PREPARING FOR REUSE

TOWARDS COOPERATION FOR THE INNER CYCLES AND THE LOCAL LOOPS

BY

RIKKE MARIE MOALEM

DISSERTATION SUBMITTED 2022

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AALBORG UNIVERSITY
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Reuse what you can,
repair what is broken, remanufacture
what cannot be repaired, recycle what
cannot be reused

Stahel, 2016

CV

Rikke Marie Moalem, Ph.D. Fellow, Aalborg University Campus Copenhagen, Denmark

Rikke Marie Moalem is a Ph.D. fellow at Aalborg University Campus Copenhagen (AAU), Denmark. Rikke holds a bachelor's degree in integrative geography from Alborg University, Denmark, where, among other themes, she has taught and researched development theory and practice, including experience economy. Rikke also holds a master's degree in Geography from Oxford University (OUCE). Her Ph.D. takes a point of departure in research, stating, *"Too many products which can still be used end up as waste."* Her core focus is investigating local prevention and preparation for reuse schemes. During her Ph.D., Rikke was a visiting researcher at Lund University, International Institute for Industrial Environmental Economics (IIIEE), Sweden, where she investigated Swedish models around preparing waste for reuse and repair.

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Rikke Marie Moalem

Hellerup, April 2022

ABSTRACT

The EU waste policy aims to protect the environment and human health and support the transition to a circular economy, in which waste is perceived as a valuable resource. Nevertheless, the average European produces 5 tons of waste each year, of which only 38 percent is recycled. Further, over 60 percent of household waste goes to landfills in some EU countries. Therefore, the EU waste policy sets objectives and targets to limit landfilling, stimulate innovation in recycling, and improve waste management. Under the revised Waste Framework Directive, all European countries will have to recycle at least 65 percent and landfill less than 10 percent of municipal waste by 2035. This includes implementing circular business models that encourage extended use of products, components, and materials. The circular economy concept encompasses a resource-and-business strategy. Thus, there are new insights to acquire from the circular economy concept for the waste sector, currently governed by the waste hierarchy. These include a mindset change from seeing waste as a problem to be solved to seeing it as a resource and business opportunity. Moreover, the circular economy concept emphasizes systems thinking and the creation of new types of collaboration between actors that may not traditionally have collaborated. There is not yet a common understanding of how the waste sector can apply to the circular economy concept in practice.

The overarching aim of this research is to advance the understanding of potentials and constraints for citizens and municipal waste management companies to prolonging the life of products through reuse and repair. From a citizen perspective, the focus is mainly on the experiences with repair cafes. From a municipal perspective, the focus is on municipal waste management companies and their ability to prolong the lifetime of products that have been disposed of at reuse stations or as bulky waste.

This thesis draws on concepts from waste policy, product-life extension, collaboration, circular economy, and systems thinking. The conceptual framework consists of lock-in rationales, primarily political, cultural, technological, and economical. Finally, this thesis takes a qualitative approach wherein research draws on those concepts through empirical investigation using a mixed-method approach.

The analysis identifies possible solutions for citizens and municipal waste management companies to extend the life of products through reuse and repair and reveals conflicting roles within the system. Based on systems theory and the concept

of ‘lock-in’ (political and cultural), several challenges are identified in implementing schemes in the current system. Finally, possible ways to improve the implementation of repair-and-reuse schemes are discussed.

Keywords: waste, preparation for reuse, repair, collaboration, local loops, inner cycles

SUMMARY

The current volume and patterns of consumption and production put the earth's resources under pressure. This has brought the circular economy onto the political agenda. In 2015, circular economy and waste were put on the same agenda through the EU's first CE action plan. However, the change from a linear economy to a more sustainable, circular one requires action and new solutions. As an example, products that can still be used end up as waste (DAF, 2017b), resulting in them and their components being prematurely recycled or incinerated. This contradicts the aims of a circular economy. One solution is to extend the life of products through reuse and repair.

The Waste Framework Directive (2008/98/EC), as amended by Directive 2018/850, contains an increased focus on extending the lifetime of products through reuse and repair. Initiatives aimed at extending product life do exist and include the establishment of second-hand shops, repair cafes, and other related initiatives. From a waste perspective, waste practices favor recycling over reuse. This contradicts the aim of a circular economy where the inner cycles of repairing, sharing, and reusing should be prioritized over the outer cycles.

This research aims to reveal local opportunities to promote prolonging the lifetime of products through repair and reuse, where initiatives can occur either alone or in collaboration with other local actors. The main research question is (RQ):

> **What happens when the principles of the inner cycles of the circular economy meet the current practices based on the waste hierarchy?**

A series of case studies related to prolonging the life of products through preparation for reuse, and reuse and repair, at a local level are analyzed. For each case, different methodological choices were applied. Methods included desk studies and engaging in practice through action research; attending conferences; conducting study trips in Denmark and abroad to Brussels and Sweden; applying different techniques for fieldwork, including interviews; observations; and sparring with external partners.

The thesis is divided into four parts, which are outlined in the following, and includes three manuscripts for academic journals that primarily build on empirical data and experiences from collaborations within the FUTURE project (see Section 1.3). Other outcomes related to the FUTURE project include webinars on repair and reuse conducted with Gate 21 and Sustainable Business HUB, Sweden, co-creating

solutions with students at Aalborg University during teaching, and, finally, starting and facilitating a new interregional repair-and-reuse network, which now counts over 60 members of practitioners and academia from both Sweden and Denmark.

Part I of the thesis introduces the contextual and conceptual framework of the project. This includes a presentation and discussion on the EU Waste Framework Directive and associated waste hierarchy and an introduction to the project (FUTURE) as this forms the basis of this research. The FUTURE [Fremtidens Intelligente Energi-og Ressourcesystemer] project is funded by Interreg, the Capital Region of Denmark, and Region Zealand (Interreg ID: NYPS 20201560).

Part II frames the research, sets the scene, and outlines the main concepts that the work draws on. The conceptual framework includes collaboration and the circular economy as an umbrella concept, where focus is maintained on slowing the resource loops. The research design is also presented, highlighting data collection methods for the thesis.

Part III of this thesis presents the research findings. Specifically, Chapters 4 to 6 present vital findings, answering the three subquestions of the thesis.

Part IV includes a discussion and conclusion, revisits the research question, summarizes the contributions of the research, and discusses the implications of the conclusions for practitioners and future planning and research.

RESUME

Vores nuværende forbrugs- og produktionsmønstre sætter jordens ressourcer under pres. Dette har sat cirkulær økonomi og affald på den politiske dagsorden. I 2015 kom cirkulær økonomi og affald på dagsordenen sammen via EU's første CE-handlingsplan. Men, forandring fra en lineær økonomi til en mere bæredygtig og cirkulær økonomi kræver handling og nye løsninger. For eksempel ender produkter der stadig kan bruges som affald (DAF, 2017b) og dermed bliver de og deres komponenter genanvendt eller afbrændt i utide. Dette står i kontrast til målene for en cirkulær økonomi. En løsning er at forlænge produkternes liv ved hjælp af genbrug og reparation.

Affaldsrammedirektivet (2008/98/EF), som ændret ved direktiv (2018/850), indeholder et øget fokus på at forlænge produkternes levetid gennem genbrug og reparation. Initiativer der sigter mod at forlænge produktets levetid, omfatter blandt andet etablering af genbrugsbutikker, reparationscaféer og andre relaterede tiltag. Fra et affaldsperspektiv favoriseres genanvendelse fremfor genbrug. Dette er i strid med målet for en cirkulær økonomi hvor de indre kredsløb af reparation, deling og genbrug bør prioriteres højere end det ydre kredsløb af genanvendelse.

Denne forskning har til formål at undersøge lokale muligheder for at fremme forlængelse af produkters levetid gennem reparation og genbrug, hvor initiativer kan ske enten alene eller i samarbejde med andre lokale aktører. Det primære forskningsspørgsmål er:

> **Hvad sker der, når principperne for den cirkulære økonomis indre cirkler møder den nuværende praksis baseret på affaldshierarkiet?**

Specialet analyserer en række casestudier relateret til forlængelse af produkters levetid gennem genbrug og reparation på lokalt niveau. Tre delforskningsspørgsmål styrede forskningsprocessen. For hvert enkelt tilfælde blev der anvendt forskellige metodiske valg. Metoderne omfattede skrivebordsstudier og involvering i praksis gennem aktionsforskning, deltagelse i konferencer; gennemføre studierejser i Danmark og i udlandet; anvendelse af forskellige teknikker til feltarbejde, herunder interviews, observationer samt sparring med eksterne samarbejdspartnere.

Specialet er opdelt i fire dele skitseret i det følgende og omfatter tre artikler til akademiske tidsskrifter der bygger på empiri og erfaringer fra de deltagende kommuner i projektet FUTURE. Se yderligere Afsnit 1.3. Andre resultater relateret til projektet FUTURE inkluderer webinarer om reparation og genbrug udført med

Gate 21 og Sustainable Business Hub, Sverige, samskabelse af løsninger med studerende på Aalborg universitet under undervisningen og endelig opstart og facilitering af en ny interregional reparation og genbrug netværk, der nu tæller over 60 medlemmer af praktikere og den akademiske verden fra både Sverige og Danmark.

Del I af dette speciale introducerer den kontekstuelle og begrebsmæssige ramme, som projektet foregår inden for. Dette inkluderer en præsentation og diskussion om EU's affaldsrammedirektiv og tilhørende affaldshierarki og en introduktion til projektet FUTURE, som har dannet basis for forskningen. Projektet FUTURE [Fremtidens Intelligente Energi-og Ressourcesystemer], er finansieret af Interreg, Region Hovedstaden og Region Sjælland (Interreg ID: NYPS 20201560).

Del II sætter scenen og skitserer de vigtigste koncepter, som afhandlingen trækker på. Begrebsrammen omfatter samarbejde og cirkulær økonomi som et paraplykoncept, hvor fokus ligger på at bremse ressources cyklusser. Forskningsdesignet præsenteres også her i del II hvor dataindsamlingsmetoder til specialet fremhæves.

Del III af denne afhandling præsenterer forskningsresultaterne. Specifikt præsenterer kapitel 4 til 6 vitale resultater, som besvarer afhandlingens tre underspørgsmål.

Del IV inkluderer en diskussion og konklusion, genbesøger forskningsspørgsmålet, opsummerer bidragene fra forskningen og diskuterer konsekvenserne af konklusionerne for praktikere og fremtidig planlægning og forskning.

LIST OF PAPERS

Paper I

Moalem, R.M, Remmen, A., Hirsbak, S., & Kerndrup, S. (2022). Struggles over waste: preparing for reuse in the Danish waste sector. Submitted to Waste Management and Research.

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Paper III

Moalem, R.M. & Mosgaard, M. (2021). A critical review of the role of repair cafés in a sustainable circular transition. *Sustainability*. 2021; 13(22):12351. https://www.mdpi.com/2071-1050/13/22/12351/pdf

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OTHER CONTRIBUTIONS

Book chapter

Christensen, D., Hjul-Nielsen, J., **Moalem, R.M.**, & Johansen, B. (2021). Circular economy in Denmark: Bornholm's vision to achieve 100 percent reuse and recycling in: *Circular economy: Recent trend in global perspective*. Springer Nature. Book chapter. Published: https://link.springer.com/book/9789811609121.

Journal article

Ramsheva, K.Y., **Moalem, R.M.**, & Milios, L. (2020). Realizing a circular concrete industry in Denmark through an integrated product, service and system perspective. *Sustainability*. 12. 9423. 10.3390/su12229423. Published: https://www.mdpi.com/2071-1050/12/22/9423

Moalem, R.M. & Schmidt, K. (2022). Municipal solid waste management in the bordering of commercial and non-commercial repair: Lessons from Denmark and Sweden. Submitted to Journal of Cleaner Production. In process.

Project reports

Miliute-Plepiene, J. & **Moalem, R.M.** (2020). *Increasing re-use of construction and demolition materials and products—Measures for prevention of waste at Swedish recycling centres*. IVL Swedish Environmental Research Institute. ISBN 978-91-7883-207-1. Published: https://www.ivl.se/download/18.4c0101451756082fbad9d/1603698664195/C547.pdf

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Other

Project FUTURE results and cases: Gate 21 https://www.gate21.dk/nyhed/intelligent-brug-af-produktdata-der-fremmer-genbrug/ September 2021.

FIGURES AND TABLES

ABBREVIATIONS

CBM	Circular business model
CE	Circular economy
EOL	End of life
MSWM	Municipal solid waste management
PfR	'preparing for reuse' (PfR) means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be reused without any other preprocessing
PLE	'Product lifetime extension' is a concept developed as one of the multifaceted solutions to create a circular economy
EU	European Union
EWFD	European Waste Framework Directive. DIRECTIVE 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 on waste and repealing certain directives
MS	Member state
Reuse	'Reuse' means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived
Reuse station	A common terminology used in this thesis for recycling-and-reuse sites/stations
RQ	Research question
SDG	Sustainable Development Goal
SQ	Subresearch Question
'Waste'	Classified waste is not necessarily waste. Situation signs are set to indicate this tension

PART I

Introduction

The ongoing transition in Denmark from traditional waste management to circularity and resource management is discussed in the following section (Part I). The aim is to introduce the context and motivation for this research.

This Ph.D. thesis positions itself around the waste treatment option—preparing for reuse (PfR) and product life extension— mainly focusing on how actors promote local solutions for the inner cycles of reuse and repair, either alone or in cooperation.

The section is arranged in the following way: firstly, an introduction to the problem field and the EU project (FUTURE), which has initiated this research and contributed to the raised research questions, and secondly, introducing the underlying assumptions and motivation for undertaking this research, followed by the thesis research question, scope, and delimitation. A reading guide finalizes this section.

1 INTRODUCTION

Over two billion tonnes of waste from households are generated globally each year (Kaza et al., 2018). In a European context, waste generation increased by approximately 7.5 percent from 1995 to 2019, of which 60 percent was neither reused nor recycled in 2019 (Eurostat, 2021). However, major variations among member states within the EU exist in terms of both waste generation and management, reflecting differences in consumption patterns and economic wealth. ‘For 2020, municipal waste generation totals vary considerably, ranging from 282 kg per capita in Romania to 845 kg per capita in Denmark’ (Eurostat, 2021). Denmark ranks first both when it comes to the amount of waste generated per capita and the percentage of the waste being incinerated (Eurostat, 2021).

The amount of waste is steadily increasing in Denmark (Eurostat, 2021). Waste amounted to 12.7 million tonnes in 2019, of which household waste consisted of 28 percent, the construction industry 40 percent, and other industries such as services and agriculture 33 percent. Although municipal waste accounts for a smaller percentage than industries, it has a high political profile, explained by its link to consumption patterns, complex character, and composition (Eurostat, 2021).

F**igure 1** Garbage truck with the message 'reuse is gold' in the city of Copenhagen

Only a few scientific studies have been undertaken to assess the preparation for reuse potential of products that have ended up as 'waste' at reuse stations (Milios & Dalhammar, 2020). Several investigations point towards an untapped potential in preparation for reuse rather than recycling (Messmann et al., 2019; Milios &

Dalhammar, 2020; Parajuly & Wenzel, 2017; Zacho, Mosgaard et al., 2018). For example, in a case study at collection points in the German state of Bavaria, between 13 and 16 percent of the 'waste' streams of furniture, leisure goods, and electric and electronic equipment could be immediately prepared for reuse rather than recycled or incinerated (Messmann et al., 2019). Parajuly and Wenzel (2017) investigated potentials for reuse and recycling for WEEE products in a Danish context, mainly focusing on their resale value, and found significant potential for reuse across different product types. Further, Zacho, Mosgaard et al. (2018) assessed the size and characteristics of the potential value from resources embedded in 'waste' at recycling stations in Denmark, concluding that preparation for reuse holds larger potential than recycling in terms of local employment and economic value. On this basis, they suggested that 'prepare for reuse' should play a more significant role in future waste management in a circular economy (Zacho, Mosgaard et al., 2018). The Danish Waste Association (DAF) backs this up, stating that too many products that can be reused get prematurely recycled or incinerated (DAF, 2017b). For an example, see Figure 2. Thus, several aspects of the current waste management practices do not correspond with the upper levels of the European Waste Framework Directive (Directive 2008/98/EC). This issue is further dealt with in Section 1.2 and Chapter 4.

Figure 2 Barbie Dolls disposed of in a container for recycling

Due to a growing interest in reuse, the reuse market has expanded recently, as has competition as more actors have emerged on the waste market, including municipal

waste management companies (Affaldskontoret, 2019). Nevertheless, a large residual of reusables is being disposed of at municipal reuse stations still (Affaldskontoret, 2019). Subsequently, some municipal waste management companies have established second-hand shops associated with their reuse stations. See Figure 3. Here, items collected at the sites are prepared for reuse and sold. However, this practice has spawned an ongoing debate. Documents from the National Board of Appeal, the Danish Waste Association, and consultation responses show that the critique consists mainly of three elements: 1) It is a task for private companies to manage and sell reused goods; 2) Goods for reuse should be handled by and for charity; 3) Are products sold in these shops 'waste'? (AST, 2015; AST, 2017; DAF, 2017a; HORTEN, 2017).

Thus, different positions and diverse perceptions exist concerning how reuse should be managed, including a dichotomy between public and private tasks. This apparent tension is dealt with further in Chapter 4.

Figure 3 Municipal reuse shop in Denmark, Affaldsselskabet Vendsyssel, AVV

The following section contains a brief introduction to the EU waste framework, followed by a historical outline to show why this theme is important to study in the first place. Then, there is an introduction to the EU project (FUTURE), followed by the research questions of this Ph.D. thesis. A reading guideline finalizes this chapter.

1.1 The EU Waste Framework Directive

The waste hierarchy was introduced in western Europe 40 years ago, and it outlines a priority for the various waste management options (Williams, 2015). The waste hierarchy was introduced in the framework directive established in 2008 and member states have since been obliged to adopt waste management plans following the waste

hierarchy and specific targets (directive 2008/98/EC, Art. 4) (EU, 2008) (see Figure 4).

According to the directive (2008/98/EC), the waste hierarchy shall apply a priority order in waste prevention and management legislation and policy, ranking 'prevention' first, followed by 'preparing for reuse' (PfR), then 'recycling,' 'other recovery,' and 'finally disposal.' For the upper levels, the following definitions apply (2008/98/EC):

> ‘prevention' means measures taken before a substance, material or product has become waste that reduces: the quantity of waste, including through the re-use of products or the extension of the life span of products
>
> 'preparing for reuse' means checking, cleaning, or repairing recovery operations, by preparing products or components that have become waste so that they can be reused without any other pre-processing

Waste, however, is a generic concept defined differently by authorities (Pires & Martinho, 2019). In the waste framework directive, 'waste' is defined as *'any substance or object that the holder discards or intends or is required to discard'* (2008/98/EC, Art. 3). Nevertheless, this definition can be interpreted differently by different actors (Moalem, R. M. et al., 2022). Gsell et al. (2019) frame it in the following way: 'Despite this apparent ambiguous regulatory framework, reuse often happens in a gray zone between waste management and social activities, and a clear differentiation is extremely challenging' (p. 23). Further, actors' perceptions on waste differ amongst the EU member states, i.e., whether textiles collected from containers should be considered waste differs from member state to member state and *within* a member state (Gsell et al., 2019). As a result, preparing for reuse is often understood in unclear terms. From a legal perspective, Luciano Butti (2012) points to the same challenge: ‘The apparently simple definition of the concept of waste seems to be impossible to outline in regulatory terms’ (Butti, 2012 p. 1621). Based on this ambiguity, then, the role of different stakeholders is understood in various ways in European countries.

1.2 From waste towards resource management

To ‘guide’ the EU’s transition to a circular economy, a circular economy action plan—the ‘First Circular Economy Action Plan’ (COM (2015) 614)—was introduced by the EU commission in 2015 (EU, 2015). One of the major components in the plan related to changes in waste management led to the amended EU waste directive in 2018 (Directive (EU) 2018/851), which provides the new legislative framework for the collection, transport, recovery, and disposal of waste (EU, 2018b). The implementation process of the amended directive in a Danish context is described in the following. This is done with a particular focus on two critical issues that affected

the outcome of the final agreement for a national plan for waste prevention and management, namely the previously mentioned legal disputes from 2015 to 2017 concerning municipal waste management companies' right to operate secondhand shops and settlement in the Danish Parliament in June 2020, concerning access rights to reusables at the reuse station.

