Troubled wastewaters: the politics of transitions to a circular economy

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GHENT UNIVERSITY

FACULTY OF POLITICAL AND SOCIAL SCIENCES

TU Delft

KASPER AMPE

TROUBLED WASTEWATERS

THE POLITICS OF TRANSITIONS TO A CIRCULAR ECONOMY

THE *POLITICS* OF *TRANSITIONS* TO A *CIRCULAR ECONOMY*

KASPER AMPE

Design and lay-out by Eliot Notredame, art by Loes De Gendt

Troubled wastewaters: the politics of transitions to a circular economy

Dissertation

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‘How could we deem “realistic” a project of modernization that has “forgotten” for two centuries to anticipate the reactions of the terraqueous globe to human actions? How could we accept as “objective” economic theories that are incapable of integrating into their calculations the scarcity of resources whose exhaustion it had been their mission to predict? How could we speak of “effectiveness” with respect to technological systems that have not managed to integrate into their design a way to last more than a few decades? How could we call “rationalist” an ideal of civilization guilty of a forecasting error so massive that it prevents parents from leaving an inhabited world to their children?’

Down To Earth – Bruno Latour, 2018.

Contents

Samenvatting

Het overschrijden van de grenzen van een ecologisch veilige en sociaal rechtvaardige plek voor de mensheid confronteert de samenleving met nooit eerder geziene uitdagingen.

Hét uitgangspunt van deze thesis is dat incrementele verandering en technologische oplossingen langs de gebaande paden niet zullen volstaan om deze maatschappelijke uitdagingen aan te pakken. Ze zijn immers veroorzaakt door bijzonder langdurige, complexe en weinig duurzame consumptie- en productiepatronen in de socio-technische systemen die ons van energie, mobiliteit, voeding en water voorzien. Baanbrekende veranderingen in de richting van nieuwe socio-technische systemen zijn daarbij cruciaal. Tot op heden blijft het realiseren van duurzaamheidsdoelstellingen en het fundamenteel ingrijpen op maatschappelijke systemen echter uit of voltrekt zich in een tergend traag tempo.

En toch ontwikkelen zich in de schoot van de aanhoudende milieucrisissen en de rigide, weinig duurzame socio-technische systemen opvallende innovatieve activiteiten. Ze richten zich op een paradigmaverschuiving naar een circulaire economie maar leiden hooguit tot incrementele verandering in de socio-technische systemen. Zo blijft het 'dweilen met de kraan open' omdat de politieke dynamieken die schuilgaan achter het wijzigen van paradigma's ongemoeid blijven. Vandaar dat de thesis precies die politieke processen onderzoekt die beperkt blijven tot incrementele verandering en bijgevolg de socio-technische systemen bestendigen via diepgewortelde ideeën, verankerde netwerken, vastgeroeste regels en grootschalige infrastructuur. De focus richt zich in deze thesis op de afvalwatersystemen van België en Nederland. De urgentie van snelle veranderingen naar een circulaire economie zorgt er voor nieuwe initiatieven, maar beide systemen laten zich tegelijk kenmerken door grootschalige infrastructuur en rigide instituties.

In zes hoofdstukken spit de thesis de politiek van duurzaamheidstransities naar een circulaire economie in de afvalwatersystemen van België en Nederland uit.

Het inleidende hoofdstuk beschrijft het afvalwatersysteem en de circulaire economie en toont de noodzaak aan meer empirisch en theoretisch onderzoek naar dominante en alternatieve interpretaties of discoursen van een transitie naar een circulaire economie in het afvalwatersysteem en naar hoe specifieke interpretaties

dominant worden. Hieruit volgen de onderzoeksvragen: wat zijn de dominante en alternatieve interpretaties van een transitie naar een circulaire economie in de Nederlandse en Belgische afvalwatersystemen? En hoe en waarom worden bepaalde interpretaties dominant en beïnvloeden ze deze systemen?

Het tweede hoofdstuk licht de interpretatieve methodologie toe, waarna de gepubliceerde hoofdstukken drie, vier en vijf en het afsluitende zesde hoofdstuk bovenstaande onderzoeksvragen verder uitdiepen.

Het derde hoofdstuk analyseert drie uiteenlopende interpretaties van een transitie naar een circulaire economie in het Nederlandse afvalwatersysteem. Voor bepaalde actoren staat het optimaliseren van de grootschalige infrastructuur en het ontwikkelen van *business cases* centraal. Andere actoren hebben het over kleinschalige, gedecentraliseerde zuiveringssystemen en het bewustzijn van burgers. En weer andere actoren breiden de discussie uit tot micropolluenten in oppervlakte- en drinkwater. De drie uiteenlopende interpretaties leggen enkele van de te maken politieke en maatschappelijke keuzes bloot: ze geven aan dat transities door en door politiek zijn precies omwille van de strijd over het definiëren van problemen en oplossingen. Zo kan de eerste interpretatie dominant worden omdat ze voortbouwt op de bestaande, grootschalige infrastructuur en de gevestigde politiek-economische instituties. De interpretatie geeft op die manier vorm aan een transitiepad dat gekenmerkt wordt door incrementele verandering en padafhankelijkheid in plaats van fundamentele verandering in het gevestigde afvalwatersysteem te beogen.

Het vierde hoofdstuk behandelt een cruciale actor in de dominante interpretatie. De vaststelling luidt dat de aanpak van milieuproblemen eerder gestoeld is op incrementeel aangepast of ongewijzigd beleid dan op baanbrekend beleid. Een benadering via de *policy feedback approach*, een machtskader en beleidsarrangementen analyseert met een gevalstudie de trage heroriëntatie naar een circulaire economie in het Nederlandse afvalwaterbeleid tussen 2008 en 2018. Om te concluderen dat gevestigde actoren zich voortdurend verzetten tegen verandering door het gebruik van incrementele hervormingen. En bijgevolg vorm blijven geven aan een door padafhankelijkheid gekenmerkt transitiepad.

Het vijfde hoofdstuk verkent een alternatieve interpretatie aan de hand van een gevalstudie over een baanbrekend gedecentraliseerd afvalwaterzuiveringsproject in Gent. Via literatuur over duurzaamheidstransities en een machtskader bevestigt het

dat gevestigde actoren verschillende positieve rollen opnemen in innovatieve projecten. Dit doen ze vaker als ze behoren tot lokale overheden en/of tot naburige en verderaf gelegen beleidsdomeinen of systemen. Tegelijk kunnen die actoren als het ware 'profiteren' van de krachtige behoefte aan structurele duurzaamheidstransities. In die context draagt het hoofdstuk bij aan inzichten over gevestigde actoren, die onder bepaalde voorwaarden baanbrekende projecten kunnen versterken.

De conclusie reflecteert op de onderzoeksvragen door de hoofdstukken drie, vier en vijf te combineren en zo de trage vooruitgang in het bereiken van duurzaamheidsdoelstellingen beter te begrijpen. Niettegenstaande een resem aan innovatieve, activiteiten spelen politieke processen met hun verankerde regels en gevestigde actoren een cruciale rol in de interpretatie van transities. In het bijzonder vertalen deze processen brede, vaak radicale interpretaties of discoursen in specifieke discoursen die niet meer dan een incrementele verandering beogen. Gevestigde actoren kunnen dan wel een positieve rol opnemen in transities, maar ze doen dat onder specifieke voorwaarden in kleinschalige projecten die doorgaans niet leiden tot fundamentele veranderingen in socio-technische systemen. Anders geformuleerd, geeft dit aan dat socio-technische systemen, gekenmerkt door grootschalige infrastructuur, verankerde regels en bijhorende actoren, innovatieve activiteiten sterk beïnvloeden via politieke processen. Specifiek conditioneren die processen nieuwe discoursen wat resulteert in onveranderlijke stabiliteit en hooguit incrementele verandering langs de geijkte paden, waardoor fundamentele duurzaamheidstransities uitblijven.

Afsluitend, bevat de conclusie aanbevelingen voor beleidsmakers, innovators en onderzoekers. Een reflexieve benadering helpt om te gaan met de geobserveerde padafhankelijkheid, complexiteit en verschillende interpretaties. De benadering erkent het belang van meerdere soorten kennis en perspectieven voor duurzaamheidstransities. Zo kan er meer aandacht uitgaan naar de verschillende soorten kennis over water/afvalwater en een circulaire economie. Specifiek kan dat door fundamentele vragen te stellen als waar moeten we naar toe? Wat wilt u? Wat kunt u? Wie is voor zijn voortbestaan van u afhankelijk? Met wie kan u samenleven? Wie of wat kan u bedreigen? De vraagstelling staat stil bij de resultaten van de hoofdstukken drie, vier en vijf aan de hand van een reflexieve *governance* benadering. Aansluitend, verkent de conclusie de reflexieve en transdisciplinaire onderzoeksbenadering via het Marie Skłodowska-Curie project (SuPER-W),

waarvan deze thesis het resultaat is. Kortom, om te ontsnappen aan trage veranderingen en inertie, luidt de toekomstgerichte suggestie diverse actoren en perspectieven te betrekken en zo de definitie van problemen en oplossingen in beleids- en wetenschappelijke processen te openen en/of te verbreden in plaats van ze af te sluiten.

Summary

Humanity faces major challenges because the boundaries of an ecologically safe and socially just space are transgressed.

This thesis' point of departure is that these societal challenges result from long-term, complex, unsustainable consumption and production patterns in socio-technical systems such as energy, mobility, agriculture and water. These challenges cannot sufficiently be addressed by incremental improvements and technological fixes along path-dependent trajectories but also require path-breaking changes towards new socio-technical systems. So far, however, progress has been rather limited in achieving long-term sustainability objectives and fundamentally transforming these systems. Put differently, societal change does not happen or it takes place at an agonisingly slow pace.

Against this backdrop of persistent environmental problems and rigid, unsustainable socio-technical systems, innovative activities are being developed to enable a paradigm shift towards a circular economy. However, as such shifts are highly political, these new activities typically result in inertia or, at most, incremental changes in established socio-technical systems. Therefore, the thesis investigates the political processes underlying inertia and incremental change in established socio-technical systems, directing attention to the power of deep-rooted ideas, entrenched networks, embedded rules and vast infrastructure that hinder fundamental change. To do so, it focusses on the wastewater systems of Belgium and the Netherlands. Here novel activities are being developed that arise from the need for rapid shifts to a circular economy. Yet these wastewater systems are also characterised by large, stable infrastructures and robust institutional arrangements. As a result, the main topic of this thesis is the politics of sustainability transitions towards a circular economy in the wastewater systems of Belgium and the Netherlands.

In six chapters, the thesis delves into the politics of transitions towards a circular economy in the Dutch and Belgian wastewater system.

The first chapter describes, and then raises questions about, the wastewater system and the circular economy, motivating that more empirical and theoretical research is needed on the dominant and alternative interpretations of a transition towards a circular economy in the wastewater system as well as on how specific

interpretations become dominant. This led to the main research questions of the thesis: what are the dominant and alternative interpretations of a transition towards a circular economy in the Dutch and Belgian wastewater systems? And how and why do certain interpretations become dominant and influence these systems? These questions are explored in the three published chapters, namely chapter 3, 4 and 5 of this thesis, and the concluding sixth chapter.

After elaborating on the interpretive methodology in the second chapter, the thesis' third chapter observes and then analyses diverging interpretations of a transition towards a circular economy in the Dutch wastewater system. It identifies three discourses or interpretations: some actors want to optimise the large-scale infrastructure to recover resources, for which business cases have to be developed; other actors look at citizen awareness and small-scale, decentralised treatment systems to recover resources from wastewater; and, at the same time, the discussion is expanding on the contamination of surface and drinking water by emerging pollutants. These three discourses reveal some of the political and societal choices to be made, reflecting the political environment of transitions in which struggle emerges over the definition of problems and solutions. The chapter also illustrates that the first discourse has an advantage in becoming dominant because it draws on the existing large-scale infrastructure and current political-economic institutions. The findings also suggest that this discourse shapes a transition pathway that is characterised by path-dependency and, at most, incremental changes instead of a fundamental shift in the established Dutch wastewater system.

Chapter 4 delves into a crucial actor of the dominant discourse. It first observes that environmental problems are usually not tackled with path-departing policies but rather with incrementally adjusted or unchanged policies. Using the policy feedback approach, a power framework and the policy arrangement approach, it analyses a case study of the reorientation towards a circular economy in Dutch wastewater policy between 2008 and 2018. The chapter shows that powerful actors continuously struggle to resist change through the use of incremental reforms, leading to a transition pathway that is characterised by path-dependency.

Chapter 5 explores an alternative discourse by using a case study of a path-breaking decentralised wastewater treatment project in the city of Ghent (Belgium). By using the literature on sustainability transitions and a power framework, it illustrates that established actors may play various enabling roles in path-breaking wastewater treatment projects. Specifically, they may do so when they belong to local

authorities, neighbouring and more distant policy fields or systems, whilst they may also use the power of structural trends related to the urgency of sustainability to enable the project. Overall, the chapter contributes to the understanding of established actors and the conditions under which these may strengthen path-breaking projects.

By using chapter 3, 4 and 5, the conclusion reflects on the main research question of the thesis. It provides useful indications for understanding the slow progress in achieving long-term sustainability objectives. Despite a host of innovative activities, the thesis shows that the political processes related to the wastewater system's large infrastructure, entrenched institutions and powerful actors play a critical role in the interpretation of a transition, particularly in narrowing broad interpretations or discourses to specific discourses that typically propose incremental changes. And although established actors may play an enabling role in path-breaking projects, they do so under specific conditions and small projects do not immediately lead to fundamental change in established systems. Taken together, this indicates that innovative activities in a socio-technical system characterised by large infrastructure, entrenched arrangements and the associated actors are strongly influenced by political processes, conditioning newly emerging discourses that ensure stability (i.e. the status quo) and impede fundamental transformations towards sustainability.

The conclusion also offers recommendations for policymakers, practitioners and researchers. As a result of the observed path-dependency, complexity and multiple interpretations of a transition, a so-called reflexive approach is described. It acknowledges the relevance of different types of knowledge and perspectives for sustainability transitions. Here attention may be directed to the different ways of knowing water/wastewater and a circular economy, particularly by asking foundational questions such as what do you want? What are you capable of? With whom can you live? Who depends on you for subsistence? Who are your enemies? Accordingly, the chapter dwells on the results of chapter 3, 4 and 5 by using a reflexive approach to governance. It also elaborates on the Marie Skłodowska-Curie project of which this thesis is a result (SuPER-W) by reflecting on a reflexive and transdisciplinary research approach. Hence, as a way out of inertia and slow changes, the chapter encourages the inclusion of diverse actors, perspectives and understandings in ways that open up, rather than close down, the definition of problems and solutions in policy and scientific processes.

Chapter 1: *Introduction*

Humanity faces major challenges because the boundaries of an ecologically safe (Rockström et al., 2009; Steffen et al., 2015) and socially just (O'Neill, Fanning, Lamb, & Steinberger, 2018; Raworth, 2017) space are transgressed. This thesis' point of departure is that these societal challenges result from long-term, complex, unsustainable consumption and production patterns in socio-technical systems such as energy, mobility, agriculture and water. These challenges cannot be addressed adequately by incremental improvements and technological fixes along path-dependent trajectories but also require path-breaking changes towards new socio-technical systems (Creutzig et al., 2018; Geels, Sovacool, Schwanen, & Sorrell, 2017). So far, however, progress has been rather limited in achieving long-term sustainability objectives and fundamentally transforming these systems (EEA, 2019a; UN Environment, 2019). In other words, societal change does not happen at all or happens at an agonisingly slow pace.

Against this backdrop of persistent environmental problems and rigid, unsustainable socio-technical systems, innovative activities, including novel ideas, investments and projects, are being developed to facilitate a paradigm shift towards resource recovery and a circular economy. However, as such shifts are highly political (Scoones et al., 2020; Stoddard et al., 2021), these innovative activities typically result in the status quo or, at most, incremental changes in established socio-technical systems (Grin, Rotmans, & Schot, 2010; Leach, Scoones, & Stirling, 2010), which I also observed in the Dutch wastewater system in the initial years of the research project. Therefore, the thesis investigates the political processes underlying the inertia or stability and incremental change in established socio-technical systems, highlighting the power of deep-rooted ideas, entrenched networks, embedded rules and vast infrastructure that hinder fundamental change. To do so, it focusses on the wastewater systems of Belgium and the Netherlands. Here innovative activities are being developed that arise from the need for a rapid shift towards circularity. Yet these wastewater systems are also characterised by large, stable infrastructures and robust institutional arrangements. As such, the main topic of this thesis is the politics of sustainability transitions towards a circular economy in the wastewater systems of Belgium and the Netherlands.

In this introductory chapter, I set out the broad context for the published research that follows; particularly, I seek to make the research more accessible to social scientists who are unfamiliar with wastewater and to engineers, microbiologists and chemists who are not acquainted with political sciences. Therefore, I first introduce

the wastewater system and the circular economy, then establish the importance of analysing the politics of sustainability transitions and, finally, present the research questions. The chapter is thus divided into four sections. The first section specifies the water/wastewater system, the different attempts to establish a sustainable, circular wastewater system as well as the project (SuPER-W) of which this thesis is a result. This sets the stage for exploring the conventional understanding of the circular economy, as well as alternative interpretations that suggest different political choices. These two sections inspire the need for political analysis, particularly for understanding the diversity of interpretations of concepts such as 'transition' and 'circular economy' in the wastewater system and for examining stability and incremental change in the systems' transitions towards a circular economy. In the third section, I therefore elaborate on how political analysis sheds lights on these subjects. Specifically, it draws attention to the interpretation of environmental problems, the power struggles that arise from these different interpretations, and the political processes in which these interpretations are constructed and frequently lead to inertia. Hence, concerning a transition towards a circular economy in the Dutch and Belgian wastewater systems, I aim to understand *what* the dominant and alternative interpretations are, and *how* and *why* certain interpretations become dominant and influence the systems. The fourth section builds on this theoretical background in presenting the research questions.

After the introductory chapter, the second chapter establishes my interpretive research philosophy and the implications of this approach for my research. The third chapter provides a discourse analysis of a transition towards a circular economy in the Dutch wastewater system. In chapter four, the policy feedback approach and a power framework are used to analyse the incremental steps towards a circular economy in the Dutch wastewater system. The fifth chapter applies a power framework to understand the enabling role of established actors in a path-breaking wastewater treatment project. Chapter six discusses and concludes the findings laid out in the published chapters three, four and five, and provides recommendations for policymakers and practitioners as well as avenues for future research.

1.1 The wastewater system and sustainability

As the main system analysed in this thesis is the wastewater system, this section elaborates on it, the efforts to become sustainable and two criticisms of innovation in the wastewater system. I first provide an overview of the developments of water/wastewater technology and the large-scale, centralised infrastructure over the past centuries. Next, I turn to the efforts to establish a sustainable wastewater system, elaborating on the recovery of resources from wastewater, a more circular wastewater system and the SuPER-W project. Finally, I describe two criticisms, discussed in the literature, related to the recovery of energy and resources from wastewater as well as to the slow pace of changes (i.e. stagnation) in the water/wastewater system. The section demonstrates that the majority of activities, research and interpretations aim to optimise the large-scale wastewater treatment system. In times when more sustainable and circular systems are necessary, this underscores the need for political analysis that examines *what* the different interpretations of sustainability in the wastewater system are and *how* and *why* particular interpretations become dominant and influence the system.

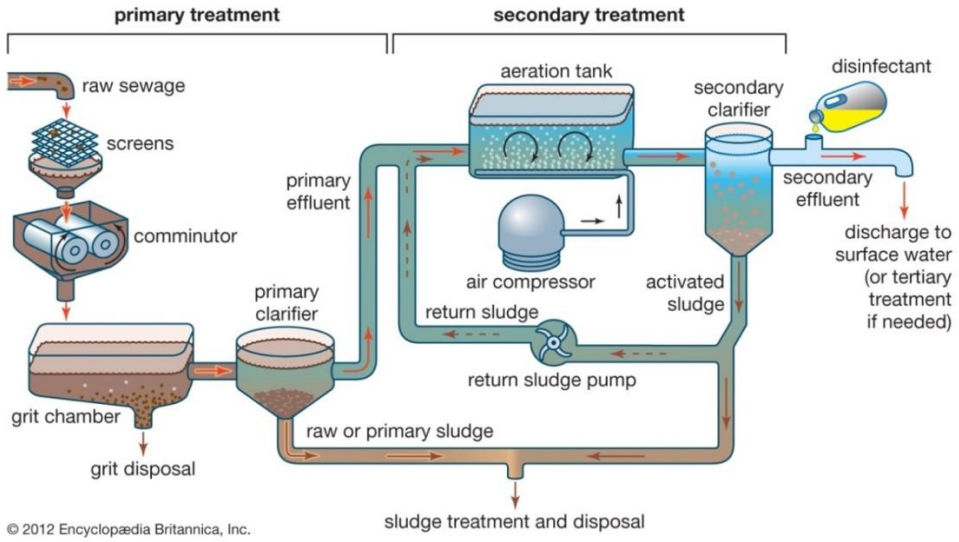
1.1.1 The large-scale, centralised wastewater infrastructure and technology

This section describes the broad developments in the wastewater system over the past centuries, which eventually led to the large-scale, centralised infrastructure in Belgium and the Netherlands (De Korte, 2018; van Lohuizen, 2006; Mulder, 2016; de Swaan, 2004; Van Braeckel, 2005). Before the nineteenth century, piped drinking water supply did not exist and waste and water were discharged into the streets or cesspools. However, from the nineteenth century, urbanisation increased and wastewater accumulated in the streets, canals and rivers. At the same time, cesspools too overflowed because the piped water supply was being implemented increasingly. The wastewater, containing human faeces, flowed into the cities, leading to cholera outbreaks. From the 1850s, public health and hygiene received more attention, leading to an increase in the delivery of purified piped water supply, produced from surface water or groundwater, and the construction of large-scale sewers to collect and transport the wastewater.

However, as the wastewater remained untreated, water-borne diseases cropped up and downstream communities, fishermen and beaches suffered from water polluted by sewage, raising the issue of treating the wastewater before disposal. In 1913, activated sludge was discovered, which is a biological wastewater treatment process. Here the gold standard for North American and European wastewater

systems emerged: using gravity or pumps, the wastewater was transported by extensive sewerage networks to large-scale, centralised wastewater treatment plants outside the city. During the treatment process in the plants (see Figure 1), solid waste is first removed from the raw sewage (the primary treatment process) and air added to the wastewater (the secondary treatment process). Due to the addition of return sludge and aerating of wastewater, a biological process occurs that removes pathogens and nutrients (nitrogen and phosphorous). After this biological process, the wastewater flows to a clarifier to separate the treated water from the semi-solid slurry called sludge. In some plants, the sludge is then anaerobically digested before being sent for incineration or landfill, and the treated wastewater is discharged to surface water, which may be used as an influent for drinking water production by drinking water treatment plants.

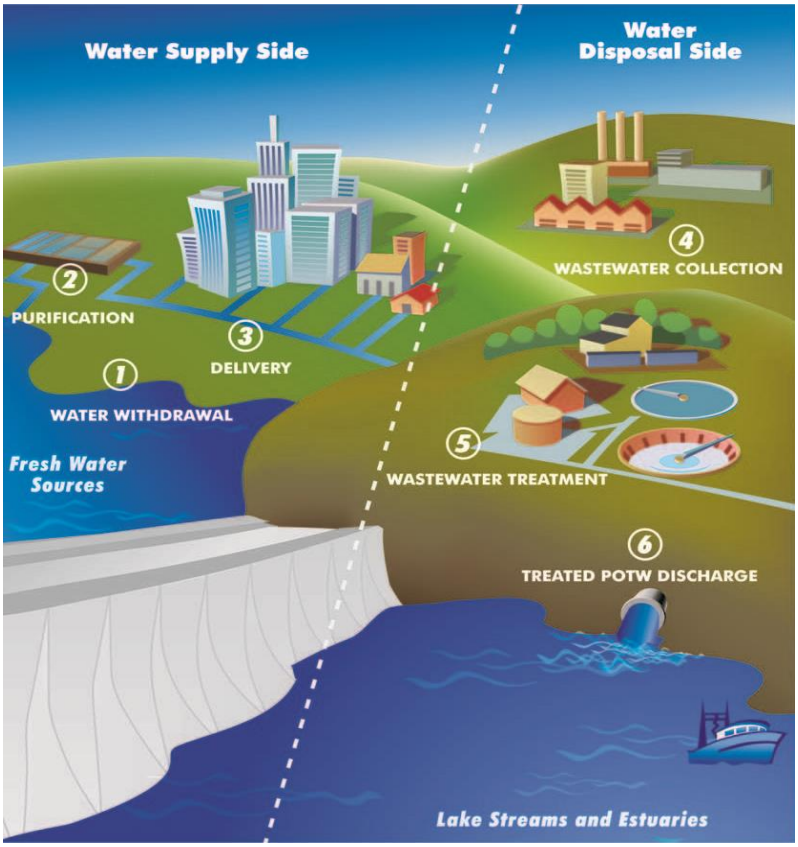
Figure 1: the activated sludge wastewater treatment process (Encyclopædia Britannica, 2012)



In the nineteenth century, the developments in the North American, European and Australian sanitation sectors were motivated by concerns over public health and, from the 1950s, by the quality of surface water (see Melosi (2000) for an American perspective; Cooper (2001) for the UK; Beder (1989) for Australia; and Lofrano & Brown (2010) and Sedlak (2014) for international perspectives). In Belgium and the

Netherlands, the large-scale, centralised wastewater infrastructure was constructed from the twentieth century onwards and did not undergo any major changes to date (for historical perspectives, see e.g. De Korte, 2018; van Lohuizen, 2006; Mulder, 2016; de Swaan, 2004; Van Braeckel, 2005). Figure 2 illustrates the broader urban water cycle, of which the activated sludge wastewater treatment process (5) forms one part, in addition to water withdrawal (1), purification (2) and delivery of drinking water (3) by drinking water treatment plants, wastewater collection in sewers (4) and, after treatment, the discharge of treated wastewater to surface water (6).

Figure 2: simplified urban water cycle (POTW is the abbreviation of publicly owned treatment works) (EPA, 2004)



1.1.2 Resource recovery, a circular economy and sustainability in the wastewater system

Recently, there are increasing calls for a transition towards resource recovery, a circular economy and sustainability in the wastewater system, which is a new concern in addition to public health and the quality of surface water. Among the reasons are pressing issues for the large-scale, centralised wastewater system such as the use of fossil fuels in the treatment process for pumping and aerating, decaying sewers and treatment plants, drought and intense periods of rainfall, emerging pollutants and, generally, the depletion of critical resources (EEA, 2019b; UN WWAP, 2017).

It is argued that a paradigm shift or transition is needed to recover water, energy and resources from wastewater (e.g. Guest et al., 2009; Kehrein et al., 2020; Larsen, Alder, Eggen, Maurer, & Lienert, 2009; Pikaar, Huang, Fatone, & Guest, 2020). For example, water may be reused in the following ways: the effluent can be treated and purified for drinking water use (i.e. direct potable reuse); before purification by a drinking water treatment plant, it is possible to inject the effluent into an aquifer (i.e. indirect potable reuse); it is also possible to match the quality of the effluent to the intended reuse scheme such as irrigation or industrial cooling processes (i.e. water fit for purpose). In addition to water, it is possible to recover resources from wastewater such as biogas (energy), phosphorus and struvite (fertilisers), cellulose, alginate-like polymers, critical metals and bioplastics.

Along these lines, wastewater scholars such as engineers, environmental biologists and chemists are developing new ideas, concepts and practices. Waste management's concept of Reduce, Reuse and Recover is adapted to the wastewater system: the impact of the wastewater system should be reduced; water and sludge should be reused; and resources should be recovered from wastewater (Lema & Suarez, 2017). In the Belgian water sector, for instance, scholars define the 'hot topics' as resource recovery, micropollutants, water scarcity and integrated water management, inter alia (De Mulder et al., 2016). Yet others point to improving the efficiency of energy use and resource recovery of the established, activated sludge treatment plants (van Loosdrecht & Brdjanovic, 2014). In turn, a review paper informs decision-makers about the technical possibilities, market supply potentials and bottlenecks for a shift from the established wastewater treatment plants to so-called water resource facilities (Kehrein et al., 2020). As chapter 3 and particularly chapter 4 will show, the majority of research and activities in the wastewater sector

are geared to the optimisation of the centralised, large-scale wastewater treatment system to recover resources. In chapter 4, it becomes clear that resources such as cellulose, alginate-like polymers and phosphorus are selected for recovery because it is possible by optimising the current infrastructure.

Interestingly, some authors indicate that this large-scale system is reaching its limits, leading to proposals for more fundamental shifts towards sustainable sanitation systems (Brands, 2014). For example, alternative practices to sewer-based urban water management are provided by exploring source separation, the decentralisation of treatment plants, hybrid systems (Larsen, Udert, & Lienert, 2013) or nature-based solutions (Kisser et al., 2020). Additionally, since the centralised water system cannot keep up with modern challenges because of institutional momentum, long life cycles of equipment and lack of competition among service providers, extreme decentralisation is proposed, which comprises household-level systems or 'personal water systems' (Rabaey, Vandekerckhove, Van de Walle, & Sedlak, 2020).

Such shifts towards sustainability and circularity are also addressed in research projects. The SuPER-W project focusses on Sustainable Product, Energy and Resource Recovery from Wastewater and is the European Marie Skłodowska-Curie Action joint doctorate programme, of which this thesis is a result. In 2016, fifteen early-stage researchers were recruited to investigate 'a much-needed paradigm shift from wastewater treatment to resource recovery' and the 'major economic and environmental drivers' of this shift. My project was intended to investigate 'regulatory, economical and technical bottlenecks' (SuPER-W, 2017, pp. 1–3). The network consisted of thirteen engineering or natural scientists, one environmental scientist and a social scientist (myself). These PhD candidates were expected to concretise this shift in the wastewater system. The project included engineering companies and consultancy firms, while governments and NGO's were not directly involved. The research of most of the engineering and natural scientists was focussed on recovering energy and resources by optimising the large-scale treatment system.

Taken together, as a result of a range of challenges in the centralised, large-scale treatment system, the actors involved in the system are increasingly considering sustainability and circularity as possible ways forward. However, as I describe in the next section, the search for sustainability, circularity and innovation is problematised by at least two other perspectives on innovation in the wastewater system.

1.1.3 Innovation in the wastewater system: two criticisms

Besides the above-mentioned natural, technological and economic perspectives about the recovery of energy and resources, it is possible to discern at least two other perspectives about innovation in the wastewater system. The first perspective raises intriguing questions about the recovery of energy and resources from wastewater, whereas the second questions the slow rate of changes (i.e. the status quo) in the infrastructure and institutional arrangement of the wastewater system.

The first perspective raises questions about recovering energy and resources from wastewater. Marlous Blankesteijn (2019), for instance, identified multiple challenges in recovering phosphorus from wastewater in the Netherlands: the lack of markets for the recovered phosphate in Europe, water managers lacking experience in commercialising their products and legislation and regulatory frameworks limiting innovative activities. In turn, it has been found that the recovery of phosphorus (phosphoric acid and struvite) represents only an incremental adaptation to the wastewater system (Jedelhauser, Mehr, & Binder, 2018), particularly reinforcing the large-scale treatment plants and fostering existing path dependencies in the system (Barquet, Järnberg, Rosemarin, & Macura, 2020; Jedelhauser & Binder, 2018). Further, social, institutional and technological contexts lead to slow progress in Egypt's rural wastewater management and reuse schemes (Tawfik, Hoogesteger, Elmahdi, & Hellegers, 2021). A new activity such as water recovery also disrupts established practices and ideologies of water management. Consequently, it leads to a governance mode that is highly regulated and heavily controlled to align the new developments with the centralised infrastructure, institutions and techno-scientific expertise (Meehan, Ormerod, & Moore, 2013). The recovery of energy and resources in the established wastewater system thus faces major challenges and is far from unproblematic.

In addition to this perspective on energy and resource recovery, the second perspective questions the slow pace of changes in the institutional arrangement of the water/wastewater system, generally leading to the suggestion that the change

of such arrangements needs to be part of the debate about technological innovation. In China's wastewater system, a global, dominant institutional rationality, characterised by conventional, centralised wastewater infrastructure, shaped the developments in the sector from the nineties onwards. Today, this implies that China's wastewater system follows a trajectory that hardly differs from the focus on technological and economic efficiency that is typical of most countries, in which alternative rationalities that emphasise environmental sustainability are excluded, leading to an unsuccessful transition (Fuenfschilling & Binz, 2018). Eva Lieberherr and Lea Fuenfschilling (2016) argued that sector characteristics such as large-scale centralised pipes and infrastructure, natural monopoly structures and the importance of public and environmental health may hinder liberalisation reforms in the water sector. Further, cost and financing and risk and regulatory compliance form barriers to innovation in the wastewater sector (Kiparsky et al., 2016). Similarly, existing paradigms, sunk investments, sector silos, legal constraints and fragmented responsibilities form obstacles to addressing the current challenges and delivering long-term sustainable outcomes in water infrastructure. Therefore, the renewal of institutional arrangements needs to be part of the debate about adequately implementing technical innovation (Trapp, Kerber, & Schramm, 2017). Specifically, an editorial of Nature Sustainability recently took issue with so-called engineering solutions to water problems, which are 'portrayed in elegant terms that may appear simple and make us feel better, precisely because they ignore the messy institutions, norms and processes that underlie our relationship, as individuals and as a society, with water in the first place' (Too much and not enough, 2021, p. 659). It is further demonstrated that the hegemony of civil engineering in Dutch sewage treatment is not only decisive in the selection of technical means to given political ends but also in the policies that set the standards for evaluation (Van de Poel, 2008). Overall, in exploring the potential of non-grid, small-grid and hybrid solutions (e.g. decentralised treatment) in urban water management, Sabine Hoffmann and colleagues (2020) further confirm that lock-in effects take place at the technical (e.g. infrastructure and single technologies) and the social level (e.g. the organisations and users involved as well as regulation, policy, paradigms and culture) of the centralised system, leading to strong path dependencies and incremental changes in water/wastewater arrangements.

To sum up this section, the large-scale, centralised wastewater treatment system has recently come under scrutiny because of sustainability challenges, which are being addressed by accelerating transitions towards resource recovery and a circular

economy. However, the majority of activities and research aim to optimise the established large-scale treatment system, of which the SuPER-W project is but one example. Accordingly, questions are raised about the challenges related to energy and resource recovery and about the slow pace of changes or overall inertia of the wastewater system, suggesting that investigating institutional arrangements in transition processes is necessary. Based on these findings, I contend that it is worthwhile to explore *what* the interpretations of sustainability or circularity in the wastewater system are, elucidating the societal choices to be made about optimising the established treatment system, developing hybrid systems, creating markets for resources, involving citizens, selecting resources, implementing subsidies etc. Additionally, *how* and *why* such interpretations gain influence requires closer scrutiny, particularly because they shape the direction of the transition pathways in a system characterised by inert institutional arrangements. Hence, these questions serve as a motivation to use a political science perspective. Yet before delving into the politics of sustainability transitions, I turn to the circular economy, leading to a similar motivation and questions.

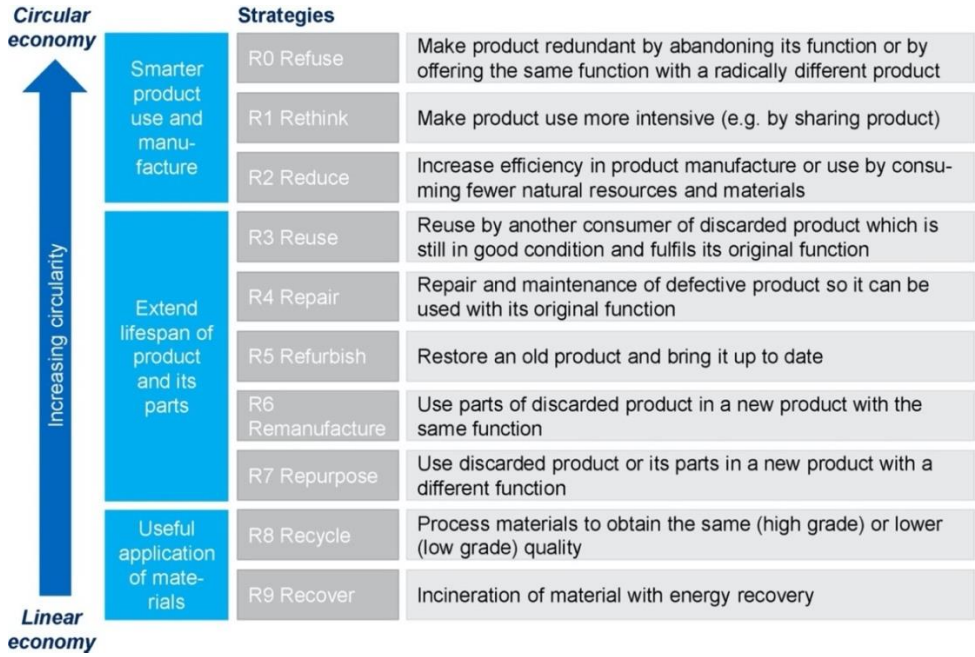
1.2 The circular economy and resource recovery

In addition to the wastewater system, the circular economy is one of the core elements of this thesis, which I address in this section. I first introduce the circular economy and the ways the concept is interpreted by the majority of policymakers and researchers. In turn, I describe three criticisms related to the circular economy, particularly the low circularity of the current economy; the discrepancy between the fashionable, ambitious narrative and the stability of institutional arrangements and infrastructure; and, as the concept is ambiguous, the proposals to expose the transformative potential of the circular economy. In all, I contend that a political science perspective is crucial to understand *what* the different interpretations of the circular economy are, as well as *how* and *why* specific interpretations become dominant and influence the system, typically leading to the status quo instead of radical change.

