary participation:
- Your participation will be anonymous and will be stored cautiously.
- This interview will be recorded using the online meeting tool and an audio recorder to help me transcribe and document the interviews afterwards. Direct quotations may be used derived from these interviews, but these will be kept anonymous.
- The recording will only be heard and seen by me for the purpose of this study and will be destroyed after the interview has been transcribed.
- You have the right to withdraw from the study at any time. In case you choose to withdraw from the study, all your information (including recordings) will be destroyed and will not be included in the research.

You are welcome to ask questions or raise concerns at any time about the research, method
or questions that I am asking. Please feel free to contact me at the contact details listed above.
The insights from this interview will be used to write a research report. If you wish, this report can be sent to you after the completion of the study, which is expected to be February 2020. You can indicate by email or during the interview if you wish to receive the report.

By signing this form of consent, I acknowledge that I, _____, have read and understand the above information and agree to participate in this study.

Date: Date:

Signature interviewee: Signature interviewer (Mieke van de Veerdonk):

Appendix B: Interview guide

	Dutch	Components
	1. Wat is uw positie in de RET in Noord-Brabant en welke rol voert u daarvoor uit? 2. Hoe is deze rol bij jou terecht gekomen en wat vind je hiervan? 3. Hoe vind je dat het proces voor het organiseren van deze RET tot dusver is verlopen? 4. Wat is er goed verlopen? 5. Zijn er ook problemen die je bent tegen gekomen? 6. Heb je het gevoel dat het RES level het juiste uitvoeringslevel is voor de RET? 7. Heb je het gevoel dat je de juiste kennis/middelen tot je beschikking hebt om je huidige rol in deze transitie te vervullen? 8. Weet je welke (type) kennis je aanvullend nodig zou hebben?	• *Introduction* • *Who* • *What*
	1. Verbind je met andere actoren om kennis te delen? 2. Welke kennis ben je momenteel aan het verzoeken/delen met andere actoren? 3. En hoe? (gebeurt dit in face-to-face meetings/mail/online)? 4. En hoe vaak? 5. Als je dit doet, ervaar je dit als waardevol? Wanneer is het wel en niet waardevol, verschilt dit per kennis, actor, situatie? 6. Zo niet, denk je dat het wel waardevol zou kunnen zijn (en waarom, krijg je hieruit een verandering in kennis, actie of inzichten)? 7. Heb je het gevoel dat kennis delen een belangrijk aspect is in de RET en waarvoor zou het nuttig kunnen zijn?	• *What* • *How* • *Dynamics* • *Results*
	1. Met welke anderen actoren van de RET heb je (voornamelijk) contact? 2. Wat is jouw verwachting van deze andere actoren en voldoen ze aan deze verwachtingen? 3. Weet je wie je moet aanspreken voor welk onderwerp/vraag? Zou dit vergemakkelijkt kunnen worden, hoe kom je hier nu achter? 4. Wat denk je dat andere actoren van jouw rol verwachten?	• *Who* • *How* • *Dynamics*
	1. Heb je het gevoel dat de betrokken actoren een vergelijkbare visie op de RET hebben? En wat betreft de urgentie hiervan? (en wat is jouw visie) 2. Denk je dat deze voldoende zijn afgestemd om interactie en van elkaar leren mogelijk te maken? 3. Wat betreft kennisniveaus, denk je dat er behoefte is aan (basis) kennismodules om het kennisniveau te verhogen en een gelijke taal van spreken te hebben? 4. Wat zijn voor jou belemmeringen om kennis te delen of te leren? Vertrouw je de andere actoren voldoende om informatie en hulp van hen te vragen? Verschillen deze gevoelens van vertrouwen per actor? 5. Hoe veel tijd ben je bereid te besteden aan het verzamelen van kennis? En ben je ook bereid hier mankracht en financiën aan te wijden? 6. Heb je liever zelf alle kennis in huis of te weten 'bij wie je moet zijn'?	• *How* • *Results*