1.2.1 The amended directive

The amended directive intended to pave the way for the CE and obliges all EU member states to increase preparing for reuse and the recycling of municipal waste at a minimum of 65 percent by weight by 2035, having the following key objectives: "To protect the environment and human health by preventing or reducing the generation of waste, the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use, which are crucial for the transition to a circular economy and for guaranteeing the Union's long-term competitiveness" (EU, 2018/851, Art. 1). Thus, the amendments indicate a transition from traditional waste management towards emphasizing PfR and the circular economy.

Nevertheless, the amended directive states the following regarding prevention:

> Member states shall take measures to prevent waste generation. Those measures shall, at least: (d) encourage the re-use of products and the setting up of systems promoting repair and re-use activities, including in particular for electrical and electronic equipment, textiles, and furniture, as well as packaging and construction materials and products. (Art. 9 Prevention)

The amended directive has the following to say about PfR:

> The Member States shall take measures to promote preparing for reuse activities, notably by encouraging the establishment of and support for preparing for reuse and repair networks, by facilitating, where compatible with proper waste management, their access to waste held by collection schemes or facilities that can be prepared for reuse but is not destined for preparing for reuse by those schemes or facilities, and by promoting the use of economic instruments, procurement criteria, quantitative objectives or other measures. (Art. 11 Repair)

Central to this definition is the wording 'where compatible with proper waste management practice.' It is stated in the directive that:

> Member states shall facilitate proper implementation of the waste hierarchy, including taking appropriate measures to encourage the use of

> products and components of products that are suitable for multiple use, that are technically durable and easily reparable and that are, after having become waste, suitable for preparing for re-use, without compromising the free movement of goods in the internal market. (EU 2018/851, §20).

However, where to draw this line is interpreted differently among actors (product/waste), creating conflicts and uncertainties among them. Such a dynamic may slow the transition from waste to resource management. This issue and its implication are dealt with in Chapter 4.

1.2.2 Establishing the legal basis for implementing the amended directive

EU member states are obliged by the amendment to bring "into force the laws, regulations and administrative provisions necessary to comply with this directive" (2018/851, Art. 2 Transposition). This obligation implied the establishment of the legal basis for implementing the amended directive. In a Danish context, this implied changes to the Danish Environmental Protection Law, wherein a division of roles was made between 'waste and 'non-waste' (2019/1 LSF 94, 2019). Clarity around roles is vital concerning waste management and the associated waste hierarchy. This division of roles guides where the responsibility lies for waste prevention and PfR. The municipalities do not prepare municipal plans for waste prevention. Instead, waste prevention plans are prepared at the national level (MFVM, 2019). Thus, 'prevention' is not included in the Waste Executive Order but is instead included in the Environmental Protection Act (LBK nr 1218 of 25/11/2019). Furthermore, there is a distinction in the act between prevention (non-waste) and the remaining levels (waste) that implies a transparent role distribution between prevention (repair and direct reuse) and PfR. However, as previously mentioned, where to draw the line seems unclear in the daily practices—or, rather, different interpretations are still prevalent. Therefore, this issue is analyzed further in Chapters 4 and 5.

1.2.3 Revision of the waste executive order

With the legal basis in place, the next step was to revise the existing Waste Executive Order. The executive order on waste contains rules on collecting and handling waste by the municipalities and private actors, e.g., the collection companies. This process entailed two critical events for waste management in a Danish context.

First, some legal disputes originated from 2015–2017 concerning the right of municipal waste management companies to operate secondhand shops (Moalem et al., 2022). Municipalities are obliged to conduct waste-handling schemes in such a way that preparing for reuse is promoted before other treatment of the waste (EU, 2008).

This obligation follows the EU waste hierarchy. Some municipalities believe this obligation is best met by establishing a secondhand shop connected to the reuse station (Soja & Bockhahn, 2015).

In 2017, the National Board of Appeal concluded that it is legal for municipalities and municipal waste companies to operate a secondhand shop with the sale of items handed in at the reuse station if products are sold at market price (AST, 2017; Soja & Bockhahn, 2017). However, the case led to disputes amongst actors from the private sector, humanitarian organizations, and the Danish Waste Association (Moalem et al., 2022). One dispute concerned whether municipal waste management companies should be allowed to conduct sales activities that distort or impede private competition (Moalem et al., 2022; Soja & Bockhahn, 2015). Further, humanitarian fundraising organizations should take over the collected products to help vulnerable people (Zeuthen, 2016).

Another critical event that affected the outcome of the final agreement for the national plan included a settlement in Parliament, culminating in 'The Climate plan for a green waste sector and circular economy' in June 2020 (Regeringen, 2020).
In brief, it states that municipal waste management companies should focus on sorting the waste into the proper fractions and managing it. At the same time, the agreement obligated municipal waste management companies to establish donation corners for reusables for charities to access first and foremost (Regeringen, 2020):

> All municipal reuse stations are obliged to make an area, container, or similar available where citizens can deliver items for direct reuse. The objects must first be made available to private actors, including voluntary organizations and citizens. The municipality may sell the residual items in municipal secondhand shops or to socioeconomic enterprises. The municipality is obliged to involve voluntary organizations in the local implementation of the initiative. (p.13)

The municipal waste companies that have invested in advancing on preparing for reuse schemes—i.e., secondhand shops, storage-testing, and repair facilities—fear that this will lead to a reduced basis for operating, for instance, secondhand shops and therefore question the wording in the 'June 2020' settlement.

Those companies fear that the climate agreement will reduce the amounts of items reused and that the intended climate effect will not be achieved (AVV, 2020). Further, free access to reusable items, free of charge, may create a) unnecessary additional consumption, b) anarchy at the reuse station, and c) conflicts at the reuse station between actors, i.e., who has the right to the goods? Economic concerns include increased expenditure for the municipalities and thus for citizens, e.g., the cost of

clearing and cleaning up space for donations will increase (AVV, 2020). Finally, municipal waste management companies question how the donated items should be registered. At present, waste management companies weigh and register the prepared for reuse effects, and quantities are reported in the Waste Data System. Reused items which the citizens take home, on the other hand, will not be registered and accounted for (AVV, 2020).

Nevertheless, the Danish Ministry of the Environment created a framework for the handling of 'waste' at a national level on the agreement in the Parliament resulting in a national plan for waste prevention and management named the *"Action plan for the circular economy. National Plan for Waste Prevention and Management 2020–2032"* (Title in Danish: Handlingsplan for cirkulær økonomi. National plan for forebyggelse og håndtering af affald 2020 – 2032) (MST, 2021). The national plan describes the current conditions and direction for waste prevention and waste management in Denmark until 2032. The Danish Ministry of the Environment will uncover the specific implementation of the initiative in more detail, including how the new obligations can be implemented, in legal terms (MST, 2020).

However, the EU lacks experience from its member states to base proposals on both in terms of exchange information and sharing of best practices (EU, 2018/851, Art. 38). Article 38 states:

> The Commission shall organize a regular exchange of information and sharing of best practices among Member States, including, where appropriate, with regional and local authorities, on the practical implementation and enforcement of the requirements of this Directive, including on e.g.:
>
> (a) the application of the calculation rules set out in Article 11a[1] and the development of measures and systems to trace municipal waste streams from sorting to recycling; (b) adequate governance, enforcement, cross-border cooperation; (c) innovation in the field of waste management;
> (g) prevention and the setting up of systems which promote re-use activities and the extension of life span.

Thus, exchanging information and sharing best practices concerns measures and systems to trace municipal waste streams, including PfR, innovation in waste management, prevention, and systems that promote reuse activities and the extension of product life span. The commission therefore needs more research at member states

[1] 'Preparing for re-use and recycling' (EU, 2018/851, Art. 11a).

level to gather experience from its member states on which to base proposals (EU, 2018/851Art. 38, 2). This implies member states developing new practices. Therefore, the EU and member states support frontrunner projects and stakeholders to experiment and test new practices. One of those projects is the project FUTURE. The project FUTURE was an integral part of this research and provided waste companies with the opportunity to experiment and test new practices promoting CE through waste prevention and preparing waste for reuse. On this basis, this thesis aims to contribute new knowledge to this implementation gap by investigating what happens in the meeting between CE and the current practices based on the waste hierarchy.

Summing Up

The above points to both opportunities and constraints in the change from traditional waste management towards resource management based on circular economy principles. At present, no clear guidelines exist for how the proposed measures from the climate plan are to be implemented. The result is that the process is 'stuck' in several places and hinders increasing PfR. In addition, public and private actors may look differently at where their roles lie between preparing for reuse and prevention in DK.
On this basis, this Ph.D. thesis positions itself in the contested area of preparing for reuse (PfR), investigating how actors related to reuse promote local solutions for the inner cycles, either alone or in cooperation, as illustrated in Figure 4.

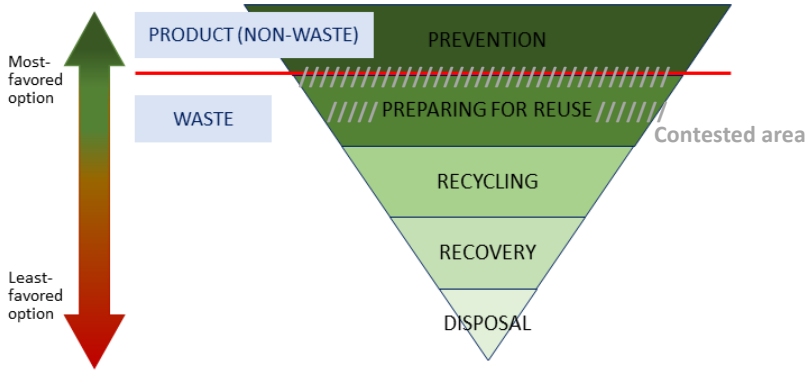

Figure 4 Positioning of thesis in the contested area of preparing for reuse (based on Directive 2008/98/EC, Art. 4)

1.3 Project FUTURE

The EU project Intelligent Energy and Resource Systems of the Future (FUTURE) is an integral part of this research and has been a significant element in the framing of the context and motivation of this PhD thesis. Furthermore, key learning from FUTURE contributed to the empirical foundation of this research.

The following holds a reflection on how FUTURE has contributed to the shaping of this thesis. This includes a reflection on how the project has evolved over time and influenced this thesis's research questions, and approach. A more formal presentation of the research design is provided in Chapter 3 Research Design.

The project FUTURE was a three-year project (Feb. 2018 to Aug. 2021) and expanded another six months due to the coronavirus pandemic. Behind the initiative were Region Skåne, the Capital Region, and Region Zealand with the goal of their energy consumption being covered by 40 percent of renewable energy by 2020 and being among the most resource-efficient regions.

The project goal was to develop and consolidate the position that Greater Copenhagen has in the energy and resource area, including strengthening the field's business players as well as ensuring knowledge sharing and value creation. The goal was for the collaborations around the pilot cases to experiment and develop new and effective solutions that can be transformed into concrete solutions in future energy and resource systems. This resulted in the development and testing of a range of pilot projects within two independent tracks: 'renewable energy' and 'resource utilization.'

The pilot project provided an opportunity for exploring and experimenting with new circular practices. Project FUTURE conducted experiments supportive of the inner cycles providing partners with an opportunity to test new practices concerning promoting CE and prolonging the life of products through reuse and repair. This also included challenging the legal framework conditions for practices related to the upper levels of the waste hierarchy. All partners co-created and played an active role in the development of the pilot cases.

A precondition for receiving the funds was that empirical findings should be included in the Ph.D., e.g., as publications, seminars, and as part of my teaching. Empirical data from other reuse and repair schemes were added to supplement these findings. Findings and discussions related to FUTURE are documented in Chapters 4, 5, 6 and Appendix A, the advisory report on increasing reuse of construction and demolition materials and products (Miliute-Plepiene & Moalem, 2020), and finally presented on the homepage for the FUTURE project (Gate 21, 2021). The research design section addresses this further.

1.3.1 Project aims and description

The FUTURE project consisted of seven pilot case collaborations across the three regions in Greater Copenhagen (Region Skåne, the Capital Region, and Region Zealand). Thus, pilot projects were untaken in both Denmark and Sweden. This Ph.D. research has been part of case 7, one of three cases in the resource track. An overview of cases in the resource track is provided in Table 1

Table 1: Resource utilization track and associated cases. Project FUTURE.

Case 5: Circular solutions with integration between energy, resources, and waste
Case 6: Residual textiles as part of the buildings of the future
Case 7: Intelligent use of products and product data that prepares and promotes reuse in the circular society of the future

The point of departure for case 7 was the circular economy action plan 'Closing the loop—An EU action plan for the Circular Economy' (COM/2015/0614), adopted by the European Commission in 2015 (EU, 2015). The plan included objectives to accelerate Europe's transition by helping "close the loop" of product life cycles through recycling and reuse (COM/2015/0614). Thus, waste management was part of the plan: "Waste management plays a central role in the circular economy: it determines how the EU waste hierarchy is put into practice" (COM/2015/0614, p. 9). The latter also included actions taken to prepare products for reuse, including components, stating that "[t]he reuse and repairs sectors are labor-intensive and therefore contribute to the EU's jobs and social agenda" (COM/2015/0614, p. 8).

The aim of case 7 was to test and demonstrate the role of municipal companies regarding putting CE into practice, particularly the testing and demonstrating reuse, preparing for reuse, and repair activities. According to the FUTURE project description, municipal companies should have a particular focus on the following:

1. Examine the basis for the development of a data model that can control product and component flows to extend the life of products and components
2. Develop two to three pilot cases that promote reuse and repair and demonstrate that extended service life can be managed locally at district or municipal level
3. Develop a replicable business model for each demonstration case

Three municipal waste management partners and associated pilot projects contributed to the testing and demonstration (Project FUTURE: https://www.gate21.dk/nyhed/intelligent-brug-af-produktdata-der-fremmer-

genbrug/). Partners included one Swedish and two Danish waste management companies. An overview of partners and pilot projects is provided in Table 2.

Table 2: Case 7 collaborators and pilot projects on prevention and PfR

Partners	Pilot projects
Lund Renhållningsverk, Sweden	Local repair shops as means to achieve long-term waste reduction
BOFA, Denmark	Preventing waste through partnerships with civil society organizations
Affald Plus, Denmark	Preparing waste for reuse: registration and communication platform

1.3.2 Project FUTURE development and research journey

Project FUTURE and my PhD provided an exceptional opportunity to go on a journey to explore, discuss, co-create, visit, meet, observe, and gain insight into the practice field of reuse and repair, and how implementing circular activities may challenge practices that are embedded within, or born linear.

The journey began with collaborators from the project FUTURE, namely Affald Plus, BOFA, and Lund Renhållningsverk, and took point of departure in the project description. However, as the time progressed, field visits, desk study, study trips, workshops, and attending conferences provided new inspiration to all and the network grew. As a result, the project FUTURE evolved over time to include new ideas, new initiatives, other cases, and other stakeholders. Over time it became impossible to tell whose idea had led to what. The point is to say that the research process was iterative, ideas emerged, and obtained knowledge was built on existing knowledge. The learning process of mutual reflection is dealt with further in 3.4.2 Action research.

Activities from my side span from partaking in a wide range of conferences, meeting with collaborators, leaders, and experts in the field, to conducting interviews with end-users, producers, and volunteers making repairs, to informal visits, observing behavior and practices in repair cafes, secondhand shops, and reuse stations, to helping site workers sort ‘waste’, and to driving with garbage trucks, collecting bulky wastes from households.

Types of activities and collaborations are illustrated in Figure 5. For simplicity, only formal elements are included. The light blue arrow illustrates how networking increased over time. The research journey should be understood as an emergent

process, taking shape as understanding increases. Moreover, quarterly workshops were conducted in Denmark and Sweden (marked with * in Figure 5), for partners to exchange knowledge and reflect on obtained learning. Workshops supported 'loop-learning' and acted fixed points between action and critical reflection (Figure 25). Finally, a study trip to Brussels was conducted (marked with ** in Figure 5). The aim was to strengthen cross-border collaboration, exchange information, and share best practices, visiting De Kringwinkel, The Tools Library, and Rreuse.

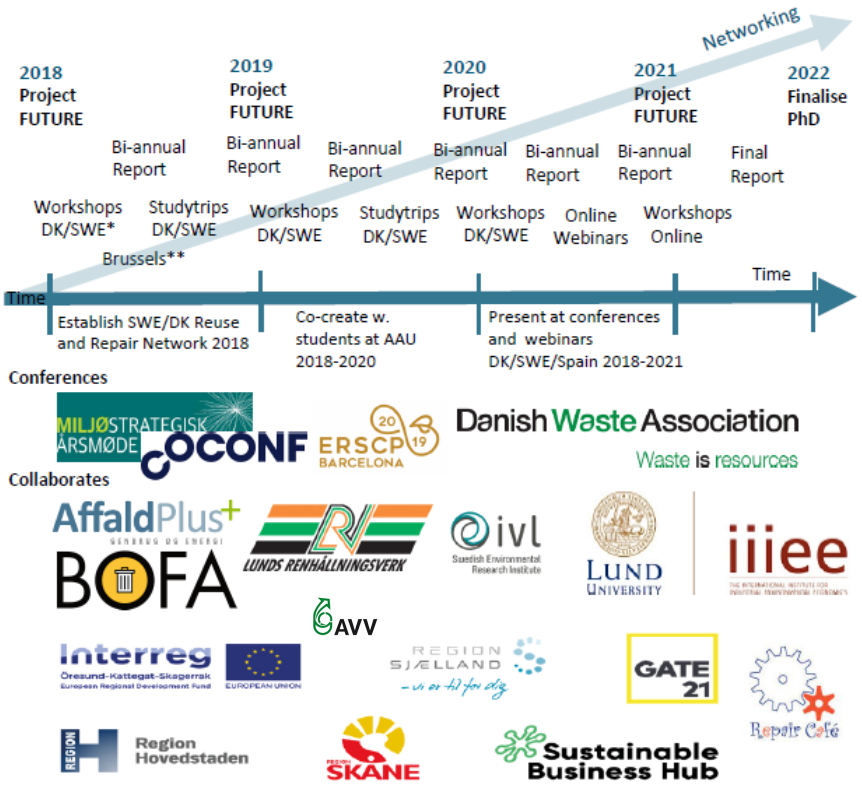

Figure 5 Research activities, partners, and network in the PROJECT future

This journey, these insights, and the evolving network have contributed over time to shaping the direction of my Ph.D. which began with some basic assumptions about challenges and possible solutions. Assumptions were revised along the way partly because of the development within the area of regulations, initiatives, and from discussing with collaborators. All of this together has shaped my insights and is reflected in the research questions. In particular, this increased a desire to investigate solutions, where resources can circulate locally, preferably through collaboration, and

on this basis investigate the relationship between circularity and the upper levels of the waste hierarchy.

In the following, an introduction to each pilot case is followed by a discussion on how the project FUTURE has influenced the research methodology and research questions.

1.3.3 Affald Plus, Denmark

Affald Plus has, since 2014, conducted preparation for reuse activities, i.e., establishing reuse shops. This case was intended to study optimization through data collection, analysis, and dissemination to improve and scale up these activities. A registration and a communication platform were the idea of Affald Plus to reap the benefits of data.

The aim was to investigate and operationalize the potentials that lie in registering, systematizing, analyzing, and using data on material and waste flows to continuously optimize and improve resource utilization from the waste streams. Further, the aim was to optimize the environmental profile and resource economy, for the benefit of society and the citizens of the owner municipalities; and secondly, to ensure more optimal management of the reuse streams for the company's four secondhand shops, including the sizeable secondhand shop PlusByg, selling reused building and construction supplies. One of the advantages for Affald Plus is getting 'control' of its own resources in terms of material, and product waste flows. Thus, the pilot project focused on developing a comprehensive registration and communication platform that (with minimal manual effort) can register and communicate waste prepared for reuse to citizens and partner companies. An illustration of the registration platform is provided in Figure 6.