1.2.1 The concept: science and policy

The concept of the circular economy received increasing attention from scientists over the last decade (Homrich, Galvão, Abadia, & Carvalho, 2018; Korhonen, Honkasalo, & Seppälä, 2018; Stahel, 2016), particularly of industrial ecologists, engineers and business and management scholars (Blomsma & Brennan, 2017; Hobson, 2020; Merli, Preziosi, & Acampora, 2018). Generally, it proposes closing the loops of material and energy cycles by reducing waste and reusing and recycling resources and products. It also provides an alternative model to the linear take-make-dispose system of waste management, addressing its negative environmental, economic and social effects. Numerous visions and strategies have been related to a circular economy, perhaps best summarised by the so-called 9R framework displayed by Figure 3 (Kirchherr, Reike, & Hekkert, 2017; Potting, Hekkert, Worrel, & Hanemaaijer, 2016). The framework distinguishes among nine strategies of circularity, in which the strategies ranked highest (refuse, rethink and reduce) equal, as a rule of thumb, most environmental benefits because fewer or no resources are required to produce new products. By contrast, in the lowest-ranked strategies (recycle and recover) of circularity, resources are still required to produce new products or materials. A circular economy thus comprises, inter alia, refusal to produce or consume new products (R0), sharing certain products among consumers or citizens (R1), ecologically designing products to increase reparability (R2), refurbishing old products (R5) and the recycling (R8) and recovery (R9) of certain resources.

Figure 3: the 9R framework (Kirchherr et al., 2017)



In addition to academic attention, there is widespread interest in the circular economy among policymakers as well. In the European Union, the concept has gained traction over the past decade, particularly due to the activities of the Ellen MacArthur Foundation and the European Commission (Bocken, Olivetti, Cullen, Potting, & Lifset, 2017; Kovacic, Strand, & Völker, 2020; Lazarevic & Valve, 2017). The former organisation was created in 2010 and inspires business, academia, policymakers and institutions to accelerate the transition to a circular economy. In 2013, the Foundation published its first report titled 'Towards the circular economy: economic and business rationale for an accelerated transition.' Here the influential 'butterfly diagram', which comprises biological and technical nutrients, mimicking the ecosystem, was published. In the report, the circular economy is defined as:

> *'An industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.'* (Ellen MacArthur Foundation, 2013, p. 7)

A few years later, an influential communication of the European Commission titled 'Closing the loop – An EU Action Plan for the circular economy' was published, as a follow-up to earlier communications. The definition in this report is reproduced in numerous policy documents and reads thus:

> *'The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource-efficient and competitive economy.'* (European Commission, 2015, p. 2)

The Ellen MacArthur Foundation has played an important role in framing the circular economy as an opportunity for business models, innovation and environmental protection. From 2015, the European Commission aligned with this approach by emphasising the role of a competitive economy, resource efficiency and business opportunities. Nonetheless, although the circular economy is becoming increasingly significant in policy, it has been questioned over the past few years from at least three different perspectives, described in the following paragraphs.

1.2.2 Three criticisms of the circular economy

The increased recognition of the circular economy is accompanied by critical inquiry. Here I distinguish three types of critique of the circular economy: its low circularity, the discrepancy between the inertia of current institutional arrangements and the ambitious circular economy narrative, and proposals to expose the transformative potential of the concept.

First, although the circular economy has become extremely popular among academia and policymakers, the economy is far from being circular. The Circle Economy, a not-for-profit organisation that wants to accelerate the implementation of the circular economy, published 'The circularity gap report', highlighting that the global economy was only 9,1% circular in 2018 and 8,6% in 2020. The report laments that 'the news is not just bad, it is worse' (p. 15) and identifies the main reasons as high rates of material extraction, the ongoing stock build-up (in buildings and infrastructure) and increasing but still low levels of material efficiency, extending and intensifying use and end-of-life recovery (The Circle Economy, 2020). Similarly, the European Environment Agency notes that the circular economy is still in its 'infancy', as only approximately 10% of the materials used in the European Union are recovered and reused (EEA, 2019c). By the same token, industrial ecologists started measuring the circular economy in biophysical terms by accounting biophysical flows of materials: in 2005, the degree of circularity (measured as the share of recycled materials in the total processed materials) was approximately 6% in the world (Haas, Krausmann, Wiedenhofer, & Heinz, 2015) and, in 2014, 9,6% in the European Union (Mayer et al., 2019). Although these numbers depend on fragmented data and how and what is measured (Kovacic et al., 2020; Reike, Vermeulen, & Witjes, 2018), they indicate that the current economy is far from a completely closed-loop which, moreover, may be impossible without slowing the economic process according to biophysical perspectives (Giampietro, 2019).

Second and not surprisingly, political and social scientists have observed a discrepancy between the fashionable circular economy narrative and the stability of, or incremental changes in, policy, institutions, infrastructure and ideas. For instance, when the European Union's Circular Economy Package is viewed in the light of historical trends (1970-2018), it becomes clear that most policy instruments and mixes are patched or layered onto the existing policy, mirroring conceptual recycling and predominantly leading to continuous incremental change. It is hence

concluded that 'successfully disrupting deeply entrenched, unsustainable patterns of production and consumption requires, in our view, altogether more radical approaches to EU policy design than CE proponents currently acknowledge' (Fitch-Roy, Benson, & Monciardini, 2019, p. 996). Similarly, it is found that while the EU (re)produces a holistic circular economy discourse, the policies remain stuck in end-of-pipe solutions, leading to little changes to address core socio-ecological challenges (Calisto Friant, Vermeulen, & Salomone, 2020a). In the German packaging sector's shift to a circular economy, Machteld Simoens & Sina Leipold (2021) observe that public and private stakeholders are apprehensive of radical change, which created a lock-in situation between opposing narratives that was, eventually, resolved by pursuing incremental instead of radical change. Further, in Boston's transition towards more sustainable waste management, Lily Pollans (2017) shows that actors interested in new ways of waste disposal lack access to decision-making processes, whereas the established mode of waste disposal is protected by institutional and physical fragmentation, professional norms, financial incentives and vested interests. These findings are similar to other works on barriers to the implementation of the circular economy in cities (Campbell-Johnston, ten Cate, Elfering-Petrovic, & Gupta, 2019; Yalçın & Foxon, 2021) and the European Union (Kirchherr et al., 2018). Finally, scholars indicate that the research, policy and implementation of the circular economy align with the prevailing model of economic growth and technological innovation by the following: sustaining norms of growth and material throughputs (Hobson & Lynch, 2016); avoiding the scrutiny and critique necessary to ensure biodiversity conservation (Buchmann-Duck & Beazley, 2020); commodifying industrial waste (Martin, 2019); creating a rebound effect (Zink & Geyer, 2017); pursuing an ecological modernist position (Hofmann, 2019); and marrying capital accumulation with environmental challenges at the urban scale (Bassens, Kębłowski, & Lambert, 2020; Savini, 2019). Overall, although the expectations arising from the circular economy are high in terms of the potential for radical change, the majority of research on the topic finds that established, unsustainable policy, institutions, ideas and infrastructure have remained stable or have not changed more than incrementally.

Third, despite present efforts to achieve a circular economy not leading to radical change and its implementation aligning with prevailing paradigms, a few authors underscore that the concept of the circular economy is ambiguous, open-ended and contentious and, accordingly, indicate that the circular economy is potentially

something more than incremental change or business as usual. The circular economy has been defined as an 'essentially contested concept' (Korhonen, Nuur, Feldmann, & Birkie, 2018) and an 'umbrella concept' (Blomsma & Brennan, 2017). Kirchherr and colleagues (2017), by analysing 114 definitions, find that the circular economy means different things to different people. They find, inter alia, that practitioners emphasise economic prosperity in their definitions and frequently neglect the 'reduce' principle. Most of the definitions exclude social considerations, a link to sustainable development and a systemic perspective. As such, to avoid a refurbished form of greenwashing, other scholars propose a more inclusive, comprehensive and complex discussion on the circular economy by expanding the imagery about many possible circular futures. This led, for instance, to proposals that expose the transformative potential of the circular economy, ranging from a 'reformist circular society', 'technocentric circular economy' and 'transformational circular economy' (Calisto Friant, Vermeulen, & Salomone, 2020b); a circular economy based on convivial technology instead of technocratic eco-modernism (Genovese & Pansera, 2020); to 'planned circularity', 'circular modernism', 'bottom-up sufficiency' and 'peer-to-peer circularity' (Bauwens, Hekkert, & Kirchherr, 2020); and a 'circular society' (Jaeger-Erben, Jensen, Hofmann, & Zwiers, 2021), 'circular justice' (Kirchherr, 2021) and 'post-growth circularity' (Bauwens, 2021). The interpretive flexibility of the circular economy concept thus leads to a range of definitions and possible, transformative futures but, as the previous paragraph demonstrates, a specific interpretation is acquiring dominance.

Summing up this section about the circular economy, the concept has received growing attention from researchers and policymakers. However, the current economy is hardly circular, as there is a discrepancy between the fashionable concept and the stability of institutional arrangements, with the transformative potential of the circular economy typically obscured. In line with the questions raised about innovation in the wastewater system in the first section, it emphasises that a political science perspective is needed to understand these issues, to which I turn in the paragraphs below.

1.3 Politics and sustainability transitions

The first two sections of this chapter not only introduced the wastewater system and the circular economy but also indicated that the two main topics require further examination from a political science perspective. One is the importance of elucidating *what* the dominant and alternative interpretations of a transition towards a circular economy in the wastewater system are. The other is about *how* and *why* specific interpretations become dominant and influence the system. I now show that these topics have to be explored from a political science perspective. I elaborate on politics and power, then turn to discourses and environmental problems and, subsequently, to the political processes in which these interpretations are being constructed and institutionalised. As these perspectives are used in, and supplement, chapters 3, 4 and 5, I will now refer to these chapters, which I further discuss in the conclusion of this thesis. In the fourth and final section of this introduction, the research questions are presented.

The third chapter of this thesis is published as: Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2020). A transition in the Dutch wastewater system? The struggle between discourses and with lock-ins. *Journal of Environmental Policy & Planning*, *22*, 155-169.

The fourth chapter of this thesis is published as: Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2021). Power struggles in policy feedback processes: incremental steps towards a circular economy within Dutch wastewater policy. *Policy Sciences, 54,* 579-607.

The fifth chapter of this thesis is published as: Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2021). Incumbents' enabling role in niche-innovation: Power dynamics in a wastewater project. *Environmental Innovation and Societal Transitions*, *39*, 73-85.

1.3.1 Politics and power

Although how politics and power are conceptualised in this thesis is addressed in chapters 3, 4 and 5, I now briefly consider this topic to highlight that the scope of political analyses stretches beyond, on the one hand, governments and political parties and, on the other, decision making power.

First, political analysis is not only about governments. Politics and the political are 'concerned with the distribution, exercise and consequences of power' (Hay, 2002, p. 3), implying that politics is found not only within the realm of government and political parties but also in organisations, culture, law, science and the domestic sphere. Political science and political analysis thus encompass the entire sphere of the social; all events, processes and practices have the potential to be political and can be subject to political analysis (Hay, 2002; Stoker & Marsh, 2002).

Second, the analysis of politics focusses on power, which is not only about decision-making power. Yet there is little agreement on what power is, making it an essentially contested concept (Lukes, 2004) or a 'family resemblance concept' (Haugaard, 2010): it may be repressive or constitutive, it can be conceptualised in terms of agency and structure and the identification of power can be an analytical and normative exercise (Hay, 2002). Further, it is possible to distinguish between power-over, power-to and power-with (Pansardi & Bindi, 2021), different dimensions of power (Haugaard, 2021) and faces of power (Baldwin, 2021), amongst other ways of conceptualising power (Ledyaev, 2021). For example, the first face of power directs attention to the decision-making of those who inhabit positions of influence within the state, whereas the second face of power concerns the topics excluded from the state's agenda, emphasising agenda-setting and so-called non-decisions. The third face of power underscores that power is also exercised through preference-shaping:

> *'Is it not the most insidious exercise of power to prevent people, to whatever degree, from having grievances by shaping their perceptions, cognitions, and preferences in such a way that they accept their role in the existing order of things, either because they can see or imagine no alternative to it, or because they see it as natural or unchangeable, or because they value it as divinely ordained and beneficial?'* (Lukes, 1974, as cited in Hay, 2002, pp. 178–179)

Power analysts thus focus on the struggles of the decision-making process, the shaping of the agenda of the process, and the shaping of perceived interests and political preferences. As these debates are ongoing, some authors attempt to arrive at a framework that can be applied to empirical phenomena, capturing the broad contours of the power debate. In the third chapter of this thesis, for instance, I cite Maarten Hajer (1995), who argues that there is considerable power in structured ways of seeing (i.e. discourse) and that 'The political conflict is hidden in the question of what definition is given to the problem, which aspects of social reality are included and which are left undiscussed' (p. 43), similar to the third face of power in particular. Accordingly, Hajer notes that power can be studied directly through discourse, implying that 'discourses constitute the world and conversely they are constituted by it' (Keller, 2013, p. 25). In chapter 4 and 5, I draw inspiration from the work of Arts & van Tatenhove (2004), amongst other researchers, who define power as 'the organisational and discursive capacity of agencies, either in competition with one another or jointly, to achieve outcomes in social practices, a capacity which is however co-determined by the structural power of those social institutions in which these agencies are embedded' (p. 347). I find this definition useful because it identifies the following: the organisational and discursive capacities of agencies, emphasising the role of ideas and preferences in addition to coalitions, rules and resources; consensual and antagonistic power relations; agency and structure; as well as the power to achieve outcomes in interactions and more structural forms of power.

This brief overview demonstrates what analysing politics and particularly the distribution, exercise and consequences of power may imply. For instance, if perceptions and ideas exercise power, it is useful to investigate the interpretations of a transition towards a circular economy in the wastewater system and to analyse how these interpretations shape specific policies, investments, regulations, behaviours, subsidies, infrastructure and, more generally, transition pathways. Further, it may be worthwhile to examine the events, processes and practices in which specific interpretations of a transition are developed and possibly institutionalised (i.e. become sedimented), while other interpretations are intentionally excluded or not considered and do not gain power through the process of institutionalisation. Such an analysis focusses on how certain interpretations become dominant and influence the system, which is generally in line with recent literature on the politics of sustainability transitions (e.g. Avelino, Grin, Pel, & Jhagroe, 2016; Grin, 2010; Meadowcroft, 2011; Scoones, Leach, & Newell, 2015).

Hence, political science perspectives are useful to investigate the what, how and why-questions developed in the previous sections, which I now consider by elaborating on the interpretation and particularly discourses in environmental politics (3.2) and then on the political processes in which these discourses are institutionalised in stable arrangements (3.3).

1.3.2 Discourses and environmental politics

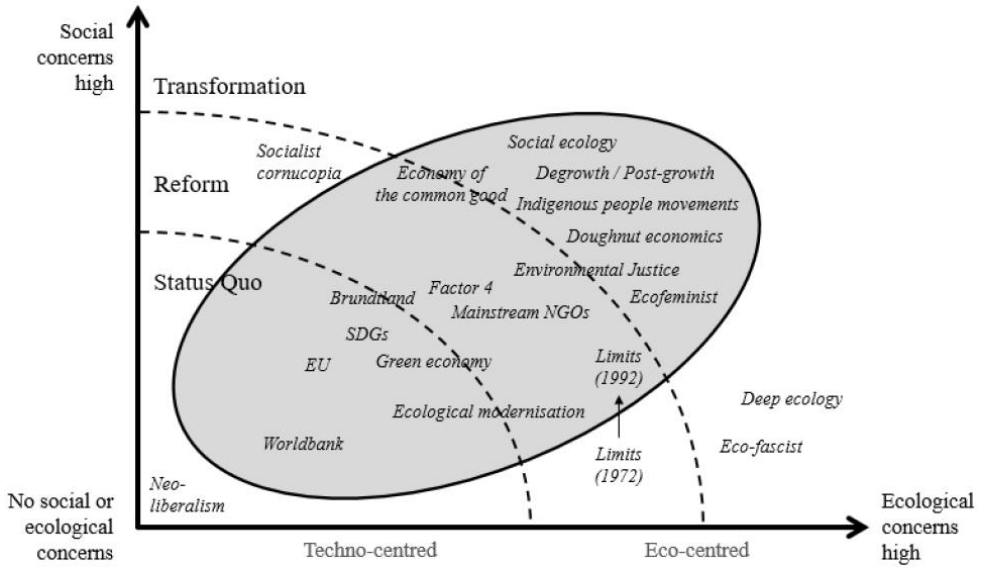
As indicated in sections one and two of this chapter, choices can be made about optimising the established, large-scale wastewater system (e.g. hybrid treatment systems) or the dominant meaning of a circular economy (e.g. a transformational circular economy). I now first argue that these societal choices are related to the question about dominant and alternative interpretations (i.e. *what*) and then on a couple of ways in which these interpretations may be classified, also indicating that *how* and *why* certain discourses become dominant and influence the system requires more research.

Scholars of environmental politics argue that environmental problems are interpreted in multiple ways because ecosystems are complex, as are social systems (Dryzek, 2005; Feindt & Oels, 2005). Specifically, environmental problems are characterised by systemic interdependencies, long time horizons and multiple spatial scales, while social systems are typified by numerous actors who interpret environmental problems and propose solutions that match their rationalities, ideas and preferences. Similarly, sustainable development takes place in a context where power is distributed not only among societal actors such as public authorities, private companies and civil society at the vertical and horizontal layers of governance but also across diverse societal subsystems such as law, science, politics and the economy, all operating on their own rationalities, ideas and preferences (Meadowcroft, 2007). There is then a complex and continuous struggle over how to interpret and react to environmental phenomena, raising questions of what sustainable and circular mean, whose sustainable or circular counts, what is to be changed and who will implement these changes (Blythe et al., 2018; Hajer, 1995; Scoones et al., 2015).

As the interpretation of environmental problems matters, several scholars have attempted to map the interpretations of environmental issues and the related societal choices (e.g. Clapp & Dauvergne, 2005; Dobson, 1990; Dryzek, 2005; Hopwood, Mellor, & O'Brien, 2005). For example, Dryzek (2005) states that environmental interpretations may diverge in a reformist (i.e. small changes) or

radical (i.e. large changes) way from industrialism and that these departures may be prosaic (i.e. taking the political-economic institutions of industrialism as a given) or imaginative (i.e. seeking to redefine the political-economic institutions). The classification results in a 2x2 matrix with four main interpretations: environmental problem solving (reformist and prosaic), survivalism (radical and prosaic), sustainability (reformist and imaginative) and green radicalism (radical and imaginative). Further, four narratives of green transformations, reflecting different understandings of problems, solutions and versions of sustainability, have also been identified: technocentric, marketised, state-led and citizen-led pathways towards sustainability (Scoones et al., 2015). Drawing inspiration from an earlier attempt at mapping sustainable development (Hopwood et al., 2005), Block & Paredis (2019) consider social and ecological concerns on two separate axes to distinguish three broad views on the extent and direction of societal change, namely the status quo, reform and transformation. They then plot actors, interpretations and publications on a map that covers these three views, illustrating the myriad ways in which sustainability and transitions are interpreted (see Figure 4). Here again, it becomes clear that, for instance, the European Union's interpretation of sustainability or the narrative of ecological modernisation are not neutral. These interpretations are based on political and societal choices about the nature and depth of the envisaged changes and, moreover, may be challenged by and contrasted with more transformative approaches such as degrowth (e.g. D'Alisa, Demaria, & Kallis, 2015) and environmental justice (e.g. Schlosberg, 2013). Hence, these discussions underscore the different ways in which environmental problems are interpreted and play an important role in environmental politics and the related societal choices.

Figure 4: mapping views of sustainability and transitions (Block & Paredis (2019) based on Hopwood et al. (2005))



One way to analyse dominant and alternative interpretations of a transition towards a circular economy in the wastewater system is discourse analysis (Fischer, Torgerson, Durnová, & Orsini, 2015; Hajer, 1995; Keller, 2013; Sharp & Richardson, 2001; Wodak, 2008). Hajer's (1995) work investigates how specific interpretations of environmental problems influence and construct policy by focussing on discourses. The latter is 'a specific ensemble of ideas, concepts, and categorisations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities' (p. 44). A discourse represents aspects of an environmental phenomenon that might be represented differently by different actors and their projects of change. Once a discourse becomes dominant, it is authoritative and discredits and excludes other discourses. It may also make certain elements appear as fixed or normal, requiring no further action, while other elements appear as problematic and require changes, raising intriguing questions of 'What can be thought within its structures? Where does it hit its conceptual limits? In what sense does it open up solidified relations of power?' (p. 4). As such, in the third chapter of this thesis, I use discourse analysis to explore *what* the interpretations of a transition in the Dutch wastewater system are.

Yet the third chapter not only focusses on identifying the interpretations used but also examines *how* and *why* specific interpretations become dominant and influence established arrangements. Following Hajer, the chapter focusses on the ways discourses are 'produced, reproduced, and transformed in a particular set of practices' (p. 44), investigating how specific discourses ensure permanence. Specifically, Hajer first defines a discourse coalition as a particular group of actors that share a set of interpretations. He then invokes two concepts to analyse the influence and strength (i.e. power) of a coalition's discourse: structuration and institutionalisation. Discourse structuration takes place if a particular discourse starts to dominate the way a given social unit (e.g. a sector, scientific discipline or policy domain) understands and perceives environmental problems, solutions and strategies. In other words, it structures how the world is interpreted and defined. Discourse institutionalisation occurs if the discourse is translated into, inter alia, institutional arrangements, concrete policies, regulation, organisational practices and the development of technology or infrastructure. If these two conditions are met, a discourse is said to be dominant in a given social unit, influencing the power structures of society. Along these lines, chapter 3 maps different discourses but also tentatively suggests that discourses that draw on established infrastructure and existing political-economic institutions have an advantage in becoming dominant. Looking back, however, discourse analysis may be strengthened by considering the wider institutional context (Kern & Rogge, 2017). More work is needed on the role of discourse in the continuity or discontinuity of institutional arrangements as well as infrastructure, to understand how discourses institutionalise and may lead to stable arrangements that impede fundamental change over time.

Overall, discourses are important in environmental politics. I discussed that discourses influence transition pathways (e.g. the extent and direction of societal change), also indicating that *how* and *why* discourses become dominant and interact with stable arrangements over time requires more research. Thus, different discourses are identified in chapter 3; while chapter 4 analyses, inter alia, how a dominant discourse is institutionalised to ensure stability in an arrangement; and chapter 5 examines the struggles between the regime and innovative actors involved in an alternative project. I elaborate below on the literature used in chapters 4 and 5, generally focussing on political processes in the stability and incremental change of institutional arrangements.

1.3.3 Stability and incremental change in institutional arrangements

Having established the importance of *what* the interpretations of a transition towards a circular economy in the wastewater system are, I now further elaborate on *how* and *why* certain interpretations become dominant and influence the system, by successively describing two approaches to the stability of institutional arrangements that constitute the research that follows. The first approach focusses on path dependency and policy feedback processes, and is used in the fourth chapter to analyse a case study of the incremental reorientation towards a circular economy in Dutch wastewater policy. The second approach analyses socio-technical systems and is used in the fifth chapter in a case study of an alternative socio-technical configuration, namely a path-breaking decentralised wastewater treatment system.

1.3.3.1 *Policy feedback processes and the role of actors*

The policy feedback approach asks how path-dependent policies influence or feed back into political processes that, in turn, shape or feed back into policy. In this thesis, the approach is useful to explore how certain interpretations institutionalise and remain dominant. I describe the approach below and indicate that more work is needed on the role of agency and power struggles in policy feedback processes.

With work on path-dependent policies, Pierson (1993, 2000) is interested in the self-reinforcing feedback generated by the prevailing policies or institutional arrangements. When feedback from past policy choices begins to accumulate, it generates a powerful cycle of increasing returns that may become path-dependent over time, making path-breaking change difficult. Specifically, the existing policy may create lock-in effects induced by fixed costs, networks, standards and expectations (Pierson, 1993) as well as organisational persistence, institutional constraints, political authority and the complexity of politics (Pierson, 2000). Along these lines, policy feedback research is concerned with understanding policy stability and change (Béland, 2010; Weaver, 2010). It investigates how existing policy feeds back into political processes and how these politics subsequently feed back into policy over time, particularly through the resources and the capacities, interests and preferences of the actors involved in politics. Existing policies may thus create their own bases of political support that lead to self-reinforcing dynamics and stability. Recently, however, policy feedback scholars have also focussed on self-undermining feedback that may result in policy change and, therefore, also inquired how actors influence policy feedback processes (Béland & Schlager, 2019; Sewerin, Béland, & Cashore, 2020), which requires more research.

In sum, the struggles of actors in sustaining and reproducing stability and incremental change in established policy or institutional arrangements require more attention in policy feedback research. Therefore, after identifying a dominant discourse in the third chapter, the fourth chapter explores how an established policy arrangement, consisting of actors, ideas, rules and technology, influences the power struggles between innovative and established actors, resulting in incremental instead of fundamental change in the policy arrangement. In doing so, I illustrate *how* and *why* dominant ideas and policies ensure permanence and how change happens only incrementally over time.

1.3.3.2 *Socio-technical systems and the role of actors*

The literature on socio-technical systems is a perspective that focusses on stability and change in regimes or, broadly, institutional arrangements, underscoring that unsustainable patterns of consumption and production in established socio-technical systems require radical shifts or so-called sustainability transitions in those arrangements. In this thesis, the perspective is useful to explore *how* and *why* certain interpretations get institutionalised and become or remain dominant. In the following paragraphs, I describe the sustainability transitions perspective and suggest that more work is required on the role of agency and the politics of sustainability transitions.

Sustainability transitions research uses a multi-level perspective to conceptualise sustainability transitions in socio-technical systems by distinguishing among three levels of structuration (or degrees of institutionalisation, see Fuenfschilling & Truffer, 2014): landscape, niche and regime. The landscape comprises the slowly changing context and shocks. A niche is a space in which radical, green innovations are protected from the selection pressures of the regime. The socio-technical regime is defined as 'the "deep structure" that accounts for the stability of an existing socio-technical system. It refers to the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems.' (Geels, 2011, p. 27). It is thus the locus of usually unsustainable, dominant practices and the associated technology, actors and rules. These are stabilised through lock-in effects such as economies of scale, sunk costs, vested interests and learning effects, mainly resulting in incrementally-changing or path-dependent regimes that narrow the diversity of alternative, radical innovations to the regime's path (Geels, 2011; Unruh, 2000). In theory, the interplay between the processes functioning at the three levels may lead to

fundamental transitions: long-term, multi-dimensional processes of change through which established socio-technical systems shift to more sustainable modes of consumption and production (Geels & Schot, 2007; Markard, Raven, & Truffer, 2012).

However, the sustainability transitions field is criticised for downplaying certain types of agency and politics (Geels, 2011). Early on, it was recognised that the emphasis of transitions research on stability and path-dependent dynamics underestimates the role of agency, fails to consider complex reality and power dynamics (Avelino & Rotmans, 2009; Smith, Voß, & Grin, 2010) and undervalues situated actors' possibilities (e.g. navigational strategies and sense-making) in transition processes (Jørgensen, 2012). Due to these criticisms, the field has engaged with power processes that influence regime change and stability (Avelino et al., 2016). For instance, Geels (2014) uses a neo-Gramscian perspective on hegemonic alliances between incumbent firms and policymakers to underscore that the regime's stability is not to be taken for granted but requires active resistance from incumbent actors. By applying field sociology to analyse power processes in transitions, it is found that incumbents' blockages can be overcome by creating coalitions with countervailing power, leading to incorporation instead of marginalisation (Hess, 2013). Based on the literature of institutional theory and strategic management, the stability of the regime is said to be partially dependent on the active support of powerful actors, who try to influence their environment through strategies such as setting technical standards and providing information and arguments to policymakers and the general public (Smink, Hekkert, & Negro, 2015). On the politics of sustainability transitions, Meadowcroft (2011) observes that transitions are messy and painful processes that disrupt prevailing interests, institutions and ideas. More recently, Lena Partzsch (2017) and Flor Avelino (2017) took issue with the focus on 'power over' (coercive power) or structure to explain gridlock in environmental politics, both suggesting the positioning of the agency for change at the forefront to investigate power in transitions. Nonetheless, more research is required to understand the role of actors in sustainability transitions, particularly the roles of established actors in incremental change and in ensuring permanence in regimes.

Taken together, the literature on socio-technical systems is useful to investigate stability and change in sustainability transitions but more can be done to understand the role of politics, power struggles and agency in regimes that remain stable or change only incrementally. These debates are explored in chapters 3, 4 and 5, which, generally, address *how* and *why* particular interpretations may become dominant as well as the role of regime actors in change and stability.

1.4 Research questions

As mentioned at the beginning of this chapter, I am interested in understanding why societal change fails to happen or takes place at an agonisingly slow rate in environmental governance. Specifically, though innovative activities are being developed but typically result in inertia or incremental change. Therefore, I aim to investigate the political processes underlying stability or inertia and incremental change in established socio-technical systems, focussing on the power of deep-rooted ideas, entrenched networks, embedded rules and vast infrastructure. To do so, the thesis analyses the politics of sustainability transitions towards a circular economy in the wastewater systems of Belgium and the Netherlands.

Following this point of view, I first described, and then raised questions about, the wastewater system and the circular economy, pointing out the need for more research on *what* the dominant and alternative interpretations of a transition towards a circular economy in the wastewater system are and on *how* and *why* a specific interpretation becomes dominant and influences the system. I then argued that a political science perspective is useful to understand these *what, how* and *why*-questions. Therefore, I first established the importance of discourses in environmental politics and how they are mapped, and the need for further research on the interplay between the construction of (dominant) discourses and stable institutional arrangements. Along these lines, I then addressed two perspectives to incremental change and stability in institutional arrangements and some of the shortcomings in the extant literature, underscoring that policy feedback leaves little room for agency in policy and change and that the literature on socio-technical systems has also been criticised for downplaying certain types of agency and power, particularly in stable regimes.

Overall, these *what, how* and *why*-questions provide a point of departure for understanding the slow progress in achieving long-term sustainability objectives. Here more empirical and theoretical research is needed from a political science perspective, bringing me to the main research question of this thesis:

> *What* the dominant and alternative interpretations of a transition towards a circular economy in the Dutch and Belgian wastewater systems are? And *how* and *why* do certain interpretations become dominant and influence these systems?

The thesis seeks to answer this main research question through the following sub-questions in chapter 3, 4 and 5, respectively:

1. How do actors in the wastewater system interpret a transition towards a circular economy? And how can we understand these interpretations from a political perspective on transitions?

2. How do actors use power in policy feedback processes and how does this result in incremental instead of fundamental policy change?

3. How do incumbents use power to enable or restrict niche-innovation?

The remainder of my thesis is organised as follows. Chapter 2 presents my methodology: the interpretive research philosophy and the implications of this approach. Chapter 3 answers the first sub-question by mapping and interpreting different discourses on a transition towards a circular economy in the Dutch wastewater system. Chapter 4 centres on the second sub-question. Through a case study of the Dutch wastewater policy between 2008-2018, it investigates the power struggles of actors in policy feedback dynamics to generate a more nuanced understanding of incremental change and stability in institutional arrangements. Chapter 5 scrutinises the role of and power used by regime-actors in enabling niche-innovation in sustainability transitions, focussing on a path-breaking decentralised wastewater treatment project called DuCoop in Belgium. Finally, Chapter 6 reflects on the main research question and provides avenues for future research and policy recommendations.

Chapter 2: *Interpretive methodology*

In this chapter, I elaborate on the research plan for carrying out this thesis, which entails making a range of choices that influence my ways of seeing research and societal problems, generating knowledge and evaluating my knowledge claims. As I take an interpretive approach to science, the chapter emphasises that the results provided in this thesis are influenced by my own sense-making, while the methodology and methods meet all the scientific criteria. I first describe the interpretive research philosophy. In the second section, I turn to the implications of the interpretive approach for this thesis by addressing how it influenced my research design, namely the research questions, choices of data, methods and frameworks, and then checking my sense-making by engaging with four closely related scientific criteria to evaluate knowledge claims: reflexivity, thick description, intertextuality and transferability.

At this point, I also note that, as an inexperienced and early career researcher, it was particularly hard to understand exactly what type of interpretive moments and which interpretive concepts should be mentioned and avoided in journal publications, which of course changed once I gained experience. Further, the format of academic journals does not always allow interpretive researchers to do what they do (e.g. describing empirical phenomena extensively, using open-ended analytical frameworks and emphasising the chaotic part of research), which may also indicate that a significant number of academic journals is dominated by other scientific logics. Consequently, these dynamics influenced my ways of addressing methodology in this chapter and the write-up of chapters 3, 4 and 5. These published chapters predominantly emphasise the systematic aspects and strength of the analysis, leaving no room for elaborating on, for example, my own sense-making, which is crucial to interpretive research. In contrast to the published chapters, this methodological chapter stresses my own sense-making and interpretive moments. Hence, this chapter may underestimate some of the knowledge claims in this thesis, whereas the methodological sections and conclusions of the published chapters 3, 4 and 5 are written more straightforwardly.

2.1 Interpretive research philosophy

The intriguing title of a book chapter by Marsh & Furlong (2002) reads 'A skin not a sweater: ontology and epistemology in political science'. Through this title, the authors wish to express that social scientists' orientation to research subjects is influenced by their ontological and epistemological position, and they also remind the reader that these positions are 'like a skin not a sweater: they cannot be put on and taken off whenever the researcher sees fit' (p. 17). This implies that the ontological and epistemological position of a researcher is reflected in the studied topic, how it is studied and the status given to the knowledge produced. Ontology is about the form and nature of reality and, consequently, what is there that can be known about it. The key question is 'whether there is a "real" world "out there" that is independent of our knowledge'. The ontological position thus reflects the researcher's view about the nature of the world. Epistemology is about the nature of the relationships between the knower and what can be known, asking 'what we can know about the world and how can we know it' (Marsh & Furlong, 2002, pp. 18–19).

Here it becomes clear that all research is subject to the sense-making of the researcher. Positivist researchers and their interpretive schemes are typically part of an established, decades-old scientific paradigm, requiring no inquiry into sense-making, whereas interpretive researchers emphasise their own sense-making and the necessity for reflexivity in generating knowledge. Undoubtedly, the trustworthiness of scientific knowledge is at the heart of the scientific enterprise, but is enacted differently in interpretive and positivist approaches. More precisely, scientists taking a positivist position hold that the world exists independently of their knowledge of that world. Independent of their techniques, they can directly observe this world in a pure form to test whether a causal relationship and the resulting theory are valid or not. Consequently, they are concerned with explaining the world, making causal statements, observing rational actors and producing objective knowledge that suggests rational solutions. Interpretive scientists, by contrast, do not believe that the world exists independently of their knowledge but contend that the world is constructed: 'action is structured by the meanings that particular groups of people develop to interpret and organize their identities, relationships, and environment' (Parsons, 2010, p. 80). Emphasis is placed on the interpretations of the world by scientists and the meaning that actions, phenomena and events have for the actors and participants they study. As multiple interpretations of reality exist, interpretive research is characterised by an attitude

of doubt, a more dynamic and open-ended approach to responding to local contexts and reflexivity concerning the role of interpretation (i.e. sense-making) in research. Along these lines, results are offered as situated and contextualised; interpretive researchers ask 'knowledge about what? Knowledge for what purpose? Knowledge for whom?' (Schwartz-Shea & Yanow, 2012, p. 46), implying that the interpretations of researchers are always embedded in power relations of the status quo or otherwise.

Throughout a research project, interpretive approaches distinguish at least five interpretive moments (Riessman, 1993): when attending the field the researcher interprets what is being said; thereafter, researchers talk about their experiences with colleagues, peers and friends and construct narratives about certain observations; when transcribing interviews, new interpretations also emerge; next, the researcher explicitly analyses the transcript and edits and reshapes what was told into a research story; and, finally, readers interpret the published text, which is open to several readings by different people in different contexts. Hence, acknowledging the constructedness of scientific knowledge, interpretive scientists make their ontological and epistemological positions explicit.

In contrast to dominant, positivist approaches to political sciences such as the rational choice theory and behaviouralism (Hawkesworth, 2006; Hay, 2002), I am an interpretive scientist. I hold that the real world out there (ontology) is constructed. My perspective of what we can know about the world and how we can know it (epistemology) is that there is no real world that exists independently of the interpretations or meaning making of the actors and, accordingly, that I cannot analyse these actors in objectively (i.e. double hermeneutic).

In exploring constructivism and the space for ideas in political analysis, Hay (2002) identifies a continuum of material-ideational relationships and distinguishes three (stylised) positions: (1) some authors argue that there is no relationship because 'there is nothing outside the text' (in reference to Derrida, p. 205), (2) other scholars contend that ideas are primarily shaped by material interests and (3) still others consider a dialectical view that privileges 'the constitutive role of ideas while not entirely denying the significance of material factors' (p. 208). Regarding the third position, Dryzek (2005), for instance, not only suggests that pollution causes illness and forests really disappear but also that actors make very different interpretations of these (material) phenomena that affect what people do. Strictly speaking, my ontological position is that these phenomena and objects are established as 'real'

only through interpretation. This ontological position dovetails with my epistemological position: all knowledge is constructed, including social scientific knowledge (Yanow, 2007) and laboratory-knowledge (Goeminne, 2011; Latour, 1987). Further, these interpretations can be accessed only through methods such as observation, document analysis and interviews by, for instance, asking respondents how they interpret certain phenomena or objects. In the next section, I discuss the implications of my interpretive ontological and epistemological positions for the research that follows.

2.2 Implications of the interpretive approach

The interpretive ontological and epistemological positions have implications for the research design of my thesis as well as the trustworthiness and evaluation of my knowledge claims. First, regarding the research design, the interpretive approach influences the research questions, choices of data, techniques and frameworks (Yanow, 2006a). Second, interpretive scholars call for a thorough reflection on these subjects because they relate to the trustworthiness and evaluation of knowledge claims. To check one own's sense-making and thus the trustworthiness of research, interpretive scholars engage with four main criteria (Schwartz-Shea, 2006; Schwartz-Shea & Yanow, 2012): reflexivity, thick description, intertextuality and transferability. In what follows, I thus first elaborate on the research design and then discuss how I evaluated my knowledge claims.

2.2.1 Research design

In this section, I describe how the different elements of my research design were influenced by my interpretive research philosophy, I elaborate on my research questions, choices of data, techniques and frameworks. For every element, I first briefly present how it is understood by interpretive scientists and then what it implies for my research.

2.2.1.1 *Research questions*

In interpretive research, research questions are shaped by prior knowledge, abductive ways of knowing and literature. Prior knowledge entails scholars' daily, human experiences and knowledge of a specific setting related to the research project. The abductive – instead of deductive or inductive – logic of inquiry often starts with a puzzle, surprise or tension. The researcher learns about the research questions in the process of doing research and 'tacks continually, constantly, back

and forth in an iterative-recursive fashion between what is puzzling and possible explanations for it' (Schwartz-Shea & Yanow, 2012, p. 27), which is, moreover, done over the empirical material and the theoretical literature. Hence, the iterative-recursive relationship between prior knowledge, abductive engagement, theory and empirics leads to a non-linear, flexible and open-ended approach to research questions.