	Dutch	Components
	1. Heb je het gevoel dat je veel leert van de andere actoren betrokken in <bestuursorgaan waar ze bij betrokken zijn>? 2. Zijn er evaluatiemomenten ingebed? 3. Heb je vaker interactie met andere actoren in formele of informele omgevingen? Wanneer heb je het gevoel dat je het meest van zo'n interactie leert? 4. Heb je deelgenomen aan activiteiten specifiek om nieuwe kennis/vaardigheden te leren? Vond je deze nuttig (en waarom)? 5. Aan wat voor activiteiten zou je hiervoor deel willen nemen?	• *Who* • *How*
	1. Welke instrumenten/platforms worden momenteel aangeboden om kennisdeling en leren in staat te stellen? 2. Ben je betrokken bij werkgroepen vanuit NP-RES? 3. Gebruik je deze en ben je blij met het huidige aanbod? Zijn er functies die je mist? Wat zouden deze zijn? 4. Heb je nieuwe kennis/informatie vergaard via deze instrumenten? 5. Hoe zou je kennisdeling en leren graag georganiseerd zien voor de RET? En op welk level zou dit moeten plaatsvinden (lokaal, RES level, regionaal, nationaal)? 6. Zie je de meerwaarde van een gezamenlijke kennis- en leeragenda Brabant breed of per RES regio? 7. Welke onderwerpen/thema's zouden hier prioriteit hebben? 8. Heb je nog andere suggesties wat betreft de organisatie van de RET en specifiek de kennisdeling/leerprocessen hierbinnen? 9. Zijn er ook punten tot dusver binnen de organisatie van de RET waar je erg trots op bent?	• *How* • *Results* • *What*

Appendix C: Articles included in systematic literature review

Authors	Title	Year	Cited by
Cooke P., Uranga M.G., Etxebarria G.	Regional innovation systems: Institutional and organisational dimensions	1997	1134
Jensen M.B., Johnson B., Lorenz E., Lundvall B.A.	Forms of knowledge and modes of innovation	2007	816
Schot J., Geels F.W.	Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy	2008	792
Morgan K.	The exaggerated death of geography: Learning, proximity and territorial innovation systems	2004	496
Asheim B.T., Isaksen A.	Location, agglomeration and innovation: Towards regional innovation systems in Norway?	1997	257
Kirat T., Lung Y.	Innovation and proximity. Territories as loci of collective learning processes	1999	202
Crevoisier O., Jeannerat H.	Territorial knowledge dynamics: From the proximity paradigm to multi-location milieus	2009	151
van de Kerkhof M., Wieczorek A.	Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations	2005	148
Wittmayer J.M., Schäpke N.	Action, research and participation: roles of researchers in sustainability transitions	2014	140
Hall A., Rasheed Sulaiman V., Clark N., Yoganand B.	From measuring impact to learning institutional lessons: An innovation systems perspective on improving the management of international agricultural research	2003	134
Brown H.S., Vergragt P., Green K., Berchicci L.	Learning for sustainability transition through bounded socio-technical experiments in personal mobility	2003	126
Kamp L.M., Smits R.E.H.M., Andriesse C.D.	Notions on learning applied to wind turbine development in the Netherlands and Denmark	2004	120
Cooke P.	To construct regional advantage from innovation systems first build policy platforms	2007	113
Verbong G., Geels F.W., Raven R.	Multi-niche analysis of dynamics and policies in Dutch renewable energy innovation journeys (1970-2006): Hype-cycles, closed networks and technology-focused learning	2008	108
Luederitz C., Schäpke N., Wiek A., Lang D.J., Bergmann M., Bos J.J., Burch S.,	Learning through evaluation – A tentative evaluative scheme for sustainability transition experiments	2017	101