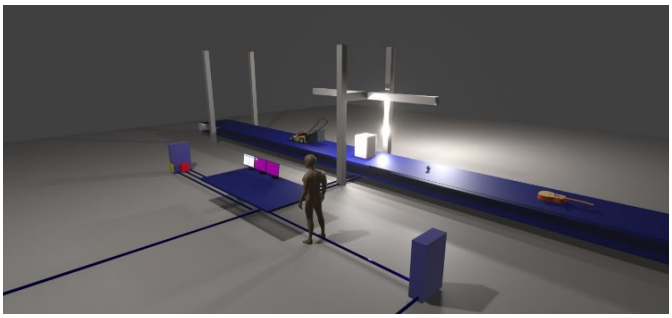

Figure 6 Preparing for reuse registration platform, Affald Plus

The idea with the registration platform was to first register all incoming items by weight, item name, and item product category; next, to register which of the incoming 'waste' products or components were handed over to people or organizations and when; then, finally, to register which incoming items were sold at which reuse shops and when.

For the communications platform the idea was to present all prepared for reuse items registered in an e-commerce platform enabling the immediate purchase of incoming goods. Further, the platform allowed for communicating needs and wishes to the waste management company, enabling the company to react by focusing effort where demand was expressed. Finally, the platform provided a forum for communicating the actions of the company, including the benefits of reusing items to the public and partners. An illustration of the front page of the communication platform can be found in Appendix B.

This pilot case is expected to support the development of PfR activities, including a network for sale, repair, maintenance, and distribution of reusables, and will allow continuous inventories of the environmental and economic effects of reuse activities, in a transparent manner. However, the development of a registration platform to register incoming reusable 'waste' products, i.e., weight, item name, and product category, turned out more complex than first assumed. As a result, a range of preliminary investigations needed to be carried out. This resulted in a conceptual solution rather than a prototype of the two platforms. Therefore, implementation, testing, and data collection were not applicable within the project time frame. A presentation of the digital solution proposals for Affald Plus is provided in Appendix B.

For this research, however, it was not possible to evaluate results from this specific pilot study project. Nevertheless, over time, co-creation with Affald Plus provided a unique insight into experiences from preliminary activities and learning leading to the development of an actual registration and communication platform.
These insights contributed to identifying research questions along the way and key learnings from this journey are discussed and documented in Chapters 4 and 5.

1.3.4 BOFA, Denmark

The pilot project in BOFA focused on innovative collaboration between the municipal solid waste company and civil society. The aim was to promote reuse and, at the same time, strengthen social cohesion in the local community. BOFA collaborated with local associations from civil society on the reuse and resale of objects that would otherwise have ended up in recycling or incineration, and which provided a source of

income for local associations. First, products were collected by the municipal waste management company at two local reuse stations on the island of Bornholm. Thereafter, they were sorted, stored, and sold by two local sports associations. A photo of one of the two donation containers is provided in Figure 7.

Figure 7 Donation container at Hasle reuse station, Bornholm

Over time, more civil organizations showed interest in collaborating with BOFA around reuse and it became apparent that BOFA could not accommodate 'all requests' in the current setup. To prevent some associations from being disadvantaged, BOFA created an online booking system where all interested parties can book access to a container for a limited period.

For this thesis, additional visits to the island were planned, but due to the increased spread of Covid-19, the visits had to be canceled. Results therefore only include initial estimates on social, environmental, and economic effects of the pilot project. Nevertheless, visiting BOFA and staying on Bornholm was a great opportunity to investigate other aspects of this pilot project. That included conducting walks and interviews with site workers and the local sports association, following the products, processes, and stakeholders from donation to sale. Moreover, insight into the value chain made it possible to discuss resource flows, practices, and spills. That broadened the understanding of different value types created through cooperation and local loops, including a deeper understanding of the value that this project initiated and for whom. Insights from this pilot project are documented in the book chapter Circular economy in Denmark: Bornholm's vision to achieve 100 percent reuse and recycling in: Circular Economy (Christensen et al., 2021) (see Appendix A), and in a final report documenting Bofa's cooperation with civil society around reuse during the project FUTURE (Moalem R. M. et al., 2021).

1.3.5 Lund Renhållningsverk, Sweden

Inspired by international civil society initiatives of repair cafes, the pilot project in Lund focused on establishing a local repair shop to achieve a long-term waste reduction in the municipality. To the best of my knowledge, this is the first repair shop driven by a municipal waste management company, at least in Denmark and Sweden. The space, open to the public and free of charge, consists of different workspaces for sewing, painting, and woodwork, enabling citizens to borrow, for example, sewing machines and a range of tools for repairing and maintenance. To prevent conflicts and avoid disrupting the professional repair market, staff employed by the waste company only provided guidance to visitors on how to use the tools and how to conduct the repairs. Further, local repairers were invited to hold workshops in FixaTill, i.e., the owner of one of the local bike shops held workshops on bike repair and maintenance. An overview of the facade and the workspace is provided in Figure 8.

Figure 8 FixaTill repair shop in Lund

Over time, the initiative expanded, i.e., to consist of a new collaboration with the local civic society organization Repair Café Lund, who assisted with repair, and the next-door humanitarian organization used the repair shop to conduct repairs on donated items. Prior to this collaboration, they had to discard the damaged donations. In addition, the waste management company initiated a range of workshops on how to conduct repair and maintenance on specific products, and lectures on zero waste conducted by local traders and startups, attracting a broad range of citizens.

Over time, this pilot project involved a range of local stakeholders, including citizens, repair cafe, job center, traders, the local housing association, and international humanitarian organizations. This pilot project is documented through this research in a range of webinars, workshops, and official project reports on the project homepage (Gate 21, 2021). Further, to spread FixaTill's message even more and to increase accessibility for residents, the waste company innovated a mobile variant of the FixaTill concept. The concept involved a mobile workshop built on a box bike that can be driven around to different places in the municipality. A sketch of the box and fold-out part is illustrated in Figure 9.

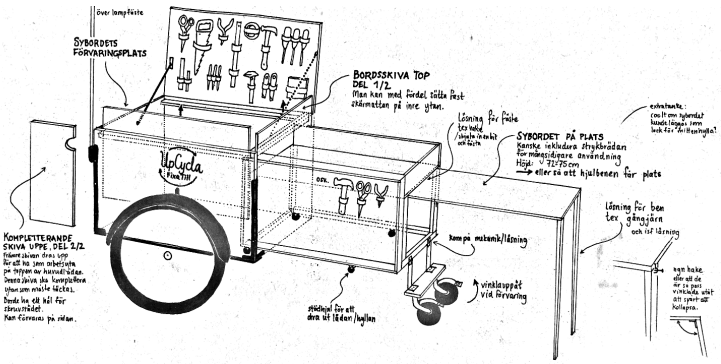

Figure 9 Sketch of the mobile variant of the repair shop 'UpCykla'. Reprinted with permission. Lena Wallin, Lund Renhållningsverk.

The prototype 'pop-up' repair cafe was completed in September 2020. The mobile workshop was named UpCykla. The UpCykla was introduced in Stortorget in Lund in September 2020. During the autumn, the bike was tested at three different places in the municipality, including the local library and a residential area. During the launch and the other visits, around 55 people used the UpCykla. Despite the short trial period, there has been a great interest in the bicycle. Among others, IKEA has shown interest in the possibility of renting the bike for various events and campaigns for a more circular IKEA. Furthermore, LKF real estate company, the library, and others have also shown interest. A likely scenario is that the bicycle will have a rolling schedule to be rented out or lent to interested parties. A picture of the prototype setup of the 'repair bike' is provided in Figure 10.

Figure 10 'UpCykla' – pop-up repair bike. Photo: With permission. Lena Wallin.

Nevertheless, being present in the workspace prior to the pandemic, observing, interviewing, and co-creating ideas with employees, visitors, and collaborators, provided insight into activities and processes from a repair perspective. For example, activities with the point of departure in repair were molded and combined into the local context and the actors present. Moreover, stakeholders' engagement seemed to emerge from a broad understanding of the value attached to the concept. Finally, interviews showed that stakeholders' relations span from formal to informal in a somewhat organic process.

These insights point to various stakeholders interested in repair, directly or indirectly. Moreover, municipal waste management companies and civil society organizations may contribute to the [missing] linkage between prevention and PfR and partake in different roles in creating or supporting repair networks in this circular transition. On this basis, this insight contributed to subresearch question three, and a broader discussion on repair from a civil society perspective is further dealt with in a literature review on Repair Cafes in Paper III (see Chapter 6 Repair Cafes).

Summing up, the pilot projects and PhD research were based on the official project description. However, the various local contexts, stakeholders, conflicting interests, collaboration, and activities along the way gave new directions for the pilot projects and for this research.

1.4 Research question

The Danish Waste Association stresses that too many products that can still be reused or repaired become recycled or incinerated (DAF, 2017b). This contrasts with the principles of the circular economy in which resources should be kept in use for as long as possible in the inner cycles (Bocken, Miller et al., 2016; Geißdörfer et al., 2017; Kirchherr et al., 2017; Stahel, 1984). Moreover, the circular economy is about creating and optimizing value, reconsidering waste, and identifying opportunities to realize the

new potential (BSI, 2017). This implies a potential for increasing the reuse of products as well as for improving activities in preparing for reuse.

Based on the introduction, the EU has so far not collected experience from its member states to base proposals for a circular transition on sharing of best practices, i.e., on preventing waste from entering the reuse stations and the setting up of systems that promote reuse activities and the extension of life span, such as repair and preparing for reuse (EU, 2018/851, Art. 38). The EU also requests experience in 'innovation in the field of waste management' (Art. 38, 1.c).

From a research perspective, only a few scientific studies have been undertaken to assess the potential of preparation for reuse of products that have ended up as 'waste' at reuse stations (Milios & Dalhammar, 2020). A systematic literature review confirmed this. For an overview, see Appendix C. Further, where the product value is not sufficient to be attractive to the existing market, value must be added and a market for these products must be created (Chapter 5). Due to fast depletion of natural and primary resources, waste valorization is increasingly attracting attention as a potential alternative to conventional solid waste disposal (Abdel-Shafy & Mansour, 2018).

From a circular perspective, value optimization concerns implementing strategies that extend the life span of products and their parts, i.e., through reuse, repair, and refurbishment (Kirchherr et al., 2017). However, value optimization is not straightforward once products have passed the waste threshold (Amasuomo & Baird, 2016; Miafodzyeva & Brandt, 2011; Vergara & Tchobanoglous, 2012), as addressed further in Chapter 2.

Research and implementation gaps are addressed further from different perspectives in Chapters 4, 5, and 6. Through a literature review and multiple case studies, this research aims to answer the following overall research question (RQ):

What happens when the principles of the inner cycles of the circular economy meet the current practices based on the waste hierarchy?

The following subquestions (SQ) allows for investigating different perspectives on a circular transition to support increased attention to the inner cycles of the circular economy:

SQ1: From a "waste" perspective: How can 'preparing for reuse' be reinterpreted through local initiatives?

To address this subquestion, case studies are used as a research strategy to explore existing waste management practices related to preparation for reuse (Chapter 4).

SQ2: From a collaborative perspective: How can current reuse and repair initiatives be strengthened through local partnership initiatives?

To address this subquestion, actors in the reuse and repair sector are identified by applying document studies to explore and evaluate the existing practices around preparing for reuse (Chapter 5).

SQ3: From a civil society perspective: How can repair and reuse be supported through local initiatives?

To address this subquestion, the role of civil society organizations is investigated, focusing on repair cafes as one way to extend product lifetime at the local level (Chapter 6).

1.5 Underlying assumptions

One underlying assumption of this research is that repair and reuse activities can be promoted. However, Denmark has an ongoing ambivalent transition from traditional waste management to circularity and resource management with associated tensions. One is an ongoing conflict concerning access rights to reusable waste items.

On the one hand, there are large quantities (tonnes) that the waste companies, including AVV, ARGO, and A +, sell in their secondhand shops that the volunteers cannot take – nor the private sector either. However, on the other hand, there are the salable high-value products. One assumption is that they [private and voluntary organizations] are only interested in picking valuable items among the waste resources: for example, the high-quality washing machines, designer furniture, and bikes with the right brand name. The challenge is that if they take those, the business case of the municipal waste companies can be undermined, since they depend on the high-value products to outbalance the potential loss from sales of large quantities of low-value products.

Another assumption is that the conflicting tensions amongst actors also link to 'lock-ins' related to infrastructures and the mindset amongst actors, e.g., existing power relations, roles, and dichotomies on public or private tasks.

However, issues related to sustainable development are challenging, and no individual organization, institution, or company can provide the solution (Gray & Stites, 2013). Instead, this process requires joint efforts, including new forms of collaboration outside the traditional public, private, *or* civic arenas. Therefore, one assumption is that part of the solution is challenging existing silo thinking and finding new ways to collaborate.

1.6 Scope and delimitations

This research investigates solutions to the transition from waste to resource management, focusing on local solutions supportive of the upper levels of the waste hierarchy: waste prevention and preparing for reuse. Thus, the research is delimited from investigating recycling, recovery, and disposal.

From a CE perspective, the focus is on activities supporting the inner cycles through 'slowing' strategies, particularly repair, reuse, and, to some extent, refurbishment (see Chapter 2). However, the circular economy's strategy for retaining material value is based on a resource hierarchy, a circular ladder, with ten 'R' associated strategies: Refuse, Rethink, Reduce, ReUse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover (Kirchherr et al., 2017) (see Chapter 2).

1.7 Target audience

The findings of this thesis are of value to a variety of actors. Most of the research was conducted together with practitioners working with reuse, repair, and preparing for reuse. Key audiences are those involved with planning (municipalities) and practitioners within the reuse sector, municipal waste management companies, and actors from the private sector, who want to collaborate around reuse and repair.

The work is also relevant to academic researchers; specifically, it is of interest to scholars investigating issues related to circularity in the reuse and repair sector. Due to the interdisciplinary nature of the research, other academic audiences may also find it relevant, including scholars with an interest in transition management, green transition, product repair, and reuse, policy, and sustainability studies. This research also intends to contribute to an academic discussion on sustainable development and transition complexity, particularly how widening the participation of multiple actors and learning at the niche levels can identify successful pathways that support society's transition towards a more circular economy.

1.8 Reading guideline

This thesis comprises four parts. The first part contains an introduction to the context in which this research is undertaken. The second part frames the research, consisting of the conceptual framework and research design. In the third part, key findings are presented and the three subquestions are investigated. The final part consists of the discussion and the conclusion, revisits the research questions, and summarizes the research's contributions.

PART I INTRODUCTION TO THE RESEARCH
Chapter 1 introduces the research context and the aim of the Ph.D. study.

PART II FRAMING THE RESEARCH
Chapter 2 sets the scene and provides an overview of the main conceptual research perspectives that the work draws on.
Chapter 3 is the research design and highlights data collection methods for the thesis.

PART III RESEARCH FINDINGS
Chapter 4 covers preparing for reuse and presents key findings and answers for SQ1.
Chapter 5 focuses on collaboration and presents key findings and answers for SQ2.
Chapter 6 concerns repair and presents key findings and answers for SQ3.

PART IV DISCUSSION AND CONCLUSION
Chapter **7** revisits the research question, summarizes the contributions of the research, and discusses the implications of the conclusions for practitioners and future planning and research.

A graphic overview of the thesis is provided in Figure 11.

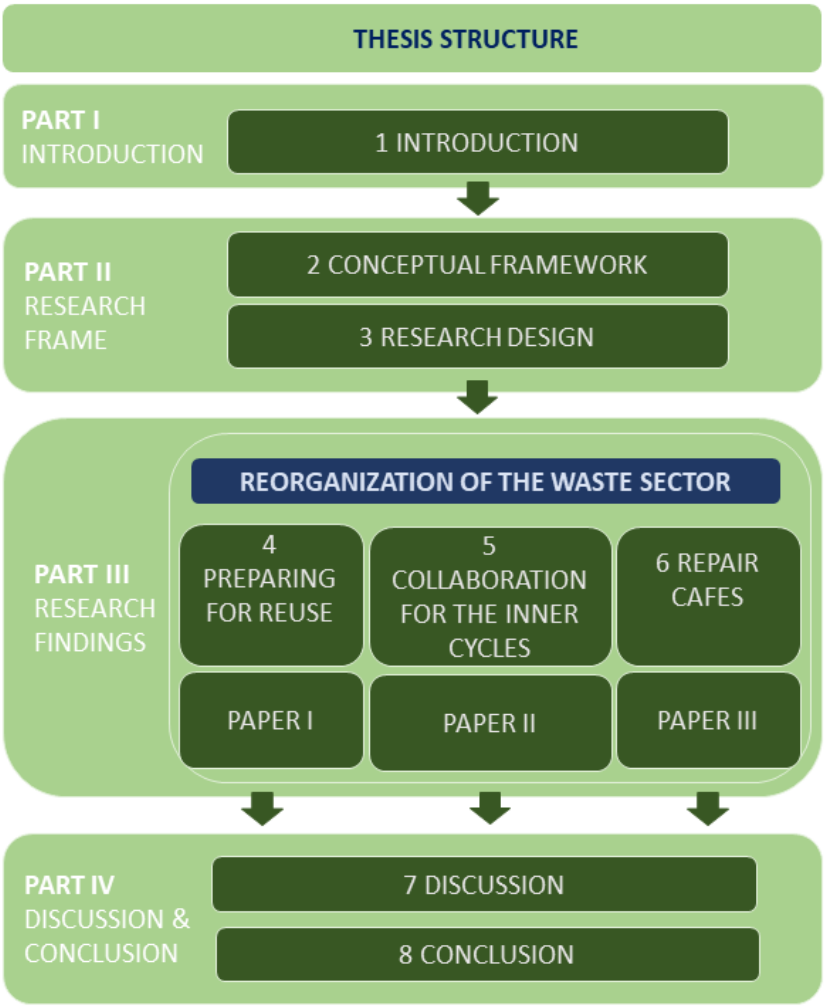

Figure 11 Thesis structure

PART II

Framing the research

Part II frames the research by introducing the conceptual framework related to the EU waste hierarchy and the concept of the circular economy (Chapter 2) and introducing the research design of the thesis (Chapter 3).

More specifically, Chapter 2 presents the EU waste hierarchy with a particular focus on the two upper layers of the waste hierarchy—prevention and preparing for reuse (PfR)—and introduces the concept of the circular economy with a particular focus on the inner cycles of repair and reuse.

Chapter 3 consists of a presentation of the scientific positioning of the research, followed by research methods and data collection methods. Reflections on research reliability and methodological delimitations complete this section.

2 CONCEPTUAL FRAMEWORK

The focal point of the conceptual framework focuses on existing knowledge on extending the lifetime of products through reuse and repair as well as laying the foundation to investigate what happens when the principles of the inner cycles of the circular economy meet the current practices based on the waste hierarchy.

The amending Directive (EU) 2018/851 (EU, 2018a) states, 'Waste management in the Union should be improved and transformed into sustainable material management, with a view to protecting, preserving and improving the quality of the environment, protecting human health, ensuring prudent, efficient and rational utilization of natural resources, promoting the principles of the circular economy' (1). Further, it argues that 'ensuring that waste is valued as a resource can contribute to reducing the Union's dependence on the import of raw materials and facilitate the transition to more sustainable material management and to a circular economy model' (2). Finally, it states, 'The targets laid down in Directive 2008/98/EC of the European Parliament and of the Council for preparing for re-use and recycling of waste should be increased to make them better reflect the Union's ambition to move towards a circular economy' (3).

In a Danish waste context, the publication "Action plan for circular economy. National Plan for Waste Prevention and Management 2020-2032" (MST, 2019) describes the current conditions and direction for waste prevention and waste management in Denmark until 2032. The focus in the action plan for the circular economy is mainly on recycling, waste collection and sorting, and to a lesser extent on prevention and preparing for reuse. As an example, reuse is mentioned 252 times in the plan, preparing for reuse 39 times, and recycling is mentioned 544 times. This priority contradicts the priorities in the CE and will be discussed in the following.

Another concept that recurs in European waste policies is the waste hierarchy, which was introduced in brief in Section 1.1. The waste hierarchy ranks different waste management options in prioritized order (2008/98/EC) based on their environmental impact (Williams, 2015). The hierarchy is used as a guiding principle in municipal waste planning and described in the Danish statutory order on waste (BEK, 2020 nr 2159 af 09/12/2020).

For the research question of this thesis, the waste hierarchy from the European Waste Framework Directive has been applied to investigate what happens when the principles of the inner cycles of the circular economy meet the current practices based on the waste hierarchy, including the tensions this may cause in a circular transition.

For this reason, this chapter begins with a presentation of the waste hierarchy; next, an introduction to the 9R's resource hierarchy (Kirchherr et al., 2017) and to the circular economy's main principles focusing on "the power of the inner cycles" (EMF, 2013) of repair and reuse; then, a discussion on how the preparation for reuse is encompassed by the concept of the circular economy; and finally, there is an introduction to collaboration, including an analytical framing to support this thesis's discussion.