When I started the project, I had no prior knowledge of wastewater but did have a background in political sciences (see section 2.2.1 as well). In the first months of the project, my research question centred around the exploration of the politics of a transition towards resource recovery in the wastewater system. However, throughout the project, this main research question was further explored in three steps or chapters (see chapters 3, 4 and 5) in an abductive manner. The third chapter, for example, was influenced by the observation that practitioners seemed to disagree about the meanings of 'the transition' and was theoretically informed by my exploration of discourse analysis in the literature. The goal of the fourth and fifth chapters, in turn, first was to explore the dominant discourse and an alternative discourse identified in chapter three. Yet empirical observations and theoretical literature (about policy feedback and incumbents in transitions) led to different research questions and puzzles. Exactly how these fields interacted with my empirical observations and, subsequently, gave shape to my research questions is described in the methodological sections of these two chapters.

2.2.1.2 *Choices of data*

With some sense of the research questions and the relevant theoretical literature, interpretive researchers proceed to explore potential sources of data whilst retaining a flexible approach that may lead to unexpected answers to the research questions. Here choices of cases and access to them are often intertwined: the abductive logic leads to an iterative-recursive process between prior knowledge, literature and the field; the researcher cannot control the settings of research participants; and interpretive researchers do not pursue a randomised sample to generalise results but, rather, are interested in the texts, phenomena and ideas that matter to the actors under study. In this context, it becomes clear that the selection of and access to data are also contingent on the identity of the researcher (see section 2.2), which further calls for transparency about the choices made concerning the data (Schwartz-Shea & Yanow, 2012).

As mentioned, the first months of my PhD project explored the politics of a transition towards resource recovery in the wastewater system, while being involved as a PhD candidate – amongst fourteen engineers, physicists, chemists and environmental scientists – in the European training network that focussed on recovering resources from wastewater. The first interview, accordingly, took place two months after I started the PhD project. The respondent was a prominent wastewater microbiologist affiliated with Delft University of Technology, also involved in the European network. The main themes in the interview were the different narratives concerning 'the transition' and the most important actors in the (Dutch) wastewater system. After this interview, I interviewed different Dutch wastewater experts who expressed divergent narratives about the transition, which led me to conduct a discourse analysis (see chapter 3). Early on in the research process, I identified two major interpretations concerning this transition: a transition that builds on centralised wastewater systems and one that builds on decentralised wastewater systems. In the context of these two interpretations, I also followed up on the important actors mentioned in the first interview.

In hindsight, interestingly, two of these actors further influenced the choices of data in the subsequent years. On the one hand, the Energy & Resource Factory (a network organisation of the Dutch water authorities) was mentioned as a possible case study. Whilst doing the discourse analysis for chapter 3, the Energy & Resource Factory was found to be one of the most important organisations concerning the implementation of resource recovery in the Netherlands. As such, it became a crucial actor in chapter 4 of this thesis that focusses on the stability of the centralised, large-scale wastewater system. On the other hand, STOWA (the research institute of the Dutch water authorities) was also mentioned in the interview. This institute organised multiple events on 'new sanitation' or decentralised wastewater systems in 2017 and 2018. In one of these events, a Dutch new sanitation expert, quite unexpectedly, presented a decentralised, small-scale wastewater treatment system called DuCoop being developed in Ghent (Belgium), which is my hometown and the city where my host institution (Ghent University) is located. In the next step, I interviewed one of the employees of DuCoop and the manager, which eventually led me to select DuCoop as a case study because it is a path-breaking project in the Belgian wastewater system (see chapter 5). Hence, my prior knowledge of different political choices and narratives, and my first field experiences influenced a big part of the cases I used in this PhD project. In retrospect, the Energy & Resource Factory and DuCoop served as excellent case

studies. More detail is provided in chapters 3, 4 and 5 about the choices made within the case studies and the selection of interviewees and documents.

2.2.1.3 *Techniques for generating data*

As interpretive researchers aim to generate contextualised understandings of how actors interpret certain phenomena, they typically access data sources such as documents, participant-observation, interviews, material artifacts and audio-visual materials through using qualitative research techniques (Yanow, 2006a). Generally, qualitative methods involve studying the meaning of people's lives; representing the perspectives of participants; embracing social, institutional and environmental conditions within which people's lives take place; understanding social behaviour; and acknowledging the potential relevance of a variety of sources of evidence (Yin, 2016). Interpretive approaches in particular rest on a belief in the existence of multiple, intersubjectively constructed realities, which can be accessed only through interactions between the researcher and the researched. Here the active sense-making of the researcher also comes into play in examining a variety of often ambiguous sources of data and looking for intertextual links across these sources (Schwartz-Shea & Yanow, 2012).

Along these lines, I applied qualitative research techniques in this thesis and particularly relied on interviews, documents and participant-observation, of which more details are provided in the methodological section of chapters 3, 4 and 5. Regarding the interviews, I conducted around forty in-depth, face-to-face, expert interviews that lasted between 60-150 minutes from 2017-2020. I also relied on documents such as field notes, policy papers, minutes of meetings, slides of presentations, periodicals, scientific, grey and popular literature, newsletters and videos. Looking back, I mainly used these documents in two ways: I usually explored a big part of them before conducting the first interview for a particular chapter (but of course came across new documents whilst doing interviews) and then, after a round of interviews, used the documents again to contextualise some of the statements of the interviewees. Additionally, I joined a range of public and private wastewater-related events such as meetings, workshops, conferences and seminars. Here I usually observed how the experts concerned spoke about resource recovery and wastewater, which was documented in field notes for further analysis. Overall, combining these three qualitative research techniques, I developed an intertextual perspective on which I drew in the analyses of chapters 3, 4 and 5.

2.2.1.4 *Analytical frameworks*

In the previous paragraphs, it became clear that an interpretive research philosophy implies an open-ended flexible approach to the research questions and the empirical material, which also holds for the analytical frameworks used in the research process. On the one hand, the selected frameworks do not prescribe certain mechanisms one should find but, rather, provide a couple of concepts that can be applied to different kinds of empirical observations. On the other hand, the abductive logic is also applied here and throughout the analysis of empirical material and literature, and the framework is adapted and specified.

Applying the open-ended approach to the research questions about the politics of transitions, the choice of analytical frameworks was shaped by the ideas I developed about what was going on in the field (see 2.1.1). In the case of the third chapter (discourse analysis), I observed that different wastewater experts made sense of a transition in different ways, which led me to select discourse analysis as a framework. Here I mainly drew on the work of Maarten Hajer (1995), first focussing only on the definition of environmental problems. Yet when I was conducting the interviews, I not only asked the interviewees about the specific environmental problems but also about their preferred transition strategies to make the wastewater system more circular, including their visions of the future. Eventually, this led me to add 'future' and 'strategies' to the analytical framework. In the fourth and fifth chapters, I use a power framework that was developed by Arts & van Tatenhove (2004) and adapted by John Grin (2010), amongst others. The framework distinguishes between three types of power: relational, dispositional and structural (see chapters 4 and 5 for definitions), which are, from my perspective, broad categories of power that can be applied fruitfully to an empirical field. Here again, the frameworks were adapted and changed over time, in correspondence with the academic literature I aimed to contribute to as well as with the empirical observations I made. Exactly how the frameworks were selected, adjusted and applied is described in chapters 3, 4 and 5.

2.2.2 Evaluating knowledge claims: trustworthiness

In addition to describing how my ontological and epistemological position influenced the research design, I also have to elaborate on what this implies for the trustworthiness of the knowledge claims in this thesis. Interpretive scholars call for a thorough reflection on these subjects because they are at the heart of the scientific

enterprise but are, as mentioned, enacted differently in interpretive and positivist approaches.

To assess social scientific research, positivists have developed standards such as validity, reliability, replicability, objectivity and falsifiability, concepts derived from the natural sciences. Interpretivists maintain that these standards are not useful for assessing the trustworthiness of research focussed on specific, situated meanings, meaning-making practices of actors in particular contexts and the interpretations of researchers. Therefore, they developed four criteria to check the trustworthiness of interpretive research: reflexivity, thick description, intertextuality and transferability. Thus, interpretivists underscore the importance of transparency and reflexivity about methodological choices for social scientists (as well as for engineers and natural scientists) and avoid anything-goes relativism or the so-called impossibility of a science of the politics. Nonetheless, interpretivists also face a dilemma: reclaiming established methodologically positivists terms (e.g. validity and reliability) or invent new terms (Schwartz-Shea, 2006; Schwartz-Shea & Yanow, 2012). Although I maintain that my research is valid and reliable (in a nuanced, interpretive way), I now engage with the four above-mentioned interpretive criteria to check my sense-making and the trustworthiness of my research. Below, I first describe how interpretive researchers define these criteria and then elaborate on how this research meets the criteria.

2.2.2.1 *Reflexivity*

Reflexivity comprises the active consideration of and engagement with how researchers' own sense-making relates to the knowledge claims made in a project, playing a crucial role in the trustworthiness of the knowledge claims. Peregrine Schwartz-Shea & Dvora Yanow (2012) describe what this implies for interpretive researchers:

> *'They are alert to the possibility of partial knowledge and multiple perspectives. Neither of these can be avoided or controlled for. But they can be acknowledged, engaged, and analyzed. Reflexivity aids in this process as researchers ask not only about their own meaning-making but also about what they are not hearing, about the silences in their interviews, readings, and observations. [...] The interpretive commitment is to increase understanding of the ways in which the characteristics of individual researchers and their academic communities affect the production of knowledge in the human sciences.'* (p. 112)

Here it becomes clear that reflexivity about the production of knowledge comprises the acknowledgement and analysis of questions about researchers' wider social milieu (1), personal characteristics (2) and different scholarly fields and communities (3), which I now address one by one.

First is the wider social milieu. I enrolled as a student of political science at the University of Ghent in 2009. After the global financial crisis of 2007-2008, the European debt crisis began, Stéphane Hessel published Indignez-vous, and Occupy Wall Street, the Indignados Movement and the Arab Spring led to a series of protests and occupations against austerity policies. In the third year of my studies, these events were explored from a Gramscian perspective in global governance and political economy courses, while I further discussed with a couple of friends during the breaks. The events surrounding the economic crisis influenced my interpretation of the world, questioning the constructedness of monetary policy and debt, as well as the inequalities resulting from austerity policies.

In the context of writing a bachelor thesis, I asked one of the professors involved in the global governance courses about the environmental policy's gridlock. I further explored these themes by focussing on the green economy from a Gramscian perspective in two master theses. Although I did not engage thoroughly with the Gramscian perspectives, the notion of hegemony influenced how I view the world. Particularly reflected in this thesis is my interest in how powerful actors use ideas and cultural institutions instead of coercion to maintain certain power relations, a specific consensus and the status quo.

During my studies, I also worked as a labourer for Katoen Natie in Ghent's harbour for about a hundred days. In the first year of my studies, I remember I was offered a contract for one month during summer, whereas I signed contracts for one day only by the end of my third year in university. Additionally, I had a hard time finding a job after university and I found that I was not eligible for unemployment benefits in the first year after graduation. Eventually, I found a job as a shop manager in a second-hand store that focussed on labour market insertion (i.e. the social economy), where I came into contact with some of the most disadvantaged groups of society. My background in political sciences, combined with facing the reality of decades of austerity measures on the labour market, led to a critical view of the current political-economic institutions, which is a recurring theme in this thesis.

Second, I have to reflect on my characteristics. Notwithstanding the embedding of these characteristics in broader contexts (e.g. SuPER-W's focus on resource recovery in large-scale wastewater systems), it is possible that these characteristics also influenced the knowledge claims and research topics in this thesis. For example, I am not only White and male but also grew up in a middle-class household in one of the richest countries in the world (Belgium). This privileged position may have influenced the topics of my focus in this thesis, which led me to overlook and ignore specific power relations in the wastewater system. For example, I have not experienced severe drought in my life, which most likely led me to focus more on resource recovery instead of water recovery or broader topics such as the right to water. Similarly, I investigated the recovery of resources such as phosphorus but narrowed my research focus to what was happening to phosphorus in Europe, neglecting wider North-South power relations in phosphorus value chains and circular economy debates (e.g. Schröder, Anantharaman, Anggraeni, & Foxon, 2019). Additionally, the wastewater system is dominated by White, male engineers and I generally felt quite comfortable within this community, which possibly led me to ignore but also reproduce the gendered power relations within this system (on masculinity in water governance, see e.g., Hartley & Kuecker, 2021; Kosovac, 2021). Hence, in hindsight, I hold that a researcher with different personal characteristics (e.g. a non-white, non-male researcher from the Global South) would probably have chosen to put more emphasis on the above-mentioned metaphorical blind spots, shaping different, perhaps more critical knowledge claims.

Third are the scholarly fields, such as wastewater engineering, sustainability transitions and political science, and scholarly communities that influenced the knowledge embodied in this thesis. At the beginning of my project, my supervisors and I did not have any prior knowledge about wastewater and the related scholarly fields. In my case, the first meetings of the SuPER-W project served as a partial, specific introduction. In these meetings, representatives from the water industry and engineers were invited, whereas social scientists and NGOs were not. Most of the time was spent on how to make the large-scale wastewater system more sustainable and efficient by recovering resources, and I recall that one professor discussed centralised and decentralised wastewater treatment systems. The focus on efficiency and green growth as well as the possibility of constructing a radically different, decentralised and small-scale system are topics I followed up on. In retrospect, although well-represented in the empirical material and literature, I may have placed too much emphasis on the dichotomies 'ecology-economy' and

‘decentralised-centralised’ in the first years of the project, indicating that more nuanced understandings may have passed unnoticed.

In the first weeks of my PhD project, I also discovered the field of sustainability transitions and particularly the multi-level perspective. The approach is a useful heuristic to make sense of socio-technical innovations, particularly the prima facie simple distinction between niches and regimes. Yet the approach downplays specific power relations related to transitions towards sustainability (Blythe et al., 2018; Kenis, Bono, & Mathijs, 2016; Stirling, 2011), which I may not have considered sufficiently. For example, notwithstanding that the third chapter (discourse analysis) does not use the multi-level perspective as an analytical framework, it was in the back of my mind. When looking back particularly, this may have shaped the results in the direction of identifying an incumbent-discourse and a niche-discourse instead of a more nuanced view of power relations, which I did of course explore in the fourth and the fifth chapters of the thesis.

The results of my research are also influenced by specific political science literature. As mentioned, I explored environmental policy’s gridlock during my studies and developed it further by reading the literature on path-dependency and lock-ins. Both topics are heavily represented in my research: the end of the third chapter discusses how current political-economic institutions and established infrastructure shape new discourses, the fourth chapter further explores the stability and incremental change in the wastewater system and the fifth chapter dwells, inter alia, on the struggles involved in establishing path-breaking innovations in the wastewater system. At the outset of each chapter, I thus wanted to question the stability of the current unsustainable policies, which influenced the selection of literature, frameworks, cases and the analysis.

In addition to these scholarly fields, there are the scholarly communities and specific people, organisations and events influential in shaping the results reported here: a summer school of STEPS Centre (University of Sussex), a workshop of the European Consortium for Political Research in Bamberg, the Centre for Sustainable Development at Ghent University and the Biotechnology and Society group at Delft University of Technology. Firstly, although I got lost in different types of literature in the first year of the research project, the second year brought me the summer school on pathways to sustainability of STEPS. During the course, Ian Scoones and colleagues argued for the need to ‘open up’ discussions to allow discursive reframing and deliberation, dialogue and participation for and within

transformations. Likewise, in Bamberg, Marie Østergaard Møller's course on interpretive methods influenced my research, particularly emphasising the role of identifying counter-discourses when doing discourse analysis. At the same time, secondly, I was a member of the Centre for Sustainable Development at Ghent University in the past years. In my view, the Centre specialises in providing nuanced, contextualised understandings of sustainability transformations by drawing on science and technology studies (Block & Goeminne, 2014), practice theory (Van Gaubergen, Paredis, & Block, 2021), discourse analysis (Paredis, 2013), wicked problems (Lönngren & Van Poeck, 2020) and, generally, perspectives that acknowledge the normative, subjective and ambiguous aspects of sustainability (Block & Paredis, 2019; Devolder & Block, 2015). My time at Delft University of Technology also influenced my knowledge claims with the technological environment helping me to make the aforementioned abstract, philosophical perspectives tangible. Hence, I believe both groups provided fertile ground for some of the basic concepts I encountered during my studies such as hegemony and the role of ideas, which also tied in with the summer school and the workshop, playing a crucial role in the adoption of the interpretive approach used in the thesis.

In sum, my wider social milieu, background and scholarly fields and communities gave shape to a critical view of 'reality' and concepts such as 'normal', 'objective' and 'efficient', raising questions such as what type of 'normal', for whom, why and how. This view is described by Parsons (2010) as 'it did not have to be this way' (p. 89) and by Hay (2002) as 'Particular constructions may serve to present a "reality" which is static, immutable or inexorably unfolding in a given direction, but the recognition of the constructed nature of the reality we perceive implies that things could and can be different' (p. 201). Although one may argue that this perspective leads to anything-goes relativism, I contend that being transparent and reflexive about my own sense-making, in addition to thick description, intertextuality and transferability – discussed in the next paragraphs, leads to trustworthy knowledge claims.

2.2.2.2 *Thick description*

Thick description refers to the presence of sufficient detail of events, settings and interaction in the research narrative to capture context-specific nuances of meaning. Such thick description of evidentiary data supports the researcher's interpretation, underscoring that the researcher was actually present on-site and eyewitness to the setting and interactions described (Schwartz-Shea, 2006). The

approach requires thickly written fieldnotes and thickly experienced observations, interviews and documentary reading, continuously adding questions of 'why' and 'how' to questions of 'what'. To produce a research text of such detail, 'a researcher has to have observed, talked, and/or read enough, and noted all of that, to generate material for those layers of contextualization' (Schwartz-Shea & Yanow, 2012, p. 49). During the in-depth interviewing, this implies seeking elaboration, reflection, and illustration, while quasi-simultaneously writing memos, transcribing, coding, analysing and selecting new interviewees and documents. The contextualised descriptions are useful for practitioners and academics, who may assess the context of the observations and transfer them to their own settings. Hence, a sufficiently thick research narrative increases the trustworthiness of the researcher's knowledge claims.

The criteria of thick description are met in several ways in the research reported in this thesis, which I here only briefly address as the methodological sections and appendices of chapters 3, 4 and 5 provide more detail. First, between 2016-2020, I joined multiple events related to water, wastewater and a circular economy, which were captured in field notes; I conducted approximately forty in-depth interviews across the Netherlands and Belgium; and read a range of documents. All the evidence was coded and analysed, usually in multiple rounds of coding over several months. These different sources of data led to a contextualised understanding of a transition towards a circular economy in the wastewater system. In addition to social scientists, this understanding was presented to practitioners in the water/wastewater system over the past years, including the interviewees, observed organisations and relative outsiders. Further, next to the contextual descriptions of the relevant settings, events and interactions, the three chapters also delve into questions of how and why specific interpretations of transitions take shape (chapter 3), become or remain dominant (chapter 4) and struggle to institutionalise (chapter 5), particularly focussing on underlying value conflicts and power relations. Overall, I contend that the descriptions and understandings in this thesis are sufficiently thick, making my knowledge claims trustworthy.

2.2.2.3 *Intertextuality*

As interpretive researchers are interested in different understandings of what is being studied, they typically first map differences of interpretation and then intertextually analyse them across evidentiary sources. The word intertextuality is preferred over triangulation because the latter refers to using two points of data

already known to locate the third unknown point of the triangle, revealing what is 'true' (Schwartz-Shea & Yanow, 2012). Evidentiary sources are broadly understood to include multiple sources of data (e.g. persons, times and places), multiple ways of accessing data (e.g. observation, interviews and documents), multiple researchers (e.g. the authors of a report and peers) and multiple theories and frameworks (Schwartz-Shea, 2006). Hence, a broad map of different interpretations analysed in an intertextual manner increases the trustworthiness of the researcher's knowledge claims.

The first years of research for this thesis focussed on mapping diverging interpretations of a transition towards a circular economy in the Dutch wastewater system, which were analysed across different sources (see chapter 3). Subsequently, I turned to intertextually analysing the actors that reproduced the dominant interpretation in chapter 4 and then to an alternative interpretation in chapter 5. As mentioned, a host of evidentiary sources was used in these three chapters. Concerning the sources of and ways of accessing the data, I interviewed forty people in four years in two different countries, also analysing multiple documents and joining multiple events. Next, although I was the only researcher who accessed data such as interviews, documents and observations, the co-authors of chapters 3, 4 and 5 as well as practitioners were involved in interpreting the phenomena I spoke about and reported in drafts. Specifically, the co-authors of the three chapters were involved in interpreting the empirics; in the interviews, I followed up on published documents, events, interactions and previous conversations and frequently focussed on my own views in the second hour of the interviews. Finally, multiple theories and frameworks were used in this thesis: broader debates about a circular economy; social scientific research on the water/wastewater system as well as engineering perspectives; sustainability transitions research; and political science, particularly drawing on two different power frameworks (discourse analysis and a framework developed by Arts & van Tatenhove, amongst others) and different types of literature (e.g. policy feedback and incumbents in sustainability transitions). As such, I believe that I succeeded in intertextually analysing the relevant phenomena, increasing the trustworthiness of the knowledge claims in this thesis.

2.2.2.4 *Transferability*

Transferability is what positivists call generalisability and refers to the degree to which the results can be transferred to other contexts or settings. In interpretive research, two criteria are provided for the transferability of the results. First,

Schwartz-Shea (2006) notes that it is the responsibility of the researcher to provide sufficient thick description so that others can evaluate how plausible it is to transfer results from a particular research project to another context or setting, whilst an intertextual analysis usually leads to thick descriptions. Second, Parsons (2010) argues that most political scientists, with divergent ontological and epistemological positions, try to capture some relationships, processes and mechanisms and show that these produce some patterns, which requires good arguments and persuasive evidence. In this context, interpretivists try to capture these relationships and processes by focussing on how actors arrive at particular ideas. Other (non-constructivist) political scientists may identify similar relationships and processes but may find that the role of ideas is exaggerated and downplays economic and institutional factors.

Cumulatively, the previous sections illustrated how the research in this thesis meets the criteria of thick description and intertextuality. In tune with Parsons' (2010) argument, chapters 3, 4 and 5 focus on the processes of change and identify several patterns, good arguments and persuasive evidence. Given that the research in this thesis meets both criteria, other researchers may transfer some of the results to their own research projects, contexts and settings.

Chapter 3: *A transition in the Dutch wastewater system? The struggle between discourses and with lock-ins*

Abstract
Recently, calls have increased for a paradigm shift or transition towards resource recovery and a circular economy in the Dutch wastewater system. However, we have observed diverging interpretations on the nature of the transition. This reflects the political environment of sustainability transitions: political struggle emerges over the definition of problems, futures and strategies to be used. In order to help clarify the emerging debate and identify political choices, we conducted a discourse analysis. We identified three discourses that reveal some of the political choices to be made. One discourse is becoming dominant and focusses on optimising the large-scale infrastructure, market development and legislative changes. The discourse draws on the existing infrastructure and current political-economic institutions, which gives it an advantage in becoming dominant. Our findings also suggest that this discourse shapes a transition pathway that is characterised by lock-in effects and, at most, incremental changes instead of a fundamental shift in the established Dutch wastewater system.

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3.1 Introduction

The Dutch wastewater system was developed predominantly with a view to improving public health. However, over the last decades, policymakers, researchers and stakeholders have started to focus on its environmental and societal questions. Examples of those questions today include greenhouse gas emissions, energy and maintenance costs, drought and floods, depletion of critical resources and emerging pollutants. Recently, experts and scholars have voiced the need for a 'paradigm shift' (Guest et al., 2009, p. 2; Larsen et al., 2013, preface) or 'transition' (ERF, 2014, p. 6; European Water Platform, 2016, p. 3). They aim at the recovery of resources (e.g. nutrients, energy and water) from wastewater and a shift to a circular economy (CE). In general, a CE proposes a reduce-reuse-recycle strategy for waste management, which challenges the negative economic and ecological effects of the linear take-make-dispose system (Ghisellini, Cialani, & Ulgiati, 2016).

However, we see interpretations diverging on a transition towards a CE in the Dutch wastewater system, which we will explore by using discourse analysis. For example, some actors want to optimise the existing large-scale infrastructure and the development of business cases for the recovered resources (e.g. ERF, 2017a). Still others look at citizen awareness and decentralised treatment systems to recover energy and resources from wastewater (e.g. Swart & Palsma, 2013). At the same time, the discussion is expanding on the contamination of surface and drinking water by emerging pollutants (e.g. Vewin, 2017) and on how energy and resource recovery may compromise the public health objective of the wastewater system (e.g. Clemens, Palsma, & Swart, 2012, February 10).

These diverging perspectives or discourses shape actions, institutions and power relations and fulfil a key role in processes of change (Fairclough, 2010; Hajer, 2006). The field of sustainability transitions also confirms that discourses influence transition pathways. For instance, the role that discourse plays in environmental policy development (Smith & Kern, 2009), the use of discourse in directing change along specific pathways (Rosenbloom, Berton, & Meadowcroft, 2016) and how incumbents discursively frame transitions (Bosman, Loorbach, Frantzeskaki, & Pistorius, 2014). These examples also demonstrate the political environment of transitions (Avelino et al., 2016; Kenis et al., 2016; Paredis, 2013): political struggles take place over what the problems are and how they should be defined, what the future will look like and the strategies to be used in a transition.

Such a transition is a long-term, multi-dimensional process of change through which established socio-technical systems (sectors that supply, for example, water, energy and transportation) shift to more sustainable modes of consumption and production (van den Bergh, Truffer, & Kallis, 2011; Markard et al., 2012). Some argue that transitions require fundamental shifts in established political-economic institutions (Hopwood et al., 2005), particularly in the roles of markets, governments, technology and citizens (Scoones et al., 2015).

A specific discourse or interpretation of a transition pathway can become dominant and leave no opening for alternative pathways (Fairclough, 2010; Hajer, 2006). This may lead to incremental rather than fundamental changes and a lock-in in the established socio-technical system (van den Bergh et al., 2011). More specifically, the characteristics of established systems set the preconditions for the development of new transition pathways (Arapostathis & Pearson, 2019; Klitkou, Bolwig, Hansen, & Wessberg, 2015; Markard, 2011), large technical systems influence discourses and vice versa (Sovacool, Lovell, & Ting, 2018) and transition experiments or platforms are captured by existing networks, markets and infrastructure (Raven, Kern, Verhees, & Smith, 2016; Smith & Kern, 2009). In this way, a new discourse may struggle with lock-ins in an established socio-technical system.

Thus different discourses may give shape to incremental or fundamental changes in the Dutch wastewater system, while a particular discourse can have more power to do so. To analyse these discourses and to avoid a lock-in in the established system, this chapter scrutinises the various interpretations of a transition. Two research questions are explored: How do the actors in the Dutch wastewater system interpret a transition? And how can we understand these interpretations from a political perspective on transitions?

After this introduction, we detail the interpretive approach, analytical framework and methods of the chapter. In the next section, we first elaborate on a historical context of the wastewater system because it shapes today's interpretations, and then present the results of the discourse analysis. Finally, we discuss the discourses from a political perspective on transitions, with a focus on dominance and lock-ins.

3.2 Doing discourse analysis

3.2.1 Interpretive approach

We took an interpretive approach that concentrated on meaning-making to understand social phenomena (Yanow, 2007), particularly on how interpretations shape transition pathways (e.g. Kern & Rogge, 2017; Rosenbloom et al., 2016). Next to ethnographic and narrative methods, one of the methods in the field focusses on discourses or sets of ideas. Generally, a discourse represents aspects of the world that might be represented differently by different actors and their projects of change (Fairclough, 2010). In the study of environmental politics, discourse analysis has also been developed (Feindt & Oels, 2005; Hajer & Versteeg, 2005), and discourse has been defined as 'a specific ensemble of ideas, concepts, and categorisations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities' (Hajer, 1995, p. 44). This power to define not only includes ideas but also excludes specific aspects from the debate, and it influences what is thought, seen and done within a social group. A discourse is thus a factor that shapes transitions.

3.2.2 Analytical framework

Following Hajer (1995), the analysis focussed on the content of what is being said (i.e. storyline), the context of the statements (i.e. the historical context or roots and the discourse coalition) and the (political) influence (i.e. discourse structuration, institutionalisation and dominance). For the construction and analysis of every discourse, we thus focussed on the roots, storyline, discourse coalition and influence (see Table 1 for an overview).

A storyline is 'a generative sort of narrative that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomena' (p. 56). It suggests the achievement of discursive closure, not only by defining what the problem is but also by suggesting solutions (Hajer, 1995) and imagining a possible world (Fairclough, 2010). Such a future vision is directly relevant to transitions because they express the objectives and the strategies by which these will be realised (Berkhout, 2006; Konrad & Böhle, 2019). Therefore, next to the problem definition and future vision, we further explored these strategies by scrutinising the role of markets, governments, technology and citizens (Scoones et al., 2015).

Furthermore, a storyline functions as 'discursive cement' (Hajer, 1995, p. 63) for a discourse coalition. The latter is an ensemble of a set of storylines, shared by a

particular group of actors and the related practices. The influence of a discourse was analysed by Hajer's two-step procedure: discourse structuration occurs if a particular discourse dominates the way a social unit conceptualises the world, and discourse institutionalisation is relevant if a discourse starts to solidify in institutional arrangements (e.g. new policy, documents, rules and investments) and organisational practices (e.g. restructuring of departments and new commissions or platforms). The two-step procedure specifies that there is a dominant discourse if a coalition succeeds in structuration and institutionalisation; this implies power concentration as well as the strong influence of a specific discourse on a transition pathway (Hajer, 1995, 2006).

Table 1: overview of the analytical framework

Roots
Storyline
- Problem
- Future
- Strategy (markets, government, technology and citizens)
Discourse coalition
Influence
- Structuration
- Institutionalisation
- Dominance

3.2.3 Methods

For the analysis, we inspected the historical context of the wastewater system (Fairclough, 2010; Hajer, 1995) and analysed documents, periodicals, literature, newsletters and videos to gain insight into the interpretations (Hajer, 2006). In addition to these documents, we also relied on twelve in-depth interviews because resource recovery from wastewater is an innovative practice (i.e. lower rate of institutionalisation). Convenience sampling (in a European training network on resource recovery from wastewater) and snowball sampling gave access to Dutch researchers and innovators. The analysed documents were usually referred to in the interviews. Furthermore, multiple events on decentral sanitation, CE, and

technology to recover resources from wastewater were visited to complete the analysis. The empirical material was mainly gathered in 2017 (see 'Appendix chapter 3' for a list of interviews, field observations, documents, videos and newsletters).

The software MAXQDA was used to code the transcripts, field notes and documents. This took place in an abductive manner (Yanow, 2006b): prior knowledge about environmental politics and preliminary field observations helped to obtain a rough idea of the different interpretations; during the coding process, we reviewed these assumptions and zoomed in on the different aspects of the analytical framework; and we asked our interviewees for alternative views (Weiss, 1995) to test our assumptions, maximise the range of our samples and construct counter-discourses.

3.3 The Dutch wastewater system: brief history and current discourses

In this section, we aim to clarify how the actors in the Dutch wastewater system interpret a transition. Before doing so, we first describe three broad shifts in the history of the wastewater system, in which we focus on political struggle and the coproduction of technology and society. The historical overview aims to describe a context for today's interpretations, the influence of history on new discourses, possible lock-ins and interaction with other socio-technical systems. After the overview, we present today's discourses.

3.3.1 Historical overview

The first shift came at the beginning of the 19th century. Around this time, wastewater was disposed on the streets, or (in wealthy households) in cesspools. However, as urbanisation grew, issues started to arise. There were cholera outbreaks, and cesspools overflowed because of the newly emerging piped water supply. Furthermore, liberal ideas that public expenditures should be kept low led authorities to curb investments into solutions. Yet some social groups pointed to alternative solutions and proposed changes to wastewater disposal. The medical community claimed that contaminated drinking water, not stench, was the cause of cholera and therefore argued for disposal outside of the city. As a result, engineers supported large-scale sewer construction. The democratic struggles at the end of the century further stimulated notions of public health and clean water. All these interpretations deviated from official policies but gained in influence and played a

role in a shift from cesspools to sewers (Geels, 2006; Rockefeller, 1998; Sedlak, 2014).

Sewers transported wastewater outside of the city, but it remained untreated. As a consequence, water-borne diseases emerged, and downstream communities, fishermen and beaches suffered from water polluted by sewage (Halliday, 2013; Mulder, 2016). This led to a second shift, after multiple discussions on the direction of change. Scientists, for example, refuted the idea of self-purification of water by dilution, and the medical community identified biological organisms (pathogens) as the cause of diseases. The need for sewage treatment became clear, and methods were available as well, but several negative aspects were perceived. Sewage farms were disfavoured because of space requirements, waterlogging and smell; chemical treatment produced too much sludge and failed to remove all pathogens; and artificial fertilisers further discredited treatment systems linked to organic fertilisation (e.g. Liernur's pneumatic sewerage system and barrel collection). In 1913, engineers discovered activated sludge, a biological treatment process that removed pathogens, was odourless, and was low in cost and space requirements. A second shift was coproduced by the sewage infrastructure and political debate linked to public health and drinking water, odour, costs and space requirements. From this moment onwards, wastewater was transported by sewers to large-scale, centralised treatment plants outside of the city (De Korte, 2018; Melosi, 2000; Sedlak, 2014).

A third shift took place from the 1960s onwards: alongside public health, the quality of surface water became more important in the water/wastewater system. The reasons included increased public awareness of environmental issues, driven by Rachel Carson's book *The Silent Spring* and the report 'The Limits to Growth'. In the European Union, both public health and environmental concerns became institutionalised in, among others, the Urban Waste Water Treatment Directive (1991), the Drinking Water Directive (1998) and the Water Framework Directive (2000) (Lema & Suarez, 2017; Melosi, 2000; Pahl-Wostl, 2015).

Today, public health, water quality and the centralised and large-scale infrastructure can be conceived of as elements of the conventional wastewater system. Massive sewers transport wastewater to large-scale plants outside of the city. After treatment, the water is discharged to surface water which may be used as influent for drinking-water production (Sedlak, 2014). Over time, not much has changed: 'If a water or sanitary engineer from over 100 years ago was to return to

the present time [...] they would probably marvel that we continue to use the very same infrastructure that they and their colleagues installed' (Thomas & Ford, 2005, p. 135). In the Netherlands, piped drinking water emerged in the 19th century and is now managed by drinking water companies. Sewers were constructed during the first half of the 20th century, and since the 1950s, wastewater has been treated by the water boards (Langeveld, 2004).

In sum, our historical overview shows how the conventional wastewater system has developed step by step, mostly incrementally, but sometimes in a quite fundamental way, accompanied by political struggles. Previous studies have also highlighted the role of history, lock-ins and incremental changes in the water/wastewater system. For instance, it is captured by a global rationality of the centralised infrastructure (Fuenfschilling & Binz, 2018); sector characteristics such as the large-scale infrastructure, monopolies and high environmental externalities can hinder reforms (Lieberherr & Fuenfschilling, 2016; Meehan et al., 2013); and regulatory, environmental and industrial interests are a powerful 'drive to sewer' (Rockefeller, 1998, p. 12). In this way, the overview provides a foundation for exploring today's discourses, the influence of history and possible lock-ins.

3.3.2 Three discourses on a transition in the Dutch wastewater system

In this part of the chapter, we identify three discourses, for every discourse we discuss the roots, storyline (problems, future and strategy), coalition and influence. We will observe similarities and conflicts, as well as how the three discourses struggle to influence the transition pathway. Whether they succeed in doing so is discussed in section 3.4. A summary of the main results is also presented in a table at the end of this section (see Table 2).

3.3.2.1 *Discourse 1: 'from a technology push towards a market pull'*

The first discourse aims at the optimisation of the existing large-scale infrastructure to recover resources from wastewater. Market development ('market pull') and legislative changes are needed to sell these recovered resources. The storyline is narrated mainly by the incumbent actors in the Dutch wastewater system.

Roots

Twenty-one water boards are responsible for flood control, water quantity and quality in their designated areas. Since the 1960s, however, there has been a discussion on the raison d'être of the water boards (e.g. Raadschelders & Toonen,

1993). The tarnished reputation of the water boards, societal expectations and high-quality effluent led to the rise of WaterWays (WaterWegen, our translation) in 2008 (Interview 5). In this 'free space', a group of innovators brainstormed possible futures for wastewater and the water boards (Interview 5; WaterWays, 2012). Around the same time, STOWA (the water boards' research institute)[1] published a vision report on Nutrient, Energy and Water (NEWater) recovery in 2030 (2010). A few years later, a more general roadmap for 2030 was published as well (Dutch Water Authorities & Association of Netherlands Municipalities, 2012).

In 2014, all these ambitions combined in the network and knowledge centre called the Energy & Resource Factory (ERF). The ERF is a joint initiative of all the water boards that 'aims to enable a transition towards resource recovery in the wastewater system' (ERF, 2014, p. 15). Since 2017, the slogan of the ERF has been 'from a technology push towards a market pull', which indicates the necessity of market development for the recovered resources (ERF, 2017a, p. 6; Interview 8).

Storyline

Problems

At least three problems signify the need for a transition. First, the intensive energy use of wastewater transport (pumping) and treatment (aeration) causes greenhouse gas emissions. Second, the maintenance and construction costs of the wastewater system are high. Third, limited resources on earth call for resource recovery (Interviews 5, 7 & 8; STOWA, 2010).

Future

A CE addresses these problems. Biogas recovery solves the issues of high energy use, emissions and costs, while earth's limited resources such as phosphorus can also be recovered (Interviews 7 & 8). This is reflected in a 'top 5 resources report', where the ERF (2017a) aims to recover and sell phosphorus, cellulose, alginate-like polymers, bioplastics and biomass.

[1] STOWA and the Dutch Water Authorities play a role in more than one discourse. Hajer notes, however, that a discourse coalition is 'related to practices in the context of which actors employ story lines [...] It thus becomes possible to come to terms with the fact that some actors might utter contradictory statements, or indeed help reproduce different discourse coalitions' (2006, p. 70).

