Pursuing a Circular Economy in the Danish Waste Sector

Scale and Transition Dynamics in Transformative Innovation Policy

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STINE HACH JUUL MADSEN
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Pursuing a Circular Economy in the Danish Waste Sector explores the conceptual understanding of transformative innovation policy through empirical research focusing on the transition towards a circular economy in the Danish waste sector.

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Title and subtitle: Pursuing a Circular Economy in the Danish Waste Sector. Scale and Transition Dynamics in Transformative Innovation Policy.

Abstract:

The overall aim of this thesis is to advance the conceptual understanding of transformative innovation policy through empirical research focusing on the transition towards a circular economy in the Danish waste sector. Under this broad aim, the thesis is more specifically concerned with exploring issues relating to the geography of transformative innovation policy as well as transition dynamics and agency in socio-technical system change. Three overarching research questions guide the thesis. First, how does the theoretical assumption that transformative innovation policy is best pursued at the subnational scale correspond with current developments in the multi-scalar organization of Danish waste management aimed at stimulating the promotion of a circular economy? Second, how can the understanding of transition dynamics and agency be developed to explicitly account for variation in the structural characteristics of sectors? And third, how do empirical insights from the Danish waste sector illustrate and illuminate this alternative understanding of transition dynamics and agency?

In addressing these questions, the thesis makes two key contributions. First, based on analysis of the spatial organization of Danish waste management, this thesis develops a novel conceptual approach to the multi-level governance of transformative innovation policy. This conceptual approach is based on a constructivist notion of scale, which emphasizes the potential transformative power of rescaling and the need to develop a dynamic and variated approach to the spatial organization of transformative innovation policy. Second, this thesis develops a conceptual approach for studying transition dynamics that takes the structural characteristics of socio-technical systems and their influence on agency into account. This approach is influenced by and illustrative of empirical insights from the Danish waste sector, which is characterized by an elaborate structural setup, currently experiencing growing misalignment due to the advancement of circular economy policies and regulation.

Key words:

Transformative innovation policy, Scale, Transition dynamics, Waste management, Multi-scalar organization, Sustainability transition, Circular economy.

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Til Daniel, Olga og lille P2. Mit livs lys og centralvarme.

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Stine HJ Madsen
November 28, 2022
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List of articles

The thesis consists of the following three articles:

Article I

Grillitsch, M., Hansen, T. & Madsen, S. (2021) 'Transformative innovation policy: a novel approach?', in B Godin, G Gaglio and D Vinck (eds), *Handbook on Alternative Theories of Innovation*, Edward Elgar, Cheltenham, 2021, 276-291.

Article II

Madsen, S. (2022) A constructivist approach to the spatial organization of transformative innovation policy. *Environmental Innovation and Societal Transitions*, 42, 340-351.[1]

Article III

Madsen, S., Miörner, J. & Hansen, T. (2022) Axes of Contestation in Sustainability Transitions. *Environmental Innovation Societal Transitions,* 45, 246-269.

[1] Unfortunately, the formatting of this article is a bit odd in the PDF version (the appendix has ended up in the findings). I recommend reading the web browser version where the layout is correct.

Lists of figures and tables

Glossary of Danish actors, acronyms, and abbreviations

CCS	Carbon Capture and Storage
Civilstyrelsen	Department of Civil Affairs
CO_2	Carbon dioxide
DAKOFA	Dansk Kompetencecenter for Affald og Resourcer (Danish Network for Waste and Resources)
Danmarks Naturfredningsforening	Danish Society for Nature Conservation
Danmarks Statestik	Statistics Denmark
Dansk Affaldsforening	Danish Waste Association
Dansk Erhverv	Danish Chamber of Commerce
Dansk Industri	Confederation of Danish Industry
Energistyrelsen	Danish Energy Agency
EU	European Union
Kommunernes Landsforening	Local Government Denmark
Københavns Kommune	City of Copenhagen
Miljø- og Fødevareministeriet	Ministry of Environment and Food
Miljøministeriet	Ministry of Environment
Miljøstyrelsen	Environmental Protection Agency
MIS	Mission-oriented innovation system
MLP	Multi-Level Perspective
NGO	Non-governmental organization

OECD	The Organisation for Economic Co-operation and Development
R&I	Research and innovation
Plastindustrien	Danish Plastics Federation
Regeringen	The government
Regeringens Klimapartnerskaber	The government's climate partnerships
RIS	Regional innovation system
SIP	Strategic Innovation Programmes

1 Introduction

The summer of 2022 saw historic heat waves hit across the Northern Hemisphere. In some places the extreme heat led to droughts, while in others it triggered rapid melting of glaciers, which in turn contributed to devastating floods (Rosenthal and Patel, 2022; Zhong, 2022). Scientists argue that these extreme weather events add to the body of evidence showing that human-induced climate change is happening (McCarthy, 2022; Schumacher et al., 2022). Adding to this rather bleak picture, climate change is believed to happen in parallel with a wider human-driven biodiversity crisis. Multiple causes for the continued loss of biodiversity have been identified, including changes in land use, the introduction of invasive species, overexploitation, pollution, and climate change. These different causes are all intimately linked to the growing global consumption of natural resources. The ecological, social, and economic effects of these interlinked crises are expected to be many and varied. Moreover, the effects are expected to be disproportionately felt by marginalized communities, increasing the complexity of already existing challenges related to poverty and inequality (Pörtner et al., 2021).

Against the backdrop of these urgent and grand challenges it is increasingly acknowledged across policy areas and academia that contemporary systems of consumption and production must change (e.g., European Commission, 2019; Messerli et al., 2019). This thesis explores one corner of this broad call for change. It zooms in on the waste sector, which on the one hand provides a key societal service by collecting, treating, and utilizing discarded materials, but on the other hand, faces a multitude of challenges. It is estimated that five percent of global greenhouse gases emitted in 2016 were generated by solid waste management. Moreover, symptomatic of the growing global consumption of natural resources, it is expected that annual global waste generation will increase by 70 percent by 2050 compared to 2016 levels (Kaza et al., 2018). In some places, inefficient waste management has profound health consequences, is a source of environmental pollution, and causes the loss of valuable resources (European Environment Agency, 2014).

In the Danish waste sector, which is the specific empirical focus of this thesis, multiple actors, including the Danish government (Regeringen, 2020), the Organisation for Economic Co-operation and Development (OECD) (2019), and the European Environmental Agency (2016), highlight two particular challenges. First, Denmark is one of the highest per capita generators of municipal waste in the

European Union (EU). In 2020, Danish municipal waste generation amounted to more than 800 kg per capita, which is almost 60 percent more than the EU average (Eurostat, 2022), putting a heavy burden on the unsustainable consumption of natural resources (Regeringen, 2020). Second, Denmark has one of the highest shares of waste incineration in the EU (Eurostat, 2018). In 2019, 25 percent of all waste generated in Denmark and roughly half of the country's household waste was incinerated (Miljøstyrelsen, 2020). Up until recently, waste incineration was branded as 'carbon dioxide (CO_2) friendly' in Denmark due to efficient recovery of heat and power. However, as energy production increasingly shifts towards renewable sources and more emphasis is placed on resource efficiency, the view of incineration is changing among many actors. This means that the levels of incineration in Denmark are now of concern partly due to the direct CO_2 emissions from incineration plants as well as the assumed loss of resources when materials are incinerated (Regeringen, 2020). In light of these challenges, attempts are currently being made to transform the Danish waste sector. These attempts are guided by the expectation that the Danish waste sector should contribute to tackling grand challenges such as climate change, overexploitation of natural resources, biodiversity loss, and pollution, rather than participate in creating these problems. This transformation is formulated as a transition towards a circular economy.

Today, the broad principles of waste management in Denmark are laid out in EU regulation, which also applies to the vision of a circular economy. The European Commission describes the transition to a circular economy as "systemic, deep and transformative" because it is to fundamentally change production and consumption processes through technological innovation and institutional change (European Commission, 2020, p. 24). The first legislative steps made towards implementing the Circular Economy Action Plan (European Commission, 2015) strongly promote recycling while encouraging reduced incineration (Domenech and Bahn-Walkowiak, 2019). This somewhat disapproving view of incineration clashes with the current waste management system in Denmark, where investments in incineration have been made and encouraged for decades.

The vision of a circular economy is highly contested in the Danish context, and actors with a stake in the system are mobilizing in attempts to shape the current changes. Some actors work to defend the system of incineration, other actors align with the promotion of recycling, and several actors want to see more radical changes and in turn promote increased reuse and reduced consumption. The unfolding attempts to change the Danish waste sector raise a number of broad questions regarding the impact of EU policy on sectors in member states, processes of translating and implementing policy across governance levels, as well as the role of actors in shaping change. These questions are broad starting points for this thesis.

Conceptual anchoring

To explore the empirical case study, this thesis takes two related bodies of literature as points of departure: innovation policy research, particularly recent research under the so-called 'normative turn', and scholarship on socio-technical system transitions. Both bodies of literature, combined with my geographical focus, provide useful conceptual lenses to explore the promotion of circular economy in the Danish waste sector as they focus on the promotion of policy aimed explicitly at tackling contemporary grand challenges as well as systemic change processes.

In innovation policy research, the last decade has been characterized by scholarly debate on the need to shift the objectives of innovation policy. It is argued that innovation policy should work towards tackling grand challenges and enabling transformative change, rather than focusing mainly on economic growth objectives or more narrow societal agendas (Edler and Boon, 2018; Foray et al., 2012; Kuhlmann and Rip, 2018; Mazzucato, 2018; Schot and Steinmueller, 2018; Steward, 2012; Stilgoe et al., 2013). To achieve this shift in objectives, innovation policy is expected to extend beyond the traditional economic policy domain and involve a broader set of actors, resulting in the design of more multifaceted policy interventions (Diercks et al., 2019; Haddad et al., 2022; Kuhlmann and Rip, 2018). These debates in innovation policy have taken place under various labels, but when considered collectively reflect a broader 'normative turn' (Uyarra et al., 2019). This thesis refers to this broader normative turn, but also uses the particular phrase 'transformative innovation policy' because this approach connects explicitly to research on socio-technical transitions (Schot and Steinmueller, 2018; Steward, 2012).

In order to meet the more wide-ranging expectations of innovation policy, some scholars have argued that innovation policy needs to explicitly consider the transformation of whole systems. In this regard, Weber and Rohracher (2012) suggest that innovation policy should go beyond the traditional focus of addressing market and system failures, which mainly enable optimization and support for the existing system of innovation. Instead, they develop an additional four transformational system failures, which are to explicitly address system-wide change. The transformational system failures specifically, and research on innovation policy for system-wide change more generally (e.g., Grillitsch et al., 2019; Raven and Walrave, 2020; Schot and Steinmueller, 2018), draw heavily on the field of socio-technical system transitions also referred to as transition studies or sustainability transitions research.

In transition studies, sectors are conceptualized as socio-technical systems that are characterized by the societal functions and services they provide, for example, transportation, energy supply, or waste management (Markard et al., 2012). The underlying assumption of research in the field is that system-wide change involves

the transformation of all elements that make up the system, including technologies, institutions, infrastructures, and user practices (Markard and Truffer, 2008). This is expected to be a complex and long-term undertaking, because the system elements have developed and aligned over time, reinforcing the stability of the configuration in place (Geels, 2004). In other words, incremental change is not considered sufficient to cope with the grand challenges facing contemporary society. Instead, a key aim of transition studies is to conceptualize and try to explain how more radical change can take place in socio-technical systems despite their path-dependent and inert nature (Köhler et al., 2019). Arguably, innovation plays a key role in achieving more radical change; however, the type of innovation that is needed is comprehensive system innovation rather than the advancement of individual products and processes (Kemp, 1994; Loorbach and Rotmans, 2010).

Aim and research questions

Research on the normative turn in innovation policy has been criticized for its conceptual bias and lack of empirical work (Haddad et al., 2022; Janssen et al., 2021). However, there are a few notable exceptions. For example, Borrás and Serger (2022), Dierks et al. (2019), Grillitsch et al. (2019), Janssen (2019), and Parks (2022) study different aspects of the design, implementation, and assessment of specific transformative innovation policies. This research points to contradictions and challenges that arise when transformative innovation policy is pursued in practice. A few papers also look specifically at the formulation and implementation of regional transformative innovation policy (Hassink et al., 2021; Martin, 2020). They begin to unpack the opportunities and limitations that regions have in bringing about transformative change. In another recent contribution, Brown (2021) examines the rationale for and validity of a mission-based policy initiative. He finds that the policy initiative insufficiently considers the regional innovation system in which it is located, and in turn concludes that mission-based policy needs to be designed with an explicit sensitivity to context.

Taken together, this recent set of papers shows the value of empirical work in challenging and furthering our conceptual understanding of innovation policy under the normative turn. This points to the broader argument that empirical material is an important resource for problematizing existing conceptual understandings and inspiring new lines of theoretical and conceptual development (Alvesson and Kärreman, 2011). Given that the normative turn in innovation research has only recently emerged and begun to materialize, more empirical work is needed to understand and explain this evolving phenomenon. To this end, the overall aim of this thesis is *to advance the conceptual understanding of transformative innovation policy through empirical research focusing on the transition towards a circular economy in the Danish waste sector.* Under this broad aim, the thesis is more

specifically concerned with exploring issues relating to the geography of transformative innovation policy as well as transition dynamics and agency in socio-technical system change.

This thesis's focus on the geography of transformative innovation policy attempts to address scholarly critique arguing that research of innovation policy under the normative turn is largely insensitive to geographical context and does not take spatial and scalar aspects into consideration (Brown, 2021; Coenen and Morgan, 2020). While recent research on regional transformative innovation policy begins in part to address the issues of geographical context and spatial variation (Flanagan et al., 2022; Hassink et al., 2021; Isaksen et al., 2022; Martin, 2020; Tödtling et al., 2021), little scholarship is explicitly concerned with the multi-scalar governance of transformative innovation policy. Wanzenböck and Frenken (2020) and McCann and Soete (2020) are noticeable exceptions. Following subsidiary arguments, both papers explore the multi-scalar organization of transformative innovation policy and propose strong theoretical arguments in favour of subnational transformative innovation policy, which they assume will increase policy effectiveness due to its democratic and context-sensitive nature. As the arguments developed by Wanzenböck and Frenken (2020), as well as those of McCann and Soete (2020), are largely theoretical in nature, this calls for empirical scrutiny. To address this particular shortcoming, the following research question has been formulated:

1. *How does the theoretical assumption that transformative innovation policy is best pursued at the subnational scale correspond with current developments in the multi-scalar organization of Danish waste management aimed at stimulating the promotion of a circular economy?*

This thesis's second focus on transition dynamics and agency more exclusively engages with the literature on sustainability transitions, but the research also has implications for policies aiming for system-wide change. In the field of transition studies, scholars have increasingly emphasized that the structural characteristics of socio-technical systems differ (Alkemade, 2019; Andersen et al., 2020; Miörner et al., 2021). However, the potential transition dynamics, as well as the actor struggles that may result from this structural variation, remain largely unexplored, both conceptually and empirically. To address this shortcoming, the following research questions have been formulated:

2. *How can the understanding of transition dynamics and agency be developed to explicitly account for variation in the structural characteristics of sectors?*
3. *How do empirical insights from the Danish waste sector illustrate and illuminate this alternative understanding of transition dynamics and agency?*

By exploring these research questions, the thesis makes the following contributions:

1. Based on analysis of the spatial organization of Danish waste management, this thesis develops a novel conceptual approach to the multi-level governance of transformative innovation policy. This conceptual approach is based on a constructivist notion of scale, which emphasizes the potential transformative power of rescaling and the need to develop a dynamic and variated approach to the spatial organization of transformative innovation policy.
2. Additionally, this thesis develops a conceptual approach for studying transition dynamics that takes the structural characteristics of socio-technical systems and their influence on agency into account. This approach is influenced by and illustrative of empirical insights from the Danish waste sector, which is characterized by an elaborate structural setup (i.e., multiple niche and regime like configurations), currently experiencing growing misalignment due to the advancement of circular economy policies and regulation.

Overview of articles

This thesis includes three articles, which contribute to the overarching aim and research questions in the following ways:

Article I (*Transformative innovation policy: a novel approach?*) considers how the focus and instruments of innovation policy have changed over previous decades. We critically examine periods of innovation policy offered in the literature and consider the novelty of the recent shift towards transformative innovation policy. The paper finds that a gradual change is currently taking place in innovation policy research. Recently, transformative elements have been foregrounded, but some of these elements can also be identified in previous perspectives. The paper highlights three aspects of transformative innovation policy as particularly novel: the aim to transition entire socio-technical systems, the emphasis on experimentation, and the deliberate intention to destabilize unsustainable regimes. The paper contributes with a conceptual foundation for the thesis work and a starting point for the two empirical articles, which are the core of the thesis.

Article II (*A constructivist approach to the spatial organization of transformative innovation policy*) addresses the first research question. It mobilizes an analysis of the spatial organization of Danish waste management and calls into question recent theoretical arguments made in favour of pursuing grand challenges at the subnational scale. Instead, the paper suggests that the spatial organization of

transformative innovation policy needs to cater to the particular scalar arrangement produced in a socio-technical system.

Article III (*Axes of contestation in sustainability transitions*) addresses the second and third research questions. The paper introduces the concept of the contestation axis to encourage an analysis of transition dynamics with explicit attention to the structural characteristics of the system in question. A focus on contestation axes highlights interfaces between multiple configurations in a socio-technical system and shows how agency can play out and frictions materialize along other axes than the niche-regime, which traditionally has been emphasized in transition studies. Exploring Danish waste management through the lens of the contestation axis framework, the paper begins to unpack the importance of intra-regime dynamics as well as the heterogeneity of niche-like socio-technical configurations.

Taken together, these articles unpack the unfolding attempts to change the Danish waste sector. The papers point to the contested nature of the transformation. They show how the EU vision of a circular economy is interpreted and implemented in the Danish context and across multiple levels of governance where actors work to shape the changes in various ways.

Thesis outline

In addition to the three articles outlined above, this thesis consists of this introductory framing text, the *kappa*. Following this introduction, chapter 2 of the kappa offers a conceptual background to the research project. It introduces the normative turn in innovation policy research, as well as the field of sustainability transitions, in greater detail. Chapter 3 briefly introduces the Danish setting and then moves on to present the empirical case study focusing on changes in the rationalities, practices, and actors involved in Danish waste management. Chapter 4 goes on to discuss methodology, including the research process, ontological and epistemological underpinnings, as well as methods for data collection and analysis. Finally, chapter 5 provides a summary of the findings for each article followed by overarching conclusions to the thesis's research questions, concluding by considering limitations of the project, as well as areas for future research.