Davies A., Evans J., König A., Farrelly M.A., Forrest N., Frantzeskaki N., Gibson R.B., Kay B., Loorbach D., McCormick K., Parodi O., Rauschmayer F., Schneidewind U., Stauffacher M., Stelzer F., Trencher G., Venjakob J., Vergragt P.J., von Wehrden H., Westley F.R.			
Bos J.J., Brown R.R.	Governance experimentation and factors of success in socio-technical transitions in the urban water sector	2012	97
van Mierlo B., Leeuwis C., Smits R., Woolthuis R.K.	Learning towards system innovation: Evaluating a systemic instrument	2010	87
Hegger D.L.T., Van Vliet J., Van Vliet B.J.M.	Niche management and its contribution to regime change: The case of innovation in sanitation	2007	83
Bos J.J., Brown R.R., Farrelly M.A.	A design framework for creating social learning situations	2013	77
Hoppe T., Graf A., Warbroek B., Lammers I., Lepping I.	Local governments supporting local energy initiatives: Lessons from the best practices of Saerbeck (Germany) and Lochem (The Netherlands)	2015	74
Klerkx L., Proctor A.	Beyond fragmentation and disconnect: Networks for knowledge exchange in the English land management advisory system	2013	74
Asheim B.	The Changing Role of Learning Regions in the Globalizing Knowledge Economy: A Theoretical Re-examination	2012	68
Benneworth P., Coenen L., Moodysson J., Asheim B.	Exploring the multiple roles of Lund University in strengthening Scania's regional innovation system: Towards institutional learning?	2009	62
Fazey I., Schäpke N., Caniglia G., Patterson J.,	Ten essentials for action-oriented and second order energy transitions, transformations and climate change research	2018	58

Hultman J., van Mierlo B., Säwe F., Wiek A., Wittmayer J., Aldunce P., Al Waer H., Battacharya N., Bradbury H., Carmen E., Colvin J., Cvitanovic C., D'Souza M., Gopel M., Goldstein B., Hämäläinen T., Harper G., Henfry T., Hodgson A., Howden M.S., Kerr A., Klaes M., Lyon C., Midgley G., Moser S., Mukherjee N., Müller K., O'Brien K., O'Connell D.A., Olsson P., Page G., Reed M.S., Searle B., Silvestri G., Spaiser V., Strasser T., Tschakert P., Uribe-Calvo N., Waddell S., Rao-Williams J., Wise R., Wolstenholme R., Woods M., Wyborn C.			
Forrest N., Wiek A.	Learning from success - Toward evidence-informed sustainability transitions in communities	2014	57
Borrás S.	Policy learning and organizational capacities in innovation policies	2011	56
Malecki E.J.	Everywhere? The geography of knowledge	2010	51
Dolinska A., d'Aquino P.	Farmers as agents in innovation systems. Empowering farmers for innovation through communities of practice	2016	42

von Malmborg F.	Stimulating learning and innovation in networks for regional sustainable development: the role of local authorities	2007	39
Anadon L.D., Chan G., Harley A.G., Matus K., Moon S., Murthy S.L., Clark W.C.	Making technological innovation work for sustainable development	2016	37
Smit T., Junginger M., Smits R.	Technological learning in offshore wind energy: Different roles of the government	2007	38
Laes E., Gorissen L., Nevens F.	A comparison of energy transition governance in Germany, The Netherlands and the United Kingdom	2014	36
Quist J., Tukker A.	Knowledge collaboration and learning for sustainable innovation and consumption: Introduction to the ERSCP portion of this special volume	2013	33
Antonelli C., Quere M.	The governance of interactive learning within innovation systems	2002	29
Beers P.J., Van Mierlo B., Hoes A.-C.	Toward an integrative perspective on social learning in system innovation initiatives	2016	28
Beers P.J., Hermans F., Veldkamp T., Hinssen J.	Social learning inside and outside transition projects: Playing free jazz for a heavy metal audience	2014	27
Isaksen A., Trippl M.	Innovation in space: The mosaic of regional innovation patterns	2017	26
Schäpke N., Omann I., Wittmayer J.M., van Steenbergen F., Mock M.	Linking transitions to sustainability: A study of the societal effects of transition management	2017	24
Van Mierlo B., Janssen A., Leenstra F., van Weeghel E.	Encouraging system learning in two poultry subsectors	2013	23
Asheim B.T.	Territoriality and economics: On the substantial contribution of economic geography	1998	20
Schreuer A., Ornetzeder M., Rohracher H.	Negotiating the local embedding of socio-technical experiments: A case study in fuel cell technology	2010	19
Domènech L., March H., Vallès M., Saurí D.	Learning processes during regime shifts: Empirical evidence from the diffusion of greywater recycling in Spain	2015	17
Clark W.C.	A transition toward sustainability	2001	16