Business cases provide a win-win situation for the environment and the economy (Interview 7; STOWA, 2010). An interviewee confirms: 'The CE enables the water boards to sell resources, reduce costs and increase revenues to invest in sustainability' (Interview 1). An interviewee from the ERF imagines 'a zero-emission production facility, in which wastewater enters and, at the end of the production line, the recovered resources are sold to green businesses' (Interview 8).

Strategy

An interviewee underlines the importance of 'a market pull' by saying, 'Systems only change if there is profit to be made' (Interview 1). An interviewee from the Dutch Water Authorities states: 'We create an economic story, and I notice that Brussels talks only about jobs and economic growth. We don't get anywhere if we don't fit our circular economy in that frame' (Interview 7).

The government is not expected to fund such a transition, because the revenues from the recovered resources are sufficient. However, the government needs to play a role in facilitating market development, in combination with changes in the End-of-Waste regulations (Interviews 7 & 8).

The interviewees argue that the optimisation of the large-scale, centralised technology provides economies of scale, sustainability gains and general (cost) efficiency (Interviews 5, 8 & 12). Likewise, the top 5 report describes the efficient recovery of cellulose, alginate-like polymers and phosphorus in large-scale plants (population equivalent of over 200.000) (ERF, 2017a). It is agreed that technology does not form a bottleneck, while R&D cooperation between universities, governments and the private sector is necessary for innovative solutions (Interviews 5 & 8).

Citizens do not play a role in this transition, as 'it is not feasible to involve citizens in technological issues such as Nereda[2]' (Interview 7).

Two interviewees argue for the convenience of citizens paying taxes, flushing the toilet and taking showers without having to care about anything else (Interviews 8 & 12). A similar argument is reproduced in NEWater (STOWA, 2010). The top 5 report (ERF, 2017a) and the 2030 roadmap (Dutch water authorities & Association

[2] This is a new biological and large-scale wastewater treatment technology in which the recovery of alginate-like polymers may be possible.

of Netherlands municipalities, 2012) do not elaborate on the role of citizens (and end-users).

Discourse coalition

The discourse coalition that narrates the storyline is linked to the incumbent actors in the Dutch wastewater system. For instance, the Dutch Water Authorities (the umbrella organisation of the water boards) initiated WaterWays. The latter combined staff from multiple water boards and their ideas were further developed in what is now the ERF. In the ERF-steering group, the Dutch Water Authorities, STOWA and the managers of several water boards are represented. STOWA has also provided research for the ERF, for example by the publication of a report (2015) on resource recovery that is in line with the top 5 report. Some of the interviewees (e.g. 5 & 12) that (re)produce this discourse are influential wastewater experts who work at the Delft University of Technology and have collaborated with the water boards.

Influence

The discourse coalition reiterates the view 'from a technology push towards a market pull', and this interpretation structures the debate about a transition among the incumbent actors in the wastewater system. The storyline is institutionalised by the organisational practices of the ERF, which receives financial support from every water board (which results in a yearly budget of about €500.000) (ERF, 2014). It is also institutionalised by the optimisation of the established infrastructure; 24 out of 314 plants are now trying to recover cellulose, phosphorus or biogas (ERF, 2017b, December 19). Furthermore, it institutionalises in reports and publications of STOWA (e.g. 2010), the ERF (e.g. 2017a) and Dutch wastewater experts (e.g. Guest et al., 2009; van Loosdrecht & Roeleveld, 2015). In sum, the coalition of incumbent actors succeeds in discourse structuration and institutionalisation; whether this also leads to dominance is discussed in section 3.4.

3.3.2.2 *Discourse 2: from a 'sub-optimal system' towards a modernised mixture*

The second discourse proposes a mixed – central and decentral – treatment system, focussing less on resource recovery and more on citizen awareness. Some scholars have labelled this system a modernised mixture (e.g. van Vliet, Spaargaren, & Oosterveer, 2010). The storyline is narrated by some scholars (loosely) affiliated with Wageningen University. Over the past decade, a few small-scale treatment projects were realised but the large-scale treatment infrastructure prevails.

Roots

In the 1990s, (technological) research emerged on source separation and closing loops at the community level of the wastewater system (e.g. Larsen & Gujer, 1997; Zeeman & Lettinga, 1999). In a book chapter about decentralised (small-scale) treatment in the 2000s, two STOWA affiliates remark that 'certain groups in the Netherlands were becoming dissatisfied with the way in which human wastewater was collected and treated in their country' (Swart & Palsma, 2013, p. 431). In turn, their organisation involved new actors and put wastewater on the agenda by means of research projects, pilots, a coordinating body and a website (saniwijzer.nl). Today, an interviewee argues for 'a shift from the conventional, sub-optimal, system towards a mixed system' (Interview 4).

Storyline

Problems

The interviewees identify five problems. First, the transport and treatment of diluted wastewater require a great deal of energy, which involves high costs and emissions. Second, expensive optimisation of the conventional wastewater infrastructure is questioned; one says: 'this is the easy way out' (Interview 4). The third problem is the flush-and-forget culture and lack of end-user awareness. Fourth, emerging pollutants end up in the environment as a consequence of effluent disposal and combined sewer overflows. Lastly, over time, there is uncertainty about population growth in some areas, which could render large-scale treatment plants obsolete (Interviews 4 & 9).

Future

The storyline proposes a mixed system as a solution to the 'sub-optimal' conventional wastewater system. Two interviewees also note that resource recovery should not be the sole focus of a transition because the amount of resources in municipal wastewater is low (excluding energy and water recovery). Along these lines, they describe how decentralised systems solve the aforementioned problems: these reduce the energy and maintenance costs of the conventional system; local embeddedness raises citizen awareness of water use and the flush-and-forget culture; emerging pollutants are effectively tackled in concentrated streams; and the modular design deals with uncertain demographic trends (Interviews 4 & 9).

A modernised mixture consists of 'a mix of scales, strategies, technologies, payment systems and decision-making structures' (van Vliet et al., 2010, p. 5). An

interviewee confirms that 'central and decentral systems can co-exist for the next 30 or so years' (Interview 4). The interviewees do not argue for the complete separation of black (faeces), grey (sinks, bathtubs, etc.), yellow (urine) and rainwater pipes straightaway. They state that the first steps would ideally be rainwater harvesting at the household level, the installation of pharma filters in hospitals, the collection of yellow water from urinals in public buildings, and separate black and grey pipes in newly constructed and rural areas (Interviews 4 & 9).

Strategy
The market has a limited role. One interviewee imagines, for example, a local economy: a farm receives yellow water (fertiliser) from nearby households, and then the latter are partially exempted from treatment taxes (Interview 4).

The interviewees want a government that actively develops a modernised mixture and examines every investment in the conventional wastewater system. Some policy instruments are suggested: changes in the End-of-Waste regulations, increased R&D budgets, space for experiments, (financial) incentives to enable, for example, the installation of decentralised systems and, lastly, an intensified collaboration between municipalities, companies, water boards, project developers and citizens (Interviews 4 & 9).

Technologically, the proposed mixed system departs from the current infrastructure. It ranges from rainwater harvesting, over NoMix toilets and constructed wetlands, to separate pipes for black, grey and yellow water (Interview 4). An interviewee adds, 'Technology does not form a bottleneck; it's not rocket science, you know' (Interview 9). Both interviewees also mention that the technology is cost-efficient and sustainable.

There should be 'a focus on the interests of citizens and what they desire' (Interview 4). Along these lines, an interviewee notes, 'End-users will realise: it is my energy, in my sewer, which is supplied to my house!' (Interview 9). On awareness, one says, 'Citizens are not going to flush whatever they want if they know the toxic stuff is going to end up in the pond next door, where the kids play' (Interview 4).

Discourse coalition
The coalition that narrates this storyline finds its roots at Wageningen University, in the work of, for example, the professors Gatze Lettinga and Grietje Zeeman (e.g.

Lens, Zeeman, & Lettinga, 2001). A research institution (LeAF) with which both professors are also associated has facilitated decentralisation projects. STOWA has also (re)produced the storyline, as has a company called DeSaH. LeAF, STOWA and DeSaH have been involved in the development and evaluation of the first and most popular decentralised treatment system in the Netherlands: 'Waterschoon' (in Sneek) (Interview 9; Waterschoon, 2011).

Influence

The coalition realises discourse institutionalisation to a certain degree, but significantly less than the first 'market-pull' discourse. For example, some small-scale treatment projects were realised, such as, notably, about 500 NoMix toilets (see Swart & Palsma (2013) for an overview). Furthermore, the Buiksloterham project in Amsterdam also aims at source separation (Gladek, van Odijk, Theuws, & Herder, 2014), while DeSaH installed the decentral treatment system in both Waterschoon and Buiksloterham. STOWA, LeAF and some scholars at Wageningen University have published on this topic, and STOWA's saniwijzer.nl keeps track of new developments. The bi-annual STOWA-event on 'New Sanitation' is the most important organisational practice in the Netherlands that (re)produces the storyline. There is thus hardly any discourse structuration and a low rate of institutionalisation, which becomes particularly clear in comparison to how the market-pull discourse (and thus the dominant actors) structures the transition debate and how it is institutionalised by the ERF.

3.3.2.3 *Discourse 3: water quality, public health and emerging pollutants*

The third discourse partially shifts the debate away from resource recovery by (re)asserting the importance of public health and water quality (the core objectives of the conventional wastewater system). The storyline is narrated by incumbent actors who are mainly associated with the water/wastewater sector. It has stimulated a debate on how a CE could compromise the public health objective and on emerging pollutants.

Roots

An interviewee observes that a lively public debate has developed on emerging pollutants since a pyrazole crisis in 2015[3] (Interview 11). These emerging pollutants

[3] A company discharged a chemical compound (pyrazole) into the Meuse, this was detected by a (downstream) drinking water company which, in turn, filed a lawsuit.

can be defined as 'chemicals that are not commonly monitored but have the potential to enter the environment and cause adverse ecological and human health effects' (Geissen et al., 2015, p. 57).

Storyline

Problems

First, Vewin (an association of drinking water companies in the Netherlands) regards the wastewater from hospitals and industry as problematic because it contains emerging pollutants that are not entirely removed by wastewater treatment plants (2017).

An interviewee adds, 'The main problem is endocrine disruptors and antibiotics [...] most come from agriculture, but this is not dealt with because of the economic value of the sector' (Interview 10). Second, the priorities of a transition towards a CE are still vague. In a press article, for example, a professor and two STOWA associates argue that energy and resource recovery could compromise the public health objective of the wastewater system (Clemens et al., 2012, February 10). Likewise, an interviewee notes that 'the treatment of emerging pollutants is an expense [...] while other things might be profitable for the water boards, such as energy recovery'. And he also observes: 'the water boards are concerned about water quality with regard to environmental standards and not to drinking water standards' (Interview 11).

Future

An interviewee and Vewin argue for an integrated approach, in which sharing knowledge and transparency is of importance. This requires the involvement of stakeholders such as the pharmaceutical and chemical industry, agriculture, hospitals, citizens, water boards and drinking water companies. Moreover, there should be a consensus on what emerging pollutants are, who is responsible for them and who invests in a solution (Interview 11; Vewin, 2017).

Strategy

Except for the supply of clean drinking water, market dynamics do not play a role in the strategy of this storyline, while the government does. First, the government should be playing a role in enforcing the source control principle, and implement precautionary and polluter-pays principles (Interview 11). In a press statement, the president of the Dutch Water Authorities says, 'The pharmaceutical industry is

responsible for pharmaceuticals in water and therefore needs to contribute to additional investments in treatment systems' (2017). Similarly, an interviewee argues for stricter licensing of who disposes what and how much in sewers (Interview 11). Second, the government should set identical quality standards for disposal of wastewater effluent in surface water, and for the intake of surface water for drinking water production (Interview 11; Vewin, 2017).

The main obstacle is not technology, but rather who among the stakeholders should invest in infrastructure to remove emerging pollutants. Citizens play an important role: public awareness should be raised by, for example, campaigns on emerging pollutants (Interview 11).

Discourse coalition

The storyline is narrated by Dutch drinking water companies, Vewin, STOWA and the Dutch Water Authorities. These are all incumbent actors in the Dutch water/wastewater system and they now focus on emerging pollutants. However, especially interesting is that the issue is connected to a transition towards a CE (and the possible trade-offs) by some interviewees and documents, while there are neither organisational practices nor coalitions that (re)produce their storyline[4].

Influence

The storyline highlights public health and water quality, both of which are elements of the conventional wastewater system. Thus they are also present in the two other discourses and are highly institutionalised in, among others, European directives. By contrast, the emerging pollutants are on the agenda and stimulate a lively public debate, but the discourse has not yet been institutionalised. In 2017, the water boards received a one-time subsidy (30 million euros) to initiate additional treatment (H2O, 2017, October 26), and STOWA published a few technical reports about pharmaceuticals in wastewater. Altogether, there is a coalition and discourse structuration on emerging pollutants. However, the rate of institutionalisation is still lower than that of the market-pull discourse (and the second 'modernised-mixture' discourse), particularly regarding the interconnection with resource recovery and a CE. We elaborate on this in section 3.4.

[4] It is likely that a similar prevention discourse (and coalitions and practices) may be found in, for example, the broader NGO sector. However, this is out of the scope of this chapter.

Table 2: summary of the three discourses

	'From a technology push towards a market pull'	**From a 'sub-optimal system' towards a modernised mixture**	**Water quality, public health and emerging pollutants**
Roots	- Tarnished-reputation water boards - Societal expectations - WaterWays	- Research agenda - 'Certain groups in the Netherlands' - STOWA	- Pyrazole crisis
Storyline: problems	- Energy use transport and treatment - Maintenance and construction costs - Limited resources on earth	- Energy use transport and treatment - Maintenance and construction costs - Flush-and-forget culture - Emerging pollutants - Demographic factors	- Hospitals, industry and agriculture dispose emerging pollutants - Vague priorities of transition
Storyline: future	- Energy and resource recovery - Win-win, business case	- Mix of scales, strategies, technologies, payment systems and decision-making structures	- Integrated approach: industry, agriculture, hospitals, citizens, water boards and drinking water companies - Sharing knowledge, transparency - Who is responsible and who invests
Storyline - strategy: role of markets	- Market pull/development - 'Economic story'	- Limited, a local economy	- Supply clean water

Storyline - strategy: role of governments	- Facilitate market development - Change End-of-Waste regulations - No financial support	- R&D, incentives and change End-of-Waste regulations - Intensified collaboration: municipalities, companies, water boards, project developers and citizens	- Source control, precautionary and polluter pays - Identical standards for wastewater effluent and drinking water influent
Storyline - strategy: role of technology	- Optimisation of large-scale and centralised treatment - Cost-efficient and sustainable - Not a bottleneck, but cooperation of universities, governments and private sector needed	- Mixed central (large-scale) and decentral (small-scale) treatment - Cost-efficient and sustainable - Not a bottleneck	- Spread investments over water cycle - Not a bottleneck
Storyline - strategy: role of citizens	- 'Not feasible' - Passive	- System in interest of citizens - Awareness	- Public awareness
Coalition	- ERF (all water boards), Dutch Water Authorities, STOWA, Delft University of Technology	- LeAF, STOWA, Wageningen University, DeSaH	- Vewin, water/wastewater sector, STOWA, Dutch Water Authorities
Influence	- Structuration and institutionalisation	- No structuration and low institutionalisation	- Structuration and (low) institutionalisation

3.4 Discussion

In the previous sections, we described the emergence of different interpretations on a transition in the Dutch wastewater system, and we aimed to explore the political struggles in such a transition. Therefore, two research questions were formulated. The first question, about how the transition is interpreted, was answered in the previous section by identifying three discourses. The second question was about how to understand the interpretations from a political perspective on transitions. We explore this question in three steps: we argue that the market-pull discourse is becoming dominant, discuss why this is so, and finally, reflect on what this means for a fundamental shift to sustainability in the Dutch wastewater system from a theoretical and empirical perspective[5].

First, we argue that the market-pull discourse is becoming dominant. The results show that both the market-pull and water-quality coalition (regarding emerging pollutants) succeed in discourse structuration, although they struggle to define exactly what the priorities of a transition are (i.e. resource recovery or water quality). The storyline of the market-pull discourse is also institutionalised more broadly in documents, organisational practices and the optimisation of 24 treatment plants, particularly regarding resource recovery. On the contrary, the modernised-mixture coalition does not succeed in discourse structuration, and the discourse is barely institutionalised. As such, the market-pull discourse is becoming dominant and will most likely shape the future of the Dutch wastewater system, in line with a specific conception of what the problems and solutions are.

Second, the market-pull discourse draws on the existing infrastructure and current political-economic institutions of the Dutch wastewater system, which gives it an advantage in becoming dominant. On the one hand, we have the large-scale infrastructure that consists of sewers and centralised treatment plants (as described in the historical overview). The market-pull discourse chooses to optimise the large-scale plants to recover resources. Thus it is influenced by, and interacts with, the existing infrastructure. In fact, the large-scale infrastructure is taken for granted, becomes performative and exercises power. A choice for optimisation is then easily made, which is typical of large technological systems (Hughes, 1989;

[5] Such a focus implies that the conflict between the content of the different discourses is not discussed in detail here. Nevertheless, the third section of this chapter and table 2 do highlight some of these conflicts.

Walker, 2000). In this context, an interviewee observes: 'An alternative, possibly more sustainable, solution is nearly impossible because of the current infrastructure' (Interview 8). This suggests a transition pathway characterised by incremental changes and technological lock-ins.

On the other hand, we have the political-economic institutions. Here we also observe that the dominant discourse aims at incremental changes in the existing institutions, particularly if we concentrate on the roles of markets, governments and citizens. With regard to the role of markets, there is a focus on win-win situations, market development for green resources, legislative changes and R&D cooperation. This bears similarities to ecological modernisation (Dryzek, 2005), which has recently been linked to dominant ideas about the CE as well (Gregson, Crang, Fuller, & Holmes, 2015; Hobson & Lynch, 2016; Hofmann, 2019). Of particular interest is the fact that ecological modernisation has been associated with the status quo and modest reformist strategies (Hopwood et al., 2005).

Similarly, there are no fundamental shifts in the role of governing bodies; the same role is played by, for example, STOWA, the Dutch Water Authorities and the water boards. Furthermore, the role of citizens does not change; they remain passive. Stability and incremental changes in existing political-economic institutions suggest lock-ins.

This brings us to a third step in the discussion, focussing on the discrepancy between the increased calls for a transition and our findings on the dominant market-pull discourse, incremental changes and lock-ins. Questions may be raised about the nature of this transition and the different transition pathways to sustainability (Berkhout, Smith, & Stirling, 2004; Geels & Schot, 2007; Klitkou et al., 2015). Geels & Schot differentiate between (among others) so-called 'transformation', 'reconfiguration' and 'substitution' pathways. In our context of lock-in effects, the incumbent actors are, at most, gradually reorienting the established system (known as 'transformation'). This can be interpreted in two ways: over time, the incremental changes may lead to a sequence of transition pathways; a transition then shifts, for example, from 'transformation' to 'reconfiguration' (substantial changes in the economic and power structures), and eventually the 'substitution' of the whole system. However, and by contrast, our findings suggest that the market-pull discourse shapes a transition pathway that is characterised by lock-in effects instead of a fundamental shift in the established system.

Thus the market-pull discourse has an advantage in becoming dominant by drawing on the existing infrastructure and political-economic institutions. Both mechanisms give shape to a lock-in and undermine a fundamental shift in the wastewater system. This is in line with findings in other empirical studies on water/wastewater: the activities in the wastewater system are influenced by a dominant rationality that is characterised by the large-scale infrastructure and technological and economic efficiency (Fuenfschilling & Binz, 2018); and because effluent recovery may disrupt existing practices and ideologies of water management, it requires greater levels of control and thus concentrates on the existing centralised infrastructure, institutions and techno-scientific expertise (Meehan et al., 2013). Furthermore, it is clear that a wastewater transition platform such as the ERF may be constrained and captured by prevailing actors, institutions and infrastructure, which has been observed previously in other sectors (Raven et al., 2016; Shove & Walker, 2007; Smith & Kern, 2009). In this way, our findings indicate that a new discourse in the wastewater system may be conditioned by the past, particularly by the established infrastructure and institutions.

3.5 Conclusion

There are increasing calls for a transition in the Dutch wastewater system, and our discourse analysis has identified three interpretations of this transition. We have also shown that one discourse ('market-pull' discourse) is becoming dominant. It is most successful in defining what a transition is, according to a specific storyline about the optimisation of the large-scale infrastructure, market development and legislative changes. Subsequently, we argued that this discourse suggests, at most, incremental changes and draws on the existing infrastructure and political-economic institutions. This gives it an advantage in becoming dominant. Our findings also indicated that the discourse shapes a transition pathway that is characterised by lock-in effects that undermine a fundamental shift in the established system. Overall, and in line with recent research on the CE (e.g. Hofmann, 2019; Lazarevic & Valve, 2017; Moreau, Sahakian, van Griethuysen, & Vuille, 2017), the conflicts are not being played out yet and there are choices to be made about a transition towards a CE in the Dutch wastewater system.

Chapter 4: *Power struggles in policy feedback processes: incremental steps towards a circular economy within Dutch wastewater policy*

Abstract
Environmental problems are usually not tackled with path-departing policies but rather with incrementally adjusted or unchanged policies. One way to address incremental change is the policy feedback approach, which initially focussed on self-reinforcing feedback and path-dependency. Today, self-undermining feedback is also increasingly being studied, centring on agency and change. However, it is unclear precisely how actors use power in policy feedback processes. Therefore, this study applied a power perspective and the policy arrangement approach to a case study of the reorientation towards a circular economy in Dutch wastewater policy between 2008–2018, which resulted in incremental instead of fundamental policy change. Here it was observed that self-undermining feedback was generated from 2008 onwards but the balance quickly shifted back to self-reinforcing feedback, indicating that the analysed power struggles led to incremental change. These dynamics resemble a shift from the so-called paths and forks (i.e. fork in the road) towards the boomerang pattern (i.e. returning to its original position) of policy change. The patterns are explained by focussing on powerful actors that resist change through the use of incremental reforms, the ongoing struggles of these actors in facilitating self-reinforcing feedback and the role of interpretation in using feedback as a resource. Overall, this study provides a nuanced understanding of incremental change by directing attention to the power struggles of actors in policy feedback processes. For practitioners, the study emphasises the importance of power struggles in enabling a circular economy.

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4.1 Introduction

In 2019, the European Commission published the Green Deal and articulated its intention to develop a low-carbon and circular economy for Europe by 2050. Member states are expected to develop elaborate plans to reach intermediate goals by 2030. Although the goals for the next decades are challenging, the policy progress has been rather limited in terms of achieving these long-term sustainability objectives (EEA, 2019a; UN Environment, 2019). According to the European Environment Agency, 'Europe will not achieve its 2030 goals without urgent action during the next 10 years to address the alarming rate of biodiversity loss, increasing impacts of climate change and the overconsumption of natural resources' (EEA, 2019d). From a policy sciences perspective, this raises the intriguing question of why policy—even under the pressure of long-term catastrophic tendencies—remains unchanged or changes only incrementally.

One way to address this question is the policy feedback approach. It is concerned with the understanding of stability and change by inquiring how established policies influence politics and how the politics subsequently shape policies. This approach is typically used to emphasise path-dependency and self-reinforcing feedback (or positive feedback) (Pierson, 1993). However, recent studies have also focussed on self-undermining feedback (or negative feedback) that may result in policy change and, therefore, also inquired how actors influence policy feedback processes (Béland & Schlager, 2019; Sewerin et al., 2020).

By examining a case study of a shift from self-undermining towards self-reinforcing policy feedback, resulting in incremental instead of fundamental policy change, this study seeks to explore such incremental change by focussing on the power struggles of actors in policy feedback processes. The struggles of actors were recently highlighted by several policy feedback researchers (Béland, 2010; Dagan & Teles, 2015; Haelg, Sewerin, & Schmidt, 2020; Jacobs & Weaver, 2015; Moore & Jordan, 2020; Schmid, Sewerin, & Schmidt, 2019). Béland (2010) confirms that existing policies shape the behaviour of actors but suggests that additional research is needed to understand how actors embrace alternative ideas to challenge existing policies and induce change. Similarly, when policymakers perceive the consequences of established policies as negative, they may search for alternative ideas and create new coalitions for change (Jacobs & Weaver, 2015). Furthermore, multiple overlapping self-reinforcing and self-undermining feedback processes make certain policy changes more likely but the interpretation and use of this

feedback by actors is crucial for the final outcome (Moore & Jordan, 2020). When taken together, these contributions give us an idea of the role of actors in generating policy feedback, particularly in self-undermining policy feedback. However, more research is required to elucidate exactly how actors use power to fuel policy feedback dynamics.

This study attempts to address this gap by considering an existing perspective on the power struggles of actors in policy processes (Arts & van Tatenhove, 2004) and the policy arrangement approach (Leroy & Arts, 2006), which resembles the so-called policy regime (Howlett & Ramesh, 2003; May & Jochim, 2013). The broad goal of Arts & van Tatenhove (2004) is to evaluate the interaction between actors and the structural context (a particular policy arrangement and long-term trends). In turn, the policy arrangement approach focusses on the established technology, powerful actors, rules of the game, dominant discourses and resources of an arrangement and is particularly useful to identify what has changed or remained stable in these dimensions over time. Both frameworks help in understanding the following feedback processes: the influence of an established policy arrangement on the power struggles of actors and the subsequent effect on the original policy arrangement. Accordingly, the research questions posed in this study are how actors use power in policy feedback processes and, more specifically, how this results in incremental instead of fundamental policy change.

Thus, we selected as a case study the reorientation of the Dutch wastewater policy arrangement towards a circular economy between 2008–2018, in which we observe a shift from self-undermining towards self-reinforcing feedback dynamics, leading to incremental instead of fundamental change. The network and knowledge centre called the Energy & Resource Factory was crucial in this process as it aims to enable a transition towards resource recovery from wastewater. Generally, wastewater policy arrangements are characterised by inertia, which is induced by cost efficiency and large-scale infrastructure (Ampe, Paredis, Asveld, Osseweijer, & Block, 2019; Fuenfschilling & Binz, 2018; Kiparsky et al., 2016). However, pressing challenges such as energy use, decaying infrastructure, drought and intense periods of rainfall, emerging pollutants and depletion of critical resources (EEA, 2019b; UN WWAP, 2017) have led to innovative activities focussing on a circular economy (e.g. Guest et al., 2009; Lema & Suarez, 2017; van Loosdrecht & Brdjanovic, 2014). In the Dutch wastewater policy arrangement, these challenges also shape activities centred around a circular economy (e.g. Blankesteijn, 2019; van Leeuwen, de Vries, Koop,

& Roest, 2018). As such, the general stability of wastewater arrangements (i.e. likely to function as strong self-reinforcing policy feedback) and the challenges and innovative activities (i.e. likely to facilitate self-undermining policy feedback) make the circular economy in the Dutch wastewater policy arrangement a suitable case for exploring the power struggles of actors in policy feedback processes.

By applying the two frameworks to the case study, our study contributes to the understanding of policy feedback by generating novel insights about the power struggles of actors in feedback processes. Using existing frameworks that are not directly related to the policy feedback literature, the study also systematically engages with theoretical and conceptual discussions in other studies about agency and actors, which was an approach recently suggested for policy feedback researchers (Sewerin et al., 2020). The study also empirically grounds feedback processes with an in-depth, qualitative case outside of the overwhelming focus on the United States and social policy (Béland & Schlager, 2019; Kern & Rogge, 2017; Roberts et al., 2018). For practitioners involved in enabling a circular economy, the focus on power also highlights a different way of understanding the potential beginnings of a circular economy.

The remainder of this chapter is organised as follows: Section 4.2 focusses on policy feedback and the power struggles of actors. Section 4.3 introduces the analytical frameworks, research techniques and the case study. Section 4.4 presents the empirical analysis of the Dutch wastewater policy arrangement around the year 2008, the power struggles in 2008–2018 and, finally, the arrangement in 2018. Section 4.5 discusses the analysis and Section 4.6 concludes the chapter and provides suggestions for future research.

4.2 Policy feedback and the power struggles of actors

In this section, we describe the conventional understanding of policy feedback. We elaborate on self-reinforcing and self-undermining feedback, particularly on the power struggles of actors in policy feedback processes, which will be explored in the subsequent sections through the application of an established power perspective and the policy arrangement approach to our case.

Drawing inspiration from Pierson's (1993, 2000) work on path-dependency and self-reinforcing dynamics, the policy feedback approach focusses on understanding

policy stability and change. Specifically, it investigates how an existing policy influences political processes and how these politics subsequently feed back into policy over time (Jordan & Matt, 2014; Sewerin et al., 2020). Established policies influence the allocation of resources and the capacities, interests and preferences of actors involved in politics, which affects subsequent policies. For example, during the Second World War, the social security policy involved challenges but it was protected by powerful lobbies and interest groups, leading to the expansion of this policy from the 1950s onwards in the United States (Béland, 2010; Béland & Schlager, 2019). Thus, over time, existing policies may create their own bases of political support that lead to self-reinforcing dynamics and stability.

As such, it is argued that when self-reinforcing feedback from past choices accumulates, it generates a powerful cycle of increasing returns that may become path-dependent over time, hindering path-departing change. More precisely, an existing policy may create lock-in effects that are generated by fixed costs, the development of particular skills, the coordination of activities in social and economic networks and the adoption of prevailing standards and expectations (Pierson, 1993). These increasing returns arguments were drawn on economic theories and subsequently extended to politics by directing attention to a few factors conducive to increasing returns, namely collective action and organisational persistence, institutional constraints, political authority and the complexity of politics (Pierson, 2000). Although Pierson indicates that the concept of increasing returns does not imply a 'frozen social landscape' but continuous change as well, the policy feedback approach has predominantly emphasised self-reinforcing feedback, leading to a rather narrow understanding of policy change or, more critically, the understanding of policy stability rather than processes of policy change.

Recently, self-undermining feedback has been increasingly studied (Béland, Rocco, & Waddan, 2019; Daugbjerg & Kay, 2020; Jacobs & Weaver, 2015; Millar, Bourgeois, Bernstein, & Hoffmann, 2020; Weaver, 2010). In contrast to the self-reinforcing feedback effects of existing policy, the study of self-undermining feedback focusses on the effects of existing policy that gradually undermine the policy. Specifically, Weaver (2010) shares the perspective that past policy choices influence politics but argues that most policy regimes produce self-undermining feedback, influencing the political, fiscal or social sustainability of the regime. Such self-undermining feedback may take the form of problems that are recognised at the outset as well as

slowly developing consequences of the policy, which may result in new political demands and subsequent changes in the original policy.

Weaver (2010) then focusses on the balance between self-reinforcing and self-undermining feedbacks to identify different patterns of policy regime change: strong self-reinforcing effects which prevent any exit from the policy regime (labelled as cul-de-sac); strong self-undermining effects and the absence of policy regime choices, in which the policy regime is abandoned and replaced by a new one (labelled as chutes and ladders); moderately strong self-reinforcing effects and constrained choices dictated by the original regime (paths and forks); mixed patterns because of the characteristics of the policy regime; and delayed self-reinforcing effects that initially permit choice but then force reversal (boomerang). However, Weaver (2010) suggests that these policy change patterns are not only influenced by the balance between self-reinforcing and self-undermining feedbacks. They also depend on the availability of incremental patches or reforms that constrain changes and help to maintain the existing policy regime as well as on the existing regime transition opportunities, which may be politically unfeasible, considerably expensive and blocked by powerful actors.

As policy feedback literature is increasingly sensitive to the interaction between self-undermining and self-reinforcing feedbacks, it also directs more attention to the role of actors in feedback processes (e.g. Béland, 2010; Jacobs & Weaver, 2015; Jordan & Matt, 2014; Moore & Jordan, 2020; Sewerin et al., 2020), leading to the identification of several mechanisms through which politics can facilitate or block change. In a study on a policy instrument to reduce emissions from new cars, the absence of strong self-undermining feedback is clarified by showing that car-manufacturers took active political steps to intentionally steer the instrument towards incremental adjustments in their technologies. Here questions also arise about how to evaluate the agency in policy design whilst considering more structural commitments to incumbent technology (Jordan & Matt, 2014). In a case on health-care reform in the United States, Jacobs & Weaver (2015) identify three mechanisms under which self-undermining feedback is likely to emerge, namely unanticipated negative outcomes for powerful actors, strategic behaviour and expansion of the set of imaginable policy alternatives. Concerning the latter, they note that when the consequences of the existing policy are interpreted as negative, politicians, bureaucrats and experts may search for alternative ideas and create new coalitions for fundamental change, generally highlighting ‘the agency of political

actors in the politics of policy change' (Béland & Schlager, 2019, p. 190). However, these actors are also dependent on the opening and closing of windows of opportunity (e.g. electoral factors) within a specific institutional setting (Jacobs & Weaver, 2015). Similarly, as the black box around self-reinforcing processes is opened, it is found that institutions, resources, ideas as well as agency and structure matter in feedback processes: 'Supporters and opponents may not take the feedback effects of preexisting policies as given, but may instead actively seek to amplify or suppress such effects, to the extent feasible within institutional constrains' (Patashnik & Zelizer, 2013, p. 1083). Furthermore, in a case on the Emissions Trading System of the EU, it is demonstrated that feedback makes certain policy options more likely but the outcome also depends on the role of actors in the social construction of feedback, particularly on how feedback is interpreted and used as a resource by these actors (Moore & Jordan, 2020). They can draw attention to the consequences of policy to facilitate policy undermining feedback but this requires overcoming powerful cognitive, organisational and political obstacles when this feedback is not anchored in shared understandings and formal institutions (Dagan & Teles, 2015).

Hence, these examples illustrate the relevance of focussing on the role of actors in policy feedback processes as existing policies affect their behaviour. However, additional research is needed about how these actors embrace alternative ideas to challenge existing policy and induce change. Specifically, 'the relationship between the agency of actors, existing policy legacies, and institutional change' (Béland, 2010, p. 583) requires more attention in policy feedback research. Therefore, we focus on how actors use power in policy feedback processes. As such, the next section elaborates on the policy arrangement approach, a power perspective, the research techniques and the case study.

4.3 Methodology

4.3.1 Two analytical frameworks – one analytical approach

The chapter aims to investigate how actors use power in policy feedback processes. Therefore, we develop an analytical approach that consists of two analytical frameworks. We use the policy arrangement approach to describe the original policy arrangement and the new policy arrangement in a comparative perspective and thus to detect change or stability over time. In turn, a power perspective helps to analyse

how the power struggles of actors are influenced by the original policy arrangement and influence the new policy arrangement, particularly assessing how these struggles strengthen the original arrangement (i.e. self-reinforcing feedback) or undermine this arrangement (i.e. self-undermining feedback).

First, the policy arrangement approach defines a policy arrangement as 'the temporary stabilisation of the content and organisation of a particular policy domain' (Leroy & Arts, 2006, p. 13). A policy arrangement resembles the so-called policy regime, which captures 'how policy institutions, actors, and ideas tend to congeal into relatively long-term, institutionalized patterns of policy interaction' (Howlett & Ramesh, 2003, p. 234). Similarly, an arrangement consists of four interrelated dimensions, namely the actors involved in the policy domain, the rules of the game (ranging from informal norms and routines to formal legislation and guidelines), the dominant discourse (i.e. interpretive schemes, ranging from formal concepts to popular storylines) and the resources (e.g. knowledge, money and personnel) of the actors involved. As the wastewater system comprises large infrastructure, we included technology as the fifth dimension of an arrangement because it is likely to influence the policy arrangement (Hughes, 1989; Pierson, 1993). Fundamental change in policy arrangements or regimes involves substantial changes in the content, organisation and institutionalised patterns of policy interaction, whereas incremental change does not affect the basic contours of an arrangement and comprises, for instance, the introduction of an adapted discourse while maintaining the other dimensions of an arrangement (Arts & Leroy, 2006; Howlett & Ramesh, 2003). Hence, the policy arrangement approach helps to analyse how the original policy arrangement feeds back into a new policy arrangement over time, particularly by describing the two arrangements in a comparative perspective to detect change or stability.

Second, Arts & van Tatenhove (2004) introduced a perspective to analyse multiple layers of power in policy practices, which was subsequently used and adapted (e.g. Ampe, Paredis, Asveld, Osseweijer, & Block, 2021; Avelino, 2017; Grin, 2010; Hoffman, 2013; Kok, Loeber, & Grin, 2021; Liefferink, 2006; Paredis, 2013; Ramírez-Monsalve & van Tatenhove, 2020). This power perspective focusses on change and stability in policy practices by acknowledging the influence of actors and of the structural context in which these actors operate. Power is then defined as 'the organisational and discursive capacity of agencies, either in competition with one another or jointly, to achieve outcomes in social practices, a capacity

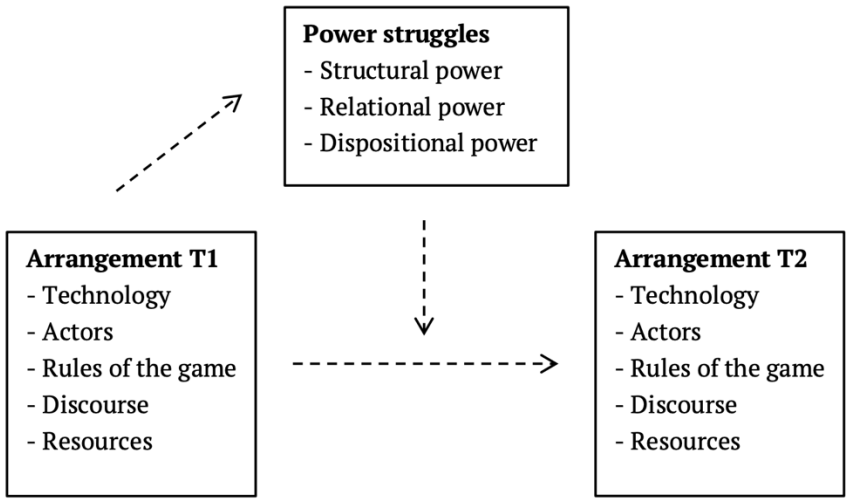
which is however co-determined by the structural power of those social institutions in which these agencies are embedded' (Arts & van Tatenhove, 2004, p. 347).