2 Conceptual background

Against the backdrop of social, economic, and environmental challenges, there is immense interest across civil society, policy, and academia to understand the processes of transformative change. This is also a key concern in this thesis, and to explore the topic further I engage with literature on innovation policy, namely recent work on the normative turn in innovation policy, as well as the field of sustainability transitions. These bodies of literature are introduced in this chapter of the kappa. The intention of this chapter is to present the general conceptual background from which the papers depart.

Situating 'the normative turn' in innovation policy

Over the last decade, we have seen scholars and policymakers advancing different types of innovation policy, which are supposed to better meet the pressing grand challenges faced by contemporary society, including poverty, inequality, and climate and population changes. One stream of literature has emerged under the label 'responsible innovation' (Hellström, 2003; Stilgoe et al., 2013; von Schomberg, 2013), another as 'innovation policy for grand challenges' (Boon and Edler, 2018; Edler and Boon, 2018; Frenken, 2017; Kuhlmann and Rip, 2018; Ulnicane, 2016), a third group of scholars have emphasized the need for transformative innovation policy (Diercks et al., 2019; Schot and Steinmueller, 2018; Steward, 2012), while the notion of 'new mission-oriented policy' has also grown increasingly popular (Foray et al., 2012; Mazzucato, 2018, 2016, 2013). Inspired by Uyarra et al. (2019), I describe these multiple literatures as part of a more overarching and ongoing normative turn in innovation policy. The following paragraphs introduce the main characteristics of the normative turn and situate this shift against previous periods in innovation policy.

Under the normative turn, the expectations of innovation policy are changing in various ways. The expected objectives of innovation policy are first of all being refashioned. In previous innovation policy approaches, the main objectives of innovation policy were either predominantly economic, emphasizing innovation as a means to stimulate economic growth and competitiveness, or focused on more narrow societal agendas. With regard to the latter objective, innovation was seen as a means to meet national strategic priorities, for instance, national security. The

Manhattan Project and the Apollo Project are classic examples. Under the normative turn, the objective has shifted towards a new emphasis on innovation as a means to tackle grand challenges (Cagnin et al., 2012; Diercks et al., 2019; Mazzucato, 2018; Schot and Steinmueller, 2018). This shift in objective implies that innovation policy needs to go beyond its traditional economic policy domain, since grand challenges are situated in various policy domains, such as environment, health, and agriculture (Diercks et al., 2019; Weber and Rohracher, 2012). Consequently, a broader set of actors and stakeholders need to be involved, which on the one hand is likely to open up debates, but may also on the other hand create conflict and coordination challenges regarding the direction of change (Kuhlmann and Rip, 2018).

The emphasis on tackling grand challenges has led scholars to call for more multifaceted policy intervention (Haddad et al., 2022) and greater coordination between policy areas and levels of government (Weber and Rohracher, 2012). This has also led some scholars to argue for the development of 'horizontal' and 'vertical' policies, which target missions in either individual sectors or across multiple sectors (Mazzucato, 2018). Many scholars have moreover emphasized the need to develop policy mixes for transformative change that target both demand- and supply-oriented policy (Boon and Edler, 2018; Bugge et al., 2018; Chicot and Matt, 2018; Edler and Boon, 2018; Rogge and Reichardt, 2016). Others have argued for the need to develop policy mixes that both support the creation of new innovation, but also actively seeks to destabilize technologies or actor-networks that perpetuate grand challenges (Kivimaa and Kern, 2016). Taken together, these developments have led scholars to highlight the need for a more proactive and entrepreneurial state (Link and Link, 2009; Mazzucato, 2016, 2013), which in turn builds on the understanding that deliberately directed public policy can steer innovation and contribute to tackling grand challenges (Borrás and Edler, 2020).

Furthermore, the normative turn in innovation policy explicitly challenges the assumption that more innovation is inherently good and beneficial for society (Røpke, 2012; Soete, 2019, 2013; Stilgoe et al., 2013). Although innovation scholars have also previously displayed a critical awareness of the potential negative consequences of innovation (Giuliani, 2018), the normative turn places more focus on the externalities that are potentially generated by innovation. In this respect, research under the normative turn recognizes that innovation policy in its own right is deeply connected to the challenges that contemporary society faces, and which it ought to change (Schot and Steinmueller, 2018). This in turn implies that innovation policy needs to place more focus on the quality and direction of innovation rather than the rate of innovation (Uyarra et al., 2019).

All things considered, the normative turn places social and environmental concerns at the heart of the innovation policy research agenda. While previous periods of innovation policy were by no means oblivious to social and environmental concerns (Giuliani, 2018), the field was underpinned by a greater degree of optimism regarding the impacts of innovation. For example, almost twenty years ago,

Verspagen (2005, p. 487) argued that "it seems beyond dispute that a change of technology in the pure sense, coupled with organizational changes at various levels of aggregation, are the main driving factors behind the continuous increase of living standards". Similarly, Fagerberg (2005) highlighted innovation as an important explanatory factor when trying to understand why the performance of firms or places differ. He stated: "Firms that succeed in innovation prosper, at the expense of their less able competitors. Innovative countries and regions have higher productivity and income than the less innovative ones" (Fagerberg, 2005, p. 20). Both examples reflect a time when innovation was understood to be more tied to firm performance and considered influential for regional and national growth as well as competitiveness.

During the second half of the 20th century, innovation policy reflected this understanding of innovation and the general optimism about innovation. Broadly speaking, public and private actors focused on creating policies that were either intended to address a narrow social agenda or stimulate the rate of innovation expecting that this in turn would improve labour productivity and economic growth from which positive social welfare would follow (Schot and Steinmueller, 2018).

Innovation policy first focused on addressing market failures, such as underinvestment in research and development, and the externalisation of cost (Arrow, 1962; Nelson, 1959). However, innovation policy intervention was expanded once scholars began to explore the collective nature of innovation, suggesting that individual innovation actors, such as firms, public research labs, and universities depend on their environment to innovate. Different 'system' approaches were introduced to better account for the factors impacting the development, diffusion, and use of innovations (e.g., Asheim and Isaksen, 2002; Breschi and Malerba, 1997; Hekkert et al., 2007; Lundvall, 1992; Nelson, 1993). Consequently, innovation policy came to also address system failures, such as unfavourable institutional environments for innovation, as well as lacking resources, and capabilities among system actors and firms (Smith, 2000; Woolthuis et al., 2005).

Innovation system approaches diffused rapidly and have been applied across many policy contexts, including regional authorities, national governments, and international organizations (Edquist, 2005). However, in light of the increasing focus on grand challenges, innovation policy and its emphasis on innovation for economic growth and competitiveness has been met with growing critique, especially during the last decade (Alkemade et al., 2011; Biggi and Giuliani, 2021; Røpke, 2012; Schot and Steinmueller, 2018; Soete, 2013). Soete (2019, pp. 852–853) even goes so far to suggest that innovation policy and innovation studies more generally are in "a fundamental, even existential crisis […] following the increasing lack of evidence on the 'trickling down' of productivity gains from innovating firms and sectors to the rest of the economy". Soete's (2019) concern connects to the complex grand challenges faced by contemporary society. Although we have seen positive socio-economic developments since the end of the Second World War,

including a global increase in life expectancy (World Health Organization, 2022) and decrease in global extreme poverty (World Bank, 2018)[2], the world continues to be characterized by stark polarization between rich and poor. Income and wealth are increasingly concentrated and a majority of the world's countries have experienced rising inequality in the past three decades (United Nations, n.d.). Moreover, environmental problems, such as climate change and biodiversity loss, further emphasize fundamental challenges in contemporary society (IPBES, 2019; IPCC, 2022). It is against this backdrop that the normative turn calls upon innovation policy to broaden its scope and contribute to tackling these persistent grand challenges.

Tackling grand challenges

As outlined above, the normative turn renegotiates the objective of innovation policy towards tackling grand challenges. This in turn calls for a greater exploration of what grand challenges are and what 'tackling' them implies. Grand challenges are understood to be "major societal problems" (Ulnicane, 2016, p. 6) that fall into a distinct category of societal challenges conceptualized in various ways, including 'wicked problems' (Rittel and Webber, 1973), 'ill-structured problems' (Hisschemöller and Hoppe, 1995), and 'persistent problems' (Schuitmaker, 2012). This category of challenges has a number of general characteristics. First, grand challenges are complex and not defined by definitive ends, structures, or boundaries, which means that they are the result of multiple causes and expected to result in multiple consequences. Second, grand challenges are uncertain. They are only partially understood and more certain knowledge about them is not always possible to obtain. Finally, grand challenges are characterized by contestation. Since they are managed by and dependent on plural stakeholders with inherently conflicting interests it is expected that actors will support contrasting values, opinions, and framings regarding the challenge as well as its solution (Kuhlmann and Rip, 2014; Rittel and Webber, 1973; Schuitmaker, 2012; Wanzenböck et al., 2020).

Targeting this type of challenge arguably requires systemic innovation rather than individual product or process innovations at the level of the individual innovation actor (Weber and Rohracher, 2012). To this end, it is increasingly suggested that innovation policy under the normative turn could be based on frameworks and research from the field of transition studies, which focuses on systemic innovations across core societal sectors (subsequent sections will introduce the field in greater detail) (Coenen et al., 2015; Diercks et al., 2019; Grillitsch et al., 2019; Raven and Walrave, 2020; Schot and Steinmueller, 2018). Scholars have begun to explore what

[2] The combined effect of the pandemic, rising inflation, and the war in Ukraine is still unclear, but the World Bank estimates that these developments will cause a reverse of some positive trends, e.g., the number of people living in extreme poverty is expected to increase (Mahler et al., 2022).

a larger engagement with transition studies would imply for innovation policy. The following paragraphs outline key developments in this area of research, including various advancements to innovation system frameworks as well as the call for innovation policy to include active destabilization.

In light of the normative turn in innovation policy, traditional innovation system frameworks are being reassessed in various ways. Drawing on transition research, Weber and Rohracher (2012) explore how existing innovation system frameworks can be extended to consider system-wide transformation. They argue that innovation policy for system-wide change needs to go beyond the traditional focus of addressing market and system failures, which mainly enable optimization and support for the existing system of innovation. To instead legitimatize and develop policies for transformative change, Weber and Rohracher (2012) propose four additional transformation failures. First, the directionality failure, which emphasizes the need for innovation policy to proactively steer the direction of innovation towards grand challenges. Second, the demand articulation failure, which highlights the need for innovation policy to address market uptake of innovations, user practices, and expectations. Third, the policy coordination failure, which points to the importance of coherent and timely policy actions across vertical and horizontal policy areas as well as public and private sector institutions. Finally, the reflexivity failure, which calls for innovation policy to actively engage with the long-term and uncertain nature of transformative change. It is argued that innovation policy based on a combination of traditional and transformational failures will help legitimatize the formulation of policy directed towards transformative change.

This call for an extended innovation policy, which takes transformational failures into account, has led scholars to explore the development of innovation policy mixes for system-wide change. A policy mix refers to the various policy instruments that are put in place to address problems identified in the innovation system of interest (Borrás and Edquist, 2013). Kivimaa and Kern (2016) argue that innovation policy mixes for system-wide change should include both creative and destructive policy instruments. In other words, "policies aiming for the 'creation' of new and for 'destabilising' the old" (Kivimaa and Kern, 2016, p. 205). This suggestion builds on assumptions from transition studies (e.g., Turnheim and Geels, 2012), which argues that the urgency of many grand challenges, such as climate change, requires active destabilization of unsustainable systems because policies focused on supporting alternative systems are assumed to be too slow. The focus on destabilization exemplifies the very explicitly political dimension that is emphasized with the normative turn in innovation policy. To destabilize activities in a sector is bound to create contestation and probably resistance from those invested in set activities.

This political and more critical engagement with innovation is also evident in recent attempts to reassess innovation system approaches. Noticeably, scholars are working to revise the regional innovation system (RIS) concept to allow for a more

explicit exploration of how regions vary in their capacity to bring about transformative change (Flanagan et al., 2022; Isaksen et al., 2022; Tödtling et al., 2021). The primary focus of RIS has previously been to advance technological and business innovation in order to boost regional competitiveness and economic growth. However, against the backdrop of growing concern for grand challenges, scholars are advancing a revised version of the RIS concept, which "embraces a more critical view of innovation, captures the directionality of change, opens up to new innovation actors at different territorial scales and pays more attention to the application side and upscaling of innovation within the region and beyond" (Tödtling et al., 2021, p. 2139). Alongside this attempt to revise the traditional RIS concept, Hekkert et al. (2020) have advanced a new innovation system concept, the mission-oriented innovation system (MIS). The concept is currently in an early stage of development, but the overall purpose of the MIS is to support scholars and policymakers in understanding and eventually intervening in the innovation dynamics related to grand challenges.

The reassessment of particularly the RIS concept begins to address scholarly critique arguing that research of innovation policy under the normative turn is largely insensitive to geographical context and does not take spatial and scalar aspects into consideration (Brown, 2021; Coenen and Morgan, 2020). For decades, RIS scholarship has examined why innovative strengths and weaknesses differ across regions (Asheim et al., 2019), and how understanding of this variation can be used to develop more place-based and region-specific innovation policies (Tödtling and Trippl, 2005). The recent attempts to revise the RIS in response to the normative turn holds promise in terms of bringing the geographical capital of this rich tradition into conversation with the recent generation of innovation policy. Despite these developments, little scholarship has explored what tackling grand challenges means for the multi-scalar governance of innovation policy. Key exceptions are Wanzenböck and Frenken (2020) and McCann and Soete (2020), who theoretically explore the multi-scalar governance of transformative innovation policy. A key objective of this thesis is to further advance our understanding of this issue by drawing on empirical research as done in Paper II.

When theory meets practice

As outlined in the introduction, the overarching aim of this thesis is to advance the conceptual understanding of transformative innovation policy through empirical research. The aim is largely motivated by the criticism that research under the normative turn in innovation policy is biased towards conceptual work (Haddad et al., 2022; Janssen et al., 2021). However, there are some exceptions to this largely conceptual focus, which I will review in this section.

Recent research has begun to explore the design, implementation, and evaluation of specific transformative innovation policies. Looking at the policy design of two

global initiatives promoting transformative innovation policies, Mission Innovation and the Global Covenant of Mayors for Climate and Energy, Diercks et al. (2019) demonstrate that transformative innovation policy is characterized by contestation, and that its practical expressions are diverse and even contradictory at times. While both initiatives share a societal policy agenda, they differ in their understanding of the innovation process. Focusing on singular technological breakthroughs, Mission Innovation represents a narrow understanding of the innovation process that sits comfortably with conventional innovation policy. In contrast, the Global Covenant of Mayors for Climate and Energy aims for a more radical reconfiguring of urban systems, and therefore represents a broader understanding of the innovation process, which challenges conventional innovation policy. Looking more specifically at the design of policy instruments, Borrás and Serger (2022) examine and compare four research and innovation programmes across the Nordic countries aimed at addressing grand challenges. The authors explore "to what extent the design of new policy instruments for grand challenges are nested according to the rationale of transformative R&I [research and innovation] policy" (Borrás and Serger, 2022, p. 659). Here, the concept of nesting refers to the anchoring of policy instruments in the broader policy context. Analysis of the four cases shows weak or medium degrees of nesting and further illuminates challenges associated with the design of policy instruments for transformative change, for instance, trade-offs in the design of policy instruments aimed at transformation.

Going beyond a focus on the design of policy and policy instruments, Grillitsch et al. (2019) examine the design and implementation of two Swedish Strategic Innovation Programmes (SIP). They find that the SIPs struggle with some of the same key challenges that transformative innovation policy sets out to address in the first place. Conflicting interests between stakeholders inhibit the formulation of clear objectives and the programs are consequently not steered by a collectively deliberated and well-aligned vision, but rather by a broad program encompassing various competing agendas. Moreover, although the programs by design involve a broad range of stakeholders, challenges remain in terms of overcoming 'institutional mismatch' between actor communities, such as academia and industry. The involvement of industry actors is low during implementation, which in turn weakens the programs' ability to promote policy learning and coordination. Parks (2022), exploring a different Swedish SIP, similarly finds that the actors delegate the task of setting direction in an attempt to avoid conflict. In this case, urban infrastructure companies end up articulating the social challenge and giving direction to the project in the form of articulating demands, while other demand-side stakeholders, e.g., civil society, are not included. Brown (2021), examining the rationale for and validity of the establishment of the Scottish National Investment Bank, a mission-based policy initiative, finds that the initiative lacks detail and insufficiently considers the particular regional innovation system that characterizes Scotland.

In response to the diffusion of transformative innovation policies, Janssen (2019) sets out to develop a framework for evaluating policy potential. The proposed framework focuses on assessing how a transformative innovation policy contributes to building up technological innovation systems. The framework is used to assess the impact of the Dutch research and innovation strategy: Topsector. The assessment finds that Topsector has resulted in the drafting of holistic action agendas and generally has created momentum among many actors to tackle urgent issues. However, the approach falls short in terms of demand-side initiatives, such as market formation, for the envisioned innovations. Redefining directionality is also a challenge identified here, as the policy's efforts are mostly concentrated on aims and directions that firms are willing to pay for rather than new long-term goals.

Finally, a few papers have begun to specifically study the opportunities and limitations of regional innovation policy in bringing about transformative change. Martin (2020) examines regional attempts to transform the chemicals industry in the Swedish region of Gothenburg-Stenungsund. Although companies in the area have defined an ambitious plan to become leading producers of sustainable chemistry products, which is supported by regional public actors, the case study shows the difficulty of putting the plan into action. One of the main reasons given for this is that the companies located in the area struggle to legitimatize the envisioned change within their parent organizations located elsewhere in the world. Similarly, focusing on attempts to promote renewable energy in Schleswig-Holstein, Germany, Hassink et al. (2022) find that only some of the challenges experienced in the region can actually be addressed regionally. They find that many of the experienced challenges depend on actors and capabilities located beyond the region.