Key concepts, including preparing for reuse, repair, and waste value optimization, are discussed in more detail later on in the thesis, specifically in Chapters 4, 5, and 6.

2.1 The waste hierarchy

As mentioned in the Introduction (1.1), the waste hierarchy ranks different waste management options in a prioritized order based on their environmental impacts.

The waste hierarchy was not a part of the European waste legislation in 1975 (Council Directive 75/442/EEC of 15 July 1975 on waste (OJ L 194 25.07.1975 p. 39), 2006) Only in 1991, waste priorities were, to some extent, introduced in European Waste Legislation (Council Directive 91/156/EEC of 18 March 1991 amending Directive 75/442/EEC on waste (OJ L 78 18.03.1991, Art. 3)). In 2008, a revision of the waste framework directive 2008/98/EC was promoted, along with a new version of the waste hierarchy (Art. 4, EU, 2008), making it mandatory for EU member states to implement it into national legislation and to come into force in December 2010 at the latest (Bartl, 2014).

Figure 12 displays the European waste hierarchy, along with a description of each level in prioritized order from the top.

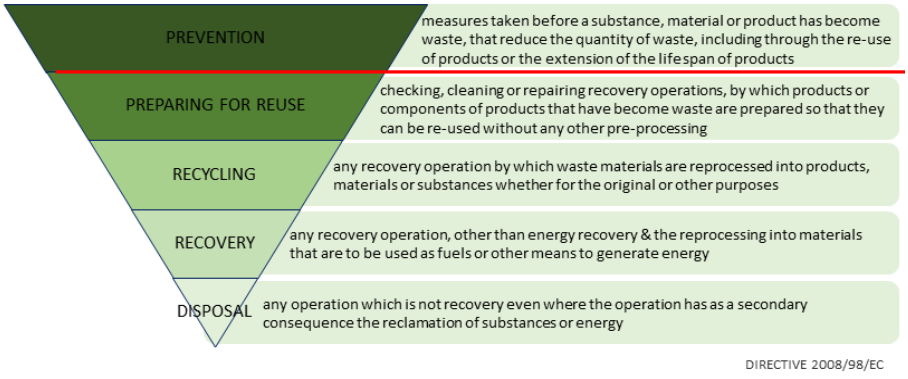

Figure 12 The European waste hierarchy (EU, 2008)

The latter functions as a rule of thumb, as there are cases in which, for example, recycling is preferable over reuse. Art. 4(2) of the Directive allows for deviations from the hierarchy in some cases. As an example, one case study found disposable bedpans in hospitals to be environmentally preferable to reusable ones, which contradicts the general guidelines of the European waste hierarchy (Sorensen & Wenzel, 2014).

The "Action plan for circular economy. National Plan for Waste Prevention and Management 2020-2032" (MST, 2019) links waste management and the circular economy and describes the current conditions and direction for waste prevention and waste management in Denmark until 2032.

However, waste management and the CE rest on different understandings and strategies. Therefore, an introduction to the concept, priorities, and principles of the CE is presented in the following, including reflection over some of the contrasting elements between the concept and the current practices based on the waste hierarchy.

2.2. Circular economy – the concept

A growing number of actors, policymakers, NGOs, and industries view a shift towards a more circular economy as a solution that is beneficial for both the planet and for business (EMF, 2013, 2015). A circular economy aims to decouple economic development from resource constraints (Wallace & Raingold, 2012). To distinguish between a linear and circular economy, Stahel (2016) described the linear economy as a river and the circular economy as a lake. In the river, natural resources are turned into commodities and made sellable through 'a series of value-adding steps.' At the point of sale, 'ownership and liability for risks and waste' is passed on to the buyer, 'who is now owner and user,' deciding 'old tyres will be reused or recycled—as sandals, ropes or bumpers—or dumped' (Stahel, 2016, "Systems thinking," para 2). In contrast, the circular economy is like a lake in which goods are turned into resources for others at their end of life, closing loops in the economy and reducing waste: The reprocessing of goods and materials generates jobs and saves energy while reducing resource consumption and waste' (Stahel, 2016, "Systems thinking," para 2).

The idea is to create a regenerative system to maintain materials, products, and components at their highest value for as long as possible (Webster, 2017). The circular economy is a model of consumption and production that extends the product life cycle and involves maintenance, product reuse, refurbishment and remanufacturing, and material recycling. The principles of a circular economy aim to close the loop of resources and reduce the environmental impact of the product life cycle at all stages of the process – from production to distribution to consumption (EMF, 2015). Thus, the vision of the circular economy is a driver for using resources efficiently, reducing

waste generation, and tackling sustainability issues more broadly (Geißdörfer et al., 2017).

The CE concept presents a system with resource cycles, in which the Ellen MacArthur Foundation distinguishes between biological and technical cycles (EMF, 2015). This is visualized in a diagram often referred to as 'The Butterfly Diagram' (see Figure 13).

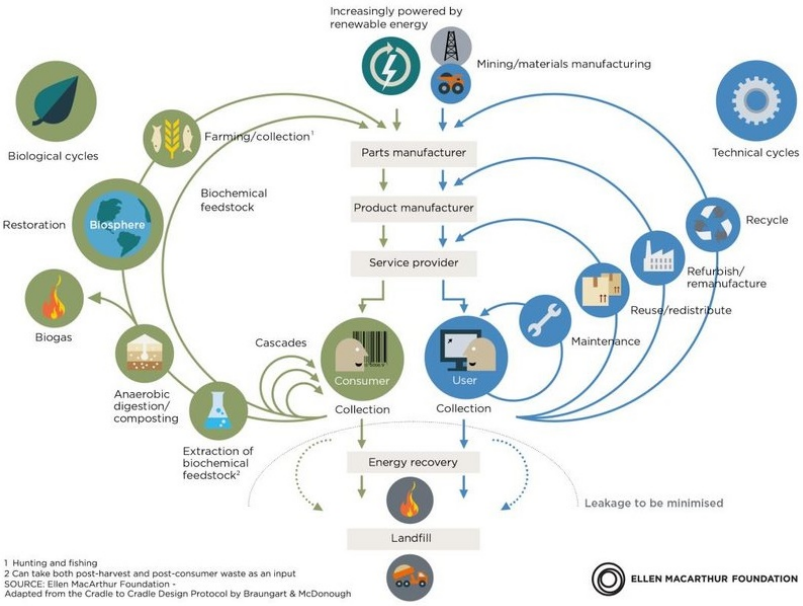

Figure 13 CE systems diagram (EMF, 2019)

2.2.1 The 9R resource hierarchy

The CE's strategy for retaining material value is based on a "resource hierarchy" divided into three primary modules with ten "R" associated strategies (Kirchherr et al., 2017): a) more innovative product use and manufacture (R0 refuse, R1 rethink, R3 reduce), b) extend the life span of products and their parts (R4 reuse, R5 repair, R6 refurbish, R7 remanufacture, R8 repurpose) and c) a valuable application of materials (R9 recover, R10 recycle).

For this thesis, reuse (R3) and repair (R4) are in focus, but refurbishment (R5) is also touched upon. An overview of the 9R resource hierarchy, including the thesis focus (marked in green), is provided in Figure 14.

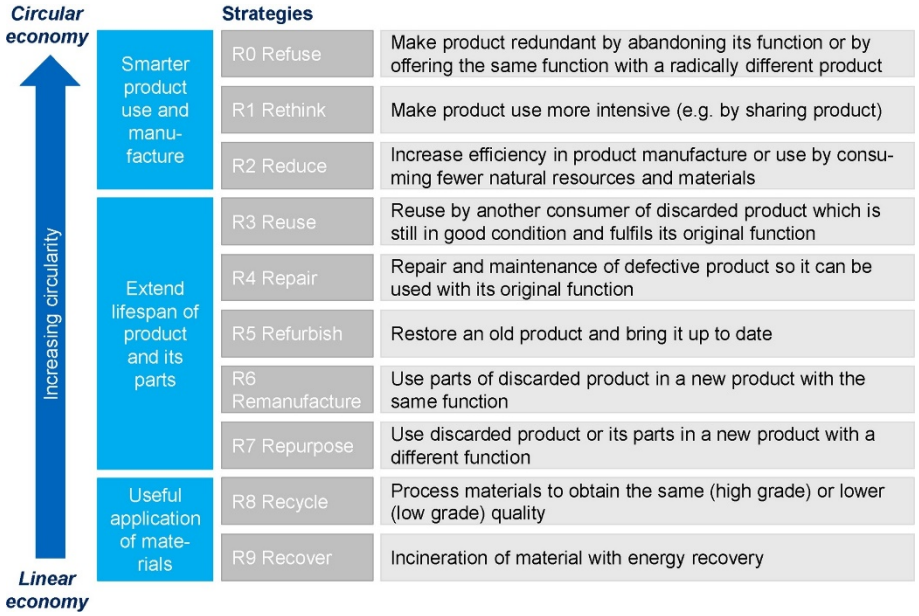

Figure 14 The 9R Framework (Kirchherr et al., 2017)

As a rule of thumb, a higher circularity level equals fewer natural resources and less environmental pressure, meaning that sharing products has higher positive environmental impacts on natural resources than repairing and reusing. Recycling and energy recovery are the least preferred options of the ten – as illustrated as part of the linear economy (Figure 14).

Thus, products should circulate the longest possible in the inner cycles, referred to as the power of the inner cycles (EMF, 2013) (see also Figure 13). When looking at the different stages of a product life cycle, the inner cycles of reuse and repair are, in most cases, preferred as they require fewer natural resources and less energy and are more economic (Korhonen et al., 2018) and creates more jobs, locally (Zacho, Mosgaard et al., 2018). This means that value creation in the inner cycles may consist of environmental, social, and economic values.

2.2.2 When the 9R resource hierarchy meets the EU waste hierarchy

When comparing the waste hierarchy with the 9R resource hierarchy, it is apparent that there are eight strategies for the first two levels of the waste hierarchy. This shows that the focus on 'life before death' is more dominant in 9R than in the waste hierarchy. Another contrasting element is that recycling is established as part of the

linear economy in the resource hierarchy. This contrasts with the priorities in the waste hierarchy in which recycling is placed 'third best.' This means that recycling ranks high in the waste hierarchy, contrasting with the priorities of the CE. Nevertheless, Cooper (2010) states that recycling is often used by governments as an important element in the transition towards circularity:

> Recycling has long been used by governments as an indicator of their environmental commitment and an important element in the transition from a linear economy to a circular economy. Despite this positive portrayal, however, recycling has negative environmental impacts that are not always fully recognized and as such offers only a 'least bad' solution to waste. (p. 12)

2.2.3 The origin of the CE concept

The idea of a circular economy is, however, not new (Geißdörfer et al., 2017). The concept has been gaining momentum since the late seventies (EMF, 2013; Geißdörfer et al., 2017), with the Ellen MacArthur Foundation popularizing the concept.

In 1984, Walther Stahel, a Swiss architect, proposed an alternative to the linear economy: a 'product-life extension model' where cycle thinking characterizes this model, illustrated by a cyclic spiral-loop system to help minimize material input and outflow (Stahel, 1984, p. 74). Stahel argues that extending product life is a good starting point for a gradual transition to a more sustainable society. The period the product is in use (product life) controls the rate at which the product needs to be replaced. Thus, the products use phase controls the consumption rate of natural resources used for manufacturing and the number of waste products created. Stahel distinguishes between three product lifetime scenarios.

The first scenario is common to a linear production-consumption system that Stahel names 'the fast depletion system,' in which product life is equal to the life of the weakest component (p. 73). In this system, there is a built-in environmental degradation at both ends, a depletion of natural resources and high-energy and water consumption at the production phase ("bigger-better-faster exciting new products"), and waste accumulation at the end of life (p. 73). The second scenario is named 'the slow-replacement system' (long-life products), in which products are *designed* to last, resulting in the use of fewer resources and a waste reduction (p. 74). The third scenario Stahel named 'the self-replenishing system' (product life extension, p. 74). In contrast to the other two scenarios, this creates an economy based on a spiral-loop system in which Stahel added four cycles to the value chain compared to a linear economy (Stahel, 1984). Figure 15 illustrates the cyclic understanding.

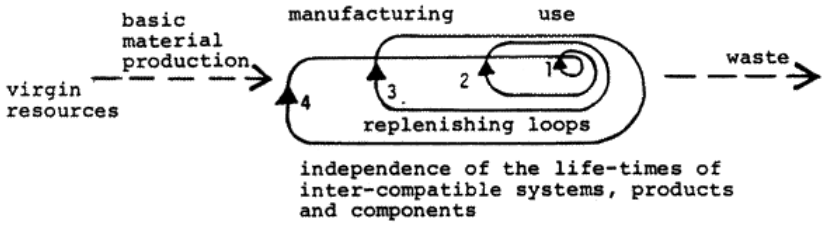

Figure 15 Product life extension (Stahel, 1984, p. 74)

The first loop consists of reuse, the second repairs and maintenance, the third of reconditioning/remanufacturing, and the fourth and most outer loop of recycling, where material scraps are used as raw material inputs for new products (Stahel, 1984). Environmental benefits decrease from reuse at the inner cycles towards the outer cycle of recycling (Stahel, 1984).

2.2.4 A common terminology around CE strategies – slowing, closing, and narrowing

To develop a common framework and terminology around strategies for the CE, Bocken, de Pauw et al. (2016) suggested a resource cycles approach based on how resources, materials, and components flow through a system. Building on the work of Stahel (1994), Bocken, de Pauw et al. (2016) developed three strategies to obtain circularity and increase the cycling of resources by making a distinction between slowing, narrowing, and closing of resource loops.

‘Slowing’ comprises the design of long-life goods and lifetime extension activities, such as repair, and the increasing of a product's utilization by intensifying its use through sharing and reuse. ‘Closing’ involves the reuse of materials through recycling, closing the loop between the product's end of life and the production phase. This strategy focuses on recycling the materials and eliminating 'leakages' from the system (EMF, 2013). ‘Narrowing’ resource loops refers to the minimization of materials used for production. Thus, this strategy relates to the concept of resource efficiency, which is also applied successfully within a linear business model (Bocken, de Pauw et al., 2016). (See Figure 16).

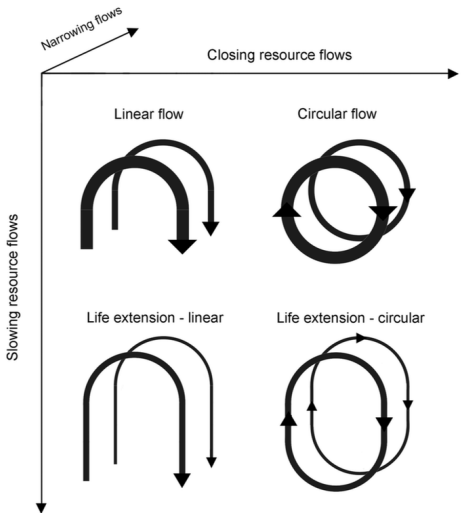

Figure 16 CE framework of slowing, closing, and narrowing (Bocken, de Pauw et al., 2016).

In 2020, Konietzko et al. expanded the three principles of slowing, narrowing, and closing with an initial set of principles: regenerate material and energy flows (Konietzko et al., 2020).

On this basis, circular transition requires developing new circular business models (CBM). A prerequisite is to change the way companies do things, including finding new ways to create value. For this, companies must experiment (Bocken et al., 2021), which presents some challenges as innovation requires different types of collaboration, new ways of interacting, doing new or doing things differently. The concepts of value optimization, innovation, and collaboration are further outlined in Section 2.3 Implementing principles of the circular economy and Chapters 4 and 5.

2.2.5 When the CE principles of 'slowing' and 'the inner cycles' meet the upper levels of the waste hierarchy 'prevention' and 'preparing for reuse'

In a waste management context, 'slowing' and 'the inner loop' correspond to action taken in the two upper levels of the waste hierarchy: prevention and preparing for reuse. Preparing for reuse is a term only used in waste legislation, which entails repairs, remanufacture, and refurbishment (Zacho, 2017). Repair, on the other hand, is considered both part of waste prevention and part of the waste management option preparing for reuse (Section 1.2). 'Closing resource loops' corresponds to recycling and the outer loop. This means that narrowing resource loops is distinct from

'slowing' and 'closing' since it concerns reducing resource use associated with the product and production process (Bocken, de Pauw et al., 2016).

Further, the circular economy strategies are envisioned as cyclic flows, whereas the waste hierarchy is depicted hierarchically. The waste hierarchy provides strategies for managing products and materials that have become waste, while a circular economy takes a more proactive strategy that incorporates considerations in business models and product design (Zacho, 2017). The waste hierarchy mainly addresses waste managers (Zacho, 2017, p. 63), whereas the concept of the circular economy mainly addresses businesses and organizations, focusing on how to maximize the value of material resources and minimize waste and overall resource use (Geissdoerfer et al., 2017; Konietzko et al., 2020). This means that CE prioritizes in reverse order as the prime idea of the CE is to help minimize material input and outflow (Stahel, 1984).

2.3 Implementing principles of the circular economy

In addition to strategies for designing products and business models for circularity, the BSI Circular Economy Standard (BS 8001) includes six further principles to framing decision-making and behavior when business models for circularity are developed: systems thinking, innovation, stewardship, collaboration, value optimization, and transparency (BSI, 2017). For this thesis, focus is on value optimization, innovation, collaboration, and systems thinking. An overview of the six principles is provided in Figure 17.

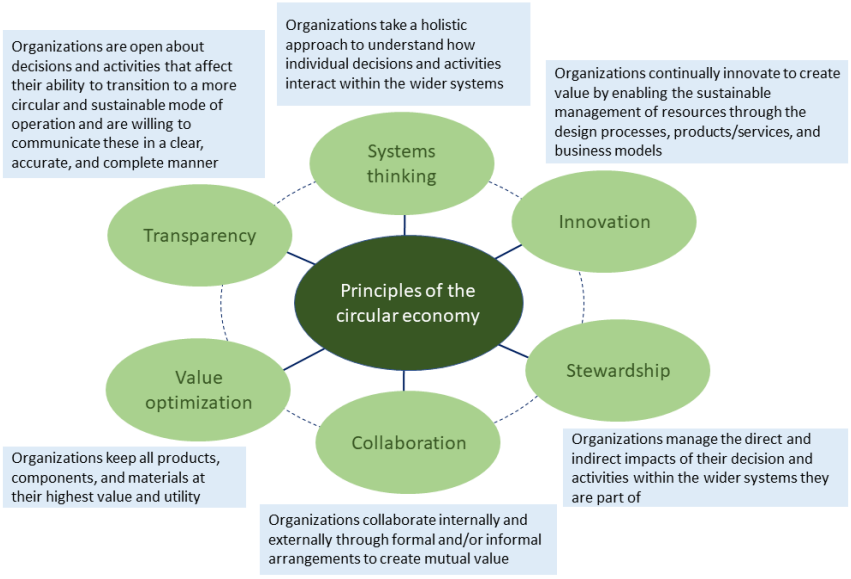

Figure 17 Principles of the CE and corresponding definitions (BSI, 2017)

2.3.1 Value optimization

The circular economy is "about creating and optimizing value by reconsidering what might be seen as waste or system losses and identifying opportunities to realize new potential from them" (BSI, 2017, p. 30). The principles behind value optimization are to keep all products, components, and materials at their highest value and utility always, continuously reducing demand for energy and improving the energy efficiency of processes and products, as prescribed by the 9R resource hierarchy (Figure 14). Innovation and experimentation are connected to value optimizations to test the viability of options and 'initiate transitions within existing companies' (Bocken et al., 2021, p. 50).

From a circular perspective, value optimizations concern implementing strategies that extend the life span of products and their parts, i.e., through reuse, repair, and refurbishment (Kirchherr et al., 2017). However, value optimization is not so straightforward once products have passed the waste threshold. First, the waste sector is born linear, i.e., waste was perceived as a burden (Amasuomo & Baird, 2016), which contrasts with the CE principles. Therefore, waste management companies may be locked in in terms of knowledge and infrastructure. Secondly, unlike pre-consumer by-products, and scrap materials left over from production, waste streams are contaminated: For example, municipal waste consists of a heterogeneous mix (Miafodzyeva & Brandt, 2011) separately collected from households. Further, it is complex due to its 'link to consumption patterns' (Eurostat, 2021) and may vary from one location to another (Miafodzyeva & Brandt, 2011). Finally, as the volume of waste increases, so does the variety (Vergara & Tchobanoglous, 2012). Moreover, municipal waste companies are legally operated as a nonprofit activity in which the total waste handling costs are recovered through waste handling fees. Waste fees are levied on households through a biannual property tax payment. Further, waste fees can only be used for specified purposes and services that are to the benefit of all those who pay the fees. This influences what waste management companies are allowed in terms of engaging in businesses.