Arts & van Tatenhove (2004) distinguish between three types of power: structural, relational and dispositional power. Structural power refers to contextual processes of structural political and social change such as increasing environmental concerns or macroeconomic processes. These slowly changing trends (i.e. longue durée) are beyond the direct influence of the actors involved in policy practices and appear to be autonomous. However, these actors may derive structural power from these trends by interpreting and mobilising them. Relational power is the capacity of agents to achieve outcomes in day-to-day interactions. Actors can be creative and can act differently in innovative activities by constructing counter-discourses to name and frame certain societal problems as policy problems as well as by mobilising resources such as knowledge, tactics, persuasion, money and personnel to formulate and realise their most desirable outcomes. Nonetheless, avoiding a voluntarist approach, Arts & van Tatenhove (2004) note that human action is highly routinised and that the capacity of agents is co-determined by dominant policy practices and the associated rules of the game, resources and discourses. Correspondingly, dispositional power is the power that derives from the positions that actors occupy in a specific situation (e.g. in established policies or an organisation). This process of positioning is mediated by actor configurations, the rules of the game, discourses, resources and, following Hoffman (2013), artefacts such as technology and infrastructure. As such, because of their position, some actors are better able than others to make use of the resources available; they can more easily use rules to achieve an outcome and they have more legitimacy when drawing on a particular discourse. Mediating dispositional power, established actors, rules, discourses, resources and artefacts thus position policy practices in a specific manner: existing policy practices will be privileged, whereas novel policy practices may be constrained by resistance and stability. Yet pressures induced by novel policy practices and slowly changing trends may affect this process of positioning which, for example, leads new actors to challenge certain rules to enable innovative policy practices (Grin, 2012). Thus, the dynamics between these three layers of power influence change and stability in policy practices and, in our case, a policy arrangement.

In our analysis, we first use the policy arrangement approach to describe the five dimensions of a particular policy arrangement at a certain time (T1). We then

consider the three types of power as conceptualised by Arts & van Tatenhove (2004) to investigate how the power struggles of actors are influenced by the original policy arrangement T1 (indicated in Figure 5 with the arrow pointing from arrangement T1 to power struggles) and influence the arrangement over time, generating self-reinforcing and self-undermining dynamics (indicated in Figure 5 with the arrow pointing from power struggles to the arrow that connects arrangement T1 and T2). Specifically, we assess how these struggles strengthen the original arrangement (i.e. self-reinforcing feedback) or undermine it (i.e. self-undermining feedback). Finally, we provide a new description of the five dimensions of the new policy arrangement at the second point in time that we observe (T2). By doing so, we can detect where and to what extent change has occurred or is ongoing in the arrangement. Figure 5 summarises the components of the analytical approach.

Figure 5: schematic summary of the analytical approach



4.3.2 Research process and techniques

In the process of selecting a case, choosing a conceptual and analytical approach, collecting empirical material, coding and analysing, we followed an abductive approach, which is embedded in an interpretive methodology (Durnová & Weible,

2020; Schwartz-Shea & Yanow, 2012). In abductive reasoning, 'an (often surprising) single case is interpreted from a hypothetic overarching pattern, which, if it were true, explains the case in question [...] During the process, the empirical area of application is successively developed, and the theory (the proposed over-arching pattern) is also adjusted and refined' (Alvesson & Sköldberg, 2009, p. 4). As such, we first heard about the Energy & Resource Factory's role in enabling a circular economy in the Dutch wastewater policy arrangement in the beginning of 2017, particularly in interviews with a few wastewater experts at a university in a previous study. In turn, prior knowledge about the Dutch wastewater sector and preliminary field observations helped to obtain a general notion of the policy arrangement and our interpretations were regularly adjusted by alternating between the different types of literature, frameworks and empirical material (see Appendix chapter 4 for a list of the interviews, observations, field notes, documents, videos and newsletters).

In the first half of 2018, we conducted 10 (out of 15) face-to-face expert interviews. The interviews included established actors and innovators and were selected by purposive and snowball sampling (Yin, 2016). The in-depth interviews lasted 60-150 min and began with personal histories and roles in the Dutch wastewater sector, after which we gradually focussed on the circular economy in the Dutch wastewater sector, the most important actors, events and trends, and enabling and constraining elements in introducing the circular economy. In doing so, we were guided by the perspective of the interviewees. Eight meetings related to the Energy & Resource Factory were also joined in 2018 to observe the activities of the innovators and the established actors, which were documented in field notes. Furthermore, multiple events on resource recovery from wastewater were visited in 2017 and 2018 to complete the analysis. These observations helped to contextualise the interviews and documents. At this time, we selected the most relevant documents collected during the field work, which were mainly used to complement the information obtained from the interviews.

The first author of this study used the MAXQDA software to analyse the empirical material in an abductive manner. In the first round of coding, ten interviews were codified into 1192 text fragments, which were assembled into five broad categories: developments in the sector (i.e. sustainability, circular economy, austerity, the reputation of the regional water authorities and so forth), dimensions of the arrangement, external drivers and the activities of innovators and established

actors. In the second round of coding, we (re)coded (1366 text fragments) these interviews by introducing the three layers of power to the coding scheme.

In the five additional interviews, the second part/hour usually focussed on the dynamics between the so-called sandboxes and efficiency (see Section 4.4), which were important topics that emerged from the previous interviews and the coding process. Next, a detailed version of the analytical framework was introduced to the coding scheme and the interviews were (re)coded, whereas the documents were coded for the first time (3469 text fragments). At this time, the coding scheme comprised codes on the developments in the sector (see above) as well as the dimensions of the two arrangements and the three types of power in two phases (see Section 4.4), meaning that the first author had an overview of who used power why, when and how. By the end of 2018, we stopped the collection of empirical material as no additional information was obtained in the interviews, documents and observations.

4.3.3 Case study

Dutch wastewater policy is part of wider water management that is carried out by the following public actors: the European Union, international river basins commissions, the Dutch Ministry of Infrastructure and the Environment and its executive agency, provinces, municipalities and the regional water authorities. In addition, numerous institutes, advisory committees and companies also shape water policy, whereas the presence of NGO's is rather limited (OECD, 2014). Dutch water management focusses on three main functions (Havekes et al., 2015; Lazaroms & Poos, 2004): flood control is the responsibility of the national government and the regional water authorities and encompasses the management of dams and dykes; water quantity comprises the amount of surface water in a particular area and is taken care of by the national government (main canals, lakes and rivers) and the regional water authorities (local bodies of water); water quality is also primarily managed by the government and regional water authorities and involves protecting surface water from pollution, in which the regional water authorities play a crucial role by treating wastewater.

In their designated territorial areas, the 21 regional water authorities are responsible for collecting and treating wastewater, amongst the other functions. To do so, they levy their own taxes and, consequently, have a democratically elected general assembly (Mostert, 2017). The assembly appoints the members of an executive committee that consists of a few governors that usually are responsible

for one of the main functions of the authorities (i.e. flood control, water quantity and quality). The authorities thus are 'an autonomous, fully-fledged authority alongside the State and provincial and local governments' (Havekes et al., 2015, p. 9) and play a crucial role in wastewater treatment under the supervision of the provinces and the national government.

Our case study of the reorientation towards a circular economy in the Dutch wastewater arrangement delves deeply into the function of wastewater treatment. As mentioned in the previous section (4.3.2), our research process started by interviewing wastewater experts at a university in a previous study. When asked who was shaping a circular economy in the Dutch wastewater sector, they typically mentioned the treatment managers and innovators of the regional water authorities. These actors belonged to the administration of several regional water authorities and were usually involved in the country-wide network and knowledge centre called the Energy & Resource Factory. This centre was founded in 2014 by the regional water authorities and plays a crucial role in promoting a transition towards resource recovery from wastewater. As we discuss in the empirical analysis (section 4.4), the establishment of the centre was preceded and followed by power struggles between established actors (e.g. the treatment governors, treatment managers and the research institute of the regional water authorities), and innovators who were usually employed by the regional water authorities and developed circular economy-activities in so-called sandboxes that allowed experimentation. Hence, our case focusses on the struggles between innovators, who were developing new activities, and established actors, who succeeded in restricting these activities by introducing incremental reforms. These struggles resulted in a shift from self-undermining towards self-reinforcing policy feedback, resulting in incremental instead of fundamental policy change.

4.4 Empirical analysis

The idea of sustainability and, subsequently, a circular economy emerged in the Dutch wastewater sector around 2008. Therefore, we first use the policy arrangement approach to describe the technology, actors, rules of the game, discourses and resources of the arrangement around the year 2008 (4.4.1). Next, we apply our power perspective. Specifically, 2014 marked a turning point as the Energy & Resource Factory was officially established and, as the analysis indicates, the power relations significantly changed. As a result, we divided our analysis of

power struggles into two distinctive phases, one from 2008 to 2014 (4.4.2) and the second from 2014 to 2018 (4.4.3). By using the power perspective, we can analyse the role of power struggles in feedback processes, particularly by focussing on how these struggles support the original arrangement (i.e. self-reinforcing feedback) or undermine it (i.e. self-undermining feedback). Finally, we compare the original arrangement of around 2008 with the description of the arrangement in 2018 (4.4.4), which allows us to detect the change that has occurred or is ongoing in the arrangement.

4.4.1 The Dutch wastewater policy arrangement around the year 2008

Using the policy arrangement approach, we describe the Dutch wastewater policy arrangement around the year 2008 along its five dimensions: technology, actors, rules, discourses and resources. First is the arrangement's technology. Over the 19th and 20th centuries, a large-scale, centralised wastewater treatment infrastructure was developed in the Netherlands. In 2008, the country had approximately 350 treatment plants, 100.000 km of sewers and a sewer connection rate of 99%. The plants treated municipal wastewater, mixed with (treated) industrial wastewater and rainwater. After treatment, most of the sludge was incinerated and the effluent was discharged to surface water.

Second are the arrangement's established actors. The 27 regional water authorities (21 in 2018) were responsible for the three main functions of Dutch water management in their designated areas, namely the quality of surface water (i.e. wastewater treatment), flood control and the quantity of surface water. In every regional water authority, a treatment governor and a treatment manager were responsible for the daily business of their particular authority's wastewater management. To support their country-wide research institute, called the Foundation for Applied Water Research (in Dutch: Stichting Toegepast Onderzoek Waterbeheer, STOWA), the regional water authorities also pooled resources. As an umbrella organisation of the regional water authorities, the Association of Dutch Water Authorities (in Dutch: Unie van Waterschappen) also operated country-wide. This Association had several decision-making committees on which the regional water authorities were represented by a governor. Specifically, a treatment governor would represent the regional water authority in the Committee on Wastewater Treatment (in Dutch: Commissie voor Waterketens en Emissies, CWE), whereas the flood control and water quantity governors were part of the Association's committees on flood control and water quantity respectively. In turn,

the wastewater treatment managers of the 27 regional water authorities frequently gathered in a well-organised, influential but informal network called the Association of Treatment Managers (in Dutch: Vereniging van Zuiveringsbeheerders, VvZB). Remarkably, the flood control and water quantity managers of the regional water authorities do not have such an association.

Third, we review the rules of the game of the arrangement. In 2008, the 27 regional water authorities were autonomous, diverging authorities, leading to widely varying rules concerning organisational cultures, budgets, election results and priorities. Furthermore, in every regional authority, the three main functions and responsibilities were translated into organisational silos, each with a different budget, staff and knowledge. More broadly, the silos cut across the whole arrangement, shaping the organisational structure of the Association of Dutch Water Authorities (e.g. the different committees), STOWA's research lines and the collaboration of the treatment managers within their Association (VvZB). In addition, as wastewater management was in the public interest and taxes were levied, the regional water authorities were bound by strict budgets, leading to the powerful rule of cost efficiency in the arrangement. Concerning decision-making rules, the governors of every regional water authority were the governing officials and part of the CWE as such, whereas the treatment managers were their non-elected officials. Overall, concerning the rules of the game, Dutch water management's three main functions are interwoven with three organisational silos which, moreover, cut across 27 diverging regional water authorities.

Fourth, the dominant discourse within the regional water authorities was typically formulated as '"dry feet", sufficient water and clean water'. 'Dry feet' indicates the role of flood control, and sufficient water and clean water refer to the quantity and quality of water. Hence, the discourse is inextricably intertwined with the three main functions of Dutch water management and, accordingly, with the three organisational silos.

Fifth, in addition to the technology, actors, rules of the game and discourse, there are the resources of the arrangement. The regional water authorities employed 11,000 people, including those concentrated on wastewater treatment. Typically, this group provided considerable techno-economic knowledge and aimed to solve problems at the end of the pipe. Furthermore, regional water authorities' taxes generated 95% of their budget (€1.7 billion in 2000 and €2.8 billion in 2018). An

increase in water taxes was generally perceived as unacceptable, which led to the decisive role of the cost efficiency rule in the arrangement.

This overview describes the five dimensions of the arrangement before the idea of sustainability started to develop (see Table 3 for a schematic summary). After analysing the two phases of power struggles in the next sections (4.4.2 and 4.4.3), we compare this original policy arrangement with the arrangement in 2018 to detect the changes in the arrangement over ten years (4.4.4).

Table 3: Dutch wastewater arrangement around 2008

Arrangement's dimensions	**Dutch wastewater arrangement around 2008**
Technology	- Large-scale treatment infrastructure
Established actors	- Regional: 27 regional water authorities, comprising treatment governors and treatment managers - Country-wide: regional water authorities' research institute (STOWA) - Country-wide: governors' Committee on Wastewater Treatment (CWE) within the Association of Dutch Water Authorities - Country-wide: Association of Treatment Managers (VvZB)
Rules of the game	- Autonomy of 27 regional water authorities - Wastewater treatment silo, next to water quantity and flood control silos - Cost efficiency
Discourse	- 'Dry feet', sufficient water and clean water
Resources	- Water taxes - Techno-economic knowledge

4.4.2 Phase 1: power struggles between 2008–2014

As mentioned, we use our power perspective to analyse how actors use power in policy feedback processes. In the first phase of struggles, both the established actors and the innovators derived power from three long-term trends, which facilitated self-undermining feedback dynamics. The innovators also developed innovative activities and an ambitious counter-discourse, seeking fundamental policy change and creating self-undermining feedback processes in the arrangement. Over time, the established actors reacted to this increasing pressure by using their strong position to guide the innovators, gradually generating self-reinforcing feedback processes.

4.4.2.1 *Three long-term trends in the Dutch wastewater policy arrangement*

Three long-term trends have been pressing the arrangement since 2008, which, as the analysis will show, were used by both the innovative and established actors in their ongoing struggles, indicating the mobilisation of structural power. The first trend is the declining reputation of the regional water authorities. Historically, their raison d'être has been challenged because of the fragmented organisation, the 1953 floods and environmental and financial problems. Occasionally, the debate arises again, particularly on how to finance the extra layer of government. This case also occurred around 2010: the regional water authorities fulfilled their formal obligations and thus the results (i.e. flood control, sufficient water and clean water) of this work appeared as self-evident to Dutch citizens, who then questioned the purpose of water taxes.

Second are the (European) developments concerning climate change, circular economy and sustainable energy. These developments also took place in the Dutch water/wastewater sector: the regional water authorities signed the Dutch Long-Term Agreements on Energy Efficiency in 2008 and, until 2018, several other agreements on climate, sustainability, energy and resources were implemented.

The third trend is the European debt crisis that had been occurring. In the Dutch water sector, the Administrative Agreement on Water Affairs of the Ministry of Infrastructure and Water Management (2011) aims to reduce costs by €750 million by 2020, of which €240 million should be saved by the regional water authorities. To achieve these goals, the objectives are effective water management, increased efficiency and sector-wide collaborations. A higher societal cost or tax increase is not an option.

4.4.2.2 *Long-term trends, innovative activities and a counter-discourse undermine the arrangement*

From 2008 onwards, the established actors exploited their dispositional power and derived structural power from the aforementioned trends, introducing the scope for acting differently. These dynamics also enabled the innovators to mobilise these trends (i.e. structural power) in several so-called sandboxes, which developed novel activities and a broad and ambitious counter-discourse that challenged the arrangement (i.e. relational power) (see Table 4 for activities 2008–2014).

The first new activity was implemented in 2008; the Association of Dutch Water Authorities' WaterWays was a sandbox that comprised 50 innovators who aimed to create a better reputation for the regional water authorities, which is a trend that is continuously used by established actors and innovators between 2008-2018 (see 4.4.2.1). To accomplish this, WaterWays challenged the sector by using a prize question about innovative solutions. Four innovators and their regional water authorities proposed the concept of the Energy Factory to recover biogas from wastewater and, subsequently, 14 regional water authorities joined the association. Furthermore, the research institute (STOWA) published a 2030 vision report called NEWater on nutrient, energy and water recovery in 2010; interviews and multiple workshops were held for the Wastewater Management Roadmap 2030; the regional water authority in Apeldoorn started producing biogas; the governors' Committee on Wastewater Treatment (CWE) included cradle-to-cradle on their agenda; the Association of Dutch Water Authorities organised a phosphate working group; and innovators brainstormed the concept of the Resource Factory, which led to the TEDx talk on How to Turn Waste Water into a Goldmine and the first informal meetings between the regional water authorities and Aquaminerals (in brief, the Energy & Resource Factory of the drinking water companies).

Table 4: main activities 2008–2014

Year	Event(s)
2008	WaterWays, Energy Factory
2010	NEWater report (STOWA), cradle-to-cradle (CWE)
2012	Roadmap 2030, Resource Factory, TEDx talk

As the sandboxes were usually affiliated with the policy arrangement, the innovators used their position in the arrangement (i.e. dispositional power) to increasingly use resources such as money, time and personnel to develop their innovative activities. For instance, the purpose of WaterWays was to influence the regional water authorities in a bottom-up manner and 'the young people in the Energy Factory were, in a way, detached from their water authority to play around, think freely and come up with the strangest things' (Interview 7). In the context of Roadmap 2030, an interviewee observes, 'In times of austerity […] it was exceptional how much space and time young, innovative engineers received to share [novel] ideas' (Interview 4). Three innovators of three regional water authorities also brainstormed for multiple days to develop their innovative ideas about the so-called Resource Factory.

Influenced by the innovators' sandboxes, a broad counter-discourse emerged that fundamentally challenged the policy arrangement. An interviewee observed 'a shift from climate adaptation or protection against the rising tide to climate mitigation' (Interview 14). This observation was also reflected by a range of problems identified in the reports NEWater and Roadmap 2030: resource scarcity (e.g. phosphorus and water), emerging pollutants, cost of wastewater treatment and dependence on fossil fuels, drought and floods, salinization and the decaying infrastructure. The reports also outlined a future vision and proposed the recovery of phosphorus, nitrogen and potassium (fertilisers); bioplastics; cellulose; algae; alginate; carbon dioxide; and sulphur and sulphate. As energy sources, the reports detailed biogas (sludge and other biomasses), heat (thermal energy), hydropower (sewers), solar and wind energies. Additionally, by 2030, the separate pipes for storm water will be in use, rainwater will be harvested and effluent will be reused in industrial processes, cooling and artificial surface water and groundwater recharge. To achieve these ambitious objectives, a combination of large-scale infrastructure and new technologies such as decentralised treatment systems and constructed wetlands were considered. A strong focus was on collaborations between the regional water authorities and municipalities, drinking water companies and sectors such as agriculture, energy, food, chemistry and project development. Consequently, the sector's slogan changed to '"dry feet", sufficient water and clean water […] connected to a sustainable environment' (Chairperson Energy & Resource Factory, 2014). Hence, the innovators mainly used relational power to develop innovative activities, involving the introduction of a counter-discourse, new coalitions across

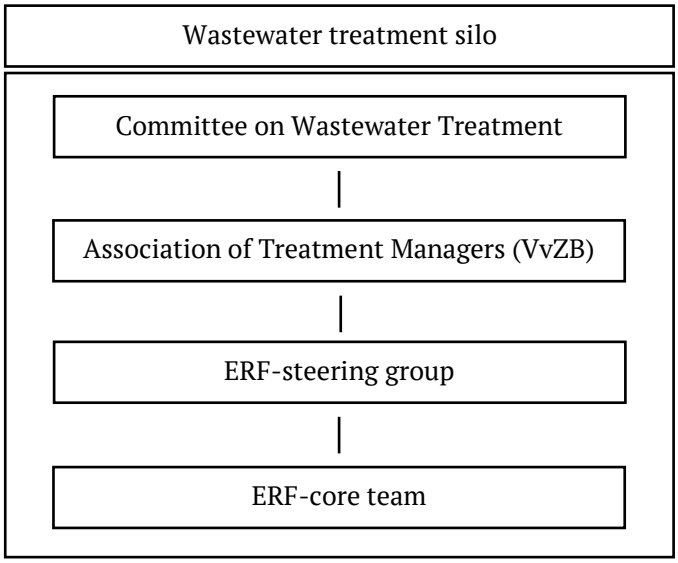
the silos and organisational methods that fundamentally undermined the original arrangement.

4.4.2.3 *First reactions to the innovative activities reinforce the arrangement*

Initially, the struggles of the innovators to act differently were partially supported by the established actors but, with time, the established actors increasingly used their strong position within the arrangement (i.e. dispositional power) to constrain these efforts, particularly by framing the sandboxes as inefficient. The treatment governors and managers started to raise questions on the cost efficiency of the sandboxes: 'Where is the taxpayer's money going? What are the results? What is the added value?' (Interview 13). Various interviewees also observe how the treatment managers attempted to influence the Energy Factory and the Roadmap 2030, which is summarised by an interviewee as follows: 'The establishment, the CWE and the managers kept on attempting to curb our sandboxes [...] to control the whole process' (Interview 6).

Consequently, the CWE (treatment governors) and VvZB (treatment managers) attempted to make the innovators' sandboxes more efficient by institutionalising these boxes, particularly by establishing a new organisation called the Energy & Resource Factory (ERF) and then by embedding the innovators in the so-called 'ERF-core team'. By doing so, the established actors gained control over the innovators and their sandboxes: the ERF was officially established, its Transition Programme was published by all the regional water authorities, all the authorities financially contributed to the ERF (for the (limited) annual budget of approximately €550,000) and the hierarchical management structure of the ERF was established. This management structure is displayed in Figure 6 and is mainly based on the flow of information between the different layers, although the managers and especially the governors have the last word. It thus shows how the established actors of the wastewater treatment silo (CWE and VvZB) are in charge. Moreover, established actors are represented in the steering group, which consists of a STOWA and Association of Dutch Water Authorities-representative, three treatment managers and the innovators of the ERF's core team. As such, the established actors locked the innovators' sandboxes in the established actor configurations and hierarchies, the silo of wastewater treatment and the focus on cost efficiency.

Figure 6: management structure of the ERF in 2014.



Summarising the first phase, the established actors and innovators interpreted and used the long-term trends, facilitating self-undermining feedback dynamics. This also allowed the innovators to develop new activities and a broad counter-discourse, leading to multiple options for radical change and strengthening the undermining processes. As this implied introducing new technologies, actors and rules that fundamentally challenged the arrangement, the established actors were increasingly pressured and cautious about these 'inefficient' activities. Therefore, they struggled to gain control over the innovators' sandboxes, gradually generating self-reinforcing processes. Overall, we observe the emergence of early, moderately strong self-undermining feedback, although the balance quickly started to shift towards self-reinforcing feedback dynamics that supported the original policy arrangement.

4.4.3 Phase 2: power struggles between 2014–2018

As the established actors of the arrangement were confronted with challenging activities in the first phase, the start of the second phase is characterised by the official establishment of the ERF and a shift in power relations. Specifically, the established actors increasingly struggled to constrain the proposed fundamental changes by introducing incremental reforms, facilitating strong self-reinforcing feedback dynamics that steered the arrangement in the direction of its original

position. Consequently, by 2018, the innovative activities and the broad counter-discourse were confined to the dimensions of the original arrangement.

4.4.3.1 *'The sandboxes are dead' while the circular economy-trend gains in influence*

From 2014 onwards, the innovators struggled to guarantee the survival of the sandboxes but their relational power to do so gradually diminished as the established actors had used their dispositional power to institutionalise the ERF. More precisely, no more space was available to act differently in the sandboxes: 'the group of freethinkers was more and more restricted by the managers and money, risk, legislation and business […], which may constrain innovation and novelty' (Interview 1). Additionally, another interviewee observes, 'the sandboxes are dead […] only six regional water authorities are still part of it and we have not met in the past 18 months' (Interview 15).

Nonetheless, the three long-term trends remained important (see 4.4.2.1). For example, the bad reputation of the regional water authorities remained an important trend, influencing the development of new activities, while the European debt crisis also pressurised the established actors to develop cost efficient solutions. The broader developments of climate change, circular economy and sustainable energy increased in relevance: in 2015, the European Commission published its Circular Economy Action Plan and, one year later, the Dutch government launched the programme A Circular Economy in the Netherlands by 2050, increasing the popularity of the circular economy. As we will discuss, the established actors in particular mobilised these trends as a source of structural power to develop a watered-down circular economy-discourse.

4.4.3.2 *Efficiency and a watered-down circular economy-discourse reinforce the arrangement*

The pressure arising from the innovators in the first phase led the established actors to use power to steer the new activities and broad counter-discourse of the innovators in the direction of the existing large-scale technology, established coalitions, dominant rules and discourses (see Table 5 for activities 2014–2018). More precisely, the CWE (treatment governors) used its position to raise questions on the (cost) efficiency of the innovators' sandboxes: 'Can you develop a realistic business case? […] How do you create a domestic market for struvite? And what is the timeline?' (2013, p. 2). The Transition Programme of the newly institutionalised ERF also stated: 'the sandboxes are not open-ended' (ERF, 2014, p. 27).

Furthermore, off-the-record, the ERF was frequently conceptualised as a 'talking shop'. The established actors thus used their strong position within the arrangement to frame the sandboxes and the ERF as neither effective nor cost efficient, indicating the use of dispositional power.

According to these established actors, the ERF had to manage its so-called problem of 'optimisation'. Specifically, the CWE requested the VvZB (treatment managers) to solve this problem: the ERF and Aquaminerals employed a business developer in 2016 and a consultancy company (Twynstra Gudde) conducted a study on the Organisational Options for the Optimisation of the ERF. The study discussed three limitations for optimising the ERF: the limited knowledge of business development, the low financial capacity and the absence of a shared vision on the governance of the ERF. Thus, the CWE asked the VvZB and STOWA to explore opportunities for business development. A report called the Top 5 of Resources was provided in 2017 by another consultancy company, which discussed the business cases of five resources (phosphorus, cellulose, bioplastics, alginate-like polymers and biomass)[6] and described the (five 'frontrunner groups' of) regional water authorities that wanted to collaborate on a particular resource. The CWE and VvZB generally agreed with this proposal, which marked the start of the ERF 2.0-trajectory.

Following the Top 5 of Resources report, the ERF 2.0-trajectory implied that frontrunner groups were established in the ERF, and each group comprised at least one treatment manager (from the VvZB) and the business developer of the ERF or a staff member of Aquaminerals. In line with the Twynstra Gudde study, this indicated that the problem concerning business case development was considered solved because Aquaminerals and the ERF's new business developer provided new knowledge. The governance problem was also perceived as solved because a manager could now enter contracts with firms. The limited financial capacity of the country-wide ERF was more challenging for the autonomous, regional water authorities and was postponed until 2019.

[6] Energy recovery is not discussed 'because a lot of regional water authorities are already working on that topic' (ERF, 2017a, p. 5).

Table 5: main activities 2014–2018

Year	Event(s)
2014	Establishment of the ERF, publication of the Transition Programme
2015	The ERF's problem of 'optimisation'
2016	Twynstra Gudde report: three limitations for optimising the ERF
2017	Top 5 of Resources report: five business cases and description of 'frontrunner groups'
2018	Start of the ERF 2.0-trajectory, including the frontrunner groups

In addition to using dispositional power in the ERF 2.0.-trajectory, the established actors also derived structural power from the circular economy-trend to shape a specific, watered-down discourse on the circular economy, which then replaced the innovators' broad counter-discourse. Elements of this new discourse can be found, for instance, in the ERF's Top 5 of Resources report subtitle, which is 'From Supply to Demand' and, correspondingly, the slogan is 'From a Technology Push towards a Market Pull', both indicating the necessity of business case development and cost efficiency. In this context, an interviewee also says: 'regarding energy recovery, the driver is money because less sludge implies less dewatering, transport and energy, and more money [...] and, similarly, I think that resource recovery is framed as green as well' (Interview 9). Furthermore, biogas and the Top 5 of Resources can be recovered by optimising the established, centralised, large-scale infrastructure. As the new circular economy-discourse revolves around cost efficiency and the large infrastructure and is said to complement the older discourse of 'dry feet', sufficient water and clean water, it is largely in line with the original policy arrangement, indicating incremental changes.

Summarising the second phase, in reacting to the challenging activities and pressures of the innovators, the established actors increasingly struggled to strengthen the original policy arrangement, which facilitated self-reinforcing feedback dynamics.

They acquired this by mobilising the three trends and by using their strong position, particularly to support the original arrangement with incremental reforms: optimising the large-scale technology to recover the Top 5 of Resources, retaining cost efficiency by developing business cases, creating a watered-down discourse

that complements the older discourse and limiting the financial capacity of the Energy & Resource Factory. Thus, the innovators' attempts to fundamentally change the arrangement were replaced by incremental reforms, indicating a shift from self-undermining dynamics in the first phase, towards strong self-reinforcing feedback dynamics in the second phase.

4.4.4 The Dutch wastewater policy arrangement in 2018

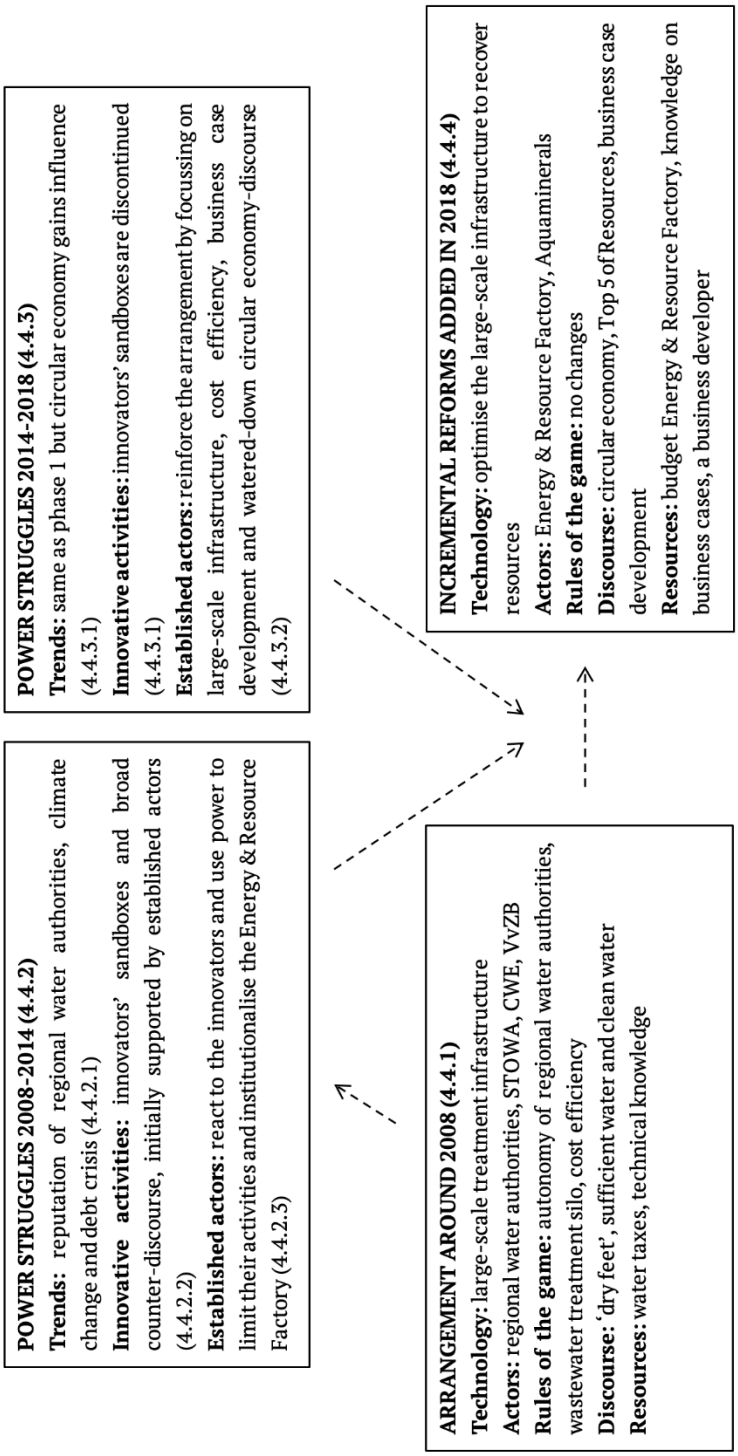
In the previous sections, we showed how the original Dutch wastewater policy arrangement of around the year 2008 influenced the power struggles of actors, which then first generated self-undermining dynamics in the first phase and, subsequently, self-reinforcing processes in the second phase. Therefore, we can also detect the changes that have occurred in the arrangement by comparing the technology, actors, rules, discourses and resources of the original arrangement with the same dimensions in 2018.

The large-scale treatment infrastructure remains in place and the Top 5 Resources selected can be recovered by optimising this technology. This is being gradually realised as approximately 20 out of 314 plants are experimenting with the recovery of cellulose and phosphorus. Although the Energy & Resource Factory (and Aquaminerals) is a new actor, the established actors such as the regional water authorities, their research institute (STOWA), Committee on Wastewater Treatment (CWE) and the Association of Treatment Managers (VvZB) clearly retain a dominant role. Similarly, the rules of the game have not changed: the autonomy of the 21 regional water authorities continues to be important, the silos are still intact and the rule of cost efficiency prevails. As discussed, the new, watered-down circular economy-discourse is said to complement the dominant discourse on 'dry feet', sufficient water and clean water. In line with the other dimensions, the resources have remained stable but the budget of the Energy & Resource Factory, knowledge on business development and the employment of the business developer indicate small changes. The general finding is that the arrangement has changed only incrementally.

Figure 7 summarises the empirical analysis. It displays the five dimensions of the original policy arrangement of around 2008 (4.4.1) and, along these five dimensions, the incremental reforms added to the arrangement by 2018 (4.4.4). Instead of fundamental policy change, incremental reforms resulted from the power struggles between 2008-2014 (4.4.2), facilitating moderately strong self-undermining feedback that quickly shifted to self-reinforcing feedback dynamics,

as well as from the power struggles between 2014-2018 (4.4.3), generating even more self-reinforcing feedback that steered the arrangement in the direction of its original position. In Section 4.5, we explore these observations, further focussing on the power struggles of actors in policy feedback processes.

Figure 7: schematic summary of the empirical analysis



4.5 Discussion

Section 4.4 described how the Dutch wastewater policy arrangement influenced the power struggles of actors from 2008 onwards and how the original arrangement then changed only incrementally by 2018. By using the specificities of this empirical analysis, in this section, we explore the research questions about how actors use power in policy feedback processes, resulting in incremental instead of fundamental policy change. Four steps are taken: (1) we interpret the results using Weaver's (2010) patterns of policy regime change and also discuss powerful actors and the availability of incremental reforms; (2) we subsequently argue that feedback processes are not a given but require ongoing struggles of political actors; (3) we turn to the interpretation and use of (long-term) feedback processes; and, (4) finally, we provide lessons for practitioners.

First, we showed that the balance between self-undermining and self-reinforcing feedbacks quickly shifted towards self-reinforcing dynamics, resulting in incremental instead of fundamental policy change. In the first phase of struggles, the long-term trends and innovative activities led to multiple options for fundamental policy change. However, as soon as the political pressure increased, this self-undermining feedback was immediately balanced with early, moderately strong self-reinforcing feedback. From this moment onwards, this self-reinforcing feedback only increased, steering the arrangement in the direction of its original position in the second phase. From Weaver's (2010) perspective on patterns of policy regime change, the first phase resembles the 'paths and forks' pattern because alternative policy opportunities emerged but these were largely determined by and developed within the original arrangement. Focussing on the second phase shows that the self-reinforcing effects were clearly delayed and initially permitted some choices for fundamental change (i.e. forks in the path) in the first phase but then, in the second phase, quickly forced a reversal in the direction of the original arrangement, corresponding to the 'boomerang pattern'. Although self-undermining feedback may emerge again over time, Weaver suggests that the occurrence of policy change is also dependent on powerful actors that may block alternative options as well as on the availability of reforms to incrementally change the original arrangement, which we discuss in sequence.

Concerning powerful actors, the analysis illustrates that the power of the established actors was crucial in the boomerang pattern and in maintaining the original policy arrangement, particularly because the balance quickly shifted back

towards self-reinforcing feedback dynamics. Specifically, although the established actors partly facilitated the first phase's self-undermining dynamics, they also used (dispositional) power as soon as these dynamics led to fundamental challenges for the established technology, hierarchies and rules. Not surprisingly, the established actors increasingly used power in the second phase to support the arrangement's infrastructure, discourses and resources, facilitating strong self-reinforcing feedback dynamics. Regarding the availability of incremental reforms, the analysis indicates that the availability of these reforms was influential in the shift from the paths and forks towards the boomerang pattern. Among the incremental reforms are: the regional water authorities' Top 5 of Resources report that only describes resources that can be recovered in the existing, large-scale wastewater treatment plants; the institutionalisation of the Energy & Resource Factory which means that the established coalitions took control over the innovators; along the lines of the rule of cost efficiency, the increased focus on business case development; the construction of a watered-down circular economy-discourse that complements the dominant discourse; and the limited amounts of financial resources that are transferred to the country-wide Energy & Resource Factory by the 21 autonomous, regional water authorities. Hence, from the end of the first phase onwards, the balance shifted towards self-reinforcing dynamics through a range of incremental adjustments to the original policy arrangement, helping to manage the self-undermining dynamics that resulted from the proposals for fundamental policy change in the first phase. Our findings thus confirm that self-undermining feedback dynamics do not automatically lead to change (Béland & Schlager, 2019; Jacobs & Weaver, 2015; Weaver, 2010), particularly when powerful actors impede fundamental changes in a policy arrangement and when these actors have incremental reforms at hand, both requiring more attention in policy feedback research.

Second, based on our findings regarding powerful actors and the availability of incremental reforms in feedback processes, the results also emphasise that self-reinforcing feedback is not a given but requires ongoing struggles from powerful actors. For instance, as soon as the self-undermining dynamics fundamentally challenged the policy arrangement's technology, hierarchies and rules, the established actors started struggling to constrain the innovative activities to the dimensions of the arrangement. Consequently, from the end of the first phase onwards, they intentionally reinforced the original policy arrangement by supporting it with incremental reforms. This highlights that the ongoing struggles

of powerful actors are important in supporting self-reinforcing feedback dynamics, particularly they continuously made political choices that sustained established policies. This finding supports recent recommendations to address the actors and agency in policy feedback research (Béland et al., 2019; Sewerin et al., 2020) and the totalising descriptions of path-dependency and lock-in (Buschmann & Oels, 2019; Garud, Kumaraswamy, & Karnøe, 2010; Klitkou et al., 2015).