A couple of consolidated insights can be drawn from the small set of empirical studies conducted so far. First, all the papers unpack various challenges and contradictions that arise when transformative innovation policies are implemented in practice. This emphasizes that transformative innovation policies are not implemented in a vacuum, but against a contextual and pre-existing backdrop. To this end, Martin (2020) shows how pre-existing inter-organizational power relationships influence the implementation of transformative ambitions, Brown (2021) points to the importance of pre-existing strengths and weaknesses in the innovation system, Borrás and Serger (2022) unpack the role of the broader pre-existing policy landscape, and Grillitsch et al. (2019) show that pre-existing institutional routines, such as different timeframes in academia and industry, matter when transformative innovation policies hit the ground. Second, a number of the papers also show the difficult nature of negotiating the directionality of transformative innovation policy (Diercks et al., 2019; Grillitsch et al., 2019; Janssen, 2019; Parks, 2022), which is a key conceptual component of the normative turn. The research carried out by both Janssen (2019) and Parks (2022) describe situations where the task of redefining directionality falls back on incumbent actors, whereas Grillitsch et al. (2019) find that the task is largely bypassed to avoid conflict

between stakeholders. Finally, the papers on regional innovation policy point to the multi-scalar dimension of transformative innovation policy. The papers by Martin (2020) and Hassink et al. (2022) suggest that transformative change is dependent on policy, actors, and capabilities across various scales.

Taken together, these empirical insights 'speak back' to theory, and contribute to further advancing our conceptual understanding of innovation policy under the normative turn. As stated in the introduction of this thesis, it is argued here that more empirical research is needed to continue new lines of theoretical and conceptual development on transformative innovation policy. Before diving into the empirical side of things, the remaining part of this conceptual background will introduce the field of sustainability transitions. As mentioned above, this field of research is increasingly linked to innovation policy under the normative turn and has been important in shaping this thesis.

Sustainability transitions research

Sustainability transitions is a burgeoning, multi-disciplinary field (Köhler et al., 2019; Markard et al., 2012) with origins in innovation studies, science and technology studies, and evolutionary economics (Smith et al., 2010). The field is underpinned by the assumption that addressing grand challenges requires transformative change of socio-technical systems. Sustainability transitions can in turn be understood as directed socio-technical transformations, which set out to radically transform the established socio-technical system towards more sustainable modes of production and consumption (Elzen et al., 2004).

The socio-technical system is the primary unit of analysis in sustainability transitions research (Geels, 2004). Sectors that provide societal functions and services, such as transportation, energy supply, or waste management are conceptualized as socio-technical systems (Markard et al., 2012). These socio-technical systems are understood to be complex configurations consisting of multiple elements, including technologies, actors, and institutions. The various system elements are highly interdependent as they develop and align over time and consequently reinforce the stability of the configuration in place (Geels, 2004). As a consequence of this stability, socio-technical systems are characterized by incremental rather than radical changes and innovation. If the system is to shift in a more fundamental manner, multiple elements in the socio-technical system have to change. This type of fundamental system change is expected to unfold over decades and involve a broad range of actors (Elzen et al., 2004; Geels and Schot, 2010). Since many sustainability transitions are not expected to bring short-term user benefits or price and performance improvements (Geels, 2011), it is argued that private actors have little incentive to initiate sustainability transitions. Instead,

public actors are expected to play a key role in driving and directing sustainability transitions though, for instance, regulations and policies (Meadowcroft, 2011).

Research in sustainability transitions is characterized by both normative and analytical ambitions. The field's attention to direction emphasizes the normative ambition. There is a prescriptive logic of wanting to steer change towards greater sustainability, which often means researchers in the field make more or less explicit statements about what a desired transition looks like and tries to achieve (Köhler et al. 2019). An example of this normative ambition is found in transition management research, where a practice-oriented governance framework has been developed to guide policymakers in ongoing transitions (Kemp and Loorbach, 2006; Loorbach, 2010).

The overarching analytical ambition of sustainability transitions research is to conceptualize and explain how, and by whom, change to socio-technical systems can be initiated and steered (Köhler et al., 2019). In this respect, the normative dimension of transitions is approached more analytically (e.g., Elzen et al., 2011; Schlaile et al., 2017). The contested nature of sustainability is acknowledged (e.g., Meadowcroft, 2011, 2009; Shove and Walker, 2007; Smith et al., 2005), which is reflected in the field's increasing focus on the power and politics of transitions (e.g., Avelino et al., 2016; Geels, 2014; Grin, 2010; Kern and Rogge, 2018; Normann, 2015) as well as the field's growing attention to ethical and moral aspects of transitions (e.g., Newell and Mulvaney, 2013; Sovacool et al., 2016; Swilling and Annecke, 2012).

Explaining socio-technical transitions

One of the most prominent theoretical frameworks used to explain transitions is the Multi-Level Perspective (MLP) (Markard et al., 2012), introduced by Rip and Kemp (1998, 1996) and subsequently advanced by Geels (2002). The key notion of the MLP framework is that socio-technical transitions come about through the interaction of three analytical levels: landscapes, regimes, and niches.

First, the landscape level describes an external backdrop of societal developments, which niche and regime actors respond to, but have little influence over in the short-term (Geels, 2004, 2002). The landscape developments include slow-changing trends, such as geopolitics, demographics, or ideology, as well as exogenous shocks, such as wars, major accidents and political upheavals (Geels, 2018). Second, the regime is understood as the stable and dominant configuration in the socio-technical system and refers to the established practices and semi-coherent rules that "orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems" (Geels, 2011, p. 27). The regime is expected to be characterized by a strong alignment between institutions, practices, technologies, and materiality (Loorbach et al., 2017). Finally, niches are conceptualized as

protected spaces where more radical and disruptive innovations can be created and tested outside the selection pressure of the prevailing regime (Geels, 2004, 2002).

In early MLP work, external sources of change are emphasized as key triggers of transitions. The destabilization of the regime is understood to be prompted by landscape developments. The instability caused by landscape developments creates windows of opportunity for novel niche configurations enabling them to potentially break through and begin to compete with the existing regime (Geels, 2004). In this early work, transitions are often understood as processes of gradual regime substitution, where niches cumulate and upscale to eventually replace the regime (Geels and Raven, 2006; Geels, 2002).

This early conception of change in the MLP has been critiqued for emphasizing niches as the key sites of novelty and the starting point for processes of regime change, which some scholars have referred to as the 'bottom-up niche bias' (Berkhout et al., 2004). This perspective has also been found prone to perpetuate rather rigid views of actors, largely assuming that regime actors defend the 'bad' existing configuration and niche actors promote the new 'good' configuration (Berggren et al., 2015). However, more diverse views of transition dynamics are developing (Strambach and Pflitsch, 2020). Research is increasingly emphasizing that transitions may take multiple pathways, beginning to nuance dichotomous views on change mechanisms as well as actor roles, and it explores the role of more endogenous sources of change. The following paragraphs explore these developments in greater detail.

Towards more diverse views of transition dynamics

The increasingly diverse view of transition dynamics is partly reflected in transition pathway typologies (Geels et al., 2016; Geels and Schot, 2007; Smith et al., 2005), which illustrate that multi-level interactions leading to transitions can take a range of forms. This work suggests that path-breaking novelty is not exclusively tied to niches and as such it begins to address the critique of the bottom-up niche bias. For instance, the transformational pathway identified in Geels and Schot's (2007) typology suggests that regimes may gradually adjust and reorient in the context of landscape pressure. In the first version of their typology, this adjustment was considered to be mainly incremental (Geels and Schot, 2007). However, in a later revised version, it is suggested that even radical reorientation may take place among regime actors in the transformation pathway, which highlights the regime as a potential source of novelty and change (Geels et al., 2016).

Relatedly, there is a broader effort among transition scholars to nuance the role of actors in transitions in order to address the field's tendency to assume that regime actors make incremental innovations and generally resist transition efforts, while niche actors are assumed to make radical innovations and generally try to overthrow

the regime (Geels, 2018; Turnheim and Sovacool, 2020). In their study of the heavy vehicle industry, Berggren et al. (2015) show that some regime actors actually drive radical innovation at the niche level. Similarly, Steen and Weaver's (2017) study of established firms in the two main Norwegian energy sectors—offshore oil/gas and large-scale hydropower—also suggests that regime actors respond in a variety of ways to changing selection pressures and windows of opportunity, including diversification into other green energy sectors such as offshore wind. These studies alongside related research (e.g., Haley, 2015; Hanson, 2018; Hellsmark and Hansen, 2020; Onufrey and Bergek, 2020) begin to present a more balanced view of particularly incumbent actors.

In the most recent paper on transition typologies, Geels et al. (2016) also begin to nuance the view of change mechanisms beyond the dichotomy of radical and incremental change, which is otherwise very ingrained in transitions thinking. Drawing on neo-institutional political science, the paper presents four additional change mechanisms developed by Thelen (2003), which go beyond incremental adjustment and radical disruption. These four change mechanisms are *layering* where "new institutions are layered on top of existing arrangements without affecting their core logic", *drift* where "on-the-ground implementation gradually changes policies-in-use without any official decision", *conversion* where "the goals of existing policies are adjusted, while instruments remain unchanged", and finally, *displacement* where "new institutions slowly over-take existing ones" (Geels et al., 2016, p. 898). Drawing on this more nuanced view of change mechanisms, Geels et al. (2016) emphasize the possibility of fluid shifts between pathways. They argue that transitions can start out on a more incremental pathway, which may at some point morph into a more substantial or radical pathway, or the other way around. Drawing on empirical case studies of the transition towards low-carbon electricity in Germany and the UK, the authors find this type of pathway shift to be largely the result of endogenous development rather than external landscape change.

An emphasis on endogenous change is also found in research on agency in transitions. This body of work is primarily concerned with human agency, focusing on the intentional actions and interventions made by actors. One exception is a recent paper by Contesse et al. (2021), which explores non-human agency in transitions. Within transitions research, scholars have worked towards conceptualizing agency more explicitly in an attempt to nuance and advance the MLP framework and the broader understanding of socio-technical change (Grin, 2010). Although the MLP's intellectual roots, especially in science and technology studies, place emphasis on structure as well as agency, empirical application of the model has been critiqued for emphasizing a structualist account of socio-technical change, while largely ignoring processes of agency (Genus and Coles, 2008; Lawhon and Murphy, 2012; Markard and Truffer, 2008; Smith et al., 2005). Moreover, researchers have recently questioned the underlying philosophical assumptions relating to the MLP's view on structure and agency. It is argued that

agency and structure are conflated in the MLP, which inhibits analysis of their interplay (Sorrell, 2018; Svensson and Nikoleris, 2018).

In response to this criticism, scholars have advanced more actor-oriented and agency-sensitive analyses. In an early special issue on the topic, Farla et al. (2012) find that strategic interventions by actors can, at least to some extent, shape changes in socio-technical systems. They moreover point to a relationship between the strategic interventions carried out by actors and their available resources, suggesting that resources both enable and represent a constraint for what actors can achieve. Other research has empirically explored or tried to conceptualize the type of actors and the type of actor roles that are needed for systemic change processes (e.g., de Haan and Rotmans, 2018; Fischer and Newig, 2016; Mossberg et al., 2018; Wittmayer et al., 2017). Scholars have also explored agency by drawing on institutional theory, particularly insights from institutional entrepreneurship (e.g., Hassink et al., 2018; Jolly et al., 2016) and institutional work (e.g., Duygan et al., 2019; Rogers et al., 2015; Sjøtun, 2019; Smink et al., 2015; van Doren et al., 2020). This research focuses on the concrete actions carried out by actors in order to, for instance, create legitimacy (Binz et al., 2016), transform an entire sector (Brown et al., 2013), or shape institutions in favour of a particular technology (Fuenfschilling and Truffer, 2016). Taken together, this growing research on agency in transitions allows for the development of a more multifaceted conceptualization of transition dynamics acknowledging both exogenous and endogenous sources of socio-technical change.

The above paragraphs outline some of the broader developments that have contributed to nuancing our understanding of transition dynamics. In the following paragraphs, I want to zoom in on two additional developments in the literature: the growing role of geographical theorizing and the emergence of configurational theorizing. Both are in some respects part of the larger developments outlined above, but are highlighted in more detail, as Paper II in this thesis draws explicitly on the former and Paper III on the latter.

Geographical theorizing

The past decade has seen growing interest in explicitly exploring geographical and spatial dimensions of socio-technical transitions (for a review see Hansen and Coenen, 2015). Some of the earliest work on this topic critiqued sustainability transition's research for failing to explain if and how context matters (Coenen et al., 2012; Hodson and Marvin, 2009; Smith et al., 2010). Since empirical work in the field at the time was very biased towards Northern Europe and particularly the Netherlands, scholars began to question whether the theoretical insights developed from these studies would be applicable to other geographical contexts. On the basis of this argument, calls were made to diversify the range of empirical case studies analyzed (Lawhon and Murphy, 2012), a development which is starting to take form in the field now; see for instance Hansen et al. (2018) who take stock of the emerging

field of sustainability transitions in developing countries. The call for greater contextual understanding has also led to research on the specific role of cities (Madsen and Hansen, 2019; Monstadt, 2007; Späth and Rohracher, 2011) and regions (Smith, 2007; Späth and Rohracher, 2012, 2010) in sustainability transitions.

This increasing focus on geography and the importance of spatial sensitivity has also led to conceptual developments. Drawing on concepts from economic geography, namely 'comparative institutional advantage' and 'institutional thickness', Coenen et al. (2012) conceptually unpack how particular conditions such as specific cultures, institutions, and political systems make places more or less susceptible to the promotion of a sustainability transition. Similarly, Bridge et al. (2013) show how key concepts from human geography more broadly can be used to explore the spatiality of low carbon energy transitions.

In parallel, key conceptual developments have been made concerning the multi-scalar nature of transitions. The multi-scalar understanding is developed in response to a tendency in transition studies to favor the national scale of analysis (Truffer et al., 2015). This research emphasizes that niches and regimes should be conceptualized as multi-scalar structures (Fuenfschilling and Binz, 2018; Hodson and Marvin, 2010; Raven et al., 2012; Sengers and Raven, 2015; Späth and Rohracher, 2010), which in turn challenges the linear model of spatial diffusion that is central to many studies based on the MLP (e.g. Geels, 2002). Studies based on the linear model of spatial diffusion tend to assume that national regime change will eventually 'up-scale' and challenge the global regime (Binz et al., 2020). However, when neither niches nor regimes are understood to be anchored in pre-defined, place-specific actor-networks, the linear model of spatial diffusion is not likely to be applicable to all types of transitions. Based on this understanding, Miörner and Binz (2021) conceptualize two alternative transition trajectories based on the understanding that socio-technical configurations differ in their degree of institutionalization and their spatial configuration of associated actor-networks. In Paper II, I argue that this understanding also has quite fundamental impact on the way we can conceptualize the spatial organization of transformative innovation policy as it supports the need for a spatially dynamic model.

Finally, geographical perspectives have been mobilized to support a strong focus on the normative aspects of transition processes. Lawhon and Murphy (2012) argue that theorizing in political economy provides useful means for explicitly exploring the power relations that shape transition dynamics. The authors highlight that at the heart of political ecology lie questions such as: who is included and excluded from decision-making processes; whose knowledge counts and why; what are the expected socio-economic and cultural consequences of decisions and how can these be shaped and mitigated for more just outcomes. A better integration of these questions into transition studies would arguably allow for the development of a transition theory more sensitive to potentially skewed power dynamics. Along the

same lines, Murphy (2015) highlights that geographical research on place and place-making has the potential to unpack the power and politics of transitions, particularly context-specific forces that influence the speed and shape of transitions.

Configurational theorizing

Recent years have seen some scholars in transitions research move towards configurational theorizing. Configurational theorizing aims to explore socio-technical transition processes in a less rigid manner than the MLP, which is critiqued for its rather categorical distinction between regimes, niches, and landscapes (Heiberg et al., 2022). Configurational theorizing draws on neo-institutional theory and builds on the understanding that a socio-technical system can be conceptualized as an organizational field with a special focus on technology (Fuenfschilling and Truffer, 2014; Geels and Schot, 2007). This understanding of organizational field relies on DiMaggio and Powell's (1983, p. 148) definition of the concept: "organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services and products". Within the configurational approach, the organizational field, otherwise known as the socio-technical system, is understood to encompass a number of socio-technical configurations consisting of actors, institutions, and technologies, which are aligned and institutionalized to various degrees (Heiberg et al., 2022). These more or less aligned and institutionalized configurations correspond with the MLP categories of niches and regimes. However, compared to the MLP, the configurational approach advances a spectrum rather than a dichotomy of configurations. An additional feature of configurational theorizing is an emphasis on the potential heterogeneity of regimes. The regime is understood to be the most institutionalized structure in the organizational field, but this structure is expected to vary between systems. A regime in a system structure dominated by one main configuration is expected to be different from a regime in a system structure composed of multiple configurations (Fuenfschilling and Truffer, 2014).

The key features that characterize configurational theorizing, including the spectrum perspective on configurations and the expectation that regimes are heterogeneous, arguably has implications for the way we can understand transition trajectories. From the configurational perspective, the conventional view of transition trajectories, where one dominant regime is replaced by one niche, represents only one of multiple transition trajectories (van Welie et al., 2018). To better appreciate the multitude of transition trajectories the structural characteristics of socio-technical systems should be taken into account (Alkemade, 2019; Andersen et al., 2020). In Paper III of this thesis, we explore transition dynamics and agency in light of this configurational theorizing and develop a framework for studying transition dynamics that takes the structural characteristics of socio-technical systems into account.

3 Empirical background

This chapter of the kappa aims to introduce the empirical background of the research. It starts with a brief introduction to Denmark and the country's overarching system of environmental governance. The chapter subsequently zooms in on waste management in a historical perspective outlining changing rationalities, practices, and actors in the Danish waste sector.

A brief introduction to Denmark

Denmark is one of the smaller countries in Europe. It covers an area of 43000 km^2 and is inhabited by a population of 5.9 million (Danmarks Statistik, 2022). Denmark is a constitutional monarchy. The country has a representative parliamentary system with a head of government (the prime minister) and a head of state (the hereditary monarch, who holds no formal legal power). Power in the Danish society is divided between three independent branches. The elected government (ministers) holds the executive power, the legislative power rests with Parliament, and the courts of justice constitute the judicial power (Basse, 2015).