These issues are further dealt with in Chapters 4 and 5, which investigate cases of municipal waste management companies engaging in CE innovation and waste valorization and how they are challenged by the linear structures of the past and present, i.e., regulatory and cultural barriers such as lacking policies that support a CE transition, operating in a linear system, and the lack of willingness to collaborate in the value chain.

2.3.2 Innovation

Innovation is closely linked to value optimization and collaboration. Innovation is anything that results in something new or changed (e.g., product, service, or process) that realizes or redistributes value (BSI, 2009) and can be encouraged through new collaboration. Moreover, innovation is required in the making of new business models, as circular economy business strategies require new ways of doing business (BSI, 2017). Thus, innovation results from interactions within a broader network spanning across diverse organizational and societal boundaries and institutions. This process may challenge existing frames of understandings, and new patterns for interactions may emerge.

Different types of preparing for reuse schemes are investigated in which some support incremental change and others relate more to the development of new innovative disruptive ideas (see Chapter 4). Several theories exist regarding the design and staging of innovative processes, from linear sequential models to complex, dynamic networks of innovations. However, for this thesis, the concept is used first to emphasize that there are traces of innovation throughout the thesis, as cases in the FUTURE project involve implementation of, or experimentation with, new practices (1.3 Project). The specific topics of innovation and valorization processes in waste management are analyzed in Chapters 4 and 5.

2.3.3 Systems thinking

Systems thinking is about the complex, nonlinear, and interconnected nature of any system in which an organization sits, in contrast to simple linear systems (BSI, 2017). ‘Systems thinking can help an organization manage change and complexity more effectively and identify potential long-term consequences (intended or otherwise) of decisions and activities’ (BSI, 2017, p. 28). In the BS 8001, systems thinking is defined as *‘an understanding of how organizations, individual decisions and activities interact within the wider system they are part of’* (BSI, 2017).

An illustration of an organizational system is provided in Figure 18.

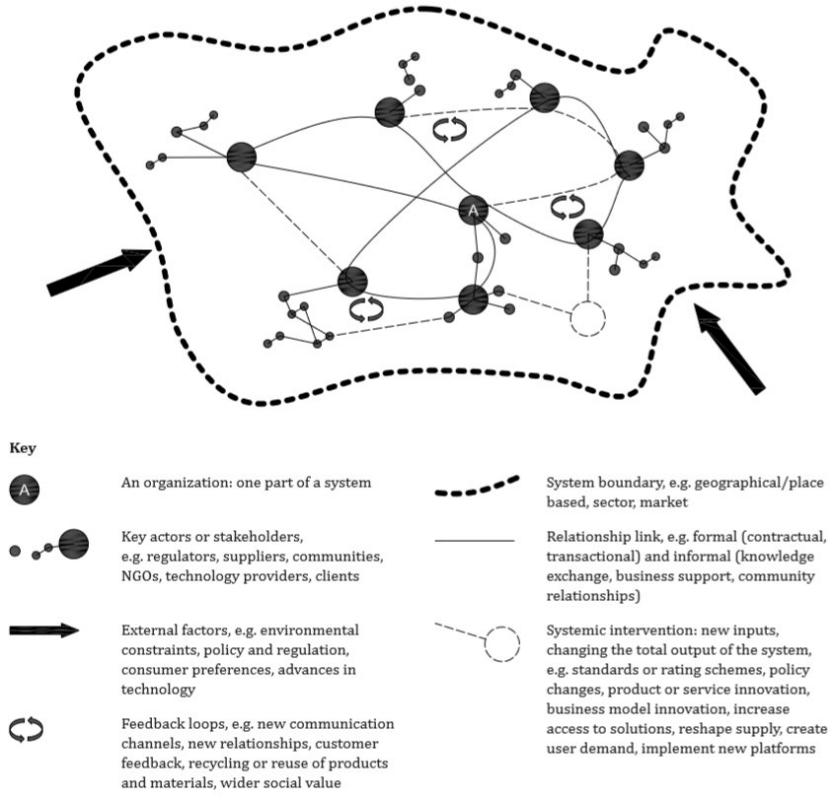

Figure 18 Organizational system with interventions highlighted (BSI, 2017)

For this thesis, a system thinking functions as an analytic tool to help understand how an organization, e.g., a waste management company, is part of a broader system, and linked to other stakeholders through formal and informal relationships. For example, if a waste management company creates new cooperation, i.e., entering public-private partnerships, new "feedback" loops can be created inside the system, and lead to, for example, increased reuse (see Figure 18). Moreover, new activities may stir up an existing balance in the system, i.e., result in conflicts between the ‘newcomers’ and existing stakeholders, as demonstrated in Chapters 4 and 5.

Another essential element of system thinking is that the system boundary is not "solid," meaning that the system is sensitive to external factors. In this thesis, external factors include, for example, changes in policy and regulation, as discussed in the introduction, and consumer preferences and advances in technology: For example, new technology to clean used building bricks led to new relationship links, e.g.,

public-private partnership and systemic intervention such as product-and-service innovation (see Chapter 5). However, external factors, including regulation and consumer preferences, influenced the process.

Moreover, systemic interventions may appear over time. For example, changing policy around preparing for reuse may result in a systemic intervention that promotes or hinders waste management companies from engaging in those types of activities. This is briefly touched upon in the Introduction and is further dealt with in Chapter 4. The timescale over which behavior manifests itself can vary (BSI, 2017).

Systems thinking is an important principle in the circular economy, as multiple actors and activities in the supply chain are involved before material loops can be closed (Ramsheva et al., 2020). A tool for system thinkers has been developed that entails six fundamental concepts: disconnection-interconnectedness, linear-circular, silos-emergence, parts-wholes, analysis-synthesis, and, finally, isolation-relationships (Acaroglu, 2021).

2.3.4 Collaboration

The emphasis on collaboration between stakeholders as being vital for the achievement of goals is something that this concept has in common with the sustainability concept (Geißdörfer et al., 2017). According to BSI (2017), it is *'unlikely that any one organization can achieve substantial progress in transitioning to a more circular and sustainable mode of operation without collaboration'* (p. 29). The German Federal Association for Sustainability argues that the first step in achieving sustainability is collaboration, and therefore points to Sustainable Development Goal 17, 'Partnerships for the goals,' as the first step (GFAS, 2021):

> If you have an idea and try to realize this idea, you often realize very quickly that you are missing something. Be it skills and capacities, be it money or other resources. Therefore, every step begins with the search for partners. (GFAS, 2021)

As collaboration is a key concept in this thesis, a more in-depth discussion concerning collaboration is provided in the following, including types of, motivations for, and challenges to collaboration.

2.4 Collaboration in unlocking sustainability

Due to the complexity of sustainability challenges, 'solving sustainability challenges will require unparalleled cooperation' (NBS, 2013, p. 5). As a result, collaboration is

pointed to as one of the keys to unlocking sustainability (Confino, 2012; Gray & Stites, 2013). The significance of collaboration is also reflected in the Sustainable Development Goals (SDG), particularly SDG17, ‘Partnerships for the goals,' which stresses the need for cross-sector and cross-country collaboration to achieve the goals (UN, 2020).

Partnerships can address complex problems that may require different skills, resources, and the involvement of several stakeholders, making partnerships a natural way to address sustainability issues (NBS, 2013, p. 4). As a result, partnerships to address sustainability challenges have grown exponentially (Gray & Stites, 2013, p. 10), but not all are successful (NBS, 2013, p. 4).

For this thesis, a suggestion is to find different ways for various stakeholders to collaborate on repairing and preparing waste for reuse. That includes reconciling various stakeholders' (competing) interests. On this basis, the collaboration between various actors is a recurring theme in this thesis (Chapters 4, 5 & 6).

Partnerships can take many forms and have differing levels of complexity (Gray & Stites, 2013; NBS, 2013; Utting & Zammit, 2009). For example, a partnership may begin as a collaboration between two sectors, e.g., public and private, but then "branch out" to include other sectors and "additional members from the original sectors" (Gray & Stites, 2013, p. 19). Moreover, one assumption is that new types of relationship and linkages may emerge when case companies are experimenting, and 'collaboration' in broad terms is then crucial to understand.

2.4.1 Motivation, challenges, and barriers to collaboration

Motivation for entering partnerships for addressing sustainability challenges includes the potential to draw on diverse competencies from different sectors, combining skills, resources, and knowledge ‘from a wide range of stakeholders’ (NBS, 2013, p. 11).

There are numerous collaborative outcomes of partnerships, but 'the basic premise about the value of partnerships is that outcomes occur that, presumably, the partners could not accomplish on their own' (Gray & Stites, 2013, p. 49). Some outcomes are 'environmental-centric,' improving sustainable practices that are beneficial to partners and the planet. Others consist of individual outcomes in learning and networking, whereas others still are sector-specific, i.e., businesses (Gray & Stites, 2013).

However, working with different organizations can prove challenging due to, for instance, varying motivation and cultures, and it takes a joint approach and mutual trust to do so. An overall recommendation that pertains to all partners, regardless of

the type of collaboration, is that partners should 'adopt a problem-centric rather than a firm-centric model of stakeholders' (Gray & Stites, 2013, p. 8). Another crucial recommendation is for partners to 'frame the partnership as a learning process.' Some challenges, barriers, and paths to success are illustrated in Table 3.

Table 3: Challenges, barriers, and steps towards successful collaboration (based on BSI 2017; Gray & Stites, 2013; NBS, 2013).

Challenges to cooperation:	Varying motivations, cultures, and requirements
Barriers to successful cooperation:	Internal silos, lack of transparency, or unwillingness to share information
	Competitions, e.g., between different business units and departments
Success towards cooperation built on:	Developing mutual trust, effective communication, and a shared vision and purpose (applies both internally and externally)
	Knowing when to take the lead in a collaborative relationship vs. playing a more supporting role
	Adopting a problem-centric rather than a firm-centric model of stakeholders
	'fram[ing] the partnership as a learning process.'

In the context of this thesis, solutions may include different types of collaboration, involving actors from different sectors of business, NGOs, governments, and civil society. Differing aspects of collaboration and associated issues are dealt with in Chapters 4, 5, and 6.

3 RESEARCH DESIGN

3.1 The research onion applied to the research design

In this chapter, the research design and methodology are explained.

The research design is explained in six steps corresponding to the six layers of the research onion (Saunders et al., 2016). First there is a brief introduction to the generic concept model of a research onion. Second comes an illustration of how the research onion has been applied, followed by an explanation of how the concept has been applied to the research design of this thesis.

A research process consists of different stages, i.e., choices of methods, concepts, and the research time frame. The 'research onion model' presented by Saunders et al. (2016) aims to explain and illustrate different stages involved in research. The onion model applies to almost any type of research (Bryman et al., 2021) and is widely used for the construction of a research framework (Melnikovas, 2018). Layers in the model represent the stance from which the research is conducted, approaches, study strategies, the research time frame, and data collection and analysis techniques. According to Melnikovas (2018), using the research onion is an approach to creating a firm basis for the development of a 'coherent and justifiable research design' (p. 30).

The six layers consist of choices and beliefs: 1) research philosophy, which entails a system of beliefs and philosophical assumptions, e.g., positivism, pragmatism; 2) an approach to theory development, e.g., induction, deduction; 3) methodological choices, e.g., mono or multi-methods; 4) strategies, e.g., experiments, case studies, action research; 5) time horizon of the research; and, finally, 6) choices related to techniques and procedures for data collection and analysis of data. Thus, layers in the research onion consist of interconnected layers.

An overview of the research onion applied to this thesis, based on the six-layered generic model, is provided in Figure 19. Dotted lines have been added to illustrate the layers' interconnectedness.

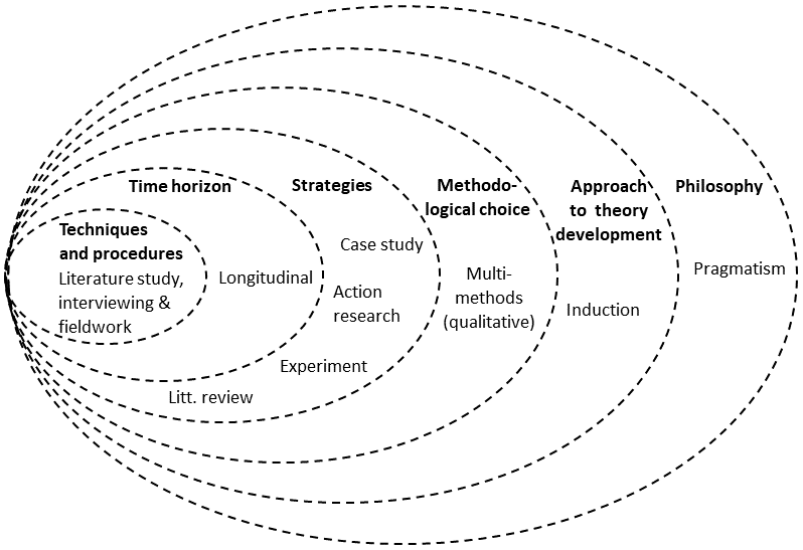

Figure 19 The research onion applied to this thesis (based on Melnikovas, 2018; Saunders et al., 2016)

The six layers of the research onion have been applied to this thesis, starting with layer one, philosophy, followed by the additional layers of approach to theory development, methodological choices, strategies, time horizon of the research, and techniques and procedures for data collection.

3.2 Pragmatism

The research design process for this thesis is shaped by the tradition of pragmatism. The primary reasons for placing my research in a pragmatic paradigm stem from the fact that the research undertaken in this thesis has emerged from a practice-based problem. Pragmatism is not a classical direction of theory but rather describes a philosophical tradition in which the basic assumption is that people acquire knowledge through actions (Dewey, 2015). In pragmatism, the researcher is preoccupied with examining how reality unfolds in concrete practical contexts, meaning they are concerned with "applications—what works—and solutions to problems" (Creswell, 2013, p. 28). Pragmatically based researchers let problems and situations in practice guide which methods they should use to investigate (Gimmler, 2018). What guides the choice of method is the 'problem' encountered in practice (Dewey, 2015). Rather than one single scientific method, all scientific methods are in principle considered applicable (Dewey, 2015). In other words, "pragmatists are free to choose methods, techniques, and procedures of research that best meet their needs

and purposes" (Creswell, 2014, p. 11), using multiple approaches to understanding (Rossman & Wilson, 1985).

3.3 Induction and multi-method approach

This research takes an inductive rather than a deductive approach, as it takes a point of departure in observations rather than a specific hypothesis (Saunders et al., 2016). In line with the pragmatic positioning, the research design builds a variety of methods, allowing for integrating different aspects of the research object and thus allowing for new forms of insight (Frederiksen et al., 2014). A discussion on the applied methods can be found in Section 3.6 Datacollection. Using multiple methods for data collection—exploring a phenomenon from different angles—leads to a richer understanding of the phenomenon. However, using several methods may also conflict with transparency. Triangulation is therefore used to promote transparency.
Triangulation is a "method of cross-checking data from multiple sources to search for regularities in the research data" (O'Donoghue & Punch, 2003, p. 78). Triangulation refers to the use of multiple methods to obtain a comprehensive understanding of phenomena in qualitative research, but it is also used as a strategy to test the validity of qualitative research (Carter et al., 2014).

Denzin (2006) identified four basic types of triangulations: (a) method triangulation, (b) investigator triangulation, (c) theory triangulation, and (d) data source triangulation. Method triangulation and data source triangulation were applied to this research and delimited from investor and theory triangulation. Method triangulation is the use of multiple methods to study a situation or phenomenon (Denzin, 2006). To secure the validity of the empirical data collected, the empirical research design rests on multi-methods, combining different methods to collect data. Thus, the strength of one method may compensate for weaknesses of others (cf. 3.2.3 Research strategy). *Data source triangulation* is the use of a variety of data sources in a study (Denzin, 2006).

3.4 Strategies

Strategies included in this thesis consist of three different research strategies: case study, action research, and literature review. The three strategies are presented in the following.

3.4.1 Case study

Affald Plus, BOFA, AVV, and Lund Renhållningsverk are municipal waste management companies. Much of this research is conducted within and about these companies, and substantial parts of the study are thus based on case studies. Case studies usually investigate social phenomena that are context dependent (Flyvbjerg, 2001; Neergaard, 2007). One of the strengths is that they are suitable for exemplifying and explaining not only how certain events take place but also why situations arise (Yin, 2009). Case study research may contribute to generating an in-depth understanding of complex issues, investigating *'contemporary phenomena' within their real-life context* (Yin, 2009). For this thesis, learnings from studying the processes that have taken place in the waste management companies has been used to gain a deeper understanding of constraints and solutions for municipal waste management companies' effort to transition from waste to resource management practices. Thereby, case studies are applied as a method to investigate and contribute to existing practice, i.e., the concept of cooperation for the inner cycles and the local loops in waste management.

Case selection criteria

Cases are often selected based on different criteria and purposes (Neergaard, 2007). For example, cases may describe something unique or something typical (Flyvbjerg, 1991; Neergaard, 2007). For this thesis, cases associated with the project FUTURE were arranged prior to the research study. The cases were not selected based on specific criteria but due to the context of experimentation with, and implementation of, strategies supportive of the inner cycles and the local loops. However, this openness to organizational change is a criterion for collaborating with these companies as this also links with action research (Duus et al., 2012) (see Section 3.4.2).

In addition to the case companies, the Danish municipal waste management company Affaldsselskabet Vendsyssel Vest (AVV) was included as a deliberate choice. AVV was chosen as a supplementary case for several reasons. Firstly, AVV was the first of its kind to develop its business from the outset to promote CE principles (Zacho, 2017). Further, AVV is a frontrunner company in terms of testing and challenging the existing linear waste management system, making AVV politically important. On this basis, AVV was an extreme case in which the purpose was to learn on the basis of unusual manifestations of the studied phenomena (Flyvbjerg, 1991; Neergaard, 2007). As the research progressed, a range of supplementary case examples were included for different purposes. For example, repair cafes were brought in to strengthen knowledge around repair, including collaborative aspects.

Case studies can be used to explore phenomena in particular contexts through various data sources (Baxter & Jack, 2015). Undertaking the exploration through a variety of

lenses contributes to the revealing of multiple facets of the studied phenomena (Baxter & Jack, 2015). It is common among cases that they test, challenge, and contribute to existing knowledge and practices in the context of experimentation and implementation of CE-inspired solutions, supportive of the inner cycles and the local loops.

3.4.2 Action research

Action research is a research strategy that combines research and action and participation in the field (Reason & Bradbury, 2008; Duus, 2012). A range of assets characterize action research, but the most common include that it 'pursue[s] action (or change) and research (or understanding) at the same time' (Dick, 2001, p.21). It does so by 'using a cyclic or spiral process which alternates between action and critical reflection, and in the later cycles, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles' (Dick, 2002, n.a). This is an emergent process which takes shape as understanding increases (Dick, 2001, Dick, 2002). Thus, the process is iterative and converges towards an increased understanding of what happens.

Finally, it is also participative (among other reasons, change is usually easier to achieve when those affected by the change are involved) and qualitative (Dick, 2001, Dick, 2002). Thus, people are partners in the research process—rather than 'subjects'—in action research (Duus et al., 2012). This contrasts with traditional research where the position of the researcher is detached, i.e., data are gathered for purposes that affect their research rather than the participants. In action research, questions arise as a shared process of reflection between participants and the researcher (Duus et al., 2012). Therefore, it was crucial that case companies were open to organizational changes and entered a 'shared' process for this thesis.

As previously noted, in action research, questions arise as 'shared processes of reflection between participants and the researcher'—in this case between the three waste management companies (BOFA, Affald Plus, and Lund Renhållningsverk) and the university. It was therefore important to consider how a 'sharing process of reflection' could be applied in practice. An illustration of how I adopted this into the context of the project FUTURE and translated this theory into practice is illustrated in Figure 20.