Third, although the empirical analysis emphasises incremental reforms and the continuous efforts of powerful actors in facilitating self-reinforcing feedback dynamics to maintain the original arrangement, it also shows that innovative actors may interpret policy consequences to use feedback as a resource to propose fundamental policy change, supporting self-undermining feedback. This becomes particularly clear in the first phase of power struggles, in which the interpretations of the three long-term trends by the established actors and innovators facilitated policy undermining dynamics. The activities of the innovators are of particular interest here: they first derived structural power from the three long-term trends and then used relational power to act differently by introducing alternative technologies, coalitions and discourses, undermining the arrangement. Here our analysis indicates that the manners in which policy consequences are constructed as self-undermining feedback require more attention (Dagan & Teles, 2015; Moore & Jordan, 2020). It also makes so-called exogenous factors (i.e. long-term trends) more endogenous, particularly by demonstrating that actors draw on long-term feedback loops such as sustainability trends or macroeconomic processes (Schmid et al., 2019). However, as mentioned, these change-inducing power struggles were quickly constrained by the established actors from the end of the first phase onwards, suggesting that when the interpretations of policy consequences are not anchored in shared understandings and institutions, innovators face powerful actors, rules and discourses (Dagan & Teles, 2015; Jacobs & Weaver, 2015). Generally, our findings also confirm that the power framework and policy arrangement approach we applied are useful tools for understanding the power struggles of actors in policy feedback processes.

Finally, for practitioners involved in enabling a circular economy, the analysis emphasises the importance of power struggles in circular economy-processes, which are often neglected in a field dominated by technological and economic knowledge (Bauwens et al., 2020; Calisto Friant et al., 2020b; Hobson, 2020). Specifically, it illustrates that the innovators' struggles to introduce a circular

economy faced resistance from established actors. Thus, these actors supported the established technology, rules and discourses with incremental changes, resulting in a largely stable policy instead of a fundamental shift towards circularity (further confirmed by Fitch-Roy, Benson, & Monciardini (2019) and Simoens & Leipold (2021), among others). Hence, we presented a different way of understanding the potential beginnings of a circular economy (Zwiers, Jaeger-Erben, & Hofmann, 2020), which may be used by practitioners in learning processes on a circular economy.

4.6 Conclusion and future research

As environmental problems are usually not tackled with path-departing green policies but rather with incremental adjustments, this study attempted to explore incremental change by analysing the power struggles of actors in policy feedback processes. To do so, we applied an established power perspective and the policy arrangement approach to a case study of the reorientation towards a circular economy in the Dutch wastewater policy arrangement between 2008–2018, which led to incremental instead of fundamental policy change. The results showed that self-undermining feedback was generated from 2008 onwards but that the balance almost immediately shifted back to self-reinforcing feedback. This resembles a shift from the paths and forks towards the boomerang pattern of policy change, indicating that the power struggles of the actors involved led to incremental reforms in the arrangement. The study clarified these patterns by concentrating on powerful actors that may impede change through the use of incremental reforms, the ongoing struggles of these actors in facilitating self-reinforcing feedback and the interpretation of the consequences of policies to use feedback as a resource. Taken together, the study's analysis of the power struggles of actors in policy feedback processes contributes to a more nuanced understanding of incremental change. Thus, we paved the path for investigating broader questions regarding 'the agency of actors, existing policy legacies and, institutional change' (Béland, 2010, p. 583) in policy feedback processes. We also provided a different way of knowing the potential beginnings of a circular economy by emphasising power struggles.

There are at least three promising avenues for future research. First, as we draw lessons from a single-case study, future research could 'transfer' our findings to other settings (Schwartz-Shea, 2006) by, for instance, investigating power struggles in policy feedback processes related to a specific policy instrument or policy mix

instead of a policy arrangement or regime, by focussing on interpretive or resource feedback effects, by analysing other sectors or policy fields, by applying different analytical frameworks, and by further exploring how, why, when and to what extent shifts from self-undermining (e.g. proposals for fundamental change) to self-reinforcing feedback (e.g. incremental reforms) occur in environmental politics. Second, we added technology to the dimensions of a policy arrangement but did not systematically analyse the materiality of technology throughout the study. It may be worthwhile to focus exclusively on technology in policy (feedback) processes, particularly by involving other research fields (e.g. Geels, 2020; Kotilainen et al., 2019; Schmidt & Sewerin, 2017). Finally, further delving into the agency of established actors is particularly important; in investigating the what, how and why of the power struggles in our analysis, why certain actors acted in specific manners was specifically intriguing and fruitful for understanding the case.

Chapter 5: *Incumbents' enabling role in niche-innovation: power dynamics in a wastewater project*

Abstract
More pluralised understandings of incumbencies are often overlooked in transitions research, which may lead to underestimating the enabling roles of incumbents in niche projects. This study explores these roles by applying a power framework to five struggles revolving around a path-breaking decentralised wastewater treatment project in the city of Ghent (Belgium). Remarkably, incumbents from multiple regimes use power to enable the niche project. The study identifies and discusses four patterns in the enabling role of incumbents in niche projects. These patterns are clarified by focussing on incumbents from multiple regimes, belonging to local authorities, neighbouring and more distant regimes, as well as on the power of structural trends related to the urgency of sustainability challenges. As such, the study contributes to the understanding of multiple incumbencies and the conditions under which these may reinforce niche projects. For practitioners, the study underscores the role of power dynamics in the water/wastewater sector.

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5.1 Introduction

Persistent environmental problems result from long-term, complex, unsustainable consumption and production patterns and require fundamental change in socio-technical systems that provide, for example, energy, food, transportation and water (Köhler et al., 2019). So far, progress has been rather limited in achieving long-term sustainability objectives (EEA, 2019a; UN Environment, 2019) because of vested interests and path-dependencies of existing infrastructure and current political-economic institutions. Here sustainability transitions research has shown how established actors or incumbents and their practices resist, delay or prevent transitions (Geels, 2014; Hess, 2014; Klitkou et al., 2015; Smink et al., 2015; Wells & Nieuwenhuis, 2012). Within a given regime, incumbents 'often have vested interests in maintaining the status quo rather than enabling transitions and will often act to strategically protect their privileged position' (Johnstone, Stirling, & Sovacool, 2017, p. 148) and they 'tend to be powerful, materially resourceful, politically influential, societally authoritative, strategically conservative and risk-averse' (Sovacool, Turnheim, Martiskainen, Brown, & Kivimaa, 2020, p. 3). Yet incumbents are also increasingly being recognised as important in accelerating transitions because of their dynamic capabilities (Stalmokaitė & Hassler, 2020), radical technology strategies (Berggren, Magnusson, & Sushandoyo, 2015) and ability and interest to mobilise resources (Hansen & Coenen, 2017). Given the urgency of addressing the different global challenges, including the development of strategies that 'build back better' after Covid-19, the involvement of incumbent actors could accelerate transitions towards more sustainable societies. In this context, Turnheim and Sovacool (2020) call attention to the diversity of incumbent actors and strategies, the transient nature of strategic positioning and the varied resources incumbents may mobilise. They propose to investigate 'how more pluralised understandings of incumbencies can lead to novel insights' (p. 183).

A number of scholars of sustainability transitions have similarly sought to overcome the typical interpretation of a monolithic and single regime that consists of resistant incumbents who have to be overthrown by radical niches. At least four different approaches can be distinguished to understand incumbents' roles. Some research has directed attention to the role of multiple regimes and systems. For instance, it has been shown that multi-regime dynamics can be induced by radical innovations that cross traditional regime boundaries (Konrad, Truffer, & Voß, 2008; Raven & Verbong, 2007) and that transformative change may also emerge from multi-system interactions (Papachristos, Sofianos, & Adamides, 2013;

Rosenbloom, 2020). Some scholars provide insights into the positive role that incumbent firms may play in radical innovation: they may overcome their limited interest in, and limited ability to mobilise resources for, new technologies (Hansen & Coenen, 2017) and, accordingly, may pursue radical and incremental innovation strategies (Berggren et al., 2015; Penna & Geels, 2015; Stalmokaitė & Hassler, 2020; Steen & Weaver, 2017). Along these lines, other scholars examine regime-to-niche activities in addition to niche-to-regime activities. Such a symmetrical perspective may uncover new mechanisms on the roles of incumbents in niches (Mylan, Morris, Beech, & Geels, 2019; Turnheim & Geels, 2019). Still other scholars, finally, emphasise the role of incumbents' power in niche-innovation. Niche organisations may form coalitions with political parties, mobilise social movements and gain support from industrial, incumbent firms with countervailing power to overcome the regime organisations' power (Hess, 2016). Dominant institutions and incumbent rules shape niche actors' room for manoeuvre (Kern, Verhees, Raven, & Smith, 2015) but local niche-initiatives may also take advantage of governance dynamics to reconfigure these institutions and rules (Barnes, Durrant, Kern, & MacKerron, 2018). Although the four approaches point to a nuanced and dynamic understanding of regimes and incumbents, more research is needed to elucidate precisely how incumbents use power to enable or restrict niche projects.

This study delves deeper into these discussions by using an existing framework on power dynamics in transitions (Avelino, 2017; Grin, 2010). A focus on power is appropriate because questions of how new socio-technical configurations replace dominant configurations involve political conflicts (Meadowcroft, 2011; Shove & Walker, 2007). Power analyses also concentrate on the politics underlying spaces of innovation, envisioned futures and actor roles in transitions (Avelino et al., 2016). Moreover, niche research acknowledges that the policy and financial support in constructing and mainstreaming protective space takes place within 'powerful incumbent regimes' (Smith & Raven, 2012). By analysing power dynamics, we thus aim to generate new insights about incumbents' power in niche projects.

Against this backdrop, we selected a niche project in which multiple incumbent actors are involved for a case study: a wastewater treatment project called DuCoop in the city of Ghent (Belgium). The wastewater regime is generally characterised by lock-in mechanisms induced by centralised large-scale infrastructure and cost-efficiency (Ampe et al., 2019; Fuenfschilling & Binz, 2018; Kiparsky et al., 2016) but DuCoop succeeded in realising a path-breaking decentralised system. It treats the

wastewater of 400 households and recovers process water, energy and nutrients. In theory and given time, combinations of pioneering projects like DuCoop may disrupt the water/wastewater regime and give shape to fundamental transitions. When a project such as DuCoop addresses pressing challenges such as water, energy and resource recovery (Kisser et al., 2020; Larsen et al., 2013), it is typically confronted with deeply embedded infrastructures, actors and rules in the wastewater sector (Hoffmann et al., 2020; Pakizer & Lieberherr, 2018). Interestingly, for our study of the role of incumbents, we observed that multiple actors such as real estate companies, a financial institution and the municipality, which do not dominate nor belong to the wastewater regime, played a crucial role in the realisation of this innovative project.

Accordingly, the research question put forward in this chapter is how incumbents use power to enable or restrict DuCoop's radical innovation. The chapter contributes to research on niche-innovation by generating novel insights about the enabling role incumbents may play in niche projects. It also empirically grounds niche-innovation with a case outside of the well-investigated energy domain (Raven et al., 2016) and thematic focus of current transitions research (i.e. energy, mobility and agro-food systems; Kanger, 2020). For practitioners in the water/wastewater system, it highlights the role of power dynamics.

The chapter unfolds as follows: section 5.2 introduces the role and power of incumbents in transitions and niche-innovation. Section 5.3 details the analytical framework and research techniques. Section 5.4 presents the case and section 5.5 the empirical analysis. In section 5.6, we discuss the analysis and section 5.7 concludes the chapter.

5.2 The power of incumbents in niche-innovation

Here the conventional understanding of the multi-level perspective, transitions and niches are first reiterated. Next, we concentrate on four – often interwoven – research streams that are associated with how incumbents may use power in niche-innovation , namely multiple regimes, incumbent firms, regime-to-niche activities and incumbents' power in niche-regime struggles. These topics are explored in the next sections by using an established framework on power dynamics.

The multi-level perspective conceptualises transitions by distinguishing between three socio-technical levels of structuration: landscape, regime and niche. The landscape comprises the slowly changing context and shocks. The regime is the locus of dominant practices and the associated technology, actors and rules that stabilise existing systems, whereas a niche is a space that protects an alternative socio-technical configuration from the regime (van den Bergh et al., 2011; Geels, 2011). The interplay between the processes functioning at the three levels may lead to a fundamental transition: a long-term, multi-dimensional process of change through which an established socio-technical regime shifts to more sustainable modes of consumption and production (Markard et al., 2012). According to research on sustainability transitions, new pathways to regime change usually emerge out of sequences of projects and niches. Early work conceived learning, networking and visioning as the drivers of successful niche development. Later on, the role of the regime came into focus as an essential factor for niche development (Schot & Geels, 2008). Some contributions then scrutinised the 'translations' (Smith, 2007), technological, network and institutional 'anchoring' (Elzen, van Mierlo, & Leeuwis, 2012) and 'adaptive linkage processes' (Ingram, 2015) between niches and regimes. In addition, Smith & Raven (2012) asked 'what is protective space' and identified three properties of niche protection: shielding (holding off selection pressures), nurturing (learning, networking and visioning) and empowerment. The latter concentrates on how innovations escape protective spaces; by making the niche competitive with the regime or by changing the regime in ways favourable to the niche.

Recently, however, transition scholars have provided more nuanced interpretations of transitions, diverging from the conventional understanding of radical niches that overthrow resistant incumbents who belong to a single and monolithic regime. We distinguish four different approaches to understanding incumbents' roles. First, some scholars have directed attention to multiple regimes and systems. For instance, it was found that interactions such as competition, symbiosis, integration and spill over between the electricity and the gas regime were important in the diffusion of combined heat and power (Raven & Verbong, 2007). Likewise, functional (e.g. shared value chains) and structural (e.g. shared infrastructure and institutions) couplings exist between multiple utility regimes and transformations may thus cross and affect established regime-boundaries (Konrad et al., 2008). The reinforcing interactions between two or more socio-technical systems may further lead to niche emergence outside of these systems and, subsequently, a system

emergence transition pathway (Papachristos et al., 2013). As sustainability challenges stretch beyond individual systems, a multi-system perspective was also proposed to capture the diverse, layered and evolving interactions between systems (Rosenbloom, 2020). These contributions thus highlight the importance of looking beyond single regimes and systems because multiple regimes may influence niche-innovation and vice versa.

Second, other scholars have provided insights into the potentially positive role of incumbent firms in radical innovation. By analysing the intense competition between incumbent firms as a result of new technological options, it was shown that the capabilities of firms to absorb and integrate radical technologies are frequently underestimated (Bergek, Berggren, Magnusson, & Hobday, 2013). In similar fashion, the technology strategies of established firms in the heavy vehicle sector are more radical than previously assumed and may consist of multiple technological paths at niche and regime levels (Berggren et al., 2015). An in-depth qualitative analysis of incumbent shipping firms in the Baltic sea region further shows that, depending on socio-political and customer pressures as well as firms' ambitions and capabilities, incumbents experiment with radical and incremental innovation in their gradual reorientation towards decarbonisation (Stalmokaitė & Hassler, 2020). Reacting to climate change and societal pressures, American automakers are also slowly developing competencies in multiple low-carbon technologies, although lock-ins and the possibility to invest in the wrong technology delay the industry's full reorientation (Penna & Geels, 2015). Similarly, external pressures and uncertainty about future developments lead Norwegian hydropower and oil and gas incumbents to proactively diversify their activities into various niche renewable sectors that offer new value creation opportunities (Steen & Weaver, 2017). In addition to these firms pursuing radical innovation, it was also found that incumbent firms' limited ability to mobilise resources for and limited interest in new technologies may be overcome by establishing new divisions within the firm, promoting internal use, providing certainty for new markets and investing in new managerial competencies (Hansen & Coenen, 2017). Finally, by reviewing five organisation theories, four typical modes of behaviour of incumbent firms during transitions are proposed: incumbent firms are the first to 'enter' niches; wait for other actors and then follow into niches; remain inert; and employ strategies to slow down transitions (van Mossel, van Rijnsoever, & Hekkert, 2018). These findings demonstrate that incumbent firms may play a positive role in transitions, in addition to their well-investigated roles in delaying and resisting transitions.

Third, still other scholars propose a so-called symmetrical approach to analyse niches in order to pay attention to the role of incumbents in niche-innovation (Geels, 2018; Mylan et al., 2019; Turnheim & Geels, 2019). Such a proposal may be due to how they observed a niche-to-regime perspective on change in research on niches (e.g. Diaz, Darnhofer, Darrot, & Beuret, 2013; Ingram, 2015; Raven et al., 2016; Smith & Raven, 2012; Verhees, Raven, Veraart, Smith, & Kern, 2013), which downplays regime-to-niche activities and leads to overlooking the roles played by incumbents in niches. Accordingly, the 'diachronic and systemic focus' of the multi-level perspective has been applied to observe how established actors are enrolled in niche networks and practices to increase their impact. Findings indicate, for example, that these new interactions influence gradual reconfigurations in local agro-food policies (Bui, Cardona, Lamine, & Cerf, 2016). Other research shows how incumbents such as coffee shop chains and supermarkets were essential for mainstreaming non-dairy products. Due to their limited sunk investments in dairy production, these actors are less locked-in to the dairy-milk regime and can engage downwardly with plant-based milk innovations (Mylan et al., 2019). In the auto-mobility regime, the positive role of incumbents characterises the developments of the French modern tramways niche, which was facilitated by actors from 'neighbouring regimes' such as railways and urban planning (Turnheim & Geels, 2019). These examples illustrate the relevance of symmetrical analyses that focus on niche-to-regime and regime-to-niche activities, especially to uncover the roles that incumbents may play in niche-innovation.

Fourth, still other scholars pay attention to incumbents' power in niche-innovation by analysing niche-regime struggles, in which the focus is often on the restricting instead of the enabling use of power by incumbents. Concerning these struggles, empowerment research recognises narratives as a 'political strategy to argue for empowering institutional reforms' (p. 1031), particularly by developing positive expectations, arguing for reforms or competitiveness and challenging the regime (Smith & Raven, 2012). Using this framework to investigate solar photovoltaic technology from 1920 to 2010, Verhees et al. (2013) have shown that the struggles of niche-advocates sometimes entangle with broader change processes in policy and socio-economic contexts. They suggest future research to pay attention to shorter periods 'where regimes and niches become intertwined' (p. 287). Furthermore, Kern and colleagues (2015) propose to examine more closely how the 'institutional (regime) context' shapes niches because their empowerment

framework mainly analyses niche actor-networks and narratives used to promote global niches.

In addition to empowerment researchers, other authors have also directed attention to incumbents' power in niche-regime struggles. A creative interplay between innovation and its context is observed in the struggles to reconfigure institutions in horticulture: novel practices bring networks of new and established actors together, who interpret and challenge routines to transform the prevailing interests, institutions and actors in which the novel practices are embedded (Hoffman & Loeber, 2016). Likewise, local institutions are reconfigured more successfully when sustainability initiatives take advantage of changes in the urban context (e.g. governance dynamics) and when their actor-network mediates between the novelty and established arrangements (Barnes et al., 2018). In niche-regime conflicts over solar energy, Hess (2016) found that niche organisations partially overcome the regime organisations' power by forming coalitions with political parties and social movements as well as by countervailing power of companies who have invested in the niche. Nonetheless, the multi-dimensional discursive approach not only shows struggle taking place between the narratives of niche-advocates and opponents but also indicates that incumbents may adopt different positions to niches over time (Rosenbloom et al., 2016). What is more, most of these findings point to niche-regime struggles and regime resistance but do not elucidate precisely how incumbents may use power to enable niche-innovation.

When taken together, the above contributions of four different research streams give us an idea of incumbents' roles in niche projects: incumbents, particularly firms, belonging to multiple regimes may use power to enable niche-innovation. However, more research is required to elucidate exactly how incumbents use power to enable or restrict niche projects. As such, section 5.3 elaborates on an existing framework on power dynamics and our research techniques to explore these themes.

5.3 Methodology

5.3.1 Analytical framework

This section elaborates on an existing framework to explore the power of incumbents in niche projects. A focus on power is appropriate as political analyses of transitions frequently concentrate on the dynamics between dominant and new socio-technical configurations (Avelino et al., 2016; Meadowcroft, 2011). Research on niches also confirms the role of power as niches aim at changing regimes: innovative projects require hard work to resist the normalising power of the regime (Bos & Grin, 2008). Further, empowerment processes take place 'within the context of a historically privileged regime, which holds the authority to arbitrate and the power to provide protective support' (Smith & Raven, 2012, p. 1032).

Several approaches are being developed to scrutinise the politics of transitions. These concentrate on: the interplay of discourses, institutional contexts and interests in influencing policy initiatives (Kern, 2011); Lukes' instrumental, structural and discursive power dimensions to examine decentralised energy transitions (Brisbois, 2019); Gramscian concepts such as hegemony to analyse regime resistance (Geels, 2014); the interaction between ideas, interests, institutions and infrastructure in shaping pathways to sustainability (Rosenbloom, 2018); and, to explain gridlock, agency's 'power with' and 'power to' in addition to environmental politics' focus on 'power over' (Partzsch, 2017). However, as we want to use the framework as a tool to explore how incumbents use power to enable or restrict radical innovation, we draw from an established power framework from Grin (2010, 2012) and Avelino (2011, 2017) that builds on three manifestations of power which are generally distinguished in the literature on power (Arts & van Tatenhove, 2004). The framework is, to our knowledge, one of the only power frameworks related to sustainability transitions' research that has been thoroughly discussed, adapted and applied (Hoffman, 2013; Köhler et al., 2019; Kok et al., 2021; Liefferink, 2006; Omukuti, 2020; Paredis, 2013; Ramírez-Monsalve & van Tatenhove, 2020). Furthermore, both Grin and Avelino elaborate on the struggles between established and new socio-technical configurations in transitions, which will help us to generate insights into the power of incumbents in niche projects.

Grin (2010) connects the three levels of the multi-level perspective to three layers of power of a framework developed by Arts & van Tatenhove (2004), who define power as 'the organisational and discursive capacity of agencies, either in competition with one another or jointly, to achieve outcomes in social practices, a

capacity which is however co-determined by the structural power of those social institutions in which these agencies are embedded' (p. 347).

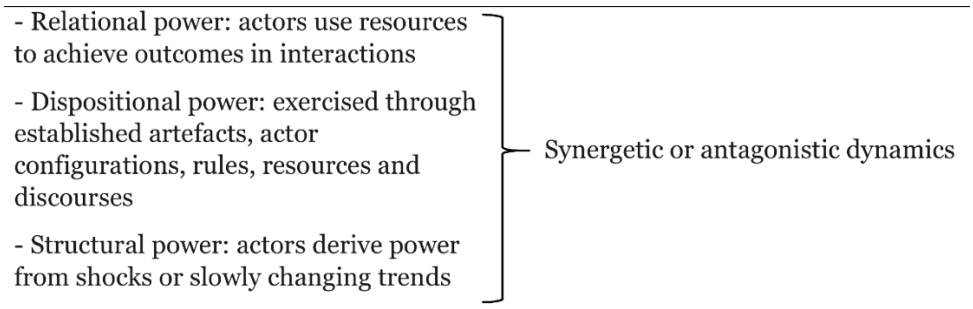
Drawing from Grin (2010, 2012) and Arts & van Tatenhove (2004), relational power is the capacity of agents to achieve outcomes in day-to-day interactions. Actors may be creative and do things differently by naming and framing certain problems as well as by mobilising resources such as knowledge, tactics, persuasion, money and personnel to formulate and realise their most desirable outcomes. Nonetheless, avoiding a voluntarist approach, Arts & van Tatenhove note that human action is highly routinised and that the capacity of agents is co-determined by dominant practices and the associated rules of the game, resources and discourses. Correspondingly, dispositional power is the power that derives from the position that actors occupy in a specific situation (e.g. in an organisation or a system). This process of positioning is mediated by actor configurations, the rules of the game (e.g. norms and routines as well as legislation and guidelines), resources, discourses and, following Hoffman (2013), artefacts such as technology and infrastructure. As such, because of their position, some actors are better able than others to make use of the resources available, they can more easily use rules to achieve an outcome and they have more legitimacy when drawing on a particular discourse. Mediating dispositional power, established artefacts, actors, rules, resources and discourses thus position practices in a specific manner: existing practices will be privileged, whereas novel practices may be confronted with resistance and stability. Yet pressures induced by novel practices and slowly changing trends may affect this process of positioning which, for example, leads new actors to challenge certain rules to enable innovative practices (Grin, 2012). Accordingly, structural power is derived from shocks and slowly changing trends such as increasing environmental concerns and macroeconomic processes. Although these trends are beyond the direct influence of the actors involved, they may be interpreted and mobilised by such actors. Hence, the dynamics between these three layers of power will then influence change or stability in socio-technical systems.

Avelino (2011, 2017) criticised this framework. Grin's contribution suggests a vertical power typology by connecting the three layers of power to the levels of the multi-level perspective, privileging the regime's dispositional power (structure) over the niche's relational power (agency) and thus stability over change. Avelino, on the other hand, proposes a more horizontal typology. The agency for change and particularly the power exercised by human actors is placed at the forefront. Niches

and regimes are then 'spaces' in which actors may exercise different types of power to enable and restrict any other type of power exercise. However, Avelino notes that a regime is the exercise of power by a group of actors to reproduce established institutions. If the dynamics between different types of power enable each other, they are synergetic, and if they prevent one another, they are antagonistic.

In our analysis, we apply Grin's three types of power but we use Avelino's contribution to underscore that these three types of power are primarily exercised by human actors, can be combined and may enable (synergetic) and restrict (antagonistic) other types of power. We focus on how actors exercise relational, dispositional and structural power and on whether this leads to synergetic or antagonistic dynamics (see Figure 8). Hence, this framework may help to explore how incumbents use power to enable or restrict radical innovation.

Figure 8: power type exercised by actors and dynamics



5.3.2 Research process and techniques

In the process of selecting a case, choosing a conceptual and analytical approach, collecting empirical material, coding and analysing, we followed an abductive approach: 'an (often surprising) single case is interpreted from a hypothetic overarching pattern, which, if it were true, explains the case in question. […] During the process, the empirical area of application is successively developed, and the theory (the proposed over-arching pattern) is also adjusted and refined' (Alvesson & Sköldberg, 2009, p. 4). As such, we first heard about DuCoop's radical innovation in a presentation of a Dutch new sanitation expert called Grietje Zeeman in 2017 (e.g. Zeeman et al., 2008; Zeeman & Lettinga, 1999). Prior knowledge about the

wastewater sector and the politics of transitions as well as preliminary field observations helped to obtain a rough idea of dominant and alternative socio-technical configurations, and our interpretations were regularly adjusted by alternating between the different types of empirical material, literature and framework.

Between 2017 and 2019, we conducted thirteen (out of fifteen) interviews and we also joined events and a field trip. The interviewees were selected by purposive and snowball sampling (Weiss, 1995; Yin, 2016) and included different incumbents and local niche actors. The in-depth interviews took 70–130 minutes and began with personal histories and roles in DuCoop, after which we gradually focussed on the enabling and restricting factors in DuCoop's development. In doing so, we were guided by the perspective of the interviewees. The observed events were documented in field notes and dealt with DuCoop, decentral sanitation and resource recovery from wastewater. At this time, we also selected relevant (internal) documents and videos (see Appendix A of chapter 5 for a list of the empirical material).

By the second half of 2019 and before the coding process, we had identified approximately twelve struggles in which we observed incumbents from multiple regimes using power to enable or restrict DuCoop's innovation. Subsequently, the empirical material was codified into 1700 text fragments in the MAXQDA software, assembled into three broad categories: DuCoop's trajectory, political struggles and the elements of the analytical framework. Throughout this process, we observed that a number of the struggles were interlinked and, by March 2020, we narrowed the analysis to five struggles in which one or more incumbents, to a certain extent, helped to enable DuCoop's innovation. The empirical material and conceptual approach guided this selection process: we focussed on the struggles that frequently reoccurred in the material; decisive struggles for the success of DuCoop; and struggles that took place after the formal establishment of DuCoop in 2014 (see 5.4.2), as a range of incumbents were involved during this period. In our analysis in section 5.5, we thus present five struggles revolving around DuCoop and centring around one or more incumbents whose power played a crucial role in enabling DuCoop's radical innovation.

In the first half of 2020, two more interviews were conducted in which saturation in responses started to appear. We then stopped gathering empirical material and asked the interviewees to give feedback on the manuscript.

5.4 Introduction to the case

This section introduces the case by describing Belgium's locked-in wastewater regime and DuCoop's pioneering project. It shows how DuCoop differs from the regime and presents the setting of, and the actors involved in, the five struggles analysed in section 5.5.

5.4.1 The Belgian wastewater regime

The dominant Belgian wastewater treatment technology is characterised by an extensive sewerage network that transports diluted wastewater and urban runoff to large-scale treatment plants. After treatment, the water is discharged to surface water, which is frequently used as influent for drinking-water production by drinking water utilities. The regional sewers and treatment plants are managed by the Flemish wastewater treatment company (Aquafin), whereas the Flemish Environment Agency oversees its economic and environmental performance. Municipalities are responsible for local sewers and the transport of wastewater on their territory. In Ghent, this responsibility is outsourced to the public-private drinking water utility (Farys).

The formal rules state that the disposal of domestic wastewater to the treatment system is obligatory. This mandatory-connection rule is related to the regime's financial means: the water bill of municipalities' drinking water utilities consists of local and regional treatment taxes, which are transferred to the municipality and Aquafin, respectively. The regional tax comprises 75% of Aquafin's budget, whereas 25% is subsidised by the region (Flanders).

Belgium's wastewater regime is further characterised by end-of-pipe management, which comes with a flush-and-forget culture. The regime is focussed on clean waterways, which is a target that is being achieved by tightening the criteria for treated wastewater and by expanding the connection rate of households to the wastewater infrastructure (as only 86% of the households is connected to sewers in Flanders, whereas this rate is, for instance, 99% in the Netherlands). Moreover, Aquafin's annual reports and R&D department recently started to cover the circular economy and resource recovery from wastewater.

5.4.2 Niche project: DuCoop

DuCoop is a cooperative company that combines path-breaking innovations in wastewater treatment, heat and water recovery, urban agriculture and shared car parks to realise the first 'circular neighbourhood' in Flanders (see Appendix B of chapter 5 for six pictures), which is done within a broader, ambitious urban development project at Ghent's outskirts. In contrast to the wastewater regime, DuCoop works with decentralised, small-scale treatment technology. It constructs pipes for black (excreta and organic food waste) and grey (showers, sinks and washing machines) water to separately treat the wastewater from 400 residential units and a school. The black water stream is highly concentrated: the vacuum toilets, installed by Roediger, only use approximately one litre of rainwater per flush and the residents' organic food waste is shredded to small particles before adding it to this stream. A fertiliser (struvite) and biogas (providing 1–2% of the heating demand) are recovered from this stream. Heat is recovered from the grey wastewater stream (providing one-third of the demand). An adjacent chemical plant (Christeyns) also recovers heat from their processes for DuCoop's residents (providing two-thirds of the demand), while using DuCoop's grey water as process water.

In 2011, the Municipal Development Agency (Sogent), that owned the land where DuCoop is located today, launched a call to develop a part of the neighbourhood of the urban development project. By scoring high on the call and particularly on the sustainability and financial components, a partnership between an investment fund (Clean Energy Innovative Projects) and three real estate companies (Revive, Van Roey and CAAAP), amongst others, won. In 2014, this led to the establishment of DuCoop. Revive and Clean Energy Innovative Projects are both associated with one of Belgium's most wealthy business families (Colruyt). In the subsequent years, a few other financiers joined DuCoop: investors related to the social economy (Trividend) and energy (EnerGent), two impact investors that are linked to Colruyt (Human Capital and OYA Seed) and the municipality's drinking water utility. In this complex construction, Clean Energy Innovative Projects' director serves as the manager of DuCoop. During DuCoop's development, the Flemish Environment Agency, the municipality and its solid waste company were involved as public actors, whereas the involved private actors are the adjacent chemical plant, engineering companies and a financial institution (Triodos).

In addition, DuCoop does not comply with the regime's mandatory-connection rule for domestic wastewater as it constructs local sewers and treatment technology. Consequently, the local and regional treatment taxes levied by the municipality's drinking water utility on the residents' water bill are directly transferred to DuCoop. The rest of the required financial means for the technological innovation came from Flanders, the EU, a financial institution and impact investors, whereas the real estate companies mainly financed the investments in the residential units. The European subsidies were also used to extend DuCoop's team with two engineers.

In comparison with the regime, DuCoop adds an extra layer to the focus on clean waterways and resource recovery. Specifically, it concentrates on end-user awareness by involving the residents in the cooperative company and it significantly outscored the sustainability criteria of the municipality in the Municipal Development Agency's call. Here DuCoop ties in with Ghent's ambition to become climate neutral by 2050, which is, amongst other things, reflected in Ghent being the first Belgian city to sign the Covenant of Mayors in 2009 and the new covenant in 2015. Furthermore, DuCoop draws inspiration from a prominent decentralised treatment system in Sneek (the Netherlands) that was constructed around 2005 and that is making waves in the international wastewater sector.

5.5 Empirical analysis of five struggles

The previous section described the context of the analysis and showed that the niche project (DuCoop) fundamentally deviates from the wastewater regime. We now use the power framework to explore how incumbents use power to enable or restrict DuCoop's innovation. We do so by analysing five struggles revolving around DuCoop and centring around one or more incumbents whose power played a crucial role in DuCoop' innovation by providing resources (5.5.1), providing a loan (5.5.2), installing specific technology (5.5.3) and circumventing established rules (5.5.4 and 5.5.5). In section 5.6, we discuss the analysis and the implications for practitioners.

5.5.1 'Traditional real estate companies' and risks

The first struggle focusses on the dynamics between the boards of 'traditional real estate companies' (Interview 9), belonging to the building regime, and a coalition between two innovators of those companies and DuCoop's team. The struggle is an example of how the power of innovators can lead to radical reorientation in incumbents' roles, providing resources such as money, personnel and know-how to

the project. From the start, the boards defined three 'risks' by using their position as funders of the project vis-à-vis the innovators (i.e. dispositional power). First, as the boards adhere to the motto 'euros per square meter', the sustainability considerations of the coalition were perceived as a risk and, accordingly, revoked by cost-efficiency. Moreover, the boards wanted to establish a competitive selling price, which does not reflect the high sustainability performance of the residential units. Second, questions were raised about the risky and delayed return on investment. The sector is used to supplying finance building by building. However, this project required them, for example, to supply finance for the neighbourhood's centralised car park and (a part of) the technologies ten years before selling the last units. Third, the boards voiced concerns about the technology, particularly about the noise produced by the vacuum toilets, explosion risk of the biogas-digester, chemicals used in the treatment process, release of odours and, as we will see in section 5.5.5, technological deficiencies. In Sneek, moreover, the residents were exposed to unpleasant odours, which is an argument the boards frequently used in these discussions (i.e. relational power). Hence, in defining three risks, the boards negatively influenced the coalition and their novel ideas. Such influence can be interpreted as antagonistic dynamics between the boards' dispositional and the innovators' relational power.

The coalition countered the first two risks (cost-efficiency and pre-financing) by convincing the boards (i.e. relational power) that most of the investment risks in the technology should be concentrated in DuCoop's cooperative company and, consequently, the real estate companies mostly had to invest in the residential units. The latter allowed the companies to offer competitive prices to their customers and to 'stick to the script: buy, develop, build and sell' (Interview 13). The coalition further persuaded the boards by directing attention to the marketing and learning-about-sustainability opportunities of the whole project as well as the municipality's sustainability criteria for developing the area, mobilising and combining relational and structural power to create synergetic dynamics. As such, DuCoop's proposal to separate the investments into sustainable technologies and residential units was realised. Regarding the odours, a filter and an air outlet were installed. The other issues of the third risk (noise, explosion and chemicals) gradually lost relevance by repeated explanations about how the technology works in the meetings between the coalition and the boards, signifying the use of relational power.

In sum, the real estate companies' boards first induced antagonistic dynamics using dispositional power, although the coalition's ongoing use of relational power (reinforced with structural power related to sustainability) led them to follow the coalition's arguments. Over time, the boards radically switched roles by providing resources such as money, personnel and know-how to the project.

5.5.2 The lending guidelines of financial institutions

The second struggle revolves around the guidelines to obtain a loan and involved four financial institutions from the financial regime and a team consisting of DuCoop's manager, innovators from real estate companies and financial consultants. This struggle is an example of how innovators can realise incremental change with incumbents, which is nevertheless crucial for realising the project. Although the loan only comprises 30% of the project's financial capital, it was necessary for the project's development. The search took more than a year during which the team meticulously prepared every meeting to convince the institutions to do things differently for once. Meeting after meeting, however, the institutions drew on the conventional guidelines. Primarily their risk analysts were not used to combinations of technologies such as wastewater treatment and heat networks. As the analysts were unable to examine the probability of default, three big financial institutions refused to provide a loan to such an unusual project. In this context, an interviewee observes: 'In the pursuit for a loan, the institutions turned DuCoop down one by one, because the project differs from other projects' (Interview 9). The institutions thus drew on established guidelines and knowledge (i.e. dispositional power) to counter the relational power of the team's proposals. From DuCoop's perspective, the antagonistic dynamics induced by the institutions shifted to more synergetic dynamics because the team ultimately persuaded one institution (Triodos) that specialises in sustainable projects.

Nevertheless, this institution was cautious about the criteria of the loan as it not only perceived the project as risky but also realised that it was the last institution available for a loan. As such, DuCoop's first loan proposal was rejected by the credit committee. Eventually, the second proposal was accepted as a result of the team's struggles and the institution's recognition of the project's connection to the bank's vision and DuCoop's contribution to sustainability (i.e. structural power). After this agreement which mainly focussed on the substantive aspects of the project (e.g. combinations of technologies), the institution raised questions about the collateral because a part of the privately-owned technology is built on land owned by the

municipality, real estate companies or the adjacent chemical plant. Such antagonistic dynamics induced by the dispositional power of the institution resulted in DuCoop's loan being characterised by strict default conditions and a high-risk premium.