There are three levels of government in Denmark: state or national administration, regional administration (five regions), and municipal administration (ninety-eight municipalities). In terms of environmental management, under which waste management also falls, authority is shared between the national and municipal administrations, while the regional level of governance has very limited authority (OECD, 2019). The national administration is responsible for laying down the legal framework and ensuring compliance with EU law. They provide guidance on implementation and develop national plans and strategies. Environmental programs have been scattered across multiple ministries and the responsibility of ministries have changed between and during various government. Waste management, however, is primarily the responsibility of the Ministry of Environment, which consists of a department and four agencies. Municipal administrations have large autonomy in environmental governance. They administer permit systems and follow up with inspections, they are responsible for planning as well as local implementation of policies, plans, and strategies (Basse, 2015; Brandt, 2018). Beyond national levels of government, Danish environmental governance is today

very dependent on EU legislation. Denmark is a member of the EU and has been since January 1973 (Brandt, 2018).

The Danish waste sector in a historical perspective

Over the past 160 years, the Danish waste sector has been guided by expanding rationalities, while waste management practices and actors have also changed. In the following sections, I intend to introduce these developments (see Table 1 for overview), as this historical perspective on the Danish waste sector has been a key backdrop against which I have explored the current attempts to pursue a circular economy. The sections aim to provide an overview of waste management, and do not go into developments in and contestations around individual waste fractions.

Table 1. Rationalities, practices, and actors in the Danish waste sector.[3]

Time period	Rationalities	Practices	Actors
1850-1960	Public health	Landfilling	Local health commissions Landowners (later municipalities) Waste producers Landfill operators Waste transport operators
1961-1985	Waste volume elimination Pollution prevention Mitigate consequences of oil crises (high raw material prices and oil dependency)	Landfilling Incineration Recycling	Provisional Pollution Council Ministry for Pollution Control/ Environment Danish Environmental Protection Agency Inter-municipal waste companies
1986-2001	Use waste to replace fossil fuels for energy production	Landfilling Incineration Recycling	Municipalities/ inter-municipal waste companies The EU
2002-2010	Increase efficiency in waste management	Landfilling Incineration Recycling	Liberal-Conservative government Private recycling companies
2011-	Address grand challenges (e.g., resource consumption) and secure resource supply and competitiveness Reduce greenhouse gas emissions to meet national Climate Act Meet EU recycling targets	Landfilling Incineration Recycling	The EU NGOs Industry associations

[3] Rationalities and actors listed for the time periods are not exhaustive, but rather refer to the actors and rationalities that drove change and stood out during the time period.

To further quantify how waste management practices have changed in Denmark, Table 2 shows the country's total waste generation across treatment types in 1985, 2000, and 2019. It is important to note that the measurement of waste treatment types during these years is based on collected volumes. This is particularly important to keep in mind when considering the reported recycling rates, since the quality of recycling is disguised in this measure. In other worlds, material can be collected for recycling and counted in the statistics, but the subsequent process of recycling can take different forms, and does not necessarily mean that the waste ends up recycled. For example, in 2018, 31 percent of Danish plastics packaging waste from households was collected for recycling, however, it is estimated that approximately half of the collected plastics packaging waste was rejected in subsequent sorting processes and instead ended up incinerated (Regeringen, 2018).

In 2018, the practice of counting recycling changed to better reflect the variation in quality, which also explains the decrease in recycling levels between 2000 and 2019. From 2018, the amount of waste used for backfilling is reported separately from the amount of waste reported as recycled. Backfilling includes recovery operations at lower quality where waste is used for e.g., reclamation in excavated areas or road construction (Miljøstyrelsen, 2020). The amended Packaging Directive (2018/852) requires member states to adopt new practices of measuring and monitoring their recycling targets. Rather than measuring the level of recycling based on the weight of material that is collected for recycling, member states are to measure levels of recycling based on the material weight that is left after all sorting processes have taken place. This practice, however, has not been implemented for the reported years in Table 2.

Table 2. Total waste generation in Denmark across treatment types in 1985, 2000 and 2019 (Miljøstyrelsen, 1991, 2001a, 2020).

	1985	2000	2019
Landfilling (%)	57	11	3
Incineration (%)	22	24	25
Recycling (%)	24	65	47
Backfilling (%)	n/a	n/a	24
Total waste generation (million tons)	9,3	13,0	12,7

Landfilling for the benefit of public health (1850-1960)

> It is fair to say that before the 1970s, waste was not really something that received a lot of attention. There was some general regulation, which was part of health policy, but as long as waste was not too much in the way and did not bother people along the coastlines then things were considered fine (Interview 13).

This introduction to Danish waste management starts in the mid-19th century when waste management rationalities were being linked explicitly to concerns for public health. The outbreak of cholera in Copenhagen in 1853 was in part the result of poor waste management, which triggered waste disposal regulation under the health statute of 1858. This regulation stipulated that waste had to be placed in landfills located at the urban periphery. It was also set forth that local health commissions in towns and cities were to administer the practice (Pagh, 2006). In addition to contributing to better public health in urban areas, landfilling also supported the reclamation of land, which further justified the practice (Eriksen, 1996). In Copenhagen, areas such as Amager Fælled, Nordhavn, and Sydhavn were reclaimed with landfilling[4] (Københavns Kommune, 2022).

The practice of landfilling was relatively crude in the sense that waste was simply placed in open holes such as gravel pits or low lying coastal areas. Once filled, the area was covered by soil and grass was planted (Pagh, 2006). Informal recycling practices developed, for instance alongside landfills where communities settled and made a living of salvaging disposed materials, e.g., discarded food waste was picked and used as animal feed until regulation eventually prohibited this in 1887 (Eriksen, 1996). Although landfilling remained the dominant waste management practice well into the 20th century, the first incineration plant was built in Denmark in 1903 and another couple of plants followed in the 1930s. However, further development ceased during the war and the immediate post-war period (Kleis and Dalager, 2007).

The local health commissions were entrusted with the supervision of waste management throughout this period. For a majority of this time, the responsibility of waste disposal was placed on landowners, who were required to dispose of the waste produced on their property (COWI, 2001). Both private and public operators ran landfills and waste transportation services. However, after the Second World War, municipalities increasingly took on the responsibility of waste collection and disposal. Waste producers were of course also a key actor and as industrialization took off in the latter decades of the 19th century, industry actors became increasingly important waste producers (Miljøstyrelsen, 2001b).

Towards a more multifaceted waste management (1961-1985)

> In the 1960s, waste volume reduction for hygienic reasons was a key motive for constructing incineration plants. These reasons outweighed that incineration was more expensive than landfilling. However, the current rise in energy prices means

[4] Land reclamation also took place in other parts of the country, but often using different techniques. For example, drainage enabled extensive wetland areas to be reclaimed for agricultural use during the second part of the 19th century (Hvidt, 2012).

> that an important goal today is to exploit the energy in the waste (Miljøstyrelsen, 1982, p. 40).

This period marks the beginning of a radical shift in the Danish waste sector. Denmark moved towards a more multifaceted waste management system both in terms of rationalities and practices. Waste management was also increasingly formalized with more comprehensive regulation and the establishment of new public actors responsible for governance of the waste sector.

During the late 1960s and early 1970s, socio-economic changes and growing awareness of pollution put increasing pressure on the landfilling regime. The 1960's intensifying urbanization and economic boom resulted in growing prosperity and higher levels of both consumption and disposal (Farbøl, 2018; Rasmussen and Brunbech, 2009). As a result, waste generation increased and landfilling capacity was exhausted in many parts of the country, particularly urban and suburban areas (Miljøstyrelsen, 1978a). During this period, pollution prevention also gained political momentum in Denmark as well as abroad. When landfill leachate was linked to growing levels of groundwater pollution, the established waste management system came under more pressure to change (Veltzé and Fischer, 2019). With the increasing pressure on landfilling capacity as well as the growing concerns over pollution, waste management rationalities expanded beyond concerns for public health. It was now vital that the waste sector rapidly eliminated waste volumes and addressed concerns over pollution.

Alongside this change in rationalities, waste management practices in Denmark also began to shift. The Danish waste sector came to be characterized by a rapid reduction in landfilling enabled by growing rates of recycling and incineration (Miljøstyrelsen, 1978a). The shift was in part supported by tighter landfilling regulation. Sites had to obtain environmental approval and new guidelines stipulated how to build and run landfill sites to reduce pollution, which consequently increased costs (Basse, 2015; Miljøstyrelsen, 1974). Moreover, the recycling law of 1978 supported the development of new recycling technology with project grants, and required municipalities to collect paper and beverage packaging from households (Miljøstyrelsen, 1983). The law initially focused on paper and beverage packaging (mainly glass bottles), but after a revision in 1984 the material focus of the law was expanded, and project grants were further increased. The collected waste volumes for recycling went primarily to private recycling companies located in the country (Miljøstyrelsen, 1985). The expansion of waste incineration was moreover supported by the presence of Danish companies with strong technological competences (e.g., producers of waste incineration plants) as well as the willingness of municipalities to co-invest in incineration plants through so-called inter-municipal waste companies (Kleis and Dalager, 2007).

Following the oil crises in the 1970s, the shift towards greater shares of recycling and incineration came to be motivated by additional rationalities beyond the

elimination of waste volumes and pollution prevention. Recycling was seen as a way to mitigate high raw material prices and attempt a reduction of resource consumption, while waste incineration was further motivated by the need to reduce Denmark's dependency on oil imports for energy production (Miljøstyrelsen, 1982, 1978b). Waste incineration came to power a significant share of district heating, which was extensively expanded in the wake of the oil crises (Fischer, 2012).

This period also saw the establishment of a number of key new actors in the waste sector. In 1969, the Provisional Pollution Council was established to assess the state of pollution in the country and give policy recommendations to improve the environmental protection from waste and other sources of pollution (Veltzé and Fischer, 2019). To follow up on the recommendations from the Provisional Pollution Council, the Ministry for Pollution Control (today known as the Ministry of Environment) and the Danish Environmental Protection Agency were established in 1971 and 1972, respectively (Brandt, 2018). The new ministry took over waste management responsibility from the local health commissions. Shortly after the ministry was established, the first Environmental Protection Act was passed in 1973, which introduced tighter regulation and initiated greater waste planning through, e.g., the collection of waste statistics (Miljøstyrelsen, 1982).

Municipal autonomy and EU awakening (1986-2001)

> Municipalities were given a lot of power and responsibility [for waste management] in the 1980s, but stakeholders in the sector generally agreed that the set-up made sense. Waste management was largely seen as a nuisance and there was no strong recycling industry interested in the waste. So municipalities were considered to take care of a problem. And of course it was a very good story that they were able to make a lot of heat from that problem, too (Interview 7).

During this period the guiding rationalities in the Danish waste sector were expanded to incorporate the growing concerns over climate change. From the mid-1990s, the recovery of heat and energy from waste incineration was highlighted as CO_2-friendly in Denmark because it replaced the use of fossil fuels in energy production (Kørnøv et al., 2016). Changes to waste management practices initiated in the past period were also continued during this period. There was a continued phase out of landfilling and increase in recycling, which was particularly attributed to changes in the treatment of demolition waste. Incineration capacity also continued to grow (Veltzé and Fischer, 2019).

Key developments characterizing this period, however, were related to changes in actors and their responsibility. Of particular importance was the strong decision-making power granted to municipalities. In 1986, amendments to the Environmental Protection Act assigned Danish municipalities the full responsibility to ensure sufficient capacity for waste management (Miljø- og Fødevareministeriet, 1986;

Miljøstyrelsen, 1990). This legislation change was made after waste haulers had dumped waste in front of parliament to demonstrate the continued challenges of securing waste management capacity (Fischer, 2012). With this change in legislation, municipalities were granted the right to allocate all waste produced within their jurisdiction to the treatment facility of their choice (allocation right). Waste producers, both households and industry, were obliged to use the waste management facility assigned to them by the local municipality (utilization duty). This prevented competition for waste and consequently made municipalities largely autonomous in managing the waste produced within their jurisdiction (Eskesen, 2005; Miljø- og Fødevareministeriet, 1989).

The allocation right and utilization duty enabled municipalities to finance a continued expansion of waste management infrastructure. With the utilization duty, municipalities could direct waste produced within their jurisdiction to their own facilities, creating security for the investments they made in the local infrastructure. Municipalities primarily invested in incineration plants, but also in sorting facilities and pre-treatment plants that prepared waste for recycling (Interviews 7-10, 12-14). The strong municipal autonomy also allowed for very different practices to develop across the country with respect to the collection, sorting, and treatment of waste. Consequently, Denmark came to be characterized by a diverse landscape of waste management. This also resulted in a wide variation in waste management fees across the country. By law, municipalities operated under a non-profit organizational principle, implying that municipal waste management activities and facilities could not in the long term run at a profit or a loss. Since the cost of waste management was paid by waste producers, i.e., households and industries in the municipality, the fee for waste management came to vary significantly across the country depending on the individual economy of the facility as well as the waste management activities that individual municipalities or the inter-municipal waste company decided to focus on (Kørnøv et al., 2016).

Alongside the changes to decision-making power within Denmark, this period also saw the growing influence of the EU. The Single European Act of 1986 provided the first legal basis for a common environmental policy, and the 1992 Treaty of Maastricht subsequently established ‘the environment’ as an official EU policy area, which further enabled the transfer of legal authority from member states to the EU (Selin and Van Deveer, 2015). With regard to waste specifically, EU legislation from before the 1990s was limited to administrative requirements. Member states were required to, for instance develop waste plans and collect waste data, however, the actual treatment of waste was decided on by individual member states. This began to change when the Packaging Directive (1994/62/EC) and Landfilling Directive (1999/31/EC) were passed in 1994 and 1999, respectively. Both directives set targets for specific types of waste treatment, e.g., recycling and landfilling, which member states were required to meet (Veltzé and Fischer, 2019). The introduction of producer responsibility in the beginning of the 2000s mandated by

the EU on end-of-life vehicles, batteries, and waste electrical and electronic equipment also shifted the financial responsibility of waste treatment to the producers of these particular waste types (Fischer, 2012). During this time period, the growing influence of the EU had a rather limited impact on Danish waste management because Danish waste legislation for the most part was stricter than the legislation stipulated by the EU. For example, EU legislation placed extensive focus on the reduction of landfilling, which Denmark at this point had already achieved (Brandt, 2018).

Contestation over the emerging efficiency rationality (2002-2010)

> The Ministry of Environment had been very strong under the Social Democratic government that ruled until 2001. Denmark was really in the forefront then and it really did feel a bit like we could walk on water. So it was a shock to many when the new government came into power in 2001. The Ministry of Environment was dismantled and an entirely new logic was introduced (Interview 10).

In 2001, a new Liberal-Conservative coalition took office, which marked the beginning of growing contestation in the Danish waste sector. From the perspective of market-based principles, the new government argued that innovation and efficiency in the sector were challenged by the prevention of competition created by the allocation right and utilization duty (Miljøministeriet, 2004; Regeringen, 2003a). In 2007, recyclable industrial waste was liberalized; however, the change was largely symbolic in nature, since industrial waste for recycling was already exempted from the utilization duty, and in effect had always operated under market conditions (Eskesen, 2005; Interview 7, 9, 10, 12). Further attempts to liberalize the sector were unsuccessful in part due to strong municipal resistance.

The critique of the sector was largely focused on the role and responsibility of municipalities, while no major change to waste management practices were considered necessary. Denmark was still living up to its responsibility as a member state (Interview 2, 7, 9, 12) and further expansion of incineration capacity was planned and encouraged by the government independent of the liberalization debate (Regeringen, 2003b).

In terms of actors, this period also marked a time when the private recycling industry started to mature more in the Danish setting. Both national and multinational companies started operating in Denmark. Their operations focused mainly on collecting and sorting waste to sell to an increasingly growing international market (Interview 12).

Circular economy visions and climate change agendas (2011-2022)

> The Climate plan [for the waste sector] represents a paradigm shift for Danish waste management and I was very surprised when it was announced. No wonder it has created conflict. It is controversial in the sense that it turns the Danish fairytale about waste incineration on its head (Interview 11).

In this final time period, rationalities in the Danish waste sector have been influenced by the introduction of circular economy visions as well as a more explicit climate change agenda. The growing influence of circular economy visions stems mainly from the EU, where environmental concerns over growing resource input and waste output is connected with the possibility of achieving economic benefits by decoupling resource use from economic development (Kern et al., 2020; Reike et al., 2018). It is argued that linear production and consumption systems increase the exposure to risks associated with supply chain challenges and uncertain resource prices. Instead, resource efficiency and the vision of a circular economy have been promoted and are expected to address the environmental consequences of inefficient resource use, while also allowing the EU to boost competitiveness and generate new jobs in a sustainable economy. The European Commission describes the transition to a circular economy as a process where "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (European Commission, 2015, p. 2). Visions of resource efficiency were already present in the 2011 'Roadmap to a Resource Efficient Europe' (European Commission, 2011), but the circular economy agenda was further cemented as a central EU policy after the Commission published legislative proposals in 2014 and 2015 (European Commission, 2015, 2014). In EU waste policy, the emergence of circular economy visions triggered a very strong promotion of recycling across all waste fractions and targeted the limitation of incineration (Domenech and Bahn-Walkowiak, 2019).

Beyond the growing importance of the circular economy agenda, rationalities in Danish waste management were also influenced by the national Climate Act of 2019, which set out to reduce the country's greenhouse gas emissions by 70 percent by 2030 compared to 1990. In the waste sector this directed attention towards the potential for CO_2 reductions if incineration capacity was reduced (Miljøministeriet, 2021).

The changes in rationality at both EU and national level has triggered attempts to change waste management practices in Denmark. Most noticeably, in 2020, the Danish government with broad support from parliament passed the *Climate plan for a green waste sector and circular economy* (Regeringen, 2020). The plan aimed to support the development and diffusion of innovations related to circular waste management. It stipulated that by 2030, incineration capacity is to be reduced by 30

percent. Moreover, the plan streamlined waste collection across the country and dismantled the allocation right and utilization duty based on the argument that the strong municipal autonomy contributes to the country's incineration lock-in (Regeringen, 2020).

In terms of actors, the EU has played a key role in triggering these recent changes in the Danish waste sector. The first legislative changes made to support the EU's transition to a circular economy introduced recycling targets, which the prevailing waste management regime in Denmark was not expecting to be able to meet (Miljøministeriet, 2021). Unlike previous time periods, EU waste policy now triggered change in Denmark, because the current Danish system was no longer considered to be at the forefront. Environmental non-governmental organizations (NGO) and industry associations also came to play an important role as both lobbied for a move away from the strong reliance on incineration (interview 12).