Gazheli A., Antal M., van den Bergh J.	The behavioral basis of policies fostering long-run transitions: Stakeholders, limited rationality and social context	2015	14
Dewulf A.E., Termeer C.J.A.M., Werkman R.A., Breeman G.R.P.J., Poppe K.J.	Transition management for sustainability: Towards a multiple theory approach	2009	11
Asheim B.T., Parrilli M.D.	Interactive learning for innovation: A key driver within clusters and innovation systems	2011	10
Kamp L.M.	The importance of learning processes in wind power development	2007	8
Sol J., van der Wal M.M., Beers P.J., Wals A.E.J.	Reframing the future: the role of reflexivity in governance networks in sustainability transitions	2018	7
Sternberg R.	Innovation	2009	7
Fastenrath S., Braun B.	Lost in transition? Directions for an economic geography of urban sustainability transitions	2018	6
Hjerpe M., Glaas E., Fenton P.	The role of knowledge in climate transition and transformation literatures	2017	6
van Mierlo B., Beers P.J.	Understanding and governing learning in sustainability transitions: A review	2020	5
Parry K., van Rooyen A.F., Bjornlund H., Kissoly L., Moyo M., de Sousa W.	The importance of learning processes in transitioning small-scale irrigation schemes	2020	5
Halbe J., Pahl-Wostl C.	A methodological framework to initiate and design transition governance processes	2019	5
Borghei B.B., Magnusson T.	Niche aggregation through cumulative learning: A study of multiple electric bus projects	2018	5
Goyal N., Howlett M.	Who learns what in sustainability transitions?	2020	3
van Doren D., Driessen P.P.J., Runhaar H.A.C., Giezen M.	Learning within local government to promote the scaling-up of low-carbon initiatives: A case study in the City of Copenhagen	2020	3
Van Poeck K., Östman L., Block T.	Opening up the black box of learning-by-doing in sustainability transitions	2020	2
Kamp L.M.	Obstacles to and facilitators of the implementation of small urban wind turbines in the Netherlands	2010	1
van Mierlo B., Halbe J., Beers	Learning about learning in sustainability transitions	2020	

P.J., Scholz G., Vinke-de Kruijf J.			
Beers P.J., Turner J.A., Rijswijk K., Williams T., Barnard T., Beechener S.	Learning or evaluating? Towards a negotiation-of-meaning approach to learning in transition governance	2019	
Ninomiya S.M., Burch S.	Beyond "The business case": The emerging role of entrepreneurs in the multilevel governance of urban decarbonization in Canada	2018	
Didham R.J., Ofei-Manu P., Nagareo M.	Social learning as a key factor in sustainability transitions: The case of Okayama City	2017	
Nevens F., Frantzeskaki N., Gorissen L., Loorbach D.	Urban Transition Labs: Co-creating transformative action for sustainable cities	2013	252
Seyfang G., Hielscher S., Hargreaves T., Martiskainen M., Smith A.	A grassroots sustainable energy niche? Reflections on community energy in the UK	2014	169
Ceschin F.	Critical factors for implementing and diffusing sustainable product-Service systems: Insights from innovation studies and companies' experiences	2013	135
Heiskanen E., Jalas M., Rinkinen J., Tainio P.	The local community as a "low-carbon lab": Promises and perils	2015	52
Scholz R.W.	The normative dimension in Transdisciplinarity, Transition Management, and Transformation Sciences: New roles of science and universities in sustainable transitioning	2017	26
Naber R., Raven R., Kouw M., Dassen T.	Scaling up sustainable energy innovations	2017	24
van den Heiligenberg H.A.R.M., Heimeriks G.J., Hekkert M.P., van Oort F.G.	A habitat for sustainability experiments: Success factors for innovations in their local and regional contexts	2017	21
Weiland S., Bleicher A., Polzin C., Rauschmayer F., Rode J.	The nature of experiments for sustainability transformations: A search for common ground	2017	17