Overall, three financial institutions refused to deviate from established guidelines. However, the ongoing struggles of the innovators led a fourth institution, specialised in sustainability, to facilitate the project by cautiously providing a loan. In doing so, it only incrementally changed its role and primarily used its monopoly position to preserve strict loan requirements.

5.5.3 Manufacturers of vacuum toilets

The manufacturers of vacuum toilets, belonging to the manufacturing regime, and the Municipal Development Agency (part of the urban planning regime) are involved in the third struggle, mainly because DuCoop also treats the wastewater of an adjacent school where providing children-sized toilets is mandatory. The struggle is an example of incremental changes in incumbents' roles in niche projects, influenced by incumbents' use of power to maintain established practices. Drawing on established rules and using its position in the development of the neighbourhood, the Municipal Development Agency asked DuCoop to install children-sized vacuum toilets. In turn, DuCoop requested the three European manufacturers of vacuum toilets to provide children-sized versions. However, the manufacturers stated that such toilets do not exist and that they were unable to produce them because the production process is not cost-efficient and there is no market demand, suggesting the mobilisation of dispositional power using established rules, resources and technology. Despite the questions of the Agency, DuCoop's relational nor dispositional power was strong enough to convince the manufacturers to produce children-sized vacuum toilets and mitigate the antagonistic dynamics.

More synergetically, however, one manufacturer used relational power by proposing to install a collector in between the school toilets and vacuum system. This idea is a cost-efficient solution the firm has previously used, clearly using established rules and knowledge (i.e. dispositional power) in an enabling way. As such, regular children-sized toilets and a collector were installed. This installation implies more than one litre of water per flush and diluting the black water stream, which results in a slight loss in efficiency of the digester used for biogas production.

Together, the rule of children-sized toilets was mobilised by the Municipal Development Agency and restricted DuCoop's plan. In turn, DuCoop did not succeed in convincing the manufactures because such toilets do not exist and the production process is not cost-efficient. However, one manufacturer incrementally changed its role by providing the collector as an alternative, cost-efficient solution.

5.5.4 The Flemish Environment Agency and the mandatory-connection rule

The topic of the fourth struggle is the mandatory-connection rule for domestic wastewater and mainly takes place between the Flemish Environment Agency, belonging to but not dominating the wastewater regime, and DuCoop. The struggle is an example of the ongoing efforts of innovators, which influences incumbents in radically reorienting their role and use of power in niche projects. From the start, DuCoop used relational power to gather stakeholders (e.g. companies, departments and agencies such as the Flemish Environment Agency) in a discussion group, improving its relationship with these actors and, over time, also enhancing its reputation and position within this group (i.e. dispositional power). In collaboration with the municipality, the Agency then asked how DuCoop would comply with the mandatory-connection rule and the local and regional treatment taxes, drawing on established rules, resources and infrastructure in mobilising dispositional power. In response, DuCoop invited the municipality's drinking water utility to their board to maintain the relations with the Agency, improving its relationship with the Agency and the municipality to discuss possible solutions (i.e. relational power). The dynamics were mostly antagonistic: many discussions went into the question about how to circumvent the mandatory-connection rule and 'how to shift the revenue of the local and regional wastewater treatment tax from Farys [the drinking water utility] to DuCoop' (Interview 5).

The struggles of the innovators were then accommodated by the Agency that used its position in, and knowledge of, the wastewater system (i.e. dispositional power), inducing more synergetic dynamics. Specifically, it drew on DuCoop's broader sustainability agenda (i.e. structural power) to point out the existence of a loophole. The latter exists as the mandatory-connection rule does not hold for certified industrial wastewater. Such certification can be obtained by collecting and then adding organic food waste to domestic wastewater. To achieve this, DuCoop had to negotiate a subcontracting agreement with the municipal solid waste company to obtain permission to collect organic food waste, indicating dynamics between DuCoop's relational power and the company's established rules and resources.

Although this is no standard procedure for the company, it signed the agreement as it acknowledged the importance of DuCoop's project regarding innovation in waste management. In line with the Agency, the company used its dispositional power and drew on structural power to support the synergetic dynamics. These power dynamics resulted in the following arrangement: the drinking water utility still levies taxes but the revenue is directly transferred to DuCoop's cooperative company, organic food waste is added to the black water through shared shredders (permitted by the solid waste company) and the wastewater is licensed as industrial by the Agency.

On the whole, the Flemish Environment Agency used its position to raise questions about the conformity of the project with established rules. In response to these mostly antagonistic dynamics, DuCoop continuously attempted to induce synergetic dynamics, eventually met with the Agency radically changing its role to enable the project.

5.5.5 The municipality's concerns over pipes built on public land, technological deficiencies and backup systems

The fifth struggle concerns the dynamics between the municipality, belonging to the urban planning regime, and DuCoop and focusses on pipes built on public land, bankruptcy, technological deficiencies and backup systems. The struggle is an example of how radical reorientations take place in incumbents' roles in niche projects, resulting from other incumbents' power. The controversy started because a part of the pipes of the privately-owned treatment technology and heat network has been built on land owned by the municipality. The Department of Public Roads, Bridges and Waterways (in collaboration with Facility Management and Legal Services) typically uses standardised contracts to collaborate with utilities to avoid liability and secure the municipality's property. In this way, 2015's agreement in principle between the municipality's council and DuCoop, which usually precedes concession agreements, stipulates that DuCoop is obliged to relocate pipes if a public authority requests so. By drawing on the established rules and resources, the Departments thus mainly mobilised dispositional power, which induced antagonistic dynamics. Consequently, DuCoop hired a law firm to temper these proposals and included the municipality's drinking water utility in their board as a trustworthy, public-private partner of the municipality, clearly using relational power and then increasing its position vis-à-vis the Departments (i.e. dispositional power).

Simultaneously, the Departments were worried about the possibility of bankruptcy and technological deficiencies (e.g. clogged pipes, odours or complete failure). As utility services and public land are involved, they assumed that the municipality would be held responsible by the residents for supplying heat and the disposal of wastewater in case of deficiencies or DuCoop's bankruptcy. An interviewee observes 'The failure of the technological system is the worst-case scenario; if the neighbourhood does not have access to sewers, the pressure on the municipality would be enormous [...] and it would be obliged to provide a solution' (Interview 12). Hence, the Departments used their position in the project to protect the municipality's resources and rules against bankruptcy and deficiencies, indicating the use of dispositional power.

These antagonistic dynamics were further strengthened as the above issues evolved into concerns over 'backup systems' for the utility services such as emergency sewers and a power plant. On top of that, the real estate companies worried about selling residential units with technological deficiencies and the Municipal Development Agency about the provision of utilities. Both actors used their position in the project to mobilise dispositional power, strengthening the antagonistic dynamics. But 'when the project was about to be jeopardised by these struggles' (Interview 15), the Department of Environment and Climate intervened in favour of DuCoop and used its position to underscore the sustainable and innovative contribution of DuCoop to the city. Such action can be interpreted as combining the three types of power to bring about synergetic dynamics.

As a result of these struggles, the 2016 concession agreement between the municipality and DuCoop prescribes mutual consultation and exploration of alternative solutions in relocating pipes. The solution also included reaching agreements in principle with energy and water/wastewater utilities to take over in case of failure; opening a savings account as a safeguard for maintenance; and authorisation of the municipality if the infrastructure is transferred to a third party. In addition to these legal agreements, an emergency sewer connects DuCoop's treatment system to the established sewer system and DuCoop holds a natural gas plant under perpetual lease from the adjacent chemical plant as an emergency power station.

Overall, the Department of Public Roads, Bridges and Waterways (in collaboration with other incumbents) mobilised dispositional power in an antagonistic manner. Concerning legal requirements, DuCoop tried to temper these dynamics but soon

faced even more challenges such as concerns over bankruptcy. Notably, the Department of Environment and Climate dealt with these challenges by using its position in the project and drawing on broader sustainability trends, eventually leading to radical changes in the municipality's role to enable the project.

5.6 Discussion

The previous section analysed five struggles between one or more incumbents and DuCoop. It explored the research question about how incumbents use power to enable and restrict DuCoop's radical innovation. By using the specificities of the five struggles, this question is now answered by identifying four patterns. Here we use an ideal-type approach that accentuates certain elements emerging from the analysis, particularly by focussing on the enabling instead of the restricting role of incumbents in niche projects. Next, we move towards a more refined and nuanced understanding of the patterns by focussing on incumbents belonging to multiple regimes as well as on the power of structural trends. Before concluding the chapter, we also provide lessons for practitioners.

5.6.1 Four patterns in the enabling role of incumbents in niche projects

5.6.1.1 *Radical reorientation through innovators' power*

This pattern is called radical reorientation through the power of innovators. It is characterised by the ongoing efforts of innovators that eventually lead incumbents to radically reorient their role to enable niche projects. In the case study of DuCoop, this is visible in how the real estate companies' boards (5.5.1) first restricted the coalition of innovators by defining three risks. However, ongoing struggles with the innovators led to radical reorientations (e.g. providing resources to the project). Similarly, the Flemish Environment Agency (5.5.4) raised critical questions about the project but the ongoing work of the innovators eventually led to an enabling role of the Agency.

5.6.1.2 *Radical reorientation through incumbents' power*

We label this pattern as radical reorientation through the power of incumbents. As a result of the incumbents' mobilisation of power, radical reorientations take place in the role of other incumbents to enable niche projects. This pattern is reflected in the struggle revolving around the municipality (5.5.5), in which we noted that incumbents (the Department of Public Roads, Bridges and Waterways, amongst

others) obstructed the project by drawing on established rules and resources. Nonetheless, these blockages were removed by the power of other incumbents (the Department of Environment and Climate), profoundly changing the municipality's role in the project.

5.6.1.3 *Incremental change through innovators' power*

This pattern is called incremental change through innovators' power. The ongoing work of the innovators influences the incumbents to change their role to enable niche projects incrementally. The pattern is reflected in the struggle involving the financial institutions (5.5.2): three institutions refused to provide a loan, whereas the innovators succeeded in convincing one institution specialised in sustainable banking after a long process. However, although the institution enables the project, the loan is stringent and in line with the established guidelines.

5.6.1.4 *Incremental change through incumbents' power*

Incremental change through incumbents' power is the name of this pattern. Incremental changes take place in the role of incumbents to enable niche projects, resulting from incumbents' use of power to maintain established practices. The struggle involving the manufacturers of vacuum toilets (5.5.3) follows this pattern. Specifically, as producing children-sized vacuum toilets is not cost-efficient, these toilets do not exist and the manufactures refused to develop such toilets (i.e. established rules). However, one manufacturer provided a watered-down, cost-efficient alternative (the collector) to the niche project, incrementally changing its role to enable the project.

5.6.2 The enabling role of incumbents from multiple regimes in niche projects

Conveying a more detailed understanding of the patterns and drawing from the four research streams described in section 5.2, we further explore the enabling role incumbents may play in niche projects by focussing on three observations. We concentrate on incumbents from multiple regimes, belonging to (1) local authorities and (2) neighbouring or more distant regimes, as well as on (3) the power of structural trends related to the urgency of sustainability challenges.

The first observation is that two local/regional public authorities are covered by the radical reorientation-patterns, namely the Flemish Environment Agency and the municipality. Both hesitated to support the project but then radically adjusted their role in the project. From our observations, we may cautiously conclude that local

authorities may radically reorient their roles in enabling niche projects by altering local rules and supporting new socio-technical configurations, which is also suggested by other studies on the leading role of local authorities in transitions (Barnes et al., 2018; Grin, 2020).

However, this first observation does not hold for the real estate companies as these are private companies who radically reoriented their roles, bringing us to a second observation about incumbents' proximity (of, for instance, missions, scales and networks) to niche projects. The real estate companies became partners in the project and the municipality was also closely involved by, for example, owning the land. This observation suggests that these actors belong to 'neighbouring regimes' (i.e. the building and urban planning regime)[7] that offered 'a way to mobilise counter-veiling power against locked-in incumbents' in the 'focal' wastewater regime (Turnheim & Geels, 2019, p. 1425). Moreover, such physical, institutional and social proximity has been observed before in cities (Grin, Frantzeskaki, Castán Broto, & Coenen, 2017), indicating a connection between multiple innovations, regimes and systems in urban transition processes (Hodson, Geels, & McMeekin, 2017). Such observations help in understanding the radical reorientations in the roles of the real estate companies and the municipality to enable niche projects.

This second observation is further supported by the lack of proximity to the project of the financial institutions and the manufacturers of vacuum toilets (e.g. not closely involved from the beginning and a more independent role), leading to incremental changes instead of radical reorientations in their roles. Furthermore, cost-efficiency, financing and production norms were important factors influencing the incremental change-patterns. These rules can then be interpreted as lock-in mechanisms of the broader and more distant manufacturing and financial regimes.

The latter, in particular, is subject to path-dependency, which may suggest a fit-and-conform 'niche-financial regime interaction' in our case (Geddes & Schmidt, 2020). These mechanisms may indicate 'multiple and interacting points of lock-in' (p. 339) across the wastewater, financial and manufacturing systems (Rosenbloom, 2020). Hence, the second observation leads us to suggest that incumbents belonging to neighbouring regimes (i.e. proximity) may radically reorient their

[7] Neighbouring regimes deviate from the focal regime but have a degree of proximity such as relevant knowledge and skills; missions and guiding rules; geographical areas and scales; or access to networks (Turnheim & Geels, 2019).

roles, whereas incumbents belonging to more distant regimes only incrementally change their roles to enable niche projects.

A third observation that clarifies the enabling role of incumbents is about the power of structural trends and particularly the urgency of sustainability challenges, observed in the radical reorientation-patterns. Specifically, the real estate companies were convinced by the innovators' argument about the sustainability-opportunities of the whole project; the Flemish Environment Agency underscored the broader sustainability agenda of the project; and the Department of Environment and Climate mobilised the sustainable and innovative contribution of the project to the city. Additionally, concerning the struggle involving the financial institutions (characterised by incremental change), we hypothesise that the lock-in mechanisms of the financial regime were partially overcome by the innovators' capacity to connect the broader sustainability agenda of the project to the vision of the institution that provided the loan. Taken together, the third observation confirms that political, social and environmental pressures influence incumbents' role in radical innovation, which is confirmed by studies of incumbent firms (Penna & Geels, 2015; Stalmokaitė & Hassler, 2020; Steen & Weaver, 2017), suggesting that the urgency of sustainability challenges and the related new policies and strategies (e.g. EU and UN) influences the enabling role of incumbents. Using our case, we also add that structural trends are interpreted and then used as a source of power by incumbent and innovative actors, which may indicate how so-called landscape elements are 'endogenized through political struggles' (Rosenbloom et al., 2016, p. 1286) and are socially constructed (Hermwille, 2016; Loorbach et al., 2016).

Summing up, the four patterns underscore the distinct ways in which incumbents may enable niche projects. In turn, closer inspection of these patterns helped to understand the circumstances required for doing so. In other words, the study both identified the 'varieties of incumbencies' (p. 183) in niche projects and the 'conditions under which these may contribute to (positively or negatively) transformative pathways' (p. 183), which supports the recommendations of Turnheim & Sovacool (2020) empirically. Additionally, the patterns and our clarification demonstrate that niche-innovation should be analysed symmetrically (Mylan et al., 2019; Turnheim & Geels, 2019) and they also confirm that the power frameworks of Avelino and Grin are fruitful tools for doing so.

5.6.3 Lessons for practitioners in the water/wastewater sector

For practitioners in the water sector, the analysis underscores the role of power dynamics in innovation processes, which are often overlooked in a sector dominated by techno-economic knowledge. Specifically, it shows that DuCoop's project ran into resistance from incumbents such as real estate companies, financial institutions and the municipality. Consequently, this required continuous creativity to do things differently from both the project and incumbents. By scrutinising the struggles between these actors, we presented a different way of knowing water (Krueger et al., 2016) that may be used by practitioners in learning processes on transitions towards sustainability in the water/wastewater sector (Hoffmann et al., 2020).

5.7 Conclusions

In this study, pluralised understandings of incumbencies, especially the roles played and power used by incumbents in niche projects, were investigated. It shows how incumbents use power to enable and restrict DuCoop's radical innovation. By applying an existing framework on power in transitions, it identified four patterns in the enabling role of incumbents in niche projects. The four patterns were clarified by focussing on incumbents from multiple regimes, belonging to local authorities, neighbouring and more distant regimes, as well as on the power of structural trends such as the urgency of sustainability challenges. This study contributes to the understanding of multiple incumbencies and the circumstances under which these may contribute to niche projects. For practitioners in the water/wastewater sector, the study presents a different way of knowing water by highlighting the overlooked role of power dynamics.

Future research could build on these findings by focussing on the enabling role of incumbents in global niches instead of a niche project. As we draw lessons from a single-case study, the conditions under which incumbents enable niche projects also require further research, particularly necessary is a typology or classification of incumbents and their proximity to certain innovations. Additionally, the findings can be refined and extended in other cases: in more 'unfriendly contexts' for niches (Verhees et al., 2013, p. 275) in which they face a steep 'uphill battle' (Schot & Geels, 2008, p. 549); in 'inter-niche competition' (Lin & Sovacool, 2020); in the absence or presence of a 'system-builder' (Kern et al., 2015); or in other (un)favourable contexts for experimentation (Torrens, Schot, Raven, & Johnstone,

2019). Finally, future research could focus on the substantive instead of the processual aspect of power, particularly on the sustainability of niches' power relations (Avelino, 2011) and 'which niche(s) and transformative pathway(s) should be nurtured and on what grounds?' (Lazarevic & Valve, 2020, p. 47).

Chapter 6: *Discussion and conclusion*

In the first paragraphs of this thesis, I specified that the progress in achieving long-term sustainability objectives has been rather limited: societal change does not happen at all or takes place at an agonisingly slow pace. Using a political science approach, I set out to question the political processes underlying stability or inertia and incremental change in socio-technical systems' processes towards sustainability, concentrating on the power of deep-rooted ideas, entrenched networks, embedded rules and vast infrastructure. More precisely, I investigated the wastewater systems of Belgium and the Netherlands because these are characterised by innovative activities resulting from the need for rapid shifts towards circularity but also by large, stable infrastructures and robust institutional arrangements. The overarching theme of the thesis was then formulated as the politics of sustainability transitions towards a circular economy in these wastewater systems. Specifically, I examined *what* the dominant and alternative interpretations of a transition towards a circular economy in the Dutch and Belgian wastewater system are? And *how* and *why* do certain interpretations become dominant and influence these systems? These research questions were split into three sub-questions, which were answered in chapters 3, 4 and 5.

This final chapter is divided into three sections. By using the results from chapters 3, 4 and 5, I first reflect on the main research question from a political science perspective on sustainability transitions in inert, stable socio-technical systems. Building on the findings of the first section, the second section provides recommendations for policymakers and practitioners, and in the third and final section, I consider avenues for future research.

6.1 The politics of sustainability transitions

In this section, I reflect on the main research question from a political science perspective. Two steps are taken by using the theoretical perspectives developed in the third section of the introduction about the politics of sustainability transitions and used in chapters 3, 4 and 5. First, I elaborate on the interpretations of a transition towards a circular economy in the wastewater system. Second, I delve into *how* and *why* specific interpretations become dominant and influence the system, particularly addressing three approaches to these political processes: the role of discourses in the continuity or discontinuity of institutional arrangements and infrastructure, the struggles of actors that sustain and reproduce stability in policy feedback processes in established arrangements and the agency in highly

stable socio-technical regimes. At the end of this section, I provide a summary and an answer to the main research question.

6.1.1 What?

The first part of the main research question asked *what* the interpretations of a transition towards a circular economy in the Dutch and Belgian wastewater system are. In turn, the third chapter of this thesis focussed on how this transition is interpreted in the Netherlands and, accordingly, three discourses were identified. To explore the diversity of interpretations of a transition, I here connect the results of chapters 3 to chapter 4 and 5.

In the third chapter, I observed that calls have increased for a paradigm shift or transition towards a circular economy in the wastewater system. Yet I observed divergent interpretations of this transition. This led to the identification of three discourses: the market-pull discourse, the modernised-mixture discourse and the water-quality discourse. First, the market-pull discourse draws on the existing infrastructure and current political-economic institutions of the wastewater system. For example, the actors (re)producing this discourse choose to use the large-scale treatment plants to recover resources and to develop markets for these resources. Generally, chapter 4 further explored this discourse, supporting the findings of chapter 3. I found, inter alia, that the discourse is constructed by established actors such as the wastewater authorities and that it focusses on developing business cases for the resources that can be recovered efficiently by using the large-scale treatment infrastructure. Additionally, in chapter 4, I identified discourses consisting of more radical elements such as water scarcity, hybrid infrastructure, citizen involvement and new collaborations in approximately 2010. Yet these elements were excluded from the debate by 2018 in the Netherlands. Second, the modernised-mixture discourse proposes considering small-scale treatment systems in addition to the existing treatment plants to recover resources and energy, to involve citizens and, generally, to develop a systemic perspective that considers socio-technical experiments, culture, demography and broader policies. Along these lines, chapter 5 covered a decentralised, small-scale treatment system, which indicated that such systems require new coalitions and networks between innovative actors and established actors. Third, the water-quality discourse raises questions about who is responsible for emerging pollutants and for investing in specific solutions, focussing on water quality before embarking on the resource recovery-journey. In this brief overview, it becomes clear that these three

discourses or interpretations suggest particular societal and political choices regarding a circular economy in the wastewater system and tend to exclude certain aspects from the debate by operating on their own rationalities and perspectives. Overall, this confirms that discourse analysis is a useful tool for investigating the politics surrounding environmental problems (Feindt & Oels, 2005; Hajer & Versteeg, 2005), especially for exploring complex social, ecological and technological processes of change.

By building on the perspective focussed on discourses in environmental politics, described in chapters 1 and 3, I draw three implications from these results. First, the three discourses influence the nature and depth of the envisaged changes, specifically, the far-reaching political and societal choices about investments in infrastructure, subsidies, roles of markets and citizens, collaborations, policies etc. Second, the market-pull discourse is becoming dominant but only proposes, at most, only incremental instead of fundamental changes in the wastewater system. This discourse resembles what Dryzek (2005) calls ecological modernisation as well as dominant interpretations of a circular economy closely related to the prevailing model of economic growth and technological innovation (Kirchherr et al., 2017; Kovacic et al., 2020; Lazarevic & Valve, 2017). Such incremental improvements and technological fixes, instead of fundamental transformations in socio-technical systems, may be insufficient to address long-term sustainability objectives (EEA, 2018; Köhler et al., 2019). Third, it is important to reiterate that discourses are 'specific ensembles of ideas, concepts, and categorisations that are produced, reproduced, and transformed in a particular set of practices' (Hajer, 1995, p. 44). When I apply this statement to the three discourses, it becomes clear that policymakers, practitioners and engineers reproduce particular choices, strategies, visions and futures, of which some may exclude fundamental changes in established institutions and infrastructure. To accelerate sustainability transitions, thorough reflection from and discussion between the three perspectives is necessary, which I further address in the sections below dedicated to future research and recommendations for policymakers and practitioners.

Summing up, a transition towards a circular economy in the wastewater system is interpreted in diverse ways, although one specific interpretation is becoming dominant. It is constructed by established actors, proposing to create markets for the recovered resources and technology to optimise the current infrastructure, which suggests that a transition is interpreted as a process of incremental change

instead of fundamental change in the wastewater system. As such, it is expedient that policymakers, practitioners and engineers pursuing transitions explicitly explore and understand these divergent perspectives on the speed, depth and direction of sustainability transitions.

6.1.2 How and why?

Having established *what* the dominant and alternative interpretations of a transition are, I now answer the second part of the research question, focussing on the political processes related to *how* and *why* specific interpretations become dominant and influence the system. In chapters 3, 4 and 5 of this thesis, this question was partially addressed. In this section, I further contribute to the three strands of literature used in these chapters: discourse analysis (chapter 3), policy feedback (chapter 4) and sustainability transitions (chapter 5). Specifically, I combine the results of the three chapters to first elaborate on the role of discourse in the (dis)continuity of institutional arrangements and infrastructure, then on the struggles of powerful actors in producing and reproducing policy feedback processes that maintain stability in institutional arrangements and, finally, on the agency in socio-technical regimes that remain stable.

6.1.2.1 *The interplay between discourses and institutional arrangements*

The second part of the main research question is now further explored by elaborating on the interplay between new discourses and established institutions and infrastructure. In chapter 3, I explored, inter alia, how a new discourse is becoming dominant by drawing on the established socio-technical system, while chapter 4 further confirmed these findings. To a certain extent, these findings apply to chapter 5 also, as it demonstrates that innovative changes and new discourses may develop within a niche project (i.e. DuCoop), although these do not immediately lead to fundamental changes in the established system.

Chapter 3 discussed that the market-pull discourse has an advantage in becoming dominant by drawing on the existing large-scale wastewater treatment infrastructure and the established political-economic institutions. When I combine chapters 3 and 4, it becomes clear that the new circular economy discourse in the (Dutch) wastewater system is constructed and institutionalised by established actors such as the treatment authorities. This discourse implies a choice for technological innovation that leads to optimising the large-scale plants to recover resources, to market creation for these green resources and to cost efficient solutions, suggesting an incremental change in the wastewater system. The

empirical analysis in chapter 4 especially demonstrates that a broad and rather radical discourse on sustainability and circularity was narrowed to the market-pull discourse in approximately ten years (2008-2018). A crucial role was played by the established actors, their institutions and infrastructure. Specifically, as these actors were increasingly pressured by novel activities, a radical discourse and long-term trends, they struggled to gain control over these radical developments and then used their power to align these developments with the system. Overall, this illustrates the close entanglement between the new, specific circular economy discourse and entrenched institutions and infrastructure, which led to a stable socio-technical arrangement and impedes fundamental change.

As it is clear that socio-technical systems characterised by large infrastructure, powerful actors and their arrangements may condition radical discourses, I make two theoretical contributions to discourse analysis. First, directing attention to the interplay between institutional arrangements and new discourses, I found that the former, consisting of established actors, the rules of the game and deep-rooted ideas, influenced the new circular economy discourse in the wastewater system, leading to stability or, at most, incremental change. This contribution may be associated with previous attempts to strengthen discursive approaches by considering wider contexts (den Besten, Arts, & Verkooijen, 2014; Kaufmann & Wiering, 2021; Smith & Kern, 2009; Yuana, Sengers, Boon, Hajer, & Raven, 2020). Further, chapter 4 illustrates that discourses may succeed in challenging established actors, leading to divergent responses and discursive repositioning. Such a situation may induce the destabilisation or reinforcement of existing arrangements (Bosman et al., 2014; Kuokkanen et al., 2018). The latter clearly is the case in my analysis of the wastewater system, which is a pattern that is unfolding in Great Britain's energy system also, as a pro-gas coalition led by established actors is presenting a 'green gas' story to reshape the decarbonisation discourse around their own interests (Lowes, Woodman, & Speirs, 2020). Further, this confirms that radical policy change may occur only when the new discourse transforms existing interests and successfully challenges prevailing institutional contexts (Kern, 2011). Overall, my results show that the new, radical circular economy discourse is constrained by established institutions, suggesting that discourse analysis may be used to analyse stability and incremental change by focussing on prevailing institutional arrangements.

Second, focussing on the dynamics between infrastructure and new discourses, my results indicate that large infrastructure, such as wastewater treatment plants and sewers, is typically taken for granted, becomes performative and exercises power. This mechanism is exemplified by the statement of an interviewee at the end of the third chapter, namely 'an alternative, possibly more sustainable, solution is nearly impossible because of the current infrastructure'. Further, in chapter 4, I described how a radical discourse was narrowed over time, particularly by established actors' interpretations of the large-scale infrastructure and the ways to optimise this technology to recover resources in a cost efficient manner. These observations are consistent with recent suggestions to investigate 'the dominant discourses that constitute and justify the very technologies, institutions and behaviours of the status quo' (Buschmann & Oels, 2019, p. 2) and with calls for more research into how discourses shape physical materiality and are influenced thereby (Keller, 2019; Leipold, Feindt, Winkel, & Keller, 2019). Hence, I found that the interplay between discourses and established infrastructure may constrain new, radical discourses, inducing inertia instead of change.

Taken together, these findings provide a first answer to *how* and *why* specific interpretations of the Dutch and Belgian wastewater systems' transitions towards a circular economy become dominant and influence the system. More precisely, the interpretation that is becoming dominant is heavily influenced by the established institutions and the interpretations of the infrastructure and vice versa. This shows that discourses have some effects but are not the all-embracing structuring principles of society and thus may be analysed along with other, similarly powerful elements (Alvesson & Karreman, 2000) such as how prevailing institutions and infrastructure are interpreted and gain influence.

Here the suggestion for discourse analysis is to pay sufficient attention to how infrastructure and institutions are interpreted by certain actors. In what follows, I use a different perspective to further delve into *how* and *why* a particular interpretation is becoming dominant and ensures permanence.

6.1.2.2 *Policy feedback, path dependency and agency*

Further exploring the second part of the main research question, I now turn to the role of actors in policy feedback processes, which is an approach closely related to path dependency perspectives. By combining the results of chapter 3, 4 and 5, I address the struggles of actors in sustaining and reproducing established

institutional arrangements, inducing processes of incremental change or overall stability that impede radical transitions towards sustainability.

In the third chapter of this thesis, I observed that a dominant discourse was being (re)produced in a particular set of practices, shaping a transition pathway characterised by lock-in effects and, at most, incremental changes. Amongst the activities reproducing the discourse were, for instance, the establishment of a network and knowledge centre, the publication of documents that confined the discussion, financial support and the optimisation of infrastructure. In turn, closer inspection in the fourth chapter illustrated that this dominant discourse had been actively constructed by the established, powerful actors in the wastewater system from around 2012. Specifically, these actors were pressured by long-term trends and a discourse advocating radical change, which led them to use their powerful position to connect the network and knowledge centre to the existing hierarchies and to select five key resources that can be recovered cost efficiently from wastewater by using the large-scale treatment plants. Further, the fifth chapter demonstrates that established actors may radically change their roles in local projects. However, it also shows that these actors frequently change their roles only incrementally to enable small, niche projects (i.e. DuCoop) and that they allow this change mostly concerning matters that do not interfere with the core business of their authority. It is clear that the local project's influence on the established wastewater system's path is extremely limited, which may indicate that the Belgian system is subject to the same self-reinforcing mechanisms that I identified in the Dutch system. Overall, the three chapters underscore the ongoing struggles of powerful actors in supporting what I labelled as self-reinforcing feedback in chapter 4 and, more generally, in sustaining and reproducing established arrangements.

The three chapters thus indicate that powerful actors are continuously making political choices that sustain the established institutional arrangement and infrastructure, which is an observation that provides a nuanced view of agency in self-reinforcing feedback processes (see chapter 4) and, more broadly, processes of path-dependency and lock-in in environmental politics. Generally, my results thus contribute to recent attempts to complement the sustainability transitions field with policy and political science perspectives that focus on path-dependency, policy feedback and agency (Derwort, Jager, & Newig, 2021; Lockwood, Kuzemko, Mitchell, & Hoggett, 2017; Roberts et al., 2018; Roberts & Geels, 2019; Rosenbloom, Meadowcroft, & Cashore, 2019). Further, the results direct attention

to how prevailing institutions and infrastructure are continuously sustained and reproduced, confirming that 'stability–far from being automatic–may have to be sustained politically' (p. 396) by 'enduring legacies of political struggles' (Thelen, 1999, p. 388). Similarly, the finding of the ongoing struggles of the established actors to construct and institutionalise a particular interpretation of a transition, leading to a stable arrangement, highlights that existing paths are constructed and self-reinforcing mechanisms are strategically manipulated and do not just exist (Araujo & Harrison, 2002; Garud et al., 2010). Hence, I show that powerful actors who face increasing pressures continuously use their power to produce stability or, at most, incremental change, illustrating that change and stability in institutional arrangements constantly co-exist and should be connected at the empirical and theoretical levels (Capano, 2009).

In sum, in addition to the conditioning effects of institutions and infrastructure on new discourses, my findings suggest that the ongoing struggles of powerful actors in ensuring permanence are a second answer to the question of *how* and *why* specific interpretations of the wastewater systems' transition towards a circular economy become dominant and influence established arrangements. Specifically, the radical changes proposed by the new discourse increasingly pressured these actors, leading them to use their strong position to propose incremental changes, largely sustaining and reproducing the stability in the institutional arrangement and infrastructure and thus hindering a fundamental shift towards circularity. The next section further explores these findings from a transition perspective.

6.1.2.3 *Agency in socio-technical regimes*

Further extending the analysis of the second part of the main research question, I now use a transition perspective. I draw inspiration from the results of chapter 3, 4 and 5 to elaborate on agency in sustainability transitions, particularly on established actors or incumbents belonging to regimes that remain stable or change only incrementally.

The three chapters addressed agency in transitions in different ways. The third chapter emphasises that established actors such as the water authorities are able to shape a transition pathway that (only) draws on the existing infrastructure and institutions, which induces, at most, incremental changes. However, in chapter 4, it became clear that established actors may open up opportunities for radical discourses to emerge, although, as soon as the pressure arising from radical discourses increased, the same actors also quickly restricted these radical

discourses by embedding them in established practices. Finally, the fifth chapter dealt with established actors, frequently belonging to neighbouring regimes, that play an enabling role in niche projects by radically or incrementally changing positions. Yet as mentioned, the influence of the project on the wastewater system is extremely limited. Hence, all these actors operate within the institutional arrangement and infrastructure of the wastewater system, shaping transition pathways towards a circular economy, in which some room is left for manoeuvring, although choices for optimising the current infrastructure in a cost efficient manner to recover resources are easily made.

The results of chapter 3, 4 and 5 of this thesis thus contribute to understanding agency and politics in sustainability transitions, which are typically downplayed in transitions research emphasis on stability and path-dependent dynamics (Avelino et al., 2016; Genus & Coles, 2008; Patterson et al., 2017; Smith et al., 2010). The chapters further show that the agency in, typically stable, socio-technical regimes is not homogenous, passive or static (Duygan, Stauffacher, & Meylan, 2019; Huttunen et al., 2021; Kuokkanen et al., 2018; Wittmayer, Avelino, van Steenbergen, & Loorbach, 2017), particularly established actors are not only shaping discourses that advocate incremental change (chapter 3) and transition pathways along path-dependent trajectories (chapter 4) but are also enabling small experiments under certain conditions (chapter 5). Further, the focus on the power struggles of actors in chapters 4 and 5 illustrates that the stability of the regime does not occur automatically but requires continuous battles. This directs attention to the regime's stability as the outcome of active resistance of regime actors (Geels, 2014), to the ways to overcome the rather totalising descriptions of lock-in in the literature on transitions (Klitkou et al., 2015) and to pluralising the discussions on incumbency in sustainability transitions (Novalia, Rogers, & Bos, 2021; Stalmokaitė, 2021; Turnheim & Sovacool, 2020). Hence, in addition to the hard work required for niche-innovation, my results indicate that maintaining the regime also requires hard work, which provides a nuanced account of the role and struggles of actors in socio-technical regimes that remain stable or change only incrementally.

In all, these findings complement the observation from the previous section by indicating that the struggles of actors are important in maintaining the stability of the regime or in allowing, at most, incremental changes. As such, this is a third way to answer the question of *how* and *why* specific interpretations of the wastewater

systems' transitions towards a circular economy become dominant and influence the regime. In the next section, finally, I summarise the answers to the main research question.

6.1.3 Summing up

The point of departure of this thesis was that fundamental change towards more sustainable socio-technical systems takes place at an agonisingly slow pace, which I further addressed in this section by using the political science perspectives developed in the introduction and by combining the results of chapters 3, 4 and 5. Accordingly, I argued that a transition towards a circular economy in the wastewater system may be interpreted in diverse ways, although a specific interpretation is becoming dominant, which answered the first part of the main research question about *what* the dominant and alternative interpretations of a transition are. Subsequently, I addressed the second part of the research question about *how* and *why* particular interpretations become dominant and influence the system. Here I pointed out the power exercised by the interpretations of entrenched institutions and vast infrastructure, influencing the construction of new, possibly radical discourses; the ongoing struggles of powerful actors to construct and institutionalise a specific discourse, proposing incremental change and, accordingly, reproducing stable institutional arrangements; and, similarly, the ongoing struggles of established actors in maintaining socio-technical regimes' stability or inertia. Taken together, I presented a crossover between ideas, material properties and institutions: actors interpret (material) phenomena, actors are influenced by these interpretations of material properties and shape and are shaped by interpretations of institutional arrangements. Such an approach was recently developed as a relational and multi-dimensional model of agency in the multi-level perspective, suggesting 'a processual conceptualisation of trajectories as the outcome of recursive interactions between agency and structure: actors are conceptualised as oriented towards other actors and socio-technical systems and as engaged in ongoing games which are structured by multi-dimensional institutions.' (Geels, 2020, p. 14).

In combining such an approach with perspectives from political sciences to analyse sustainability transitions towards a circular economy in the Dutch and Belgian wastewater system, the thesis provides useful indications for understanding the slow progress in achieving long-term sustainability objectives in socio-technical systems characterised by large infrastructure and entrenched institutional

arrangements. Despite a host of innovative activities, the thesis shows that the political processes related to the wastewater system's large infrastructure, entrenched institutions and powerful actors play a crucial role in the interpretation of a transition, particularly in narrowing broad discourses to specific ones that typically propose incremental change. Generally, it indicates that the innovative activities in a socio-technical system characterised by large infrastructure, entrenched arrangements and the associated actors are strongly influenced by political processes that condition newly emerging discourses, particularly ensuring stability and impeding fundamental transformations towards sustainability.

6.2 Recommendations for policymakers, practitioners and researchers

In the concluding sections of chapter 4 and 5, I provided brief recommendations for policymakers and practitioners that seek to enable fundamental transitions towards resource recovery and a circular economy in the water/wastewater system. The main takeaway was that my analyses provided a different way of knowing water and a circular economy by emphasising power struggles instead of technological innovation and business cases, which usually dominate the debate. As this section is written for practitioners, policymakers and water-researchers, I elaborate on the relevance of different types of knowledge and perspectives for sustainability transitions, on tools and methods to open up policy processes – such as those related to the Energy & Resource Factory (chapter 4) and DuCoop (chapter 5) – for dialogue between different perspectives, and on what this implies for research projects such as SuPER-W.