Final remarks

> The Danish waste sector has been frozen for 20 years. Nothing has happened! Municipal waste management has not improved and if we are to meet current EU recycling targets at the speed we are moving now then we will reach them in the year 3000 (Interview 12).

> Denmark has one the world's best waste management systems. But some actors have been very successful at telling a different story, they are accusing municipal waste actors of neglecting their environmental responsibility. They are being used as scapegoats to legitimatize the destruction of a world leading sector (Interview 10).

With this historical introduction to Danish waste management, I hope to show that change is not new to the waste sector. On the contrary, there are many parallels between the current attempts to pursue a circular economy and the shift we saw starting to materialize in the 1960s and 70s, where the sector moved away from the monolithic regime focused on landfilling. What is different, however, between current attempts to change the sector and the previous shift, is the level of contestation. Views on the current state of the Danish waste sector and the need for it to change are very conflictual. This is exemplified in the quotes above, which are from two interviews carried out in the same week of September 2021. In contrast, my empirical material suggests that the move away from landfilling was largely without conflict.

From my understanding of the case, I see two reasons for this difference in contestation. First, the practice of landfilling was not collectively institutionalized. While some landfilling operators went bankrupt because their operations became more expensive against the backdrop of new regulation (Basse, 2015; Pagh, 2006),

there was no formal industry organization for landfilling, and there does not seem to have been collective lobby work done on behalf of the landfilling regime when it began to face increasing pressure (Interview 9, 10, 13). Second, as the historical background shows, the Danish waste sector has incorporated an expanding number of rationalities and new actors, which has caused growing misalignment between aims and views of the sector. First, misalignments in the sector were related to organization and public-private responsibility, while actors were generally content with waste management practices. However, after visions of circularity gained momentum and after the introduction of the National Climate Act, the misalignment in the sector came to concern waste management practices and rationalities more broadly. The current guiding rationalities of securing resource supply and reducing CO_2 emissions more directly conflicts with previous rationalities of utilizing waste for energy production. In that sense, the introduction of circular economy in the Danish case is intimately linked to reducing the energy rationality in the sector.

4 Methodology

The empirical articles in this thesis (Article II and III) draw on case study research of the Danish waste sector. Case studies are rich empirical descriptions that focus on phenomena in their real-world context, allowing us to address questions of a 'how' and 'why' nature (Yin, 2014). Aligned with the aims of this thesis, case study research is suitable for generating explanations and contributing to theory development (as opposed to theory testing) (Stake, 1995). In this chapter, I describe and reflect on my research process and design, discuss philosophical assumptions underpinning the work, and present the methods used for data gathering as well as processes of analysis. My aim for this section of the kappa is to make the research process more visible than was possible in the individual papers. I intend to write a reflective account of the work done during my PhD, while still linking to relevant methodological literature.

The research process and design

My empirical engagement with the Danish waste sector started in late 2017. At this time, major amendments to EU waste directives were being negotiated between the European Parliament, the European Council, and the European Commission. This revision of waste directives was the first legislative step made towards implementing the Circular Economy Action Plan, which the European Commission had adopted in 2015 (European Commission, 2015). I was intrigued to learn more about this new legislation and particularly its implementation in Denmark, where waste management for decades had been characterized by relatively high shares of waste incineration, and therefore in many ways clashed with the visions of circularity increasingly emphasized in EU policy and legislation.

From late 2017 and until early 2022[5], I followed developments and change processes in the Danish waste sector by interviewing stakeholders, participating at sector events, and doing extensive desk-based research. I initially focused on sector changes unfolding in real time as the circular economy policy in general, and the revised waste directives in particular, were being translated by Danish policymakers

[5] I was on parental leave for 9 months during parts of 2019 and 2020 during which I mostly paused my research.

into the Danish setting. To better contextualize the ongoing changes, I also eventually began to develop a more longitudinal understanding of stability and change in the Danish waste sector.

My research process and design have been influenced by processual and emergent approaches (Alvesson and Kärreman, 2011, 2007; Dubois and Gadde, 2014, 2002; Hammersley, 2022; Morgan, 2008). This means that I did not formulate research questions or decide on data collection and analysis procedures from the outset. Instead, I allowed this to evolve over the course of the research project. I started with a fairly explorative and open approach aiming to develop a rich understanding of the Danish waste sector. However, this was by no means a purely inductive undertaking, such as that advocated by proponents of grounded theory (e.g. Glaser and Strauss, 1967). Rather, I began my fieldwork with a broad conceptual interest in socio-technical transitions and a particular curiosity about directionality and the politics of governing transitions.

The flexible research approach allowed me to follow and explore unanticipated empirical events that characterized the Danish waste sector during the course of my project, for example, the rescaling of the Danish waste sector decided on in 2020. I found inspiration in process studies of organizational change, which suggest that studying change processes as they unfold in real time provides researchers with an opportunity to develop rich empirical material that is sensitive to the messy character of change. Arguably, "[t]his approach maximizes the probability of discovering short-lived factors and changes that exert important influence" (Van de Ven and Poole, 2002, p. 875). While studying a process in real time offers the advantage of illuminating the messiness and sometimes short-lived aspects of change processes, I also found this to be a source of difficulty during my project. At times, I found it challenging to commit to a cause of action, i.e., pausing my empirical work and developing a conceptual argument based on the material I had collected, knowing that if I stayed with the process I might generate new valuable insights. A second, and sometimes related challenge, was that of going from detailed empirical material to writing a more aggregate narrative, which inevitably involved a process of sorting, interpreting, abstracting, and framing the empirical material.

I worked with and around these challenges in different ways. I shared early drafts and ideas with supervisors, colleagues, and co-authors, and once it was more formalized, presented my work at conferences or PhD courses. Getting feedback from a reader or an audience less tied to the empirical material was often very helpful. Hearing from others how my material resonated with their interpretations helped me tease out my empirical focus and helped me let go of certain more detailed descriptions. On a more pragmatic note, journal expectations with respect to word limit and format also forced me to work with my presentation of empirical material and to reduce detail. Taken together, these challenges have been a continuous reminder of my interpretive authority and subjectivity as a researcher (Vandenbussche et al., 2020). I have felt a big responsibility when developing the

empirical narratives and stories and when describing the contexts and processes taking place there.

Why a case study of the Danish waste sector?

Although going into the empirical work without clear research questions, there were a number of reasons why I thought a case study of the Danish waste sector was likely to be a good window into processes of interest. First, as alluded to above, I expected there to be a collision between the Danish waste sector—characterized by a high share of incineration—and the new policy discourse of circular economy, which the sector had to answer to after the revision of the EU waste directives. I thought it likely that this collision would make change processes visible and particularly illuminate conflictual aspects and challenges related to governing these change processes. Second, research on transitions has been quite empirically focused on the energy sector (Duygan et al., 2019; Markard, 2017) and scholars have started to suggest that conceptual knowledge in the field is perhaps too tied to these sectors, particularly energy (van Welie et al., 2018). Consequently, I expected that there was likely to be a potential for conceptual development by focusing on a different sector like waste. As such, the decision to focus on the Danish waste sector was based on a set of general expectations about the information that could be gathered from the case, and how that information could 'speak' to conceptual debates in the field.

As the research progressed and my article ideas matured, I was also able to further develop my argumentation for why a focus on the Danish waste sector was appropriate. In Paper II, it was possible to frame the governance of Danish waste management as a 'critical' case according to Flyvbjerg's (2006) typology, because the developments in Denmark contradicted conceptual arguments and thus were able to provide a strategic perspective on the general issue of the scalar organization of transformative innovation policy. In Paper III, it was the complex configurational setup of the waste sector (with multiple regime- and niche-like configurations) that made it a useful case for studying agency processes beyond the niche-regime interaction.

Approaching theory development

The key aim of this thesis is to contribute to developing the conceptual understanding of transformative innovation policy through empirical research, focused on the ongoing transition towards a circular economy in the waste sector. In going about this, I have been particularly inspired by the work of Alvesson and Kärreman (2011, 2007), who explore the process of developing theory from empirical material. They propose a methodology for the development of theory based on "encounters between theoretical assumptions and empirical impressions

that involve breakdowns" (Alvesson and Kärreman, 2007, p. 1266). Building on work by Mills (1959) and Weick (1989), Alvesson and Kärreman (2011, 2007) argue that theorization can be understood as 'disciplined imagination', and that empirical material is able to contribute to theorization because it can be a source of both imagination and discipline. They understand empirical material as a source of imagination in the sense that it can challenge our current theoretical understanding of a phenomenon and in turn trigger our imagination to make sense of the phenomenon in a different way. At the same time, they argue that empirical material creates a relative boundary for the researcher's imagination, since it ties the process of theorization to specific claims about the studied phenomenon. In their view, this is the disciplining aspect of empirical material.

Crucially, Alvesson and Kärreman (2011, 2007) emphasize a constructed or theory-infused nature of empirical material and therefore object to the separation of theory and empirics. They find that both deductive and inductive research insists on this theory/data separation: "Theory is supposed to 'fit' data – either by design, where a lack of fit should lead to rejections or revisions of a theory [in the case of deduction], or by default, where theory is understood as emerging from data [in the case of induction]" (Alvesson and Kärreman, 2011, p. 3). Instead, they rely on the Peircean understanding of abduction as an inference mechanism to develop theory. Shank (2008, p. 1) outlines the logic of the Peircean understanding of abduction in the following way:

> Some event, X, is surprising to us
>
> But if some explanation, Y, were in place, then X would be ordinary
>
> Therefore, it is plausible that X is actually a case of Y

In other words, a surprise appears between our theoretical expectation and an empirical phenomenon. In response, a new theory is articulated to make sense of the surprise, which means that theory is developed in the process of expanding the possible explanations of the surprise. Abductive reasoning accepts that the researcher cannot directly observe their developed theories and emphasizes that empirical material is contestable. Taken together, this suggests that theory development and the process of abduction are continuous processes (Van Maanen et al., 2007).

In implementing ideas from this methodology of theory development, I attempted to create a continuous conversation during my research between my empirical material and the conceptual discussions I was aware of, as well as those I became acquainted with in parallel to my fieldwork. When surprises or tensions stood out between the two, for instance, if I struggled to conceptually explain what I was experiencing in my empirical work, I explored that surprise further. Most of the time, initial surprise was resolved relatively quickly when I read more on the topic and found that scholars had already engaged extensively with the issue.

For example, early on in my research, I became intrigued by a surprise concerning plastics recycling and the vision of the circular economy. I was intrigued that the European Commission (European Commission, 2018) and other major actors such as the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2016) were creating a narrative of a circular plastics economy, while many of the actors I engaged with in the Danish setting laughed at the prospect of recycling a majority of post-consumer plastics waste such as packaging. This led me to wonder why some actors imagine a future (e.g., a circular economy of plastics) so different from current material realities experienced by other actors, in my case mainly actors from industry and research, who work with plastics and emphasize the technical and material barriers to recycling? What is this vision of circularity supposed to do? Literature on the sociology of expectations relatively quickly helped me think about these questions, as I read up on research regarding the role of visions and expectations in guiding social and technological development (e.g., Berkhout, 2006; Borup et al., 2006; Eames et al., 2006). Furthermore, I found that the vision of the circular economy was already receiving a lot of attention from scholars, who teased out and explored contradictions like the one I was intrigued by (e.g., Kirchherr et al., 2017; Lazarevic and Valve, 2017). My personal fascination with this contradiction did not diminish, but I did eventually decide that this was not a tension that would allow me to develop interesting research questions.

A few surprises, however, did remain and became the starting points of the empirical papers in this thesis. For example, when developing Paper II, I was reading literature on the scalar organization of transformative innovation policy, where recent theoretical research suggested that social and environmental challenges were best pursued at the subnational scale. This, however, seemed to contradict what was happening in the Danish waste sector where the implementation of the circular economy agenda in waste management triggered a re-organization that was doing the opposite: the subnational scale was losing decision-making power. This tension led me to explore literature on scale and multi-level governance, which eventually helped me further develop a different conceptual approach to the spatial organization of transformative innovation policy.

Exploring tensions between empirical material and conceptual discussions allowed and required me to engage in analysis throughout the research process. Echoing Dubois and Gadde (2002), the different activities of the research process were integrated and intertwined. As such, it did not follow a linear and neat set of planned ‘phases’, which is advanced in some of the more mainstream literature on case study methodology, namely Eisenhardt (1989) and Yin (2014). The more abductive approach followed in this research entailed a continuous movement between empirical material and theory.

Philosophical underpinnings

The methodological choices and considerations I have made throughout my project are underpinned by philosophical assumptions about knowledge and how we can know the world (epistemology), as well as the philosophy of being and basis of existence (ontology). This project is shaped by critical realism, a philosophy of science commonly associated with Bhaskar (e.g., 1978, 2008), popularized in human geography by Sayer (e.g., 1985, 1992) and recently also a topic of increasing interest in transitions research (Geels, 2022; Papachristos, 2018; Sorrell, 2018; Svensson and Nikoleris, 2018). Critical realism is a heterogeneous movement in the social sciences (Danermark et al., 2019), and as the following paragraphs will show, I take as my point of departure a version of critical realism that is compatible with a moderate social constructivism. Following Ritz (2020), I find that this version of critical realism is, moreover, compatible with a Peircean understanding of abduction and therefore goes well with Alvesson and Kärreman's (2011, 2007) methodology for theory development.

The epistemological understanding that underpins critical realism emphasizes that the way we understand the world is theory-laden, which means we cannot separate theory and data as two different entities. Accepting this means accepting that our knowledge of the world is always fallible and that the idea of 'objective' knowledge is nonsensical (Sayer, 1992). As asserted by Maxwell (2012, p. 86) "[e]very theory is a lens for making sense of the world, and every theory both reveals some aspects of that reality, and distorts or conceals other aspects". This also implies that our knowledge of the world is subject to revision and should continuously develop.

Ontologically, critical realists understand the world to exist largely independently of our knowledge of it, which means that the world cannot be reduced to either empirical observation—as advocated by empirical realists—or the beliefs and our language about the world—as advocated by extreme social constructivists (Danermark et al., 2019). Instead, critical realists promote a stratified ontology that consists of three domains: the *empirical*, the *actual*, and the *real*. The empirical domain refers to events that we can observe and experience and is considered a subset of the actual domain, which refers to all events that happen no matter whether they are observed or experienced. The distinction between the empirical and actual domains thus emphasizes that what is observed and what happens cannot be equated. Finally, the real domain refers to the structures and mechanisms that produce events (Danermark et al., 2019). These structures and mechanisms can be physical, social, psychological, or conceptual (Mingers and Standing, 2017).

Taking this understanding of reality as a point of departure, critical realists argue that the purpose of science is to relate events studied at the empirical domain to the real and actual domains. This requires researchers to develop theoretical explanations of causality, or in other words, try to theoretically unpack the structures

and mechanisms that generate events (Maxwell, 2012). In this regard, critical realism emphasizes that causality is the result of both structural factors, including the physical world, and human agency. It moreover argues that structures and mechanisms are context dependent and therefore will vary across time and space (Reed, 2005).

Critical realism does not dictate particular research methods, but instead expects methodological questions to be dealt with in scholarly disciplines and decided on with a sensitivity to the topic studied (Yeung, 1997). That said, Sayer (2000) makes strong arguments for the usefulness of qualitative methods in critical realist research. He finds that the intensive nature of qualitative work enables researchers to abstract causal mechanisms and begin to explain the production of certain objects or events in particular places. Yeung (1997) echoes Sayer (2000) with respect to the necessity of qualitative research, but also emphasizes that quantitative methods can inform the abstraction of causal mechanisms by demonstrating regularities between objects. Of course, causality between these quantified regularities cannot be assumed, as they reflect an understanding of causality only at the level of the empirical.

Critical realism and socio-technical change

Scholars have recently begun to explore how a critical realist perspective can contribute to transitions research (Geels, 2022; Sorrell, 2018; Svensson and Nikoleris, 2018). While these recent papers agree on the relevance of critical realism for transition studies, each point to different implications of a critical realist perspective on transitions. Geels (2022) mainly demonstrates how critical realism is well suited for transitions research, while Sorrell (2018), as well as Svensson and Nikoleris (2018), focus more on how critical realism illuminates weaknesses of the MLP, which in turn calls for further development of the theoretical assumptions underpinning the framework.

One of the main points of critique proposed by Sorrell (2018), as well as Svensson and Nikoleris (2018), is that the MLP relies on Giddens' (1984) structuration theory for understanding structure-agency relationships, which conceptualizes structure and agency as a duality that is not to be analytically separated. Building on the work of the critical realist, Archer (1995), Sorrell (2018), as well as Svensson and Nikoleris (2018), argue that to not analytically separate structure and agency hides the properties and power of both structures and agents. For instance, Svensson and Nikoleris (2018) find that the account of agency in the MLP is reduced to rule structures, bounded rationality, and interpretive activities, which they argue are insufficient to account for the power relations in socio-technical change processes. Consequently, they suggest that there is a need to develop "a conception of actors' position in relation to systemic structures which influence their differentiated mode of access to resources and possibilities" (Svensson and Nikoleris, 2018, p. 466).

Moreover, they argue for the need to incorporate material structures, such as spatial context and physical infrastructure, into the analysis of structure and agency.

The papers in this thesis go some way to address these concerns. The approach to transition dynamics and agency advanced in Paper III pays explicit attention to the structural position of actors in the system, as well as both material and discursive field conditions that enable or condition the ability of actors to influence system change. This goes beyond the rule based view of agency associated with Giddens' structuration theory. Although not explicitly phrased in structure-agency terms, Paper II also draws attention to how actors try to exert influence over both discursive and material dimensions of system structure, specifically scalar dimensions.

Critical realism and moderate social constructivism

Before moving on from this section concerning philosophical underpinnings, I want to briefly reflect on the relationship between critical realism and moderate social constructivism, as this relates to arguments made in Paper II. In line with scholars such as Smith (2010), Elder-Vass (2012), and Sayer (2000), I consider critical realism to be entirely compatible with moderate social constructivism. This means that I view social phenomena as socially constructed, but at the same time insist that processes of social construction can result in very real products (Elder-Vass, 2012). This implies that while on the one hand it is acknowledged that social phenomena would not exist without the process of social construction, this approach also on the other hand recognizes that social constructions come to eventually contain both material and non-material properties and powers that are largely independent from their constructors. This view emphasizes that social construction is a process, and one that takes place over time (Sayer, 2006). Moreover, this approach to critical realism finds that social constructs are not static, rather they exist as processes of either reproduction or transformation (Lawson, 2003).