Kamp L.M., Vanheule L.F.I.	Review of the small wind turbine sector in Kenya: Status and bottlenecks for growth	2015	17
Puerari E., de Koning J.I.J.C., von Wirth T., Karré P.M., Mulder I.J., Loorbach D.A.	Co-creation dynamics in Urban Living Labs	2018	15
Pellicer-Sifres V., Belda-Miquel S., Cuesta-Fernandez I., Boni A.	Learning, transformative action, and grassroots innovation: Insights from the Spanish energy cooperative Som Energia	2018	13
Barrie J., Zawdie G., João E.	Assessing the role of triple helix system intermediaries in nurturing an industrial biotechnology innovation network	2019	10
Baas L., Hjelm O.	Support your future today: Enhancing sustainable transitions by experimenting at academic conferences	2015	7
Boulanger S.O.M., Nagorny N.C.	Replication vs mentoring: Accelerating the spread of good practices for the low-carbon transition	2018	4
Peng Y., Wei Y., Bai X.	Scaling urban sustainability experiments: Contextualization as an innovation	2019	2
Collins B.	"It's not talked about": The risk of failure in practice in sustainability experiments	2020	1
Scholz G., Methner N.	A social learning and transition perspective on a climate change project in South Africa	2020	1
Rekola A., Paloniemi R.	Researcher-planner dialogue on environmental justice and its knowledges-a means to encourage social learning towards sustainability	2018	1
Karanasios K., Parker P.	Explaining the diffusion of Renewable Electricity Technologies in Canadian remote indigenous communities through the technological innovation system approach	2018	
Snowball sample			
Raven R., Heiskanen E., Lovio R., Hodson M., Brohmann B.	The Contribution of Local Experiments and Negotiation Processes to Field-Level Learning in Emerging (Niche) Technologies	2008	-
Herrero P., Dedeurwaerdere T., Osinski A.	Design features for social learning in transformative transdisciplinary research	2019	7
Geels F., Raven R.	Non-linearity and Expectations in Niche-Development Trajectories: Ups and downs in dutch biogas development	2006	316
Siddiki S., Kim J., Leach W.D.	Diversity, trust, and social learning in collaborative governance.	2017	20
Geels F., Deuten J.J.	Local and global dynamics in technological development: a socio-cognitive perspective on knowledge flows and lessons from reinforced concrete	2006	113

Appendix D: Research fields prevalence in reviewed literature sample

Fields of learning	*No. articles mentioning the term*
Social learning	41
Organisational/organizational learning	25
Interactive learning	24
Policy/policy-oriented learning	15
Technological learning	8
Collaborative learning	6
Institutional learning	6
System learning	4
Government learning	3
Political learning	3

Appendix E: Nodes relating to 'worries' node in interview transcriptions

Worries - Coding by Item

Node	Percentage
Shared vision	9.78%
Who is responsible f	10.53%
Participation	11.74%
Setting expectations	13.17%
NP-RES	14.38%
Execution	14.49%
Complexity	14.53%
Demarcation	15.22%
Different knowledge	16.61%
Interaction	17.54%
Proportionally	19.85%
When to involve who	20.53%
Technology-technics	24.43%
Importance of teachi	24.74%
(regular) citizen	27.33%
Learning through doi	27.39%
Repetition	29.59%
Online vs offline vs	34.76%
Social vs technical	37.15%
Worries	10