Figure 20 Project FUTURE goals made action based (inspired by Duus et al., 2012).

This working method illustrates the linkage to the collaborative approach in action research, which is precisely about being partners. In addition, the lines are also drawn to pragmatism, prescribing that practice is guiding (cf. 3.2 Pragmatism).

However, an element was missing still: the element of a spiraling process that 'alternates between action and critical reflection,' as suggested by Dick (2001). This also included how this process could be facilitated in the context of the FUTURE project. In regard to the latter, I took my point of departure as the learning concept of 'double-loop learning.' Due to the longevity of the project, I expanded on the concept to include 'multiple-loop' learning. It is characteristic of this type of learning that, in the later cycles, methods, data, and interpretation are continuously refined in light of the understanding developed in the previous cycles (Dick, 2001). For examples of process change in the FUTURE project, see Figure 21.

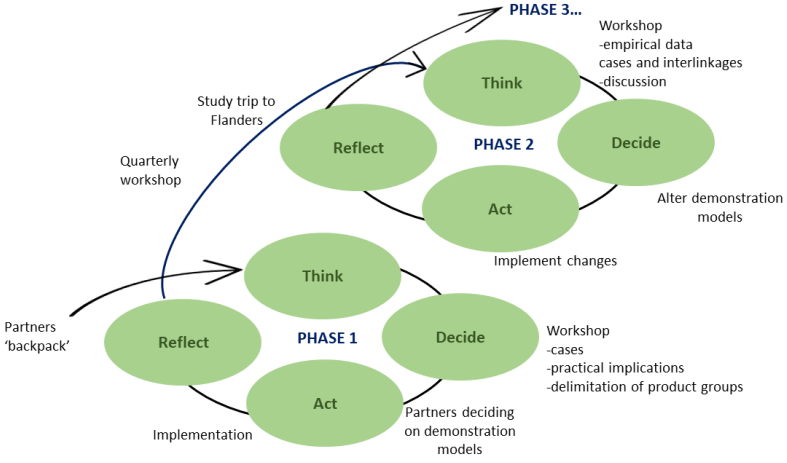

Figure 21 Loop learning facilitates processes of change (inspired by Kolb, 1994).

Examples include the project's quarterly workshops. The purpose was for partners to plan for the next loop based on the critical reflection and understanding developed in the previous cycle. It is characteristic of this type of learning process that it is an emergent process which takes shape as understanding increases (Dick, 2001; Dick, 2002). In the context of the FUTURE project, the emergent process spanned the entire project period, including the last phase of 'wrapping' up.

Models presented in this chapter were developed as communication tools to communicate my methodological approaches to case partners in the project. As previously mentioned, in action research, people are considered partners in the research process. Therefore, communicating this to the partners in the project was a key concern for me. Two major concerns stand out.

Firstly, all partners have to agree to a process of mutual reflection. If not, a risk could be that partners later will not provide free access to collecting empirical data, e.g., doing fieldwork on their premises, sharing their waste data, etc.

Secondly, although partners agreed to a process of mutual reflection, there was a risk that partners would underestimate the importance of their engagement in relation to finding a solution. In other words, we would miss out on the opportunity to learn together.

Therefore, already at preliminary meetings, action research was communicated to the partners in a visual way. That helped partners enter the project with an open mind, agreeing that solutions were developed together rather than provided.

3.5 Time horizon

The time horizon for the FUTURE project and associated research spanned three years. On the one hand, that has provided me with the ability to follow processes over time, i.e., case development in the project, and learning about constraints and opportunities for waste management companies to transition from waste to resource management, i.e., cooperation regarding the inner cycles and the local loops. From this, I have gained new and important learning. On the other hand, the longitudinal time horizon is quite challenging: For example, the scope of action for waste management companies to prepare waste for reuse has been narrowed since the start of this research. The green transition is debated concerning waste management practice and policy and followed closely within academia.

3.6 Data collection and analysis

Data collection consists of a wide range of different methods, e.g., questionnaires, interviews, focus groups, observations, and documents (Johannesson & Perjons, 2021). One or more of these may be adopted by the researchers depending on the research question and scope and using mono-, mixed-, or multi-method approaches (Saunders et al., 2016). According to Anguera et al. (2018), 'the terms *multimethods* and *mixed methods* are used differently in many publications' (n.p), suggesting further research is necessary for finding a common definition—a discussion that is outside the scope of this research (Anguera et al., 2018). Nevertheless, to create consistency in the thesis, the definition from Creswell (2015) will apply. Creswell (2015) explains what differentiates mixed methods from multiple methods in the following way:

> Mixed methods … is not simply the collection of multiple forms of qualitative data (e.g., interviews and observations), nor the collection of multiple types of quantitative data (e.g., survey data, experimental data). It involves the collection, analysis and integration of 'both' quantitative and qualitative data. When multiple forms of qualitative data (or multiple forms of quantitative data) are collected, the term is 'multimethod.' Creswell (2015, pp. 2–3)

For this thesis, different research questions necessitated different approaches, requiring multiple forms of data. Further, my research questions require qualitative data to answer, as they include 'how and why' inquiries. For this reason, I employed a multi-method approach as suggested by Creswell (2015).

Details on data collection specific to each subquestion are explained further in the articles (see Chapters 4, 5 & 6), along with the methods specific to each subquestion. Finally, an overview of empirical data related to this thesis (Feb. 2018 – Dec 2021), is to be found in the Appendix D Data archive.

The main collection methods for the studies undertaken in this thesis are highlighted in the following, including literature study, interviewing methods, and fieldwork.

3.6.1 Literature study

Literature was reviewed throughout the research process to obtain a conceptual understanding of the concepts of prevention and preparing for reuse. However, the type and use of documents varied depending on the context, i.e., the specific research question in focus.

For example, in Paper I, document study played a key role in one part of the paper in which the aim was to analyze possible constraints related to the discussion concerning legal act and the interpretation of PfR, as a concept. Documents consisted of state administration, legal documents, and internal documents. Further, media analysis was included, consisting of a broad swath of news stories, e.g., local newspapers and web news sources. Additionally, data obtained from fieldwork and interviewing methods were a substantial part of this paper (see Chapter 4 for further details).

In contrast, Paper III consisted of a systematic literature review (SLR) on repair cafes, in which literature research played a key role throughout the research process. A systematic literature review identifies, selects, and critically appraises research to answer clearly formulated questions. The literature review was chosen for two reasons: firstly, to contribute new knowledge on the upcoming research field of repair and the future roles of repair cafes, including investigating possible solutions for repair cafes to cooperate with waste management companies for the inner cycles and local loops, and, secondly, because I wanted to learn the skill of conducting a systematic review, as it consisted of a range of important elements, including systematic searches, i.e., the search strategy, text mining, choosing databases, documenting, and reviewing. Documents consisted of peer-reviewed papers, books, and peer proceedings only (see Chapter 6 for further details).

For the remaining paper (II), literature was a key component in creating a theoretical framework around waste valorization. In addition to the academic, peer-reviewed literature, gray literature was examined to widen the understanding of the topic, particularly for repair and preparing for reuse, as those topics are widely discussed by practitioners but not necessarily related to academia. (see Chapter 4 for details).

At a more general level, relevant sources were identified through a variety of academic knowledge databases, such as Web of Science (WoS), Scopus, and Google Scholar, and from NGOs, e.g., RREUSE, the International Organization of Repair Cafés, the Ellen MacArthur Foundation, the Right to Repair Organization, and the International Solid Waste Association (ISWA).

3.6.2 Fieldwork

Fieldwork was performed at various points throughout the research to obtain a practical understanding of repair and reuse (Chapters 4 & 5). One characteristic of fieldwork is that the researcher participates to observe and experience what is going on in practice (Frederiksen et al., 2014). Participant observation was applied as this is the only field method that allows for observing what people do in a real life context (Czarniawska, 2007). For this research, fieldwork consisted of multiple visits to a

range of municipal waste management companies' reuse stations in Denmark and Sweden.

Being present 'on-site' was crucial, as it allowed examination of PfR and the behavior around it in its own complex context (Frederiksen et al., 2014). A weakness related to traditional fieldwork lies in its limited, situated nature, including development over time (Frederiksen et al., 2014). Therefore, my fieldwork also consisted of company stays of longer duration of one to four full days, which were repeated over time, during the three and a half years the project FUTURE was running. Further, long-duration stays enabled me to interact with personnel and to follow the company's daily practice/routine around reuse and PfR. Being present in a company daily also gave me the opportunity to talk to a broad palette of employees and to engage in daily routines. Shadowing, (Czarniawska, 2007), applied as a supplement to participant observation. Shadowing means following practitioners in their daily work (Czarniawska, 2007). This included spending time in the field with waste collectors and repairers in repair cafes, following them while they carried out their duties (see Figure 22).

Figure 22 Waste collection of bulky wastes and collaborative repair in repair cafes

Observing at the micro level provided me with valuable insights concerning constraints to, and opportunities for, reorganizing the waste sector. For example, it made me reflect on how even minor constraints in the daily waste management and practices around reuse and repair may function as a bottleneck for changes at the system level and vice versa e.g., how rigid rules regarding material recycling act as stumbling blocks for reuse.

Site visits were always accompanied with various types of documentation, including photo documentation and fieldnotes, supplemented by passive observation and informant interviews with either project leaders, the head of reuse, or site workers.

Finally, photo documentation of products (reusable) in containers for recycling or incineration documented and supplemented knowledge on current reuse practice (c.f. Figure 2 Barbie Dolls disposed of in a container for recycling). Fieldwork related more to identifying gray zones and legal issues concerning PfR and involved conferences on legal issues around PfR.

3.6.3 Interviewing methods

For Papers I and II, interviewing methods included participating in nine Danish waste conferences on reuse/PfR with actors from the repair and reuse scene (public, private, NGO) and seven interviews with waste managers, developers, and directors on potential benefits of, and barriers to, reuse and PfR (see Chapters 4 and 5 for further details). The interview formats were both unstructured and semi-structured. The latter was characterized by open-ended questions conducted in person (Salamon, 2013). Where possible, interviews were conducted in 'the field,' and enabling interviews combined with observation of aspects of reuse and PfR in practice. Further, interviews included informant interviews with follow-up question and meetings. An overview of qualitative interviews performed is provided in Chapters 4 and 5.

At a more general level, I participated in fifteen Danish waste conferences on reuse and PfR distributed over time. During the conferences, I learned a lot by talking to, observing, and listening to actors from different sectors, as doing so provided multiple perspectives on my research project from the private, NGO, civil society, and waste sector (see Appendix D Datarchive for further details). For this thesis, this knowledge guided my written work, but insights were also shared with collaborators in the FUTURE project, during visits and workshops.

3.7 Advantages and drawbacks of selected research design

Advantages of doing case studies included the application of a range of methods to study transitional waste management practice, enabling a holistic insight into potential and constraints in the current transition.

Further, applying strategies of case studies and action research enables the researcher to both observe (learn from) existing practice and to engage with upcoming actors on the reuse and repair scene.

The iterative process provided a common framework for creating new learning through double-loop learning, contributing to reflections and the changing of practices. However, collaboration with external partners in the research process comes with a risk that the researcher could become too involved in the contextual setting. As a result, the researcher may lack the distance required to maintain objectivity and provide critical reflections (Kørnøv et al., 2011).

During my Ph.D., I have experienced situations in which it was difficult to distance my research perspectives from the perspectives and interests of the case partners. One example includes the debate concerning municipals' rights to operate reuse shops. Being situated in A+, it was difficult to observe certain debates without taking sides, i.e., adopting the view that waste management—and preparing for reuse—should remain a public task. Maintaining a close collaboration with my supervisors, university colleagues and attending conferences, helped me remain conscious of when I tended to adopt the interest of collaborators.

Another limitation may stem from the chosen research issues being exemplified in case studies of a broad range of products rather than a focus on one. This broad scope may be fruitful for the generalizability of the research, i.e., concerning selected policy issues. On the other hand, the approach tends to generalize rather than highlight product groups' unique issues and thus limits the ability to conclude on specific product groups (see section 8.3 Reflection on my own research, for further reflections).

PART III

Research findings

Different perspectives on a circular transition to support increased attention to the inner cycles of the circular economy has been explored, in particular, different perspectives on what happens when the principles of the inner cycles of the circular economy meet the current practices based on the waste hierarchy.

Findings include the practice and how actors on the repair and reuse scene promote local solutions for reuse and repair, either alone or in cooperation. Case studies, literature reviews, study trips, and attending conferences have all contributed to the findings.

This section provides an overview of the papers in this thesis, including the main findings. The findings are presented in three chapters, 4, 5, and 6, each answering one of the three subresearch questions.

In Chapter 4, municipal companies' experiences with preparing for reuse are presented, answering subresearch question 1 (SQ1). Chapter 5 addresses repair and reuse from a waste valorization and collaborative approach, answering research question 2 (SQ2). Chapter 6's focus is on extending product life through repair, particularly repair cafes, answering subresearch question 3 (SQ3).

4 PREPARING FOR REUSE

In this chapter, the potential and the barriers for preparing for reuse (PfR) are investigated, as too many products with a reuse potential end up as waste, resulting in products being prematurely recycled or incinerated. This contrasts with both the hierarchical order of the European waste hierarchy and the principles of a circular economy. The focal point of this chapter is the concept of preparing for reuse, and the aim is to answer research subquestion 1 (SQ1):

> **SQ1: How can 'preparing for reuse' be reinterpreted through initiatives at the local level?**

To address this SQ, case studies are used as a research strategy to explore existing practices (Paper I).

4.1 Paper I: Struggles over waste

Paper omitted in online version

Paper I positions itself in a CE transition perspective, in which waste is perceived as a valuable resource (Geißdörfer et al., 2017; Kirchherr et al., 2017). Waste companies play a crucial role in transitioning to a resource-efficient society where more materials and products are being reused (Milios & Dalhammar, 2020; Zacho, Mosgaard et al., 2018). Nevertheless, waste with reuse potential is ending up being prematurely recycled or incinerated (DAF, 2017b). Both these end-of-life solutions contrast with the key principles of CE in which products should be kept in use for the longest time possible, in the inner cycles, i.e., through reuse and repair (Bocken & Short, 2016; Stahel, 1984). The research field is not new. However, previous studies on the subject have mainly been focusing on barriers to, and potentials for, reusing specific product groups such as electronics (McMahon et al., 2019; Pini et al., 2019; Zacho, Bundgaard et al., 2018) or investigating the size of untapped reuse potentials in waste, including bulky waste (Messmann et al., 2019; Zacho, Mosgaard et al., 2018), rather than discussing how municipal companies are putting CE into practice.

In this paper, the practices of Danish municipal waste management companies have been investigated, since they have been change agents and frontrunners in experimenting with circular solutions.

A literature review of similar studies, interviews with relevant stakeholders, desk studies, and knowledge obtained from participation in waste conferences over three years (2018–2021) were used to analyze the reuse practice in five reuse stations in Denmark.

Results on the current waste practice revealed that frontrunners in circularity are increasingly experimenting and initiating PfR schemes to upgrade their current

recycling focus and give more attention to preparing for reuse. This indicates that frontrunners related to circularity in the Danish waste sector engage in, and embark on, an innovation journey, testing different PfR solutions to increase "waste" value by bringing used products to the market. Resulting practices include PfR schemes of varying organizational structures, involving different levels of responsibility for various partners.

Solutions reflect frontrunners' testing and demonstration of their role regarding putting the CE into practice, particularly seeking boundaries for what is possible, including in legal terms.

Solutions may inspire stakeholders to expand, or implement new activities, supporting the inner cycles. For example, waste companies may implement green tracks, as they require no shared responsibilities and allow for incremental change. Alternatively, companies may establish local value chain schemes that require the involvement of more actors but allow leapfrogging. Thus, solutions may support waste companies in an incremental or radical change, depending on how far companies are in the transition process. Moreover, solutions may open opportunities to establish relational links across silos, create positive feedback loops, and increase product reuse in the organizational system.

However, the current transition seems to consist of complex processes of an ambivalent legal framework and struggles over access and rights to resources. Consequently, a more holistic investigation seems to be needed to deepen the understanding of processes of resource management, use, and contestations around these, including a wider discussion on actors' willingness to find common solutions for the inner cycles and local loops. Thus, that is the focus of the next chapter (5).

5 COLLABORATION FOR THE INNER CYCLES

Collaboration and value optimization are critical principles for companies to create long-term business value and transition to a circular economy (BSI, 2017). However, little seems to be known about the actual waste valorization processes of solid waste, i.e., what types of new collaboration are needed? And what characterizes the waste valorization processes? The focal point of this chapter is collaboration for the inner cycles and the concept of waste valorization. The aim is to answer research subquestion (SQ2):

> **SQ2**: **How can current reuse and repair initiatives be strengthened through waste valorization initiatives and collaboration for the inner cycles, at local level?**

5.1 Paper II: The entrepreneurial role of waste companies

**Paper omitted in online version*

Continuing the groundwork laid in Paper I, this paper is based on a case study of investigating challenges to unlocking value potentials in so-called 'waste' seen from a public-private partnership and waste valorization perspective.

In this paper, two extreme cases are reported of a pioneer Danish municipal waste management company, investigating how a public waste company has tried to take advantage of the entrepreneurial opportunities that a transition from linear waste systems toward circularity seems to create. The cases explored different aspects of waste valorization. A conceptual framework was developed to map and assess the processes and activities through which the waste company transforms waste streams into value streams. A black box metaphor was used to visualize the unknown or hidden processes involved in 'unlocking' potentials (see Figure 2 in the paper).

Results in this paper reveal that waste valorization processes are complex and nonlinear, consisting of a range of elements, including entrepreneurship business development, investment, value propositions, and mobilization of stakeholders (see Figure 3 in the paper). Such a transition seems to challenge both the waste system and individual actors in the system. This suggests that alternative waste management structures, including new capabilities, are needed for the waste valorization process.

The waste sector is at a crossroad between a transition towards circularity and then traditional waste management. On the one hand, there are the growing demands from the EU to transform waste practices away from organizing and managing waste streams towards activities in which value creation is central, and that '[t]he Member States take measures to promote preparing for reuse activities, notably by encouraging the establishment of and support for preparing for reuse and repair networks, by facilitating their access to waste held by collection schemes or facilities that can be prepared for reuse but is not destined for preparing for reuse by those schemes or facilities, and by promoting the use of economic instruments, procurement criteria, quantitative objectives or other measures' (Directive (EU) 2018/851, §11Repair). On the other hand, companies are situated in a lock-in, maintaining the individual public actors and systems in existing linear economic, technical, organizational, and institutional logics and mechanisms with a focus on collection targets for ten different waste fractions. This hampers actors' opportunities to develop and experiment with new solutions and to navigate in the "new landscape" (Moalem et al., 2022).

This paper aims to open a discussion on what it takes for waste management companies to navigate the new complexities in the transition from waste to resource management. For future research, a further examination is suggested of which specific competencies are needed and how to develop them to support the transition to a circular economy and it applies to public and private waste companies, as both must adjust to the new situation.

Highlights include:

- Public-private partnerships and networking create value out of "lost" resources
- Waste valorization processes for PfR are complex and nonlinear
- New capabilities are needed to accommodate a transition from the outer cycles of recycling to the inner cycles

6. REPAIR CAFES

Local communities and their citizens play a crucial role in the transition to a more resource-efficient society, where more products are being reused and repaired (Moalem & Mosgaard, 2021). Extending the useful life of consumer products is a key element in the circular economy (Cooper, 2010). As a local-level attempt to *"reduce waste and actively engag[e] the public in sustainability,"* the first repair cafe appeared in 2009, established in the Netherlands (Charter, 2019, p. 210). In this chapter, different aspects of repair are examined from a civil society perspective to answer research subquestion 3, particularly focusing on repair cafes (SQ3):

SQ3: How can repair and reuse be promoted through local initiatives?

To address this, the roles of citizens and social movements in a circular transition are investigated, mainly focusing on repair cafes (Paper III).

6.1. Paper III: A critical review on the role of repair cafes

**Paper omitted in online version*

Papers I and II, and the case of FixaTill, in the project FUTURE, provided insight into repair from a waste perspective and into different types of relational links between actors in the system. Insights led to reflections concerning waste management companies' future roles and how initiatives may combine the best from different organizational initiatives and form new organizational models for extending product lifetime across silos and sectors, including civil society organizations. Continuing the groundwork laid in Papers I and II, and the case of FixaTill, this paper is based on a literature review, investigating repair from a civil society perspective.