I labor this point because it relates to the conceptual argument made in Article II, where scale is viewed, not as ontologically given, but as socially constructed. I argue that a social construction of scale is compatible with a critical realist perspective. Once scales are established through processes of social construction, they can over time come to take on properties that are independent from their initial constructors or subsequent observers, and as such, a distinction between scale and our understanding of it is established as advocated by the basic realist proposition (MacKinnon, 2010). An example from the Danish case is the allocation right, which is the legislation granting municipalities autonomy over the waste produced within their jurisdiction. The allocation right became a property of the local scale in Denmark, which had very real power over resource allocation, and which became independent of the actors who initially established it. However, as outlined in Article II, this property of the local scale is not static, but is now subject to transformation due to actor struggles over scale in Danish waste management.

Methods and empirical material

The empirical material that is mobilized in Paper II and III was collected using multiple qualitative methods. The use of qualitative methods and material lends itself well to this project's process-oriented and emergent research design, since the open-ended and explorative nature of qualitative research allowed me to be flexible in my focus and receptive to unanticipated topics and perspectives. Additionally, qualitative research allows for the collection of empirical material that can be used for generating possible explanations to complex processes and relationships (Cope and Hay, 2021).

Participant observation

During the course of this research, I participated in 17 events focusing on various topics related to the Danish waste sector (see overview in Table 3). Observing and participating in these events were important first steps in getting to know my object of study, the Danish waste sector (Watson, 2021), of which I had only limited knowledge before starting the research. The participant observation helped me identify key organizations in the sector, many of which I later approached for interviews. During the course of my research, participating in these events was also a way to stay informed about new developments in the sector. All of the events I attended brought together diverse actors from the sector, which often illuminated general concerns and central conflicts over waste management.

Most of the events I attended were organized by Waste and Resource Network Denmark (DAKOFA). DAKOFA is an independent member-based organization. Their members include a diverse group of public and private stakeholders across the waste and resource sector, including national and local authorities, NGOs, private organizations and companies, consultancies, and research institutions. DAKOFA organizes events for the waste sector, where actors join to discuss and share knowledge about waste management (DAKOFA, n.d.). Participants at these DAKOFA events represented the sector well. There was considerable overlap between participants at DAKOFA events and participants at non-DAKOFA events as well as the actors that have taken part in public consultations over recent national waste plans.

The conferences organized by DAKOFA were full-day events consisting of presentations and panel discussions. These took place before the COVID-19 pandemic and included lunch and coffee breaks with the other participants, where I was able to have informal conversations with actors from the sector, ask questions, share, and listen to their reflections on the topic that was covered in each particular conference. During the pandemic, DAKOFA organized webinars. These were online sessions, usually lasting three to four hours and focused mainly on

presentations. I was not able to continue the more dynamic and spontaneous interaction with other participants in the online format, which was a disadvantage of the events moving online. The webinars did, however, allow me to stay updated on many key discussions and developments in the sector.

Table 3. Overview of participant observation.

No.	Event: title (translated from Danish by the author)	Organizer	Date
1	Conference: Plastics packaging: increasing recycling and the road to phasing out the plastics problem	DAKOFA	Nov 2017
2	Conference: New EU rules and targets: what does the future hold?	DAFOKA	Mar 2018
3	Conference: Municipal waste planning: waiting for the national plan	DAKOFA	Aug 2018
4	Public hearing: Organization of the Danish waste sector	Energy, Utilities and Climate Committee	Oct 2018
5	Conference: The way out the plastics problem	DAKOFA	Jan 2019
6	Conference: The future of packaging – EPR and sustainability	DAKOFA	Feb 2019
7	Conference: Collection schemes and new sorting standards for household waste	DAKOFA	Mar 2019
8	Conference: DAKOFA annual meeting	DAKOFA	Sep 2019
9	Webinar: A new organization of the waste sector	DAKOFA	Jun 2020
10	Webinar: Crystal ball insights on the Danish waste sector	DAKOFA	Sep 2020
11	Webinar: ERP and the single use plastics directive	DAKOFA	Oct 2020
12	Webinar: Managing plastics in Denmark	DAKOFA	Oct 2020
13	Webinar: The legal and practical consequences of the Climate plan	DAKOFA	Nov 2020
14	Online debate: How do we speed-up the circular economy	Danish Plastics Federation; Danish Society of Engineers	Apr 2021
15	Webinar: The municipal waste plans and the new municipal recycling targets. What are the potentials?	DAKOFA	Apr 2021
16	Webinar: How can technology increase the quality of recycled plastics?	Danish Business Authority; EPA	Apr 2021
17	Webinar: Status on the one-year anniversary for the Climate plan	DAKOFA	Jun 2021

As a participant, I mainly gathered material through extensive note taking, but presentation slides and participant lists were also useful material gathered from these events. After every event, I wrote fieldwork reflections on key themes discussed as well as questions that the event triggered. I also made notes on how

these empirical reflections related to the conceptual work I was engaging in. Since the other participants were not informed in advance that I was there as a researcher, I decided to not use quotes from the events in my work. Instead, when topics and perspectives caught my interest, I subsequently asked the participant for an interview or searched for publicly available material produced by the participant or their organization to learn more.

Documents

Another source of empirical material are various types of documents concerning the Danish waste sector, including newspaper articles, grey literature, and regulation. Throughout the research project, I followed news concerning the sector. Practically, I did this by signing up to receive newsletters from a number of online news outlets that cover topics related to waste management specifically (e.g., the niche media WasteTech) or technology and clean tech topics more generally (e.g., Ingeniøren and Cleantech Watch). When receiving the newsletters, I scanned through the article titles and read further when something seemed interesting and relevant to my project. For the most part this was an unstructured undertaking in the sense that I have not systematically kept track of all the articles I have read over the years. Still, this exercise helped me stay updated on new initiatives, regulations, and policies and would often allow me to get a first sense of how actors reacted to these proposals or changes.

In Paper III, I also collected and analyzed newspaper articles in a more systematic manner, using the database Infomedia. I collected articles from seven national newspapers and four online media outlets. The collection of newspaper articles, which consisted of 176 articles, was used as an additional source of material to both map institutional work carried out by actors and to gain more insights on the resources, discourses, and social networks of actors. I also made use of this material to probe further in many of the interviews (see Paper III for search string details).

Beyond newspapers, I have drawn on grey literature and regulatory documents to develop a better understanding of my empirical case. Grey literature can be defined as non-peer reviewed publications that are primarily produced to communicate a message rather than being produced for commercial publication, and which is shared on many different platforms (Tillett and Newbold, 2006). In my research, I draw on grey literature such as reports, press releases, presentation slides, public consultations, waste plans, and strategies. I accessed the documents online through the homepage of organizations, online archives such as the Environmental Protection Agency's publication archive (Miljøstyrelsen, 2022), and the Danish public consultation portal (Civilstyrelsen, 2022a). Regulatory documents mainly included statuary orders and official communication from the European Commission or the Danish government, which I accessed through legal digital information systems, Retsinformation (Civilstyrelsen, 2022b) for Danish legal

documents and EUR-Lex (European Union, 2022) for EU legal documents (an outline of documents used in the thesis can be found in Table 4. See Appendix A for a full overview).

I used document analysis to keep up with sector developments in real time, but also as a way to go back in time. In that sense, document analysis allowed me to develop a better chronological overview of the Danish waste sector. I focused on identifying key events, e.g., legislative developments, the emergence of new technologies, or the changing role of actors. From this, I tried to identify periods of stability and change in waste management practices and regulation. Document analysis also allowed me to verify or specify the course of more historical events mentioned in interviews. Moreover, the analysis of documents was a way to develop an understanding of some of the contextual conditions that shaped the sector at various points in time (Roche, 2021), e.g., political and popular attitudes towards waste management and environmental protection.

Table 4. Outline of empirical documents across categories.

Document category	Quantity
EU Directives	6
Communications from the European Commission	7
Danish regulatory documents	5
Reports by or reports prepared for Danish government agencies	37
Publications by Danish ministries or governments	12
Reports and publications by international stakeholders	9
Reports and publications by Danish stakeholders	15

Interviews

A final source of empirical material are semi-structured, in-depth interviews. I carried out 29 interviews from August 2019 until March 2022 with a diverse group of stakeholders from the Danish waste sector, including politicians, civil servants, researchers, and representatives from the private sector, NGOs, and municipal organizations (see detailed list in Table 5). The conversational nature of semi-structured interviews enabled interviewees to describe and explain their experiences and views in great detail, while also creating space for unanticipated topics to emerge during our conversation (Valentine, 2005).

I approached individuals for interviews based on a purposive sampling strategy where participants were identified based on who was likely to provide in-depth empirical material of relevance to the project (Oliver, 2006). Specifically, I wanted to talk to individuals representing key organizations and stakeholders in the Danish waste sector, who held or had held key positions and therefore were able to provide

insights on either present day issues or more historical developments. In many cases, interviewees could provide both, since a majority of the people I interviewed had decades of experience in the sector. Many had occupied different professional positions in a variety of organizations throughout their career. As paper ideas developed, I targeted interviewees who had particular knowledge of the topic I wanted to explore further, i.e., rescaling for Paper II and contestations over the management of organic waste and plastics packaging for Paper III. I identified relevant interviewees during my participant observation and through the desk-based research, but also through the snowball method, where interviewees were asked to recommend individuals who they thought would be relevant future participants (Crouse and Lowe, 2018; May, 2011). In many cases, interviewees spontaneously suggested other potential interviewees during our conversations, but I also made sure to end interviews asking who else they thought I should talk to in order to get further perspectives on the themes we had discussed.

The advantage of purposive sampling is first and foremost that it allows for the collection of relevant empirical material targeting individuals with specialist knowledge and experience. Sampling of this kind relies on the researcher's subjective decision-making regarding the relevance of individuals as well as the subjective referral by interviewees through the snowball method, which can be viewed as a source of potential bias in the material and as a challenge to the validity of the research (Crouse and Lowe, 2018; Oliver, 2006). Considering the epistemological underpinnings of critical realism, this subjectivity is expected and viewed as quite unavoidable, since the idea of objective knowledge is rejected. However, one way to work with this risk of bias and its potential threat to the validity of the research is to collect empirical material using a variety of methods and sources (triangulation) (Maxwell, 2012), which is pursued in this research project.

I mostly reached out to interviewees over email, but in a handful of cases, our first point of contact was through LinkedIn or text messaging after which we communicated by email. When communicating with interviewees over email, I introduced my research as well as the purpose of the interview and the broad themes I wanted to talk about. A few interviewees asked me to send them interview questions beforehand, which I did. I prepared individual interview guides to match the interviewee, but also to match my understanding and research focus, which developed over the course of the project (see Appendix B for two interview guide examples). Five interviews were conducted face-to-face, eight over the phone, and the remaining sixteen via videoconferencing. The extensive use of remote interviewing was in some instances a result of time and space constraints, but mainly due to lock-downs and travel restrictions during the COVID-19 pandemic.

The three interview modes share some key communalities. Interviews carried out face-to-face, over the phone or via videoconferencing all take place in real time. This synchronous communication means that interviewees engage spontaneously in the conversation, which allowed me as an interviewer to probe and ask follow-up

questions (O'Connor and Madge, 2017). Across the three modes of interviewing, it was also possible to make an audio recording of the conversation (Keen et al., 2022; Sturges and Hanrahan, 2004). A major difference between the modes is of course that interviews done over the phone or via videoconferencing do not require the interviewer and interviewee to be in the same physical place. Traditionally, this is considered an advantage of phone and videoconferencing in that it can reduce travelling costs and allow the researcher to access communities or individuals that are otherwise geographically difficult to reach (Salmons, 2016). During the pandemic, telephone and videoconference interviews made it possible to continue the collection of interview material despite lock-downs and other restrictions.

A potential disadvantage of remote interviewing is that it can exclude certain participants if they do not have access to either a phone or high speed internet or if they are unfamiliar with online communication software (O'Connor and Madge, 2017). I do not expect this is a prevalent issue in the Danish setting where phone and internet access is widespread, and especially not among my target group, most of which are employed at organizations that rely on this type of technology. Moreover, the pandemic created a familiarity with remote communication tools, as they became the new normal in many organizations.

A disadvantage of telephone interviews compared to interviews done face-to-face or via videoconferencing is that it is not possible to make use of visual props nor to assess bodily cues from interviewees (Hall et al., 2021). There is, moreover, disagreement among scholars over whether or not remote interviewing impedes rapport, which refers to "the degree of comfort in the interactions between the researcher and the research participants" (Morgan and Guevara, 2008, p. 729). Some argue that remote interviewing creates faster fatigue and more shallow interactions compared to face-to-face conversations (Irvin et al. 2012; Rubin and Rubin, 2011), while others find it possible to establish rapport in both telephone interviews (Sturges and Hanrahan, 2004) and via videoconferencing (Archibald et al., 2019; Deakin and Wakefield, 2014). My experience with remote interviewing was largely positive; in particular, videoconferencing worked well. I found that the pandemic and home working was a good small-talk topic when first meeting in a Zoom room or over the phone.

I started every interview going through a number of formalities. I introduced myself and reiterated the purpose of the interview as well as the research project more broadly. I asked for permission to record our conversation. All interviewees agreed to be recorded. I asked the interviewees if I could use quotes from the interview. Again, all interviewees agreed to this; however, some asked to see the quotes before I used them and others asked to see the interview transcript, which I shared in those cases. I explained that quotes would be associated with a generic identifier, such as industry association representative, rather than names of individuals or organizations. We discussed the challenges of guaranteeing anonymity despite the steps taken above. I highlighted two challenges with respect to anonymity. First,

that the research subject studied (the Danish waste sector) is small and individuals with knowledge of key actors in the sector may be able to infer the identity of a participant or their organization based on what is said. Second, Lund University is a public authority, which entails that any email or other correspondence can be requested by a third person under the principle of public access to public records. Finally, I reminded the interviewee that they always had the right to end the interview, and always could contact me with questions or comments.

Table 5. Overview of interviews.

No.	Interview	Interview mode	Time (min)	Date
1	Industry association representative	Face-to-face	59	Aug 2019
2	Municipal association representative	Face-to-face	56	Aug 2019
3	Former MP	Telephone	84	Oct 2019
4	NGO representative, waste sector expert	Face-to-face	48	Oct 2019
5	Former MP	Telephone	63	Oct 2019
6	NGO representative, waste sector expert	Face-to-face	75	Oct 2019
7	Former civil servant	Telephone	120	Jan 2021
8	Municipal association representative	Videoconferencing	122	Feb 2021
9	Municipal waste sector representative	Videoconferencing	66	Sep 2021
10	Consultant, waste sector expert	Telephone	100	Sep 2021
11	Former Mayor of Copenhagen	Videoconferencing	72	Sep 2021
12	Industry association representative	Videoconferencing	98	Sep 2021
13	Consultant, waste sector expert	Telephone	120	Sep 2021
14	Municipal waste sector representative	Videoconferencing	24	Nov 2021
15	Industry association representative	Telephone	21	Nov 2021
16	Professor in chemical engineering	Face-to-face	60	Nov 2021
17	Biogas expert	Telephone	61	Dec 2021
18	Biomass association representative	Videoconferencing	49	Dec 2021
19	Biogas association representative	Videoconferencing	100	Dec 2021
20	Waste sector expert	Videoconferencing	120	Dec 2021
21	NGO representative	Videoconferencing	50	Jan 2022
22	Industry association representative	Videoconferencing	50	Jan 2022
23	Waste sector expert	Videoconferencing	120	Feb 2022
24	Chemical recycling start-up	Telephone	60	Feb 2022
25	Chemical recycling start-up	Videoconferencing	50	Feb 2022
26	Municipal association representative	Videoconferencing	30	Mar 2022
27	Chemical recycling start-up	Videoconferencing	60	Mar 2022
28	NGO representative	Videoconferencing	63	Mar 2022
29	NGO representative	Videoconferencing	92	Mar 2022

The interviews ranged from 21 to 122 minutes, lasting 75 minutes on average. The interviews were carried out in Danish and subsequently transcribed non-verbatim in Danish. When quoting from the interviews, I translated them to English. I wrote brief fieldwork reflections after interviews, which were often more thematically organized, and worked as a first attempt to link empirical fieldwork back to my conceptual understanding. I coded interview transcripts multiple times according to both analytical and descriptive codes that developed over the course of the research. The methods sections of papers II and III include a more detailed description of how material was organized and analyzed for the respective papers.

As alluded to above, the purpose and focus of interviews developed over the course of the project. The first six interviews were quite explorative and focused on the sector more generally. Themes covered in the interview included: perceived sector challenges, sector contestations, present and past actor alliances, and EU waste legislation and its role in the Danish context both now and previously. At the time, there was an extensive focus on the management of plastics waste, and part of the interviews therefore also focused on various initiatives relating to this particular waste fraction. I carried out a second round of interviews in the aftermath of the decision to rescale the Danish waste sector, which is the key empirical focus in Paper II. Here I focused on deepening my understanding of Danish waste management from a historical perspective, exploring causes for stability and change in the sector particularly with regards to decision-making power. Against this historical background, I asked interviewees to unpack the circumstances around the rescaling of decision-making power in the waste sector. Finally, I carried out a third round of interviews, which focused specifically on the management of organic waste and plastics packaging, which are the key empirical focus points in Paper III. These interviews covered themes such as: perceived challenges and solutions to managing organic waste and plastics packaging, triggers and events influencing this management, actor resources and allies, the specific work of actors trying to influence the management, and their motivations to do so.

Final remarks

I collected empirical material throughout most of my PhD project, which allowed for continuous analysis, and a cumulative understanding of the case to develop. As described above in the section on theory development, I focused on putting the empirical material into conversation with theory to identify tensions and further avenues for exploration. In earlier and more explorative parts of the research process, my analysis would often take the form of fieldwork reflections where I described connections that I saw between my empirical material and theory. I used some of these first reflections to eventually develop analytical codes that I then

began organizing my material around. As my paper ideas concretized, I was able to focus my data collection and analysis. In turn, the research became less explorative and more concerned with enriching my understanding of the chosen tension. At this stage, I also developed what Cope (2016, p. 378) describes as descriptive codes, which aim to sort empirical material around "'who, what, where, when and how' types of questions". I mainly coded my material by hand, from which I developed tables with material organized according to my coding or drew timelines.