As the thesis demonstrates that transitions towards circularity in the wastewater system take place at an agonisingly slow pace as a result of power dynamics, it is useful to consider an approach called reflexive governance to pluralise the policy processes of transitions (Feindt & Weiland, 2018; Meadowcroft, 2007; Stirling, 2006; Voss & Kemp, 2006). The approach emerged at the beginning of the twentieth century because the first generations of environmental policy (such as stakeholder participation, regulatory approaches and market and coordinative instruments) did not have lasting environmental and societal effects. According to scholars of reflexive governance, this is the result of the complexity of contemporary sustainability problems and path-dependency (Feindt & Weiland, 2018; Voss &

Kemp, 2006). Specifically, the complexity stemming from interlinked social, technological and ecological developments leads to uncertainty, ambiguity and divergent interpretations in the processes of transitions. The thesis demonstrated that specific interpretations of transitions may block fundamental sustainability transitions, highlighting the need for a thorough reflection on alternative, radical pathways to sustainability. Similarly, due to path-dependency, reflexive governance suggests careful anticipation of long-term systemic effects of ongoing actions and the development of the resulting paths. This implies exploring alternative paths to avoid path dependent trajectories such as the ones analysed in this thesis, that hinder fundamental change. Hence, reflexive perspectives to governance call for processes that encourage the inclusion of diverse actors, preferences and understandings in ways that open up, rather than close down, the definition of problems, visions and strategies.

Such perspectives nurture diversity and spontaneous developments that retain adaptability towards complexity and path dependence, which then co-evolve with the requirement of achieving coordination and fixing long-term goals for orientation (Voss, Smith, & Grin, 2009). The path-dependency and complexity of the wastewater system's transition to circularity thus make it worthwhile to recommend a reflexive approach to governance. Here the different ways of knowing water/wastewater (Krueger et al., 2016; Ojha, Maheshwari, & Bhattarai, 2021) and a circular economy (Bauwens et al., 2020; Calisto Friant et al., 2020b; Corvellec, Stowell, & Johansson, 2021) are worthwhile noting. In line with the reflexive approach to governance, the recent work of Bruno Latour (2018) indicates how to multiply viewpoints by raising a set of foundational questions hidden beneath the surface of reductionist 'objective', 'effective' and 'rational' approaches. To do so, he first criticises the human-nature dichotomy and embraces complexity by using the concept of Terrestrials. It helps to describe the attachment and dependency between human affairs and natural manifestations because Terrestrials are based on a system of engendering, instead of a system of production. For example, if air, trees and animals are interpreted as Terrestrials, it becomes clear that they are dependent on (i.e. engendered by) the earth's stable climate, that human beings are engendered by air and that the activities of human beings engender carbon dioxide that destabilise the earth's climate. The Terrestrial approach thus implies a politics that acknowledges human actors as well as other Terrestrials such as air, forests, animals and bacteria. Using the diverse perspectives that result from the Terrestrial approach, Latour wants us to look for an inhabitable place to land for all

Terrestrials. This can be done by asking the following foundational questions for every Terrestrial: 'What do you want? What are you capable of? With whom are you prepared to cohabit? Who can threaten you?' (p. 87) and 'what do you care most about? With whom can you live? Who depends on you for subsistence? Against whom are you going to have to fight?' (p. 96). In what follows, I address the type of governance practices and research projects in which this theoretical approach – particularly Latour's questions – may be used.

First, for practitioners and policymakers who aim to enable a transition towards a circular economy in the water/wastewater system, I present a few tools and methods to open up policy processes for debate between different perspectives. For the wastewater system in particular, the definition of goals in terms of societal needs and sustainability requirements, the involvement of end-users and other, alternative stakeholders, new and flexible institutions and more socio-technical experiments to stimulate learning processes were proposed (van Vliet, 2006). In addition, Voss & Kemp (2006) suggest techniques such as constructive technology assessment, foresight exercises, participatory decision making, cooperative policymaking and transition management. The Dutch Research Institute for Transitions also published a Dutch introduction to five methods in transition management, namely analysis, transition arena, agenda-setting, experimenting and monitoring, which may be done by using tools such as actor analysis, system analysis, back-casting, developing scenarios and participatory approaches (Roorda, Avelino, Wittmayer, & van Steenbergen, 2012). For practitioners, a resource book and toolbox to map, analyse and facilitate system innovation was recently published (de Vicente & Matti, 2016), in addition to a 'transition model canvas' to systematically map transition dynamics (van Rijnsoever & Leendertse, 2020).

The combination of the reflexive governance approach and these tools and methods may help practitioners, policymakers and researchers, involved in initiatives such as the Energy & Resource Factory and DuCoop, to avoid path dependent trajectories and incremental change. For example, when I combine the results of chapters 3 and 4, the reflexive governance approach and the related techniques and methods, I urge the Energy & Resource Factory to resume the sandboxes (or so-called 'free spaces'). Before 2014, radical ideas and activities were developed in these sandboxes by using some of the aforesaid tools and methods; the sandboxes had largely disappeared by 2018 because of self-reinforcing or lock-in mechanisms. Hence, new sandboxes could, for instance, reflect on complex, path-dependent

processes (see chapter 4) and on different discourses (see chapter 3) to learn how to enable radical transitions towards circularity in the wastewater system.

Along these lines, I provide suggestions for projects such as DuCoop by combining the results of chapter 5 and the reflexive governance approach and techniques. Here it is important to note that one of the processes that influenced the development of DuCoop's path-breaking innovation involved transition management (see e.g. Hölscher, Roorda, & Nevens, 2016; Van Poeck, Vandenabeele, & Goeminne, 2017). Further, as it took hard work to persuade multiple incumbents to change roles, it may be fruitful to reflect, from different perspectives, on the crucial socio-technical conditions for realising radical projects such as DuCoop. Yet despite the transformative potential of reflexive governance, my results also clearly show that radical, frequently reflexive initiatives are typically influenced and captured by the power of deep-rooted ideas, entrenched networks, embedded rules and vast infrastructure (widely confirmed by other scholars, e.g. Feindt & Weiland, 2018; Hendriks & Grin, 2007; Turnhout, Metze, Wyborn, Klenk, & Louder, 2020). Thus, they result only in incremental change instead of radical shifts, although it is important to note that such incremental changes may lead to a sequence of transition pathways over time (Geels & Schot, 2007).

Second, in addition to reflexivity in governance practices, the basic tenets of reflexive governance are closely related to transdisciplinary research processes (Popa, Guillermin, & Dedeurwaerdere, 2015; Voss & Kemp, 2006; Wyborn et al., 2019), which will bring me to the recommendations for research projects on transitions in the water/wastewater system. Transdisciplinary research may be defined as 'a form of learning and problem solving involving cooperation among different parts of society and academia in order to meet complex challenges of society. […] It starts from tangible, real world problems. Solutions are devised in collaboration with multiple stakeholders.' (Häberli et al., 2001, p. 7). Along these lines, ten essentials for reflexive research were developed to facilitate transformations. The essentials represent a shift in the way research is conducted and include a greater diversity of knowledge, perspectives, imaginations and approaches:

> *'(1) Focus on transformations to low-carbon, resilient living; (2) Focus on solution processes; (3) Focus on 'how to' practical knowledge; (4) Approach research as occurring from within the system being intervened; (5) Work with normative aspects; (6) Seek to transcend current thinking; (7) Take a multi-faceted approach to understand and shape change; (8) Acknowledge the value of alternative roles of researchers; (9) Encourage second-order experimentation; and (10) Be reflexive.'* (Fazey et al., 2018, p. 55)

Despite this ambitious agenda, putting transdisciplinary research into practice faces significant challenges, particularly because of path-dependency, the complexity of sustainability problems and the dominance of disciplinary, objective sciences (Lahsen & Turnhout, 2021; Scoones et al., 2020; Stirling, 2010). To overcome these difficulties, it is necessary to reconsider the nature of science, to develop supportive institutions and resources, to promote a systemic perspective in research design, and to facilitate new roles of, and relations between, researchers (e.g. as a knowledge broker and process facilitator in addition to descriptive-analytical roles) that may lead to learning processes (Hölscher et al., 2021). Here joint action is needed to support reflexive or transformative science at multiple levels. Specifically, funding and support are needed for innovative researchers who actively practice reflexive science or conduct research on research, which also requires safe spaces at the boundary of science and society to test innovations; action is also needed of politicians, funders and advisory bodies to provide supportive conditions; and the demand for transformative science should be increased at all public levels through student projects in local contexts and participatory forms of research (Fazey et al., 2018). Overall, in addition to a reflexive approach to wastewater governance, a transdisciplinary approach may be useful for research on the water/wastewater sector.

The transdisciplinary approach finally brings me to the recommendations for research projects, such as SuPER-W, that aim to enable sustainability transitions towards a circular economy in the water/wastewater system. As mentioned, SuPER-W consisted of about 14 engineers, chemists, natural scientists and myself (the only social scientist), and also involved a couple of engineering companies and consultancy firms. Additionally, most of the research in the project was intended to develop cost-efficient technologies to recover resources in an optimised large-scale wastewater system. From the preceding paragraphs on transdisciplinary research, it is evident that the research design of the SuPER-W project may be enhanced in

multiple ways. Amongst many other topics, a new SuPER-W could, for example, consider multiple perspectives on a transition towards resource recovery, of which I identified at least three in the third chapter; the processes in which resources are selected for recovery, which are typically influenced by existing institutions (e.g. cost-efficiency) and infrastructure (e.g. large treatment plants), making the processes highly political and subject to exclusion (see chapter 4); and the socio-technical conditions required for implementing path-breaking trajectories (chapter 5). Apart from my research, the knowledge generated in a new SuPER-W could be diversified by involving actors like NGO's and governments as well as researchers working on, for example, the philosophy of technology, transdisciplinary methodologies, circular business cases and law. Instead of positioning the work of 14 scientists at the end of the pipe of the wastewater system (i.e. in the large-scale wastewater treatment plants), the research could be located at different positions in this system: the users of drinking water and the so-called end-users, surface water, drinking water plants, urban water systems, industry, agriculture etc. In doing so, a new SuPER-W would generate plural knowledges that may also be used in reflexive approaches to governance and, over time, influence fundamental transitions towards sustainability, which of course requires supportive institutions and resources for this kind of scientific project.

6.3 Future research

The concluding sections of chapters 4 and 5 provided a few avenues for future research, as did the first section of this chapter, on the politics of transitions. In this section, I consider two more avenues for future research closely related to the theoretical contributions of this chapter, namely discourse analysis and agency in stable socio-technical systems or governance arrangements.

Concerning discourse analysis, I suggest three avenues for future research. First, chapter 3 not only identified three interpretations about a transition but also assessed their political influence. This influence was understood in terms of Hajer's two-step procedure: if discourse structuration and discourse institutionalisation occur, a discourse is dominant and shapes policy processes and transition pathways in a specific way. In the analysis, I mainly used a couple of categories closely related to the empirical material (e.g. amounts of subsidies received, the connection to established technologies and whether the discourse appeared in official policy documents). In retrospect, more research is needed to unravel the concept of

institutionalisation in discourse analysis. Specifically, it may be fruitful to analyse the 'degree of institutionalisation' of different discourses along dimensions such as the scale and scope of diffusion, invulnerability to intervention, levels of controversy, competition and coherence, and embeddedness in governance arrangements (Fuenfschilling & Truffer, 2014; Kaufmann & Wiering, 2021), amongst other dimensions. Second, in addition to focussing on how discourses are influenced by established institutions and infrastructure (see the first section of this chapter), the type of discourse analysis used in this thesis (i.e. building on Hajer's work) may be complemented by research on imaginaries and visions. For example, to explore discursive dimensions of energy visions, Sovacool and colleagues (2020) analyse visions according to the problems they try to address, the storylines and characters, and the discursive struggles. They analyse several aspects of future-oriented narratives, which not only helps to understand how highly abstract sociotechnical imaginaries actually shape paths and actions (Oomen, Hoffman, & Hajer, 2021; Sismondo, 2020) but also indicates that discourse analysis, visions and imaginaries may complement each other in future research (e.g. Hajer & Versteeg, 2019). Third, more work is needed on the linkages between concepts such as discourse, storylines, narratives, statements and practices (see chapter 3 that builds on Hajer's (1995, 2006) work). Although these concepts are defined and consistently applied to the empirical material in chapter 3, it is clear, in hindsight, that such an analysis may be enhanced by a more fine-grained understanding of the mentioned concepts. For example, it may be useful to explicitly consider how discourse and meaning are related: overlapping, tightly coupled, loosely coupled or uncoupled (Alvesson & Karreman, 2000). In the process, discourse may be defined as constituting subjectivity and as the structuring principle of society (i.e. overlapping). Yet it may also be understood as an element next to the text, talk, social cognition, society and culture (i.e. loosely coupled), raising intriguing questions about the uncertain, temporal or weak effects of language use or discourse on meaning, subjectivity and society. Here I discussed that the interpretations of institutional arrangements and infrastructure are particularly powerful. Along these lines, it is interesting to investigate the scope and scale of discourses. Is discourse constructed in local, situational contexts or, at the other extreme, does it relate to universal, macro-systemic vocabularies that show up in a number of contexts? Alvesson & Karreman (2000) caution that tensions may arise between rigour and social relevance in attempts to cover both dimensions.

Concerning agency in stable socio-technical systems or governance arrangements, I make two suggestions. First, in analysing the stability or inertia of socio-technical systems, more research is needed on the type of stability. Recently, in a review paper on institutional stability, it was proposed to consider stability along the axes of directionality and intentionality, leading to four modes of stability (Galik & Chelbi, 2021): passive stability holds that institutions are preserved through reinforcing processes of discourses, rules, infrastructure and resources (i.e. reinforcing institutions and non-purposeful). In active stability, actors intentionally reinforce existing institutions (i.e. reinforcing institutions on purpose). Intended inaction implies that actors intentionally seek to maintain the existing institutional constructs by foregoing disruptive actions (i.e. change avoided on purpose). Failed inaction means that actors seek institutional change, whilst this is prevented by events, institutions and other actors (i.e. change avoided and non-purposeful). Hence, in line with recent suggestions to consider stability and incumbency in multiple ways (Turnheim & Sovacool, 2020), the typology of Galik & Chelbi (2021) may further help to analyse institutional stability. Second, although the thesis mainly emphasises that established actors use power to sustain established arrangements, they may also decide to act differently. This is mentioned in the literature on the power frameworks I used (Arts & van Tatenhove, 2004; Grin, 2012) and also becomes clear in chapter 5, which illustrates that incumbents may change their roles towards niche projects. Here more work is needed on the conditions under which incumbents may act differently. Although not explicitly discussed in chapter 5, the conditions under which the niche project (DuCoop) emerged indicate that it may be fruitful to develop innovative projects in the space between different logics, regimes or systems. Specifically, it may be interesting to investigate whether incumbents feel less threatened and face less pressures in this space in between, leading to more proactive roles in radical innovation. To do so, the recent work of Runhaar and colleagues (2020) provides indications by highlighting that actors may exploit the different institutional logics in fragmented regimes, leading to more path-breaking activities. Likewise, Rosenbloom (2020) notes that the interaction between systems may induce not only new change dynamics but also new conflicts, which may create 'opportunities to accelerate change processes by leveraging these conflicts to bolster the strength of particular actor networks, facilitating their entry into neighbouring regimes' (p. 339). Hence, the creativity of niche and regime actors may further be investigated in sectors subject to multiple logics and multi-regime and multi-system interactions.

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Appendices

Appendix chapter 3

Interviews

1	Water expert, Delft University of Technology	19/1/2017
2	Water expert, Natuurpunt	16/3/2017
3	Wastewater expert, Ghent University	17/3/2017
4	Wastewater expert, STOWA	23/3/2017
5	Wastewater expert, Delft University of Technology	29/3/2017
6	Wastewater expert, Ghent University	3/4/2017
7	Wastewater expert, Dutch Water Authorities	4/4/2017
8	Wastewater expert, Energy & Resource Factory	10/5/2017
9	Wastewater expert, DeSaH	30/10/2017
10	Water expert, Delft University of Technology	9/11/2017
11	Water expert, Evides	27/11/2017
12	Wastewater expert, Delft University of Technology	5/12/2017

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- https://www.kwrwater.nl/
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- https://www.stowa.nl/
- https://www.thesourcemagazine.org/
- https://www.waterforum.net/
- http://wsstp.eu/

Appendix chapter 4

Analysed interviews

#	**Organisation**	**Date**
1	Regional water authority & ERF	15/12/2017
2	Regional water authority	6/2/2018
3	STOWA	26/2/2018
4	Consultancy company	27/2/2018
5	Aquaminerals	28/2/2018
6	Regional water authority	21/3/2018
7	Dutch water authorities, CWE & ERF	26/3/2018
8	Regional water authority & CWE	3/4/2018
9	Delft University of Technology	12/4/2018
10	Aquaminerals & ERF	19/4/2018
11	Delft University of Technology	23/8/2018
12	Rioned	22/10/2018
13	Regional water authority, ERF & VvZB	1/11/2018
14	Regional water authority	23/11/2018
15	Regional water authority & ERF	3/12/2018

Earlier interviews (on a circular economy in the Dutch wastewater system)

#	Organisation	Date
A	Delf University of Technology	19/1/2017
B	Natuurpunt	16/3/2017
C	Ghent University	17/3/2017
D	STOWA	23/3/2017
E	Delft University of Technology	29/3/2017
F	Ghent University	3/4/2017
G	Dutch Water Authorities	4/4/2017
H	Regional water authority & ERF	10/5/2017
I	DeSaH (engineering firm)	30/10/2017
J	Delft University of Technology	9/11/2017
K	Evides (drinking water company)	27/11/2017
L	Delft University of Technology	5/12/2017

Analysed (participatory) observations

#	Topic of the meeting	Date
1	70th 'holiday workshop' of the Dutch water sector	12/1/2018
2	ERF core team	12/2/2018
3	ERF core team	13/3/2018
4	ERF and CWE: ERF 2.0	14/4/2018
5	ERF working groups + core team	18/4/2018
6	ERF core team	18/4/2018
7	ERF working groups + core team	28/6/2018
8	ERF-steering group	11/7/2018

Earlier observations (related to the circular economy in the Dutch wastewater system)

#	Topic of the meeting	Date
1	Presentation Jules van Lier & Mark van Loosdrecht (kick-off SuPER-W network) (Delft)	11/2016
2	STOWA Platformdag Nieuwe Santatie [Network event New Sanitation]	4/2017
3	SuPER-W network meeting (Aachen)	6/2017
4	STOWA: platformdag Nieuwe Santatie [Network event New Sanitation]	9/2017
5	STOWA: stedelijk water: brandstof voor de circulaire economie [municipal water: driver for a circular economy]	10/2017
6	SuPER-W network meeting (Delft)	1/2018

Analysed documents

Field (internal documents)

- 20180212 - KT1 - Actielijst Programmateam bijgewerkt per31 jan
- 20180212 - KT1 - agenda Programmateam 21 februari 2018
- 20180212 - KT1 - CONCEPT verslag Programma team 31-1-2018 - ver
- 20180212 - KT1 - EFGF field notes core team
- 20180313 - KT2 - Actielijst Programmateam bijgewerkt per21 feb
- 20180313 - KT2 - agenda Programmateam 14 maart 2018
- 20180313 - KT2 - agendapunt 6 - Werkgroep *** - PT 14-3
- 20180313 - KT2 - concept verslag Programma team 21-2
- 20180313 - KT2 - field notes core team
- 20180313 - KT2 - Stavaza doelen EFGF 1e kwartaal 2018 -
- 20180322 - SG1 - 04 - Begroting 2017 EFGF - agendapunt 4 - SG
- 20180322 - SG1 - 06- 20180319_Voorstel ***_verankering
- 20180322 - SG1 - ACTIELIJST stuurgroep EFGF bijgewerkt per 6 de
- 20180322 - SG1 - Agenda Stuurgroep 22 maart 2018
- 20180322 - SG1 - CONCEPT - verslag stuurgroep 6 december 2017
- 20180322 - SG1 - Discussienotitie *** Versie 12 februari 2018
- 20180322 - SG1 - MEMO resultaat EFGF 2017 - agendapunt 4 - SG 2
- 20180322 - SG1 - Voorgang programmadoelen EFGF 1e kwartaal 2018
- 20180403 - KT3 - Actielijst Programmateam bijgewerkt per 14 m
- 20180403 - KT3 - Actielijst Programmateam bijgewerkt per 5 apr

- 20180403 - KT3 - agenda Programmateam 5 april 2018
- 20180403 - KT3 - CONCEPT verslag Programma team 14-3-2018
- 20180403 - KT3 - CONCEPT verslag Programma team 5-4-2018
- 20180414 - CWE-EFGF - Agenda bijeenkomst CWE 13 april
- 20180414 - CWE-EFGF - field notes ERF 2.0
- 20180418 - BKT1 - 19 december 2017 - Verslag Breed Kernteam EFG
- 20180418 - BKT1 - ACTIELIJST BREED kernteam EFGF - 2017
- 20180418 - BKT1 - ACTIELIJST BREED kernteam EFGF - 2018
- 20180418 - BKT1 - Agenda Breed Programmateam 19 april 2018
- 20180418 - BKT1 - breed programmateam EFGF - STOWA
- 20180418 - BKT1 - CONCEPT Agenda Breed Programmateam 19 april
- 20180418 - BKT1 - CONCEPT verslag Programma team 5-4-2018 -
- 20180418 - BKT1 - Field Notes working groups and core team
- 20180418 - KT4 - Actielijst Programmateam bijgewerkt per 5 apr
- 20180418 - KT4 - agenda Programmateam 19 april 2018
- 20180418 - KT4 - CONCEPT verslag Programma team 5-4-2018
- 20180418 - KT4 - Field notes core team
- 20180516 - KT5 - Actielijst Programmateam bijgewerkt per 19 ap
- 20180516 - KT5 - agenda Programmateam 16 mei 2018
- 20180516 - KT5 - Communicatieplan EFGF 2018-2019
- 20180516 - KT5 - CONCEPT verslag Programma team 19-4-2018
- 20180516 - KT5 - Kwartaaldoelen EFGF 2e kwartaal 2018
- 20180628 - BKT2 - ACTIELIJST BREED kernteam EFGF - 2018
- 20180628 - BKT2 - ACTIELIJST BREED kernteam EFGF - 2018
- 20180628 - BKT2 - Agenda Breed Programmateam 28 juni 2018
- 20180628 - BKT2 - CONCEPT verslag Programma team 28 juni 2018
- 20180628 - BKT2 - field notes working groups + core team
- 20180628 - BKT2 - Memo *** en *** enveloppe -
- 20180628 - BKT2 - Memo voortgang *** - tbv SG 11-
- 20180711 - SG2 - 01 - Agenda Stuurgroep 11 juli 2018
- 20180711 - SG2 - 02 -ACTIELIJST stuurgroep EFGF bijgewerkt per
- 20180711 - SG2 - 02 - CONCEPT - verslag stuurgroep 23 maart 2018
- 20180711 - SG2 - 03 - memo SK - Kwartaaldoelen EFGF 2e kwartaal
- 20180711 - SG2 - 03 -Kwartaaldoelen EFGF 3e kwartaal 2018
- 20180711 - SG2 - 04 - *** - status stuurgroep 7 juli
- 20180711 - SG2 - 06 - A - ANNOTATIE behorend bij agendapunt 5
- 20180711 - SG2 - 06 - C - notulen biomassa kopgroep 30 m

- 20180711 - SG2 - 06- D-- notulen biomassa kopgroep 25-05-
- 20180711 - SG2 - 08 - 2018-07-05_Jaarrekening 2017 van de EFGF
- 20180711 - SG2 - 09 - van 2018-07-04__Begroting 2018 versie 2.2
- 20180711 - SG2 - B - Opdracht voor verkenning
- 20180711 - SG2 - field notes steering group

CWE (internal documents for all years before 2018)

- CWE 10-13- 05-02-2010
- CWE 10-33a- 28-05-2010
- CWE 10-44a- 15-10-2010
- CWE 11-1- 10-12-2010
- CWE 11-21a- 04-02-2011
- CWE 12-1a- 18-11-2011
- CWE 12-26a- 17-02-2012
- CWE 12-55- 08-06-2012
- CWE 13-21- 15-02-2013
- CWE 13-37a- 07-06-2013
- CWE 14-41a- 09-05-2014
- CWE 15-1- 21-11-2014
- CWE 15-29a- 29-05-2015
- CWE 16-20- 12-02-2016
- CWE 16-42- 03-06-2016
- CWE 17-1- 02-12-2016
- CWE 17-16- 17-02-2017
- CWE 17-36a- 19-05-2017
- CWE 18-1a- 01-12-2017
- CWE 18-44- 18-05-2018
- CWE 18-69a-14/11/2018-EFGF2.0
- CWE 18-69b - Een slagvaardig netwerk
- CWE 18-70a
- CWE 18-70b
- CWE 18-70c
- Verslag CWE 30/11/2018

Other

- CWE - 2017 – oplegnotitie (internal)
- CWE - 2017 - oplegnotitie top 5 grondstoffen (internal)
- CWE - 2018 - Unie – EFGF (internal)
- CWE - 2018 - Unie - EFGF - bijlage (samengevat) (internal)
- De Korte – 2018 - Ondraaglijke stank en ander ongerief
- EFGF - 2010 - Energy Factory
- EFGF - 2012 - TedX EFGF
- EFGF - 2014 - Terugwinnen wat van waarde is (speech)
- EFGF - 2014 - Transitieprogramma 2014-2018
- EFGF - 2014 - Twynstra Gudde notitie
- EFGF - 2016 - Twynstra Gudde - Organisatorische opties (internal)
- EFGF - 2017 - top 5
- EFGF -2017 - doorontwikkeling - concept visiedocument (internal)
- EFGF - 2018 - EFGF 2.0. - via versie 16-3 voor SG (internal)
- EFGF - 2018 - EFGF 2.0. - versie 6-4 - DEF. versie voor CWE (internal)
- EFGF - 2018 - hoe is efgf ontstaan
- EFGF - ND - top 5 trekkers
- Havekes et al. - 2015 - The Dutch water authority model
- Lazaroms Poos - 2004 - The Dutch water board model
- Rioned - 2013 - strategienota
- Slideshow online AA en Maas - relatie Berenschot en Twynstra
- Spaan Menno - 2018 – innovatie en EFGF
- STOWA - 2008 - Frijns - Roorda - Mulder
- STOWA - 2010 - NEWater
- STOWA - 2015 - 2015-2schw017
- Unie & VNG - 2012 - Routekaart 2030
- Van den Oever - 2018 - PhD thesis
- Van veldhuizen - 2013 - water governance, EFGF
- WarerWegen - 2010 - Factsheet
- WaterWegen - 2012 - LEF document
- 2011 - Bestuursakkoord water

Observed newsletters

- https://www.aquafarm.nl/
- https://www.efgf.nl/
- https://www.eureau.org/
- https://www.h2owaternetwerk.nl
- https://www.kwrwater.nl/
- https://www.uvw.nl/
- https://www.samenwerkenaanwater.nl/
- https://www.stowa.nl/
- https://www.thesourcemagazine.org/
- https://www.waterforum.net/
- http://wsstp.eu/

Appendix chapter 5

Appendix A: list of the empirical material

Analysed interviews

#	**Organisation**	**Date**
1	Ghent University	17/3/2017
2	Ghent University	3/4/2017
3	DeSaH (engineering company)	30/10/2017
4	DuCoop	18/12/2017
5	DuCoop	1/10/2019
6	Farys	8/2/2019
7	Department of Environment and Climate	1/3/2019
8	Sogent	7/3/2019
9	CAAAP	26/3/2019
10	Aquafin	3/4/2019
11	Ghent University	4/8/2019
12	Department of Public Roads, Bridges and Waterways	19/4/2019
13	CAAAP	6/5/2019
14	DuCoop	27/4/2020
15	Department of Environment and Climate	7/5/2020

Analysed observations (field notes)

#	**Topic of the meeting**	**Date**
1	STOWA: Platformdag Nieuwe Santatie [Network event New Sanitation] (NL)	4/2017
2	STOWA: platformdag Nieuwe Santatie [Network event New Sanitation] (NL)	9/2017
3	STOWA: stedelijk water: brandstof voor de circulaire economie [municipal water: driver for a circular economy] (NL)	10/2017
4	The I-cleantech challenge (BE)	6/2018
5	3rd IWA Resource Recovery Conference (IT)	9/2019
6	H2020 project meeting: Run4Life-DuCoop (BE)	12/2019
7	Field trip DuCoop-site (BE)	12/2019

Analysed documents and videos

- 2005. The construction of Aquafin (Van Braeckel Dirk)
- 2006. Dockyards urban development (OMA Rotterdam)
- 2009. Water in dock yards (Sogent)
- 2011. Visions about water and sanitation for the cities of the future: time to rethink environmental microbial processes (Microbial Biotechnology, Verstraete & De Gusseme)
- 2011. Old dock yards: complex city projects (area-wide implementation plan, City of Ghent)
- 2011. Climate Arena Ghent: possible transition pathways (City of Ghent)
- 2012. Climate Magazine 2050: water (City of Ghent)
- 2014. Schipperskaai Development starts urban development (website oudedokken.be)
- 2014. Transition management in five European cities – an evaluation (DRIFT)
- 2014. A climate of change: a transition approach for climate neutrality in the city of Ghent (Belgium) (Nevens & Roorda)
- 2014. Annual report (Aquafin)
- 2015. New life in the old dockyards (Sogent)
- 2015. Stakeholder analysis ZAWENT (LeAF-Wageningen)
- 2015. Annual report (Aquafin)
- 2015. Agreement in principle ZAWENT - municipal council (online version, City of Ghent)

- 2015. Agreement in principle ZAWENT - municipal council (approved, City of Ghent)
- 2016. Making climate change public? A dramaturgically inspired case-study of learning through transition management (Van Poeck, Vandenabeele & Goeminne)
- 2016. Governance of urban sustainability transitions. Ghent: Fostering a Climate for Transition (Hölscher, Roorda & Nevens)
- 2016. Terms of delivery DuCoop-Ghent (DuCoop & City of Ghent)
- 2016. Concession DuCoop-Ghent (DuCoop & City of Ghent)
- 2016. Annual report (Aquafin)
- 2017. New circular life in Old Dockyard (Sogent & Eurocities)
- 2017. Nereus Interreg project proposal (DuCoop)
- 2017. Run4life H2020 project proposal (DuCoop)
- 2017. Climate day Ghent - presentation of New Dockyards (CAAAP)
- 2017. IRRC2017 abstract: Innovative decentralized sewage treatment project for 400 households and local industry, including water, nutrient and energy recovery (De Gusseme, De Wilde, Demolder, Demuynck, Jacobs & De Smet)
- 2017. IRRC2017 presentation: innovative decentralized sewage treatment project for 400 households and local industry (De Gusseme, De Wilde, Demolder, Demuynck, Jacobs & De Smet)
- 2017. Water proposal (Flanders Circular, OVAM)
- 2017. Annual report (Aquafin)
- 2018. Guideline for municipalities (Heat Network Flanders)
- 2018. Input for Nereus project (VITO/VLAKWA)
- 2018. Overview stakeholders Ghent DuCoop & Run4Life project (WE&B)
- 2018. Annual report (Aquafin)
- 2019. Presentation: new Life in the Old Dockyards (Sogent)
- 2019. Area-wide implementation plan: Koopvaardijlaan (City of Ghent)
- 2019. A circular neighbourhood in Ghent: DuCoop (Susanova Magazine)
- 2019. Focus group reports (DuCoop)
- 2019. Old Dockyards & Schipperskaai (Public-private partnership database, City of Ghent)
- 2019. Water policy framework (Environment and nature council of Flanders)
- 2019. The Mobble Sustainable Water Treatment Ghent (themobble.be)
- 2019. 2 Seas project videos (Nereus project)

- 2019. Annual report (Aquafin)
- 2019. New dockyards: groundbreaking circular economy (YouTube, DuCoop)

Observed newsletters and websites

- https://www.aquafin.be/en
- https://www.aquarama.be/
- https://www.caaap.be/nl/
- https://www.denieuwedokken.be/
- https://www.ducoop.be/
- https://www.eureau.org/
- https://www.farys.be/nl
- https://www.h2owaternetwerk.nl
- https://www.integraalwaterbeleid.be/
- https://www.leaf-wageningen.nl/
- https://www.minaraad.be/
- https://www.nereus-project.eu/
- https://www.revive.be/en/
- https://www.riorama.be/
- https://www.run4life-project.eu/
- https://www.sogent.be/
- https://www.stad.gent/en
- https://www.stowa.nl/
- https://www.susanova.be/
- https://www.thesourcemagazine.org/
- https://www.vanroeyvastgoed.be/
- https://www.vito.be/en
- https://www.vlaanderen-circulair.be/nl
- https://www.vlakwa.be/
- https://www.vmm.be/
- https://www.waterforum.net/
- https://www.wsstp.eu/

Appendix B: pictures of the niche project

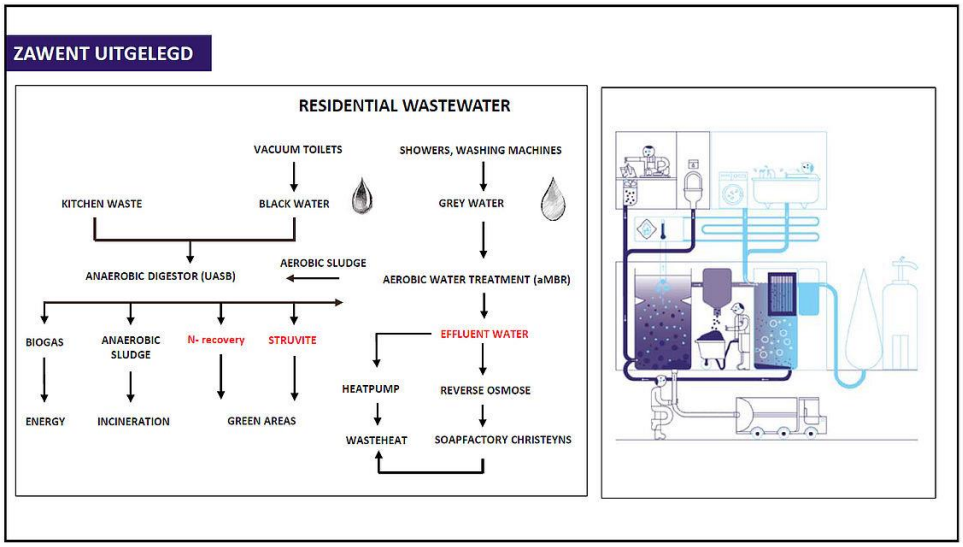
Picture 1: residential units and school (source: https://ducoop.be/)

Picture 2: residential units (l) and school (r) (source: https://www.eld.be/)

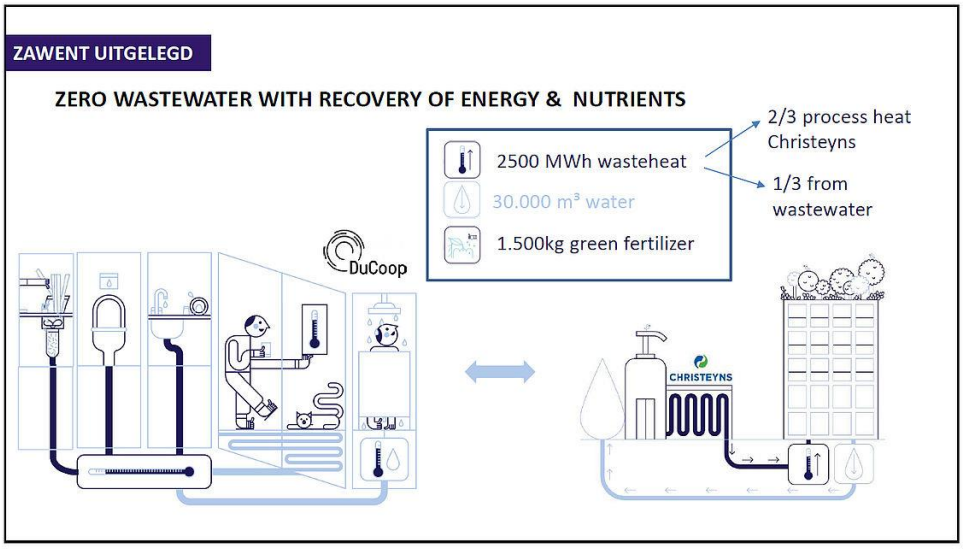
Picture 3: residential units and green areas (source: https://www.denc-studio.be/)

Picture 4: residential units (source: https://www.budgetwoningen.gent/)

Picture 5: DuCoop's technology called ZAWENT (zero wastewater and energy & resource recovery) explained (source: https://www.nereus-project.eu/)



Picture 6: ZAWENT explained (source: https://www.nereus-project.eu/)



Acknowledgements

Though writing a thesis is typically depicted as a journey from one point to the other, this thesis was more like strolling around the city to see what was on offer. It bears the name of a single author but is the product of the combined efforts of many without whom I would still be wandering around the streets.

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September 2021, Poel 16, Gent.

Curriculum vitae

Kasper Ampe was born on February 24, 1989, in Ghent, Belgium. After completing his high school diploma with a curriculum of economics and languages at GO! Erasmus in De Pinte in 2009, he obtained a master's degree in international politics in 2013 from Ghent University and, in 2014, an advanced master's in conflict and development studies in the Global South. After a stint during 2014-2016 as a shop manager in a social enterprise focussed on labour market insertion and second-hand shops in his hometown, in November 2016, he joined the Biotechnology & Society group in the Department of Biotechnology of Delft University of Technology as well as the Centre for Sustainable Development in the Faculty of Political Sciences of Ghent University as a Marie Skłodowska-Curie PhD candidate. He was promoted by Prof. Dr. Patricia Osseweijer and Prof. Dr. Thomas Block in Delft and Ghent respectively and supervised by Prof. Dr. Lotte Asveld in Delft and Prof. Dr. Erik Paredis in Ghent. During 2016-2021, he worked on the research presented in this thesis and, in November 2020, joined the Climate and Sustainable Development group in the Research Institute for Work and Society of KU Leuven.

List of publications

Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2020). A transition in the Dutch wastewater system? The struggle between discourses and with lock-ins. *Journal of Environmental Policy & Planning*, *22*, 155-169.

Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2021). Power struggles in policy feedback processes: incremental steps towards a circular economy within Dutch wastewater policy. *Policy Sciences, 54,* 579-607.

Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2021). Incumbents' enabling role in niche-innovation: Power dynamics in a wastewater project. *Environmental Innovation and Societal Transitions*, *39*, 73-85.