As the first review on this topic, Paper III investigates, and gains more knowledge about, repair cafes and critically assesses their role as a sustainability initiative, i.e., how the concept may translate into a broader sustainability context. A systematic literature review (2010–2020) was conducted, including 44 articles in a descriptive and a content analysis.

The paper adds relevant new insights and perspectives beyond the available literature on this topic. As an example, the concept of repair cafes has spread to a range of different contexts, beyond the original scope, influencing the mindset and acts of a broad field of practitioners. That indicates a wide range of possibilities for expanding the concept of repair cafes, bringing different expectations, and calling into question the future role of repair cafes.

It has been suggested that repair cafes engage in collaboration with waste management companies (van der Velden, 2021), which would comply with the waste framework directive (EU, 2018). However, repair cafes have a strong social function, embedded in the community aspect of repair cafes, which may conflict with other core values, including those of the environment.

Moreover, the aims of people involved in repair cafes span from altruistic and strategic, over personal motivations to critical consumer, financial, and educational aims. This may challenge repair cafes' future role(s), i.e., ambitions set by the International Organization of Repair Cafés to increase the repairability of consumer goods by using its data to identify common problems that arise with products or companies to demand changes from manufacturers. Notably, 'fixers' are responsible for the collection and registration of repair data, but the aim and motivation of people involved are complex and it seems that such expectation lacks alignment. The same seems to be the case in conducting repair 'collectively.' Aligning expectations and future roles amongst actors is crucial and would strengthen the future role of repair cafes in a sustainable circular transition. However, alignment may be complex as repair cafes serve different purposes to different people.

The paper confirmed the importance of repair cafes in driving a transition to a CE and revealed that lacking alignment amongst actors both horizontally and vertically may present barriers that need to be addressed for repair cafes to fully contribute to a sustainable transition. Moreover, repair cafes must not conduct repair for commercial use, nor distort competition concerning the local business community, and the association is voluntary. Finally, volunteers hold varying competencies. Those elements together limit the variety and the extent of product repair conducted in repair cafes.

Highlights include:

- A literature review on repair cafes
- Repair cafes hold the potential to play different roles in a CE transition
- Purposes of repair cafes span all three dimensions of sustainability
- Ambitions set by the international organization may lack alignment with volunteers
- The actors of repair cafes hold different motivations, from altruistic and strategic, over personal motivations to critical consumers
- Repair cafes include a limited variety of product repair, e.g., bikes, textiles, smaller electric goods, and electronics

PART IV

Discussion and conclusion

Part IV revisits the research question, summarizes the contributions of the research, and discusses the implications of the conclusions for practitioners, future planning, and research.

7 DISCUSSION

The point of departure in this research has been the challenge that "too many products that still can be used end up as waste" (DAF, 2017b) and thus are prematurely recycled (Messmann et al., 2019; Milios & Dalhammar, 2020; Moalem et al., 2022; Zacho, Mosgaard et al., 2018). This contrast shows the priorities of the circular economy in which shorter and inner cycles should be prioritized over material recycling: the outer cycle, (Bocken et al., 2016; Kirchherr et al., 2017; Stahel, 1984).

Overall, the circular economy operates with four principles by which value can be created by extending product or material life; the" power of the inner circle" refers to the idea that the tighter the circle, the more valuable the strategy (e.g., repairing and maintaining a product and the reuse of components preserves most of its value). The "power of circling longer" concerns maximizing the number of cycles to save virgin material inputs (e.g., reusing a product several times to avoid the material, energy, and labor of creating new products or components). The "power of cascaded use" refers to the idea of diversifying reuse across the value chain to offset the need for virgin material inputs. Finally, the "power of pure inputs" refers to the use of clean, non-toxic materials and maintaining the purity and quality of materials (EMF, 2015). I discuss this further in Chapter 2. Strategies to obtain circularity include slowing, narrowing, and closing resource loops, increasing resource cycling, regenerating material, and energy flows (Bocken, de Pauw et al., 2016; Konietzko et al., 2020). Closely linked to those are six enablers (implementing principles) to frame decision making and behavior when business models for circularity are developed (BSI, 2017). Innovation, systems thinking, value optimization, and collaboration, are included in this thesis.

Regarding collaboration, CE entails a system understanding in which building partnerships, doing new things with others that extend beyond the company level, and creating positive societal impacts are essential measures (NBS, 2013; BSI, 2017). Examples of cross-sector partnerships include public-private partnerships (PPP), where business and the public sector join forces, and business-NGO, where businesses team up with non-governmental organizations (Gray and Stites, 2013). However, partnerships can take many forms and have different levels of complexity (Gray & Stites, 2013; NBS, 2013; Utting & Zammit, 2009).

The goal of this dissertation was to investigate what happens when the principles of the inner cycles of circular economy meet the current practices based on the waste hierarchy. On this basis, the current study discusses the role of municipal waste

management companies and associated actors in a transition from waste to resource management. The results indicate some engaging conclusions from this practice.

In this chapter, key findings are discussed and outcomes are expanded for a broader understanding of the future role of municipal waste management in a transition from waste to resources. Based on the key findings from the literature, two main themes have been identified as particularly interesting.

First, the EU waste hierarchy is discussed regarding the principles and priorities of CE, as ambivalent signals seem to appear in this translation. This includes a discussion of what happens when the principles of the inner cycles meet the current practices based on the waste hierarchy. This part is divided into the following five subthemes:

- Recycling is in practice prioritized over PfR;
- Reusable products with a “waste” definition;
- Updating the upper levels of the EU waste hierarchy;
- Weight as a measure for PfR; and
- Silo thinking.

Second, international experiences from repair cafes and a study trip to Flanders reveal that different perceptions exist for suitable solutions for Denmark, so other ways of organizing product life-extending activities are discussed. This aspect can be divided into the following subthemes:

- Experiences from the project FUTURE;
- Charity organizations;
- Socio-economic initiatives in Flanders;
- Repair Cafes-the non-profit way; and
- Reflections over future organization of product life-extending activities.

7.1 When the EU waste hierarchy meets the principles and priorities of CE

EU member states (MS) are committed to transitioning from waste to resource management, as discussed in Chapter 1. However, when the EU waste hierarchy is discussed against the principles and priorities of CE, ambivalent signals appear. Five subthemes have been identified during the research of the current study and are discussed below.

EU legislation and the waste hierarchy are recurring points in this research. CE priorities and regulation seem to disrupt the current waste landscape and change the

conditions for the actors, making regulation and waste understanding important factors in a CE transition. The shift from linear over recycled to circular is illustrated in Figure 23.

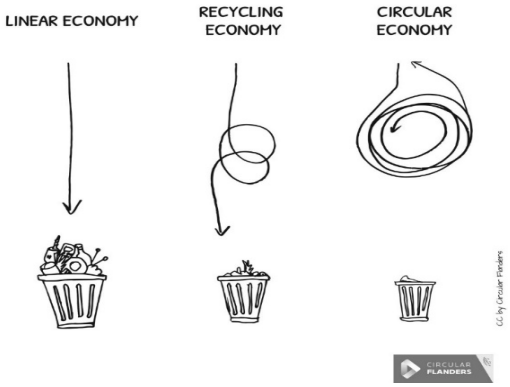

Figure 23 Transitioning from linear over recycling to circular (Circular Flanders, n.a.)

7.1.1 Recycling is in practice prioritized over PfR

First, as discussed in Chapters 1 and 2, once products and material have passed the waste threshold, PfR is the first waste management option in the EU waste hierarchy (EU, 2018a). However, waste data reported to the waste data system (ADS) show that only a modest proportion is reused when compared to recycling. An example from the Skanderborg and Odder Municipality shows that of the collected 69,520 tons of household waste, 62% was sorted for recycling (43,545 tons), whereas less than 1% (515 tons) was reused. Moreover, Remmen (2019) reviewed the waste plans of the 28 municipalities in the capital region of Denmark and found that the overall focus within municipalities concerned implementing separate collections of the 10 waste fractions and increasing the amounts of collected waste for recycling rather than on PfR. This implies a potential to increase PfR, as suggested by Milios and Dalhammer (2020) and Zacho, Mosgaard et al. (2018). More critically, it also illustrates that some PfR mechanisms do not work. For example, results from Chapters 4 and 5 illustrated that this discussion relates to various challenges, including locked-in mindset, habits, routines, and conflicting interests among actors. Moreover, according to Williams (2015), "In practice, most countries have regarded the hierarchy as a 'ladder; and have sought to climb it step-by-step from the bottom (landfill) to the top (waste prevention) "(p. 21). This explains "the slow and stepwise approach" for most EU countries when introducing the principles of the hierarchy into waste management systems (Williams, 2015, p. 21).

Currently the EU admit to "insufficient preparation for reuse and recycling," but shows a lack of knowledge concerning the reasons behind this (Ramboll, 2022). The European Commission's Joint Research Center (JRC) is researching the topic, which should lead to an impact assessment for revision of the EU Waste Framework Directive in 2023.

7.1.2 Reusable products with a 'waste' definition

Second, the waste hierarchy provide a distinction between products and waste that makes PfR difficult. Direct reuse is part of prevention, and this is within the product category. Next in the hierarchy is PfR, in which products are classified as waste, even though it concerns products that can be reused, such as old bricks or household items such as bicycles that after minor repairs, are fully functional again, as addressed in earlier chapters. In other words, PfR is characterized as waste in the EU waste hierarchy and must therefore be redefined as products. However, once products have been defined as waste, they are hard to get back to the inner circles. For example, Chapters 4 and 5 revealed two problematic aspects. First, for public waste companies, the options of the municipalities are limited partly due to the regulatory framework. Second, infrastructure, competencies, and knowledge have been built for a linear system.

This complicates activities that support preparation for reuse and creates conflicts and uncertainties, as was discussed in Chapters 4 and 5. For example, components are mentioned explicitly in the amended framework directive (EU850/2018, Art. 11) concerning that the municipality can remove components from waste products and provide them to the market without being an operator in the market.

A solution would be to move the stippled line between product and waste in the EU hierarchy and redefine the PfR as within the product category. This will require a significant change in the waste framework directive, as is highlighted below.

7.1.3 Updating the upper levels of the EU waste hierarchy

Third, nuances of the inner circles of the circular economy are lacking when comparing the upper steps of the waste hierarchy and circular economy, as discussed in section 2.2, and illustrated in the 9R resource hierarchy (Kirchherr et al., 2017). For example, in the 9R resource hierarchy, there are eight strategies for the first two levels of the waste hierarchy, prevention, and PfR (Kirchherr et al., 2017). One solution could be implementing more variations in the waste hierarchy because there are examples of this in recycling (Guldberg et al., 2021). The differentiation of recycling types should improve the quality of recycling.

A similar differentiation can be made in the upper part of the waste hierarchy to keep the products in circulation. In this relation, a "waste hierarchy" is not the most appropriate concept as the task is to abolish waste and focus on retaining resources in circulation, which better fits a "resource hierarchy. " However, "waste as a resource" seems to be associated with recycling and so could be misleading. Thus, a risk could be to "legalize" the slow and stepwise strategy from below, as stated by Williams (2015).

The International Electrotechnical Commission (IEC) has developed a Use and Waste Hierarchy in Material Efficiency as part of drafting a standard. It provides guidance on material circularity considerations in environmentally conscious design based on the circular principles (IEC, 2022: see Figure 24).

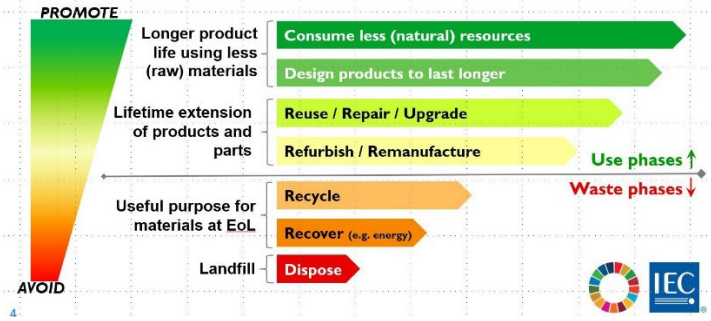

Figure 24 Use and waste hierarchy (IEC, 2022)

This hierarchy entails solutions in which the upper levels of the use and waste hierarchy are more differentiated than in the EU waste hierarchy. Moreover, the stippled line (waste threshold) has been mowed down to redefine the PfR concept apart from its waste definition.

7.1.4 Weight as a measure for PfR

Fourth, collected quantities are calculated in collection percentages and measured in weight, which is a misleading measure compatible with the linear economy (Kirchherr et al., 2017). Meanwhile, observations and interviews from the project FUTURE show a significant challenge in registering the many different "waste" products.

Observations from the case of BOFA showed that reuse registration is a complex task when volunteers are responsible for the reuse. The weighting requires extra resources (time) for the volunteers, so this is not accommodated. Volunteers registered reuse

(products and types) for one month but found it an insurmountable task because products varied in types and age from mattresses to pens, toys, and kitchen utensils. These findings support the A+ appeal, which states that the registration of reusable effects from waste streams must be automated by a registration platform registering all incoming items by weight, item name, and product category (see Appendix B).

Waste collectors must report information on all collected waste for which the company has taken over responsibility from the waste producer (BEK nr 1987 of 28/11/2020; i.e., waste type, amount (tons), source, treatment method, and indication of whether the treatment make up the definitive treatment). Reuse, however, must only be reported for actual final treatment[2] (MST, 2021). As addressed in Chapter 4, "even a small target is necessary to encourage PfR" (Seyring et al., 2015, p. 73; REEUSE, 2012). There are not separate goals for PfR, but a common goal for PfR and recycling. However, this also indicates what challenges arise with individual goals.

7.1.5 Silo thinking

Fifth, a division between private and public exists, as analyzed in Chapters 4 and 5. For example, municipal waste management companies have established secondhand shops to handle reusable products associated with their reuse sites, which has spawned an ongoing debate concerning access rights. Thus, different positions and perceptions exist, including a dichotomy between public and private tasks, rather than focusing on better stakeholder interaction and collaboration between public and private actors. This contradicts the CE principles, which state that systemic thinking and collaboration are key to framing decision-making and behavior in developing circular solutions, as sustainability challenges are complex and require unparalleled cooperation. In line with this, Sustainable Development Goal 17 [SDG 17 Partnerships for the Goals] encourages public, private, and civil society partnerships to achieve sustainability goals. However, as stated in Chapter 4, working with different organizations can prove challenging. For example, it takes a joint understanding and mutual trust to collaborate, which do not seem to be the general case for the actors mentioned above. Nevertheless, results from the project FUTURE showed that experimenting with solutions supportive of the inner cycles, including PfR and repair, spawned several new relationships and collaborations between a wide range of actors (see also 7.2.4).

[2] "Reuse" indicates actual final treatment of the waste in percentages for preparation for reuse.

7.2 Current – and potential setup for organizing product life-extending activities

Based on results from this thesis, international experiences from repair cafes, and a study trip to Flanders, potential ways of organizing product life-extending activities are discussed because different perceptions exist regarding suitable solutions for Denmark. Further, when examining cases, partnerships seem to take many different shapes and complexity levels and require different stakeholders at different stages in the development process, indicating that collaboration is a dynamic process. Further, relationships span both formal and informal, indicating that collaboration may take many different shapes. In this section, 7.2, potential organizational models are discussed for extending product lifetime including charity organizations, socio-economic initiatives, and repair cafes as a nonprofit alternative. Reflections on how initiatives may combine the best parts from different organizational initiatives end the section.

7.2.1 Status and current set-up

Different interpretations and practices occur at the municipal waste management level that support the inner cycles. For example, pilot projects and experimentation in FUTURE entailed different reuse and repair schemes, including "simple" set-up such as green tracks and donation containers over municipal reuse and repair shops to business models experimentation. In the case of A+, of the around 190,000 tons received yearly at the reuse station, approximately 1,500 tons are prepared for reuse, and the outcome is sold in the companies' secondhand shops (FUTURE, 2022). Moreover, initiatives range from creating different types of value and motivation for engagement from strengthening local communities (BOFA) to engaging citizens in community repair as a waste prevention strategy (Lund Renhållningsverk). Also, the establishment of business networks, creating environmental and social value (e.g., local jobs), has been prevalent in the case of waste companies AVV and A+. Finally, waste companies mobilize a range of stakeholders in those waste-valorizing processes while spanning cross-sectoral boundaries (see Chapters 1, 4, and 5).

According to the Danish Waste Association (DAF), there is a gray area for cooperation between such entities as municipalities and charities. Based on a statement of the Danish National Board, the municipality may not give away reusable waste if it has a market value (AST, 2017).[3] This has, according to DAF, created

[3] https://danskaffaldsforening.dk/sites/danskaffaldsforening.dk/files/media/document/one-pager_genbrugsbutikker_.pdf

uncertainty about the legality of existing collaborations between the municipality and the charities. The legal basis for municipalities' "giving away" reusable items (i.e., waste) has been raised during waste conferences.[4] For example, waste companies proposed solutions that provided citizens free access to reuse.

7.2.2 Charity organizations

One organizational model for extending product lifetime is based on charity organizations. Osterley and Williams (2018) investigated charity shops' social, environmental, and economic benefits of reuse in England and found that the charity retail sector is becoming an increasingly significant player in a circular transition. The benefits of reuse in practice have been demonstrated. For example, an estimated 95% of the clothes received in charity shops is recycled or reused, diverting 333 tons of textiles from landfills, and reducing CO2 emissions by 6.9 million tons in 2015/16 in England (Osterley & Williams, 2018, p. 29). Further, the shops raise money for charity, and many people are employed or volunteer in charity shops. Community benefits include providing affordable goods and forging local partnerships with local institutions (Osterley & Williams, 2018). Finally, charity shops maintain footfalls in high streets struggling with competition from out-of-town shopping centers (Osterley & Williams, 2018).

Meanwhile, the charity retail sector is "increasingly professionalized in their appearance and sales strategy and are thus providing greater competition with other high street retailers and countering a negative perception of charity shops as dusty and disorganized" (Osterley & Williams, 2018, p.34). This indicates where the sector is heading and thus also the variety of effects, they may find attractive.

In the Danish context, an association of charity organizations has analyzed figures from municipally owned secondhand shops and found the overall increase at these secondhand shops is largely counterbalanced by a corresponding decline in the charity shops[5] (ISOBRO, 2019). In Denmark, there are 1,057 nonprofit secondhand shops[6] (https://www.genbrugsbutikker.nu/), in contrast to 50 municipal secondhand shops (DAF, n.a.). However, an analysis of municipal waste management companies' collaboration with voluntary organizations on the marketing of reusable effects

[4] DAKOFA konferences: Samarbejder i den danske affaldssektor - fra erfaringer til muligheder - hvad må vi? (30. October 2018), Genbrug og øget genanvendelse - hvad er mulighederne på genbrugspladserne? (29. October, 2019), Regler og muligheder for fremtidens offentlige/private samarbejder (5. May, 2021).

[5] Analysis of accounting figures from six municipal owned second-hand shops (ISOBRO, 2019)

[6] https://www.genbrugsbutikker.nu/

showed that the charity organizations would be able only partly to carry out the task[7] (Affaldskontoret, 2019). According to this investigation, reasons include that the voluntary organizations only purchase reusable items on three conditions reusable items (a) must have a value (b) show a fast turnover, and (c) not present logistical challenges including increased space requirements. However, the same is expected to apply to other actors operating on a commercial basis and partly also to municipal reuse shops. None of these have plenty of space, and unsold items must be replaced at some point. In addition, charity shops in Denmark specialize in fashion shops with selected products rather than a wide product range (Affaldskontoret, 2019) and seem to be professionalizing, as in England (Osterley & Williams, 2018).

On this basis, the established collaborations with entities such as charity organizations on the disposal of reusable items from the reuse stations do not move large quantities from other waste treatment (Affaldskontoret, 2019). However, "cherry picking" has been highlighted as a possible strategy for waste companies, e.g., local businesses pick the valuable items among the waste resources only (Niras, 2017). However, interviews with waste companies that have established reuse shops show that they may depend on those items to balance the many items with a lower or negative value. Against this background, waste companies who wish large quantities of reusable items in circulation again presuppose examining various alternatives. On this basis, funding has been obtained to test a socio-economic model from Flanders, which is, "De Kringwinkel," in a Danish context. This model has proven able to move large quantities from other types of waste treatment.