5 Findings and outlook

In this final chapter of the kappa, I will discuss the conclusions from the research, reflect on the project's limitations, and consider avenues for future study. The chapter begins by summarizing the main findings of the individual papers and subsequently responds to the thesis' research questions. In the following section, I first consider boundary conditions of the case study and then present suggestions for future research inspired by the empirical material. Lastly, I end this chapter and this kappa with a final set of reflections on how current events, namely the European energy crisis, is adding new layers to the pursuit of a circular economy in the Danish waste sector which further complicates the ambition of tackling grand challenges.

Summary of findings

Paper I in this thesis is a conceptual piece looking at how the focus and instruments of innovation policy have changed over previous decades. In the paper, we critically examine various periods of innovation policy offered in the literature, and debate the novelty of the recent shift towards transformative innovation policy. In other words, we attempt to unpack the historical and conceptual roots of transformative innovation policy.

Rather than discussing entirely different frames of innovation policy, we find that a gradual change is currently taking place where research on innovation policy becomes increasingly centered on the possibilities for innovation policy to deliver transformative change. The chapter attempts to distinguish new aspects of transformative innovation policy from older aspects of innovation policy and thus goes beyond outlining the broad principles of transformative innovation policy. We suggest that three aspects of the transformative innovation perspective represent novel elements in innovation policy. First, the aim to transition entire socio-technical systems; second, the emphasis on experimentation; and third, the deliberate intention to destabilize unsustainable regimes.

In the paper, we highlight that work on implementing transformative innovation policy has not progressed to a great extent. While the literature on transformative innovation policy has elaborated considerably on the inability of traditional innovation policy instruments to deliver transformative change, it continues to be a

challenge to give details on how transformative innovation policy instruments should be designed and implemented. We also point towards developing greater geographical sensitivity in research on transformative innovation policy, since there are few insights into opportunities for transformative innovation policies at the regional scale and limited understanding of how transformative innovation policy can and should take different forms in different geographical contexts. Both these shortcomings in the literature are addressed in Paper II of this thesis. Finally, we also suggest that research on transformative innovation policy has been rather silent about the role of agency. It remains unclear what role agency plays in the transformation process and how it may be mobilized through policy. This is, in part, a topic addressed in Paper III of this thesis.

The second article in the thesis (**Paper II**) is concerned with the spatial organization of transformative innovation policy. The paper responds to recent theoretical arguments made in favor of pursuing transformative innovation policy at the subnational scale. In the paper, I suggest that these theoretical arguments risk falling into a scalar trap, because they rely on a theoretical assumption about the policy effectiveness of the subnational scale.

In the paper, an analysis of the spatial organization of Danish waste management is mobilized to challenge the theoretical argument that the subnational scale is inherently best suited to pursue grand challenges. The case study shows that the introduction of transformative innovation policy in the Danish context of waste management involves a process of rescaling away from strong subnational decision-making. The reason for this rescaling is that the central role played by municipalities has come to be considered an obstacle for the system's ability to transition to a circular economy and thereby address growing concerns over societal and environmental challenges. The rescaling process in waste management arguably disempowers municipalities in an attempt to address their perceived incumbency in the Danish waste sector. The transformative effect of the rescaling in Denmark is still to be seen, but the case demonstrates that local actors can also form part of the regime that transformative innovation policy sets out to change.

Conceptually, the paper begins to challenge the assumed transformative potential of a static 'one size fits all' approach to the spatial organization of transformative innovation policy (in the paper referred to as 'the Containerized Approach' to the spatial organization of transformative innovation policy). Instead, this paper extends the Containerized Approach by emphasizing that the spatial organization of transformative innovation policy needs to cater to the particular scalar arrangement that is produced in the socio-technical system (in the paper referred to as 'the Constructivists Approach' to the spatial organization of transformative innovation policy). Table 6 highlights the key differences between the two approaches. The Constructivist Approach moreover highlights rescaling as a source of transformative potential. It is suggested that the rescaling, which refers to a scalar shift in policy or politics, has the potential to change power relationships between actors in a socio-

technical system and could potentially be used to destabilize actors in the regime and empower niche actors.

Table 6. The Containerized Approach vs. the Constructivist Approach. Adapted from Paper II.

	The Containerized Approach	The Constructivist Approach
Scale	Ontologically given and in possession of inherent and static characteristics.	Continuously produced and contested by actors in historical and contextual processes.
Transformative potential	Assigning set responsibilities to scales based on their assumed inherent characteristics.	Rescaling as a means to alter the influence of actors in the prevailing socio-technical system.
Policy model	A "one size fits all" approach to the spatial organization of transformative innovation policy based on the assumed characteristics of scales.	A variated approach to the spatial organization of transformative innovation policy based on the assumption that transformative innovation policy will look different depending on the scalar arrangement that is produced in the particular socio-technical system.

The third and final paper in this thesis (**Paper III**) is concerned with the analysis of transition dynamics and agency in sustainability transitions. In the article, we develop a conceptual framework for studying transition dynamics in sustainability transitions, which acknowledges that sectors can vary in their structural characteristics. We introduce the concept of the *contestation axis*, which we define as: *the interface between two or more socio-technical configurations where actors engage in agency dynamics to shape institutions.* By focusing on contestation axes, we highlight interfaces between different configurations in a socio-technical system and show how agency can play out, and contestations materialize, along other axes than the niche-regime axis, which has typically been emphasized in transition studies. We apply our conceptual framework to the Danish waste sector and explore how the growing influence of the circular economy triggers misalignment between multiple socio-technical configurations. We zoom in on three contestation axes in the Danish case. For each contestation, we examine the structural position of actors, the types of institutional work actors carry out, and the constituent elements (discourses, social networks, and resources) that either enable or constrain actors' ability to carry out institutional work and influence the contestation outcome.

Our analysis points to the importance of looking at intra-regime dynamics. We show how the introduction of circular economy policy from the EU ignited contestation in the Danish waste sector between the two established configurations of recycling and incineration, and argue that such changes in the regime matter for transition processes. For example, the case suggests that the institutional work carried out by recycling actors to de-legitimize incineration in light of circular economy visions may have also indirectly supported the emerging configuration of chemical recycling. Our empirical case study also highlights the need to appreciate variation

among emerging configurations and suggests that this variation, at least in part, is shaped by the character of relations between an emerging configuration and other socio-technical configurations in the system. When zooming in on the two emerging configurations aimed at managing plastics packaging waste in the Danish setting, reuse and chemical recycling, we show how the emerging configurations position themselves differently in relation to the established configurations. Reuse more fundamentally challenges the set of established configurations in the sector, because it requires more system-wide changes, e.g., the development of new packaging, which is made and safe to use many times, and the development of new practices and take-back systems where packaging is returned or collected for reuse rather than discarded. In contrast, chemical recycling only seeks to replace the incineration configuration and is to a much greater extent an end-of-pipe approach, which places less emphasis on changes in the production and the use of packaging. We see this difference reflected in the resources, discourses, and social networks of actors and in turn the type of institutional work actors are able to carry out on behalf of their respective configuration. Reuse actors struggle to mobilize resources and social networks, whereas actors from the chemical recycling niche have successfully mobilized resources and allies from the established configurations, namely the recycling configuration.

We argue that these findings have implications for policy. In particular, they suggest the need for acknowledging the heterogeneity among emerging configurations. Niches (in classic transition terms) are not necessarily homogenous, but may consist of multiple emerging configurations with very different preconditions for initiating institutional work. In turn, these configurations are likely to require vastly different policy support to further institutionalize. In our empirical analysis, this is clearly illustrated by the chemical recycling actors, which have access to the resources and networks of powerful allies such as the petrochemical industry. This creates a vastly different context for policy compared to the reuse configuration, where resources and networks are significantly more scarce.

Returning to the research questions

The first question guiding my research is: *how does the theoretical assumption that transformative innovation policy is best pursued at the subnational scale correspond with current developments in the multi-scalar organization of Danish waste management aimed at stimulating the promotion of a circular economy?* This research question is addressed in Article II, which suggests that scalar transformation processes taking place in Danish waste management contradict the theoretical arguments made in favor of pursuing a subnational transformative innovation policy.

The case study examines the multi-scalar organization in Danish waste management and identifies a strong subnational scalar arrangement where municipalities for more than three decades have enjoyed extensive decision-making power. This subnational scalar arrangement is strongly connected to the country's well-established incineration configuration, which is experiencing increasing pressure as concerns grow over resource depletion and greenhouse gas emissions. In 2020, transformative innovation policy was introduced in the Danish waste sector, which attempts to promote a circular economy that addresses these grand challenges. The policy rescales the strong decision-making power away from municipalities. This rescaling is based on the implicit argument that the Danish incineration lock-in is attributed to the subnational scalar arrangement, particularly the financial involvement of municipalities in the incineration infrastructure as well as municipal autonomy in planning waste management. The article demonstrates that subnational transformative innovation policy can experience some of the same challenges that it sets out to address in the first place, for instance, lock-in.

These findings from Denmark therefore challenge the theoretical assumption that transformative innovation policy is best pursued at the subnational scale (McCann and Soete, 2020; Wanzenböck and Frenken, 2020). The tension between the empirical findings and the theoretical assumption triggers further conceptual work from which the paper's overarching argument is developed. Drawing on geographical perspectives of scale (Brenner, 2001; Delaney and Leitneh, 1997; Howitt, 1993; MacKinnon, 2010; Marston, 2000; Smith, 1993; Swyngedouw, 2000, 1997), the paper suggests that scales and scalar arrangements are not in possession of inherent qualities and therefore should not be viewed as an objective and deterministic structure. Instead, it is argued that scales are produced through the actions of agents and are the products of contextual and historical processes. Consequently, the article argues that a variated transformative innovation policy model based on explicit considerations of geographical context is preferable over a 'one size fits all' or a 'one scale fits all' policy model. Taken together, the paper suggests that approaching the spatial organization of transformative innovation policy should be considered an analytical task since we cannot assume that one particular scale or scalar arrangement will be best for pursuing transformative innovation policy in all socio-technical systems. Instead, we need to develop an empirical understanding of the scalar arrangement that is produced in a particular socio-technical system and design the scalar aspects of policy based on that.

In conclusion, the paper contributes to advancing conceptual understandings of the organization and implementation of transformative innovation policy by developing a greater geographical sensitivity to scale. The paper's focus on the active construction of scale and rescaling processes also invites future research to explore agency and power relationships through the lens of scale construction.

This thesis' second research question is: *how can our understanding of transition dynamics and agency be developed to explicitly account for variation in the structural characteristics of sectors?* This question is addressed in Article III, which approaches transition dynamics and agency with greater sensitivity to the structural characteristics of socio-technical systems. The article finds that previous work on transition dynamics and agency in socio-technical transitions has focused too exclusively on the contestation axis between emerging niches and established regimes. It suggests that this focus reflects a broader tendency in the sustainability transitions literature to focus on the niche-regime nexus, and conceptualize system configurations along this niche-regime dichotomy (Geels, 2014; Geels and Schot, 2007). The paper contributes with a novel conceptual framework to explore transition dynamics and agency by building on a more complex conceptualization of system patterns, which emphasizes that the structural characteristics of sectors may vary (Miörner et al., 2021). The framework is based on the identification of a number of additional contestation axes where agency can play out (axes A, C, & D in Figure 1 below).

In the paper, four ideal-type contestation axes are identified. Beyond the conventional contestation axis between a niche configuration and the established sector (Axis B, cf. Figure 1), we identify an ideal-type contestation axis between two or multiple emerging niches (Axis D, cf. Figure 1), between two or multiple established configurations within the regime (Axis A, cf. Figure 1), and finally, between an emerging niche and one or multiple established configurations, but not the entire established sector (Axis C, cf. Figure 1). While we expect that actors are able to engage in agency across these different ideal-type contestation axes, the actual frictions that manifest along these contestation axes will have to be determined empirically. We anticipate that the existence and importance of actual frictions will vary between different sectors depending on their structural pattern.

In the framework, agency is operationalized as the institutional work of actors, which refers to the concrete actions and activities that actors engage in to shape institutional change processes (Lawrence et al., 2011; Lawrence and Suddaby, 2006). Beyond examining the institutional work of actors, the paper argues that it is necessary to determine the structural position of actors, meaning an actor's association with one or more socio-technical system configurations, as well as the field conditions that enable or constrain an actor's agency. To address the latter, the paper focuses on determining the resources, discourses, and social networks of actors, which are understood to make up constituent elements of institutional work (Duygan et al., 2019).

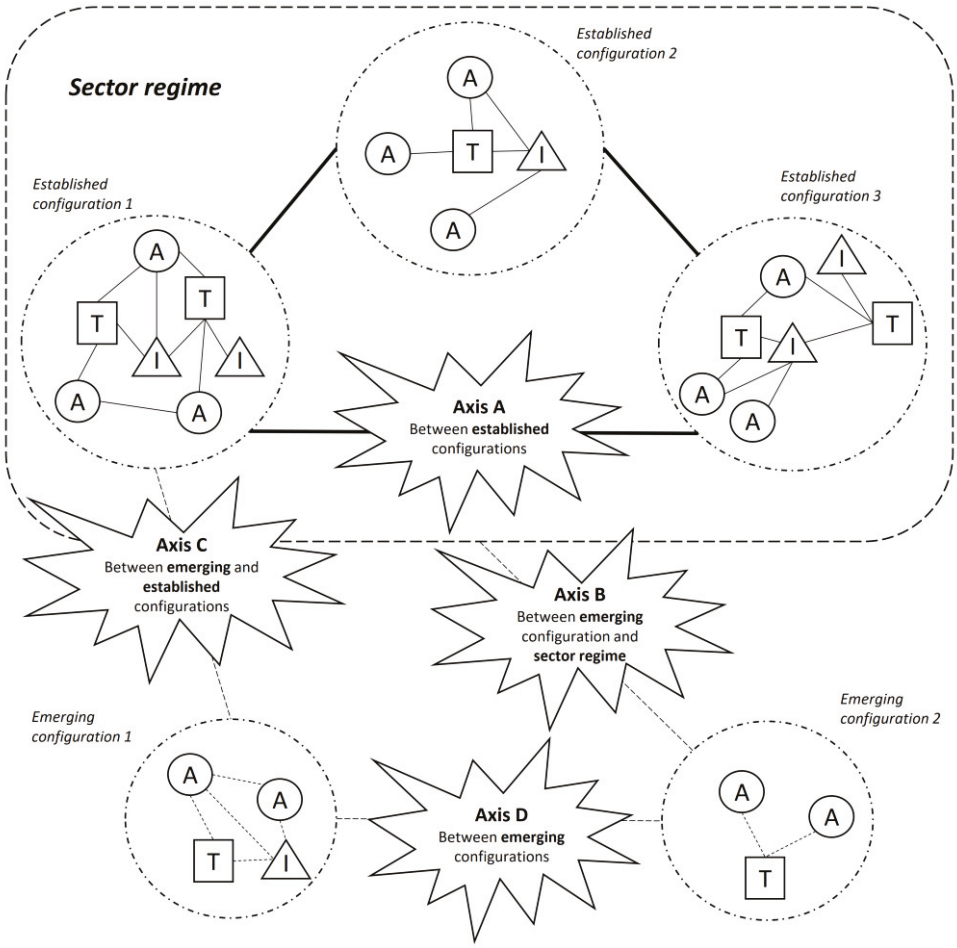

Figure 1. Contestation axes. Actors (circles), Technologies (quadrants), and Institutions (triangles) form emerging and established configurations representing different ways of providing societal functions such as water, energy, and transport. Source: Article III

The third and final research question is related to the previous question and asks: *how do empirical insights from the Danish waste sector illustrate and illuminate this alternative understanding of transition dynamics and agency?* This research question is also addressed in Paper III of this thesis, where we identify and explore three contestation axes in the Danish waste sector based on the framework described above. We find incineration and recycling actors, both part of the regime, compete over the treatment of food waste from households, illuminating frictions along the ideal-typical Axis A. We observe actors in the emerging chemical recycling niche target the established incineration configuration, which allows us to explore frictions along the ideal-typical Axis C. Finally, we identify actors from the reuse

niche trying to more fundamentally challenge the established sector, which enables us to examine the ideal-typical Axis B.

Multiple insights emerge from the empirical exploration of the frictions that materialize across the different axes of contestation in the Danish waste sector. As already mentioned in the section 'Summary of findings', the Danish case points to the importance of appreciating intra-regime dynamics as well as variation among emerging configurations. Beyond these points, there were also aspects of the Danish case which were quite surprising and which effectively illuminate and illustrate ways to further develop and explore the contestation axes framework. It was beyond the scope of the article to include these aspects, but they are relevant in the context of the broader research question and therefore included here.

First, it was surprising that we were not able to identify any institutional work carried out by incineration actors in response to the emerging chemical recycling configuration, which target the same feedstock. This may in part be a result of the rapid and intense process of de-legitimatization of incineration alongside the increased focus on CO_2 emissions, particularly from the incineration of plastics, which has taken place in Denmark. It is currently a losing game for actors in the incineration regime to argue for or otherwise work towards the incineration of plastics. However, I suspect that we have only seen the beginning of this 'battle'. In this regard, I think expectations around carbon capture and storage (CCS) may play a role in the future. There are currently incineration actors who are trying to re-legitimatize incineration by arguing that incineration in combination with CCS can indeed address the environmental concerns currently raised against the incineration configuration (e.g., Dansk Affaldsforening, 2021). A likely outcome of this is a future with a more active friction between chemical recycling and incineration with CCS.

A related surprise in the Danish case was that we could not identify the materialization of a contestation axis between the two emerging configurations: chemical recycling and reuse. When bringing up the topic with reuse actors, mainly NGOs, we were told that they focused on promoting reuse and did not have the resources to engage in a critique of chemical recycling even though they came across as instinctively skeptical towards the emerging configuration. When talking to chemical recycling actors they argued that the two configurations could co-exist without any issues. Considering the absence of an active contestation, it would be interesting to explore whether the boundary we have set for our analysis (the Danish waste sector) may be hiding contestations at other spatial scales. There are examples of European NGOs who promote the reuse agenda while also levelling critique against chemical recycling, and who are actively trying to influence the formulation of new EU legislation, which is supposed to regulate how chemical recycling is calculated (e.g., Rethink Plastic, 2021; Zero Waste Europe, n.d.). This indicates that there are particular scalar dimensions to certain axes of contestation, which can be

explored further. Taken together, these insights illustrate the value of empirical work in furthering our understanding of transition dynamics and agency.

Limitations and future research

In this section, I begin by considering boundary conditions of the case study, which on the one hand highlight limitations of the research, but also, on the other hand, emphasize the continued need to empirically follow and examine the attempted transition towards a circular economy in the EU. Empirically, this thesis focuses on the earliest legislative change that followed from the EU Circular Economy Action Plan (European Commission, 2015). These legislative changes mainly concentrate on the policy domain of waste management.[6] This in turn means that I have studied the transition towards a circular economy through a focus on attempted changes in the waste sector, which are very centered on increasing recycling. However, there is a dissonance between the legislative focus on increasing recycling and how the European Commission (European Commission, 2015, p. 2) otherwise describes the transition towards a circular economy. The European Commission (2015 p. 2) highlights the transition towards a circular economy as a process where "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised", which also implies the need to change production and consumption. Compared to this broader vision, the legislative changes can come across as quite unambitious.

I think there is a very real possibility that this dissonance between legislative change and the broader vision of a circular economy reflects a lack of support for more ambitious legislation among member states in the European Union. In that sense, it may be related to the politics of a circular economy more broadly. However, other legislative changes are currently being negotiated. For example, in March 2022, the European Commission presented its proposal for a new regulation on eco-design, which is expected to develop performance and information requirements for most physical goods placed on the EU market. The types of requirements listed in the proposal include product durability, reusability, upgradability, reparability, the presence of substances that inhibit circularity, energy, and resource efficiency, recycled content etc. (European Commission, 2022). If passed, this legislation could begin to more explicitly address the production side of a transition towards a circular economy and thereby perhaps begin to influence other policy domains than the

[6] The introduction of the extended producer responsibility on packaging (Directive 2018/852) is intended to incentivize change in the production of packaging. The effect of the producer responsibility, however, will depend on its implementation, which is still to be decided in the Danish case. The single-use plastics directive (Directive 2019/904) is also an example of legislation that addresses production and consumption, but its focus on plastics means that it does not address single-use more broadly.

waste sector. Only time will tell how these future developments pan out, which highlights the timeframe of the project as a limitation of this research.

This limitation of course also invites researchers to continue to follow and explore future developments related to the advancement of circular economy visions in the EU. In the following sections I outline a number of suggestions with respect to what this continued exploration could focus on.

Studying transitions across multiple sectors

As alluded to above, the vision of a circular economy is not confined to a single sector, but has the potential to influence multiple systems of production, consumption, and disposal at the same time. Similarly, the Danish case illustrates strong relationships between multiple socio-technical systems. For example, waste incineration is related to both the system of waste management and the system of energy provision in the Danish case. This simultaneous influence on multiple socio-technical systems and their interrelatedness calls for future research, as also suggested by other scholars (e.g., Geels et al., 2017; Markard et al., 2020; Raven, 2007). This future research can focus on conceptual questions relating to, for instance, the governance and policy coordination needed to address grand challenges in multiple, and potentially co-dependent, socio-technical systems. It is also relevant to consider methodological questions regarding, for example, analytical boundaries and the further operationalization of studying multiple systems.

Nuancing actor roles: municipalities as incumbents

The case study of the Danish waste sector encourages future research to continue nuancing actor roles in transitions. Specifically, the case encourages us to keep an open mind about what may constitute incumbency in different socio-technical configurations, which echoes recent arguments made by scholars in transition studies for the need to pluralize our understanding of incumbency (Turnheim and Sovacool, 2020). Traditionally, incumbency has been associated with private firms in mature industries that are considered to be locked into the prevailing technology and market (Dosi, 1984). However, Turnheim and Sovacool (2020, p. 181) argue that incumbency should not be assumed "the exclusive monopoly" of certain actors.

In the Danish case, the central role of municipalities can arguably be viewed as a type of incumbency in the sense that it reinforces the established incineration configuration. In many respects, Danish municipalities also exercise similar forms of power to that identified in research on more traditional incumbent actors' response to radical change. In a study focusing on the UK electricity sector, Geels (2014) illustrates how incumbents mobilize instrumental, discursive, and material

forms of power to resist climate change legislation. In the Danish case, municipalities have arguably mobilized instrumental power when faced with attempts to liberalize the waste sector. This has happened when municipal politicians use their position in the government party to challenge liberalization attempts proposed by parliament politicians in the same party. Municipalities have also mobilized discursive power when arguing that Danish incineration is superior to other countries' waste management, and that we should continue to incinerate and import waste for incineration. In their line of reasoning, doing the opposite (reducing incineration capacity) only caters to the national target of CO_2 reduction, but does not address challenges of waste management beyond the borders of Denmark. Finally, we see municipalities mobilizing material power, for instance when constructing pilot and demonstration plants to test and explore the possibility of incorporating CCS at incineration plants (ARC, 2021). Although the potential of CCS is still unclear, the promise is currently being used to re-legitimatize incineration (e.g. Dansk Affaldsforening, 2021).

The politics of implementation and evaluation

A final topic of future research relates to the political nature of implementation and evaluation, particularly the mundane tasks of counting and measuring progress, which indicate that implementation and evaluation are far from straight-forward, neutral tasks.

This is a theme that has come up multiple times as I have followed the Danish case. For example, the Climate plan on waste management (Regeringen 2020) stipulates that 60 percent of collected plastics waste from households should be recycled. At first that seems like a straightforward goal, which is measureable and possible to evaluate. However, as I talked to stakeholders, I quickly learned this is much more complicated. First, it is difficult to determine the amount of plastics in waste because plastics exist partially in so many objects that are not necessarily sorted as plastics, for instance, fabrics. This means that the goal of 60 percent recycling is open to interpretation in terms what should count as plastics in the first place. Due to this interpretive flexibility, negotiations took place between stakeholders and civil servants after the publication of the Climate plan about how to interpret and execute the regulation, which in turn influenced the directionality of the policy.

To the best of my knowledge, these types of processes have not been explored in great detail in the literature on normative innovation policy or transition studies, but future research ought to engage with these questions to better understand the politics of policy processes. These themes create opportunity to engage with other fields of research. For example, governmentality studies (Murdoch and Ward, 1997; Rose-Redwood, 2006), which explore the power and politics embedded in governance practices which create representations of reality, such as developing statistics or drawing maps. Governmentality studies emphasize the inherently political,

performative, and regulative nature of representing reality, and the techniques of governance consequently become sites of political investigation (Barry, 2013, 2010). Research of this kind may be a potential starting point for exploring questions of how directionality is negotiated through on-the-ground techniques that are necessary when implementing and evaluating change processes.

Final remarks

During the last months of writing this thesis, the European energy market has been hit by what some commentators call 'the perfect storm' (e.g., Baselli, 2022; Rosen, 2022). Energy prices are soaring as a result of multiple and complex causes, including the war in Ukraine and European overdependence on Russian gas, peaking Chinese gas imports in the aftermath of the COVID-19 pandemic, and the extreme summer heat leading to both high energy use and the underperformance of alternative energy sources (Rojanasakul, 2022; Safi 2022; Tavernise, 2022). Against this backdrop, critique of the 2020 Climate plan on waste (Regeringen, 2020) and particularly the ambition of reducing incineration capacity is gaining newfound momentum. Municipal waste companies and politicians from parties that supported the Climate plan on waste are arguing that incineration is a cheap and secure source of heating that should be utilized and not reduced in times of energy crisis (Dansk Affaldsforening, 2022; Dinesen and Aaberg, 2022). Energy rationalities have thus very much returned to the debate about the Danish waste sector, which further intensifies the contestations surrounding the pursuit of a circular economy in waste management.

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Appendices

Appendix A: Document overview

Table A1: Overview of documents across categories.

EU Directives

1994/62/EC. European Parliament and Council Directive 1994/62/EC of 20 December 1994 on packaging and packaging Waste.

1999/31/EC. Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

2008/98/EC. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

2018/851. Directive 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EU on waste.

2018/852. Directive 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste.

2019/904. Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.

Communications from the European Commission

European Commission (2011, September 20) *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Roadmap to a Resource Efficient Europe* (COM(2011) 571 final).

European Commission (2014, July 2) *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Towards a circular economy: A zero waste programme for Europe* (COM(2014) 398 final).

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European Commission (2018, January 16) *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A European Strategy for Plastics in a Circular Economy* (COM(2018) 28 final).

European Commission (2019, December 11) *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: The European Green Deal* (COM(2019) 640 final).

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Danish regulatory documents

Miljø- og Fødevareministeriet (1986) *Cirkulære Om ændring af Miljøbeskyttelsesloven*. CIR. nr. 14014 af 02/12/1986

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Reports by or reports prepared for Danish government agencies

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Appendix B: Interview guide examples

Note: I have translated the two included interview guide examples from Danish to English as the interviews were carried out in Danish. The interview guides were prepared before the respective interview. I went through the first section (Introductions and formalities) in a rather structured manner. However, the remaining part of the interview was conversational and the guides were mere guides rather than strict manuals.

Interview guide example I

The interview took place in September 2021. The interviewee was a municipal actor.

1 Introductions and formalities:

My name is Stine, I am a PhD student at Lund University. Thank you for agreeing to talk to me. As outlined in my email to you, I am in the process of writing a thesis on how visions of a circular economy are influencing the Danish waste sector – and how the Danish waste sector in turn influences the type of circular economy that is implemented in Denmark.

At the moment, I am focusing on organization and responsibility in the sector, which also is a key topic in the recent Climate plan on waste. I am trying to understand the

Climate plan in a more historical perspective. Therefore, the starting point for our conversation today are questions such as: why was the Danish waste model developed in the 1970s, how have actors responded to the model over time, what is triggering the current changes in the sector? But of course our conversation may take us other places, too.

Before we can get started, there are a number of formalities we need to go through:

- Can I record our conversation? If yes, then after the interview, I will use the recording to transcribe our conversation. This transcription is used for analysis. Access to the interview transcription is limited to myself and academic colleagues with whom I may collaborate with.
- Your name or the organization that you represent will not be published in academic publications or other outlets. Any summary content or direct quotation from the interview will be associated with a generic identifier e.g., industry association representative, municipal waste sector representative.
- Despite the steps taken above, I cannot guarantee complete anonymity:
    - The research subject studied (the Danish waste sector) is small and individuals with knowledge of key actors in the sector may be able to infer your identity or the organization you represent based on what you say
    - Lund University is a public authority, which entails that any e-mail or other correspondence can be requested by a third person under the principle of public access to public records.
- You always have the right to end the interview and you can always reach out to me after the interview with any concerns or questions.

With formalities in place – let's get started.

Tell me about your current job.

What do you do?

What is your professional journey leading up till here?

<u>2 The 2020 Climate plan on waste</u>

What are your thoughts on the 2020 Climate plan on waste?

What do you think the plan will mean for the Danish waste sector?

Did anything about the plan surprise you?

- Why is that so?

Why do you think these changes are happening now?

- What has triggered this and why?

This type of change has been discussed for many years, what is different now?

Tell me about those previous attempts to change the sector.

- What are reasons that it did not happen then?

What are the key actors with an interest in this change?

- For every mentioned actor: what is their interest? Has their interest changed over time?

Who are your closest allies/ who do you cooperate with?

Are there actors who you do not consider your allies?

- What are they then?
- Are there other actors who are allies? Have they always been that? Why? Exemplify.

Are there winners and losers created with this plan?

- Who and why?

Who has had an influence on this policy?

- How have you experienced this influence?
- Can you give examples?

In previous interviewes, I have been told that the municipal actors have less influence when decisions are made in the sector. Do you agree with this statement?

- If so, when did municipal influence decrease? How have you experienced this? Can you give examples? Why do you think this is happening?
- If not, why do you think they may be saying that?

<u>3 Danish waste management more broadly</u>

Outline what you consider to be main developments in the Danish waste sector.

- Why? What did this mean to the sector?

In 2007, recyclable industrial waste was liberalized – tell me about this?

- Was is a big change for the sector? Why/why not?
- I get the impression that there was momentum among some actors to liberalize the whole sector – what was you experience? Why did that not happen?
- What is different now compared to then?

Tell me about incineration capacity discussions? What are key arguments made at the moment? Who are making these arguments? Have the arguments changed over time?

- Do you agree that there is an incineration overcapacity in Denmark? Why/ why not?
- If yes, what are causes of this overcapacity? Regional counting?
- If yes, is the overcapacity a problem? Why/ why not?

What actors have contributed to establishing the Danish incineration infrastructure?

- Who have you worked with, where is expertise located?

What is your reaction to the following statements?

- For a number of reasons, incineration has come to play too large of a role in Danish waste management?
- Denmark has been foot-dragging when it comes to recycling?
- In Denmark, the establishment of incineration has been so successful it has been a hindrance for other waste management practices/ infrastructures?

4 Ending the interview

Now you have a fairly good idea of the topics I am interested in.

- Am I missing something in your opinion? Should I be asking different questions? If so what, which and why?
- Who else should I talk to?
- Who should I talk to, to get a perspective that is different from yours?

Thank you!

Interview guide example II

The interview took place in February 2022. The interviewee was a chemical recycling start-up.

1 Introductions and formalities:

My name is Stine, I am a PhD student at Lund University. Thank you for agreeing to talk to me. As outlined in my email to you, I am in the process of writing a thesis on how visions of a circular economy are influencing the Danish waste sector – and how the Danish waste sector in turn influences the type of circular economy that is implemented in Denmark.

At the moment, I am zooming in on the management of two waste fractions: organic household waste and plastic packaging. By looking at these, I am trying to learn more about what actors do or have done to influence processes of change with regards to the management of these waste fractions. I have reached out to you to talk about the plastics waste fraction – specifically the option of chemical recycling, but of course our conversation may take us other places, too.

Before we can get started, there are a number of formalities we need to go through:

- Can I record our conversation? If yes, then after the interview, I will use the recording to transcribe our conversation. This transcription is used for analysis. Access to the interview transcription is limited to myself and academic colleagues with whom I may collaborate with.
- Your name or the organization that you represent will not be published in academic publications or other outlets. Any summary content or direct quotation from the interview will be associated with a generic identifier e.g. industry association representative, municipal waste sector representative.
- Despite the steps taken above, I cannot guarantee complete anonymity:
    - The research subject studied (the Danish waste sector) is small and individuals with knowledge of key actors in the sector may be able to infer your identity or the organization you represent based on what you say
    - Lund University is a public authority, which entails that any e-mail or other correspondence can be requested by a third person under the principle of public access to public records.
- You always have the right to end the interview and you can always reach out to me after the interview with any concerns or questions.

With formalities in place – let's get started.

Tell me about your current job.

What do you do/ what is your role at the company?

What is your professional journey leading up till here?

2 Chemical recycling more broadly

In general terms, how would you describe the history of chemical recycling of plastics waste in the Danish/ Nordic/ global context?

- When I first began exploring issues related to plastics 4-5 years ago it seemed like quite a futuristic idea - what are key developments in recent years?

What do you consider chemical recycling to be an alternative to?

Why is chemical recycling better than said alternative?

- Is it possible to clean the plastics when chemically recycling is? With respect to mechanical recycling where there is much discussion of increasing accumulation of potentially toxic additives? Is that different for chemical recycling?
- Can you treat all types of plastics or are you limited to PP and PE?

Do you experience support for chemical recycling?

- If yes, where is this support coming from? Please exemplify.
- Are there policies specifically supporting chemical recycling of plastics? If yes, which and how?
- Was it important to you that the Danish state decided to classify chemical recycling as recycling? Was this really a new decision?

Do you experience push back on chemical recycling?

- If yes, where is this push back coming from? Please exemplify.
- Are there policies posing a challenge to chemical recycling of plastics? If yes, which and how?

What are the biggest challenges you are facing at the moment?

- Probe in terms of chemical recycling in general, and company in particular.

In terms of input – are there estimates of the proportion of e.g., household waste, which you're able to treat?

In terms of output – how much is recycled?

- How is the recycled outcome counted and documented? What do you think about the way it is done? If negative comments: how do you propose it should be done?
- Probe about REDcert scheme? Is that important? Why/ why not?

Have others than me asked questions related to input and output?

- If yes, who?
- Are they also asking other questions that I am not asking?

3 Actors

What actors are and have been important in terms of pushing/ enabling chemical recycling of plastics?

- What have they done? Please exemplify?
- Do you cooperate with other actors to try to push chemical recycling of plastics? Who? How? Success?

Are there actors actively opposing/ showing skepticism towards chemical recycling?

- If yes who?
- What have they done? Please exemplify.
- Have they been successful? If yes, in what way?
- Probe about NGOs and reuse agenda.

4 Institutional work more specifically

Do you experience prejudices about chemical recycling?

- If yes, what are these?
- Do you address them, if yes, how? Please exemplify.
- Does anyone else address them, if yes, who and how? Please exemplify.

Have there been periods with particularly high media attention regarding chemical recycling or your company specifically?

- Tell me about these periods? What triggered the attention?
- How did you react? And with what effect?
- How did others react? With what effect?

Do you actively work with a communications strategy?

- Why/ why not?
- Who are you trying to communicate with? Through what means?
- If yes, what guides this work? Changes over time?
- What are challenges when it comes to your communication? Probe about risk/ dangers of explosion, production challenges/ expectations, communicating a complicated technology?

Do you experience that there is a need for you to try to actively shape the perception of chemical recycling?

- If yes, whose perception? How do you do it? Please exemplify. Based on what key arguments? Have you been successful?

Do you as a company try to change current regulation/ policy that relates to chemical recycling or management of plastic waste more generally?

- If why how? Please exemplify? Why? Are you successful?
- Are there other actors trying to change current regulation/ policy? What do they do and why do you think? Are they successful?
- Are you actively involved in the current EU negotiations around how chemical recycling should be counted? If yes: why? What does your involvement entail? Please give examples. If no: why not? Do you know of anyone else involved? What do they do?

5 Ending the interview

Now you have a fairly good idea of the topics I am interested in.

- Am I missing something in your opinion? Should I be asking different questions? If so what, which and why?
- Who else should I talk to?
- Who should I talk to, to get a perspective that is different from yours?

Thank you!