7.2.3 De Kringwinkel – a socio-economic initiative

De Kringwinkel is a social enterprise of reuse centers in Flanders, Belgium, and is accredited by the Public Waste Agency of Flanders (OVAM) and presents a network of 28 non-profit organizations having 148 reuse shops with reuse of household goods that creates sustainable added value, offering affordable secondhand products for a broad audience of users (Delanoeije & Bachus, 2020). The major reuse centers carry out the refurbishment of white goods, bikes, and furniture, providing employees a training opportunity in repairing. To be accredited and subsidized, the Flemish Government holds three criteria: (a) social employment, (b) repair, reuse, and sorting of collected waste, and (c) coverage of a particular area in Flanders (Delanoeije & Bachus, 2020).

[7] The screening was based on 21 companies and municipalities' experiences with collaboration with voluntary organizations in January 2019 incl. information on the sale of reusable products from approximately 150 reuse stations of which approximately 90 of these donated to voluntary organizations.

Thus, De Kringwinkel's reuse shops are "more than [just] secondhand shops" (Delanoeije & Bachus, 2020, p. 10).

The umbrella organization for social employment and CE enterprises in Flanders (Herwin), ensures that reuse centers under the "De Kringwinkel" brand have a common representation toward and a range of stakeholders (e.g., the Flemish Waste Agency [OVAM], municipal waste companies, local authorities, the government, and private enterprises (Rasenko, 2022). Furthermore, Herwin supported pool funding and provided lobby work to ensure a robust legal framework for governmental unemployment subsidies and provides legal advice (e.g., in case of claims of unfair competition or legal suits; Rasenko, 2022). Finally, Herwin serves as a matchmaker between its members and private companies, such as with Siemens Bosch, who wished to explore the lease market for electronic equipment and use the capacity of existing repair in the reuse sector. Herwin members receive governmental subsidies covering the costs of activities involved in sorting and selecting items for reuse from the collected Waste. Herwin is currently developing a standard price of reuse per kilo to ensure a level playing field in the sector. Thus, Herwin plays a major role concerning securing legal and collaborative aspects.

One of the keys to the success of De Kringwinkel is its systematic approach to collection and refurbishment, including its registration system, which holds a complete closed registration flow to track the processed items (their origins, repair, and sale). This creates transparency and enables producers to control what happened to their products after resale as secondhand goods, which is why all Belgium's electrical and electronic goods producers participating in the common EPR scheme coordinated by their branch-organization RECUPEL recognize the system.

In 2019, De Kringwinkel offered employment to 5,311 employees, of which the vast majority were long-term unemployed and on transfer income (Delanoeije & Bachus, 2020). The more burdened an employee is (e.g., mentally), the larger the financial backpack that comes with the person. However, the proportion of employees with significant challenges is increasing, as was raised as a concern by De Kringwinkel during our visit. As a result, the organization had to "invent" tasks that did not necessarily increase sales and reuse. For example, one organization prepared markers for sale by sorting and counting them, putting them in small bags, and closing the bags by clipping small pieces of cardboard, or as in the picture, where Barbie dolls are wrapped (unnecessarily). See Figure 25.

Figure 25 Barbie dolls in De Kringwinkel reuse store, wrapped up for sale by employees on transfer income.

From a sustainability perspective, the model's funding, legal basis, and partnerships are based on a socio-economic perspective. Revenue from sales is used to preserve and create jobs for people on the edge of the labor market[8] and reinvested to improve the operations.[9] Moving high volumes from less valuable waste treatment options makes this model particularly interesting for Denmark. But the social workplace model used by De Kringwinkel is debatable. For example, the "reintegration of employees in the regular labor market is an option but not a primary objective" in this model (Rubbrecht et al., 2005). According to Cools and Oosterlynck (2015), "durable steps toward the regular labor market are rather exceptional" as the model is "without obligations for the reintegration into the regular labor market" (p. 21). However, this "large-scale subsidized employment model" is unique in Europe as above 40% of their income stems from employment subsidies (Cools & Oosterlynck, 2015, p. 21). However, this dependence on subsidies is a primary barrier for reuse centers to create added value (Delanoeije & Bachus, 2020) because this "limits their space for long-term planning and change management" (p.31). Meanwhile, according to the directors of the centers, "the initiative could not survive without employment subsidies" (Cools & Oosterlynck, 2015, p. 28).

However, waste and reuse are organized differently in the Flemish Kringwinkel, and the model is not directly transferable to Denmark. For example, a significant difference in the Flemish Kringwinkel system is that EEE producers contribute financially. Further, that system would require cooperation with local charities. Moreover, the socio-economic model in Flanders allows for a larger share of employment on the edge of the labor market compared to Denmark and for a more extended employment period than what is allowed under Danish conditions (AVV,

[8] https://www.dekringwinkel.be/onze-missie.html
[9] http://kringwinkel.com/site/

2018c). Therefore, a questionable aspect of the Flemish model is the considerable number of people employed for several years on transfer income and the dependency of employment subsidies. Finally, the data system used by Kringwinkel requires adaptation, as was the case of A+ in the project FUTURE (see Appendix B). Therefore, transferring the Flemish model to Denmark would require further investigations, so the models need to be tested in a Danish context, as is the case on Bornholm (EU, 2022).

7.2.4 Repair cafes - the non-profit way (citizens engagement)

A supplement to other organizational models for extending product lifetime could be the nonprofit repair cafés. As addressed in Chapter 6, repair cafés are based on volunteers and consumers with defective products participating in lifetime-extending repair. Thus, the product is not something the owner wishes to dispose of, unlike former organizational models. Typically, the repair takes place at a fixed time at fixed intervals, organized voluntarily. A host organizes the workshops, others welcome visitors with coffee, and "fixers" assist with the repairs and ensure the exchange of experience at an utterly local level. In addition, there is a shared database with over 4,000 types of repairs (https://repaircafe.org/en/about). As products are not traded, the Purchase Act does not apply, guarantee, or offer a right of complaint for products repaired in a repair café (see Chapter 6).

From an environmental point of view, repair cafés are positive as the activity occurs in the inner cycles in the circular economy. However, repair cafés may have a limited environmental impact due to the scale and thus the total tonnage through such activities. As addressed in Chapter 6, only limited types of repairs are conducted in repair cafés, depending on the available tools, existing space, and skills of the volunteers ('fixers'). Additionally, citizens do not typically bring oversized items, including furniture and white goods, to repair. Environmental criteria do not apply in repair cafes meaning that outdated products can be given a second longer life than maybe recommended. Repair cafés challenge the buy-and-throw-away-thinking of the linear economy, and this may help change people's mindsets and have a long-term contagious effect on other life-extending (repair) initiatives. Many repair cafés are not financially viable and depend on public funds' support, but it is not a goal for repair cafés to generate earnings. Instead, it is to bring back repairing into local society, maintain repair expertise, spread this knowledge, and promote social cohesion in the local community through low-key events (Repaircafe.org, 2013).

From a household economic perspective, the product owner experiences saving money by repairing instead of buying new. The social aspect is vital in the repair cafés,

since they provide a place to meet and a space for socializing, and people can repair items free of charge.

7.2.5 Cooperation for the inner cycles and the local loops to unlock value in waste

The project FUTURE showed interesting variations concerning cooperation for the inner cycles and the local loops in which initiatives foster new relationships and practices. Notably, some initiatives formed new types of collaboration (i.e., outside the split between public and private or NGO), while the line between the two upper levels of the waste hierarchy, prevention and PfR, was blurred. From a systemic perspective, examples are interesting. They may inspire how initiatives may combine the best from different organizational initiatives and form new organizational models for extending product lifetime across silos.

First, combining repair cafés with other initiatives could better use existing skills, workshops, tools, and spare parts. As addressed in Chapter 6, environmental concerns may conflict with the social values of community repair, as was the case for repair cafés to engage in repairing electronics salvaged from municipal e-waste. Therefore, civil society organizations, such as repair cafés, may engage more actively with waste management in different ways, as was the case for Lund Renhållningsverk, as addressed in Chapter 1. For example, FixaTill shared tools, spare parts, and materials with charity shops and the local repair café. In addition, the local repair café conducted workshops on electronic repair as FixaTill lacked those competencies. In addition, the charity shop assisted visitors outside regular visiting hours. Follow-up interviews on the subject revealed that A+ considers two options to collaborate with repair cafés. One is to hold workshops, with repair cafés on the premises of A+ in which citizens bring their products in need of repair. The other option is to allow citizens to repair products that others have disposed of at the reuse station during repair café sessions. The ideas could not be tested due to the Covid 19 but are to be resumed.

Secondly, another solution is for partners to create a division of labor (e.g., between waste management companies and private businesses), which was the case of AVV. For example, the case concerned that AVV entered into a division of labor agreement with the local bicycle repairer regarding repairing used bicycles at the reuse station. As a result, the waste management company and the local repairer negotiated to collaborate in preparing activities to upgrade disposed of bicycles to market and regulatory standards (see Chapter 4).

Thirdly, a Danish version of “De Kringwinkel” will be tested to investigate further organizational models for extending product life (EU, 2022). The aim is to scale a local organizational model and a joint reuse and repair platform to promote reuse

and help young people with physical or mental needs enter the education system and labor market. For example, this linked FGU Bornholm (FGUB)[10] with the need of the local business community where FGU can provide trained labor (repairers) to the private operators (EU, 2022, pp. 293–294). Bringing voluntary organizations, educational institutions, and companies together into partnerships is critical. Partners consist of the municipality of Bornholm, Møbelfabrikken, a commercial foundation committed to entrepreneurship, FGUB, and Aalborg University (EU, 2022).

This indicates that contrasts between private and public and NGOs are blurred as actors seem open to collaborating, at least when discussed at local levels.

[10] FGUB is a self-owned institution offering a primary preparatory school education for youths w. additional needs by offering regular courses, repair education, and internships that last up to two years (EU, 2022).

8 CONCLUSION

Circular economy concerns creating and optimizing value, reconsidering waste, and identifying opportunities are needed to realize the new potential. This implies a potential for increasing product life time, improving PfR activities, and establishing new collaborations.

The research objective of this thesis was to contribute to understanding what happens when the principles of the inner cycles of circular economy meet the current practices based on the waste hierarchy. Research and implementation gaps have been investigated from different perspectives through a literature review and multiple case studies.

The aims and subresearch questions are revisited in this chapter, and the contributions of the thesis are summarized. The chapter ends with a reflection on the research approach and the need and direction for future research.

8.1 Toward Cooperation for the Inner Cycles and Local Loops

This research investigated how "preparing for reuse" has been reinterpreted through local initiatives in Denmark (SQ1). As stated in the introduction of this thesis, too many products with potential reuse end up as waste, resulting in premature recycling or incinerating (DAF, 2017). This contrasts both the hierarchical order of the European waste hierarchy (EU, 2018) and circular economy principles (Kirchherr, 2017), stressing the need to further investigate PfR potentials and barriers.

The research field is not new, but previous studies on the subject have mainly focused on barriers and potentials for reusing specific product groups such as electronics (McMahon et al., 2019; Pini et al., 2019; Zacho, Bundgaard, et al., 2018). Otherwise, the size of untapped reuse potentials in waste has been investigated, including bulky waste (Messmann et al., 2019; Zacho, Mosgaard, et al., 2018), rather than discussing how municipal waste companies put CE into practice (see Chapters 1 and 4). Different aspects of the PfR process were explored in this thesis, using cases from Danish municipal waste management companies (see Chapter 4).

Frontrunners related to circularity in the waste sector are experimenting and initiating PfR schemes to give more attention to PfR. Resulting practices include PfR schemes of varying organizational structures involving different levels of responsibility for its various partners. Moreover, some solutions open opportunities to establish relational links across silos, create positive feedback loops, and increase product reuse at the

local level. Thus, the frontrunners seem to foster new practices blurring the line between the two upper levels of the waste hierarchy, prevention, and PfR (see Chapters 4 and 5). However, the current transition consists of complex processes of an ambivalent legal framework and struggles over access and resource rights. Meanwhile, there is a room for maneuver that provides companies the opportunity for testing boundaries, resulting in innovative solutions (see Chapters 4 and 5).

The investigations more closely examined how current reuse and repair initiatives are strengthened through local partnership initiatives (SQ2). Collaboration is a critical enabler for companies to create long-term business value and transition to a CE. Therefore, the focal point was to investigate collaboration to unlock value potentials in so-called waste seen from a public–private partnership and waste valorization perspective (see Chapter 5). Different aspects of the waste valorization process were explored, using two extreme cases from a pioneer Danish municipal waste management company. A conceptual framework was developed to map and assess the processes and activities, where the waste company transforms waste streams into value streams, and a black box metaphor visualized the unknown or hidden processes involved in unlocking potentials.

The waste company and collaborators succeeded in creating business cases around old bricks and WEEE. Meanwhile, waste valorization processes challenge the waste system and individual actors. Furthermore, waste valorization processes turned out to be complex and non-linear and consisted of various elements, including entrepreneurship-business development, investment, value propositions, and mobilization of stakeholders. This hampers actors' opportunities to develop and experiment with new solutions and to navigate in the "new landscape" (see Chapter 5). Consequently, public–private partnerships and networking create value out of "lost" resources, but new capabilities are needed to accommodate a transition from recycling toward the inner cycles of repair and reuse.

Insights into emerging relationships led to reflections concerning the future roles of waste management companies, particularly the option of combining the best from different organizational initiatives and forming new organizational models for extending product lifetime across silos. Therefore, the research examined how local civil society organizations' initiatives, such as repair cafés, can support repair and reuse (SQ3).

The aims of people involved in repair cafés span from altruistic and strategic over personal motivations to critical consumer, financial and educational aims. Therefore, aligning expectations and future roles among actors is crucial and would strengthen

the future role of repair cafés in a sustainable circular transition. Alignment may be complex as repair cafés serve different purposes to different people (see Chapter 6).

Moreover, repair cafés include a limited variety of product repairs (e.g., bikes, textiles, smaller electric products, electronics) due to their simple set-up. Furthermore, repair cafés must not conduct repairs for commercial use or distort competition in the local business community. Finally, volunteers hold varying competencies. These elements together limit the variety and the extent of product repair conducted in repair cafes. Therefore, repair cafés cannot be equated with professional repairers who have unique professional competencies available. Meanwhile, the purposes of repairing in repair cafés span all three dimensions of sustainability. Therefore, from a collaborative and sustainable perspective, repair cafés hold vast potential to supplement other organizational models and extend product lifetime (see Chapter 6).

Finally, the repair cafés concept has spread to a range of different contexts beyond the original scope, meaning that repair cafes may play different roles in a CE transition. Also, repair cafés have a vital social function, embedded in the community aspect, which may conflict with other core values, including those of the environment (see Chapter 6).

CE entails a system understanding in which building partnerships, doing new things with others across value chains, and creating positive societal impacts are essential measures. On the one hand, existing power relations, roles, and dichotomies on public or private tasks create tension amongst actors related to PfR. On the other hand, experimenting with PfR at the local level initiated new relationships and cross-sectoral collaboration. The latter indicates that private and public and NGOs' contrasts are blurred as actors seem open to collaborating, at least at local levels.

When the EU waste hierarchy is discussed against the principles and priorities of CE, ambivalent signals appear in this relation. That includes, among many aspects, silo thinking, and recycling prioritized over PfR in practice. Moreover, reusable products are provided with a "waste" definition, and waste valorization processes for PfR are complex and non-linear. Also, capabilities needed to accommodate a transition from the recycling toward the inner cycles are lacking.

Consequently, mainly pioneer companies seem to engage in PfR. Thus, there is a need to incentivize more waste management companies and local collaborates to engage in solutions supporting the inner cycles and the local loops. On this basis, funding has been obtained to test the socio-economic models from Flanders [DeKringwinkel), on the Danish Island of Bornholm. This model has proven to move large quantities from other types of waste treatment and may be adaptable to a regional level.

8.2 Recommendations for future research

This Ph.D. dissertation focused on different perspectives on a circular transition to support increased attention to the inner cycles of the circular economy from a local perspective. I reflect upon the research results and their implications for future research in the following.

The investigation of municipal companies' experiences with PfR activities highlighted that the current transition consists of complex processes due to an ambivalent legal framework and struggles over access and rights to resources. Despite this, a more coherent conceptual understanding of PfR, which integrates PfR activities into an overall understanding of the waste ecosystem, has not been developed. Consequently, a comprehensive investigation is needed to deepen the understanding of resource management processes, use, and contestations around these. Moreover, a mapping of actors operating in this tension around of PfR seems vital as does including a more in-depth investigation of actors' willingness to find common solutions for the inner cycles and local loops. This could prove beneficial to practitioners and policy developers.

Addressing repair and reuse activities from a collaborative waste valorization understanding revealed complex processes consisting of various elements, including entrepreneurship-business development, value propositions, and the mobilization of stakeholders. Other capabilities are needed for the waste valorization process for the inner cycles. Therefore, a further examination of which specific competences is needed to accommodate a transition from the outer recycling cycles to the inner cycles and how to develop them. This applies to public and private waste companies, as both must adjust to the new situation.

Moreover, repair cafes contribute to a limited variety of product repairs due to the simple setup (i.e., tools and volunteer competencies). Furthermore, repair cafés have influenced the mindset and act as a broad field of practitioners and serve different purposes, from environmental concerns to strengthening social cohesion. Further, as members of the Right to Repair campaign in Europe, repair cafés aim for local actors to feed in data on repair to make products more repairable and achieve "collaborative repair." This indicates that repair cafés hold the potential to play different roles in a CE transition. However, not much attention has been paid to the future role of repair cafés in the literature, including how repair cafés might sustain themselves in the future.

Finally, it would be interesting to investigate partnerships and networks related to PfR in other EU member states, focusing on cooperation for the inner cycles, to gain new

learning. It might also be helpful to investigate the implications for mowing down the stippled line (waste threshold) in the EU waste hierarchy and redefining the PfR concept away from its waste definition (as suggested in the discussion). A suggestion would be focusing on changes needed in the waste framework directive and the practical implications.

8.3 Reflection on my own research

Completing a PhD dissertation has consisted of a journey of learning through trial and error. It includes a range of positive aspects and elements I could have attempted differently. Some reflections are presented in the following.

This qualitative case study provided context-dependent knowledge and a nuanced view of the studied reality. In practical terms, that included engaging in the practical world of waste management at all levels. This entailed conducting formal interviews with waste management directors, doing walk-and-talk interviews with various staff at the reuse stations, engaging in waste collection with the waste collectors, interviewing citizens around reuse habits, and engaging in product repair in repair cafes. However, bringing in more advanced perspectives on e.g., the private sector and voluntary organizations, could have contributed to a more balanced [and fair] discussion on potentials and barriers for PfR.

Another limitation of this research includes the lack of critical assessment of quantitative measures, including the environmental and economic cost and benefits of PfR of EOL products disposed of at reuse stations or as bulky waste. It could have been beneficial to discuss such measures to validate environmental and economic perspectives in the PfR cases. In addition, focusing on a few product groups could have led to a more nuanced discussion of the triple bottom line because each product group can accommodate unique challenges and benefits.

Moreover, bringing in transition management theories could have strengthened the system thinking, enabling recognizing and addressing the challenges that span multiple domains, levels, and actors. This could also have provided a more nuanced discussion on how systems could have been addressed in this thesis. Further, it could have provided insights into new modes of governance for sustainable development, particularly the principle focused on learning at niche levels, including the concept of “Learning by doing, doing by learning,” and experiments to identify successful or unsuccessful pathways. See Section 3.7 Advantages and drawbacks of selected research design for supplementary reflections.

APPENDIX A

Project FUTURE: the case of BOFA (book chapter)

This appendix contains the book chapter Circular economy in Denmark: Bornholm's vision to achieve 100 percent reuse and recycling in: *Circular economy: Recent trend in global perspective*. Springer Nature. Book chapter. Published: https://link.springer.com/book/9789811609121.

Circular Economy in Denmark: Bornholm's Vision to Achieve 100 Percent Reuse and Recycling

13

David Christensen, Jens Hjul-Nielsen, Rikke Marie Moalem, and Brian Johansen

Abstract

Bornholm is a Danish island of approximately 40,000 inhabitants in the Baltic Sea, which has adopted a vision to be waste-free by 2032, by which time the island's waste incineration plant will be decommissioned. Because of this vision, waste management strategies are to completely transition from landfilling and waste incineration as treatment options. Instead, 100 percent of waste is to be recycled, reused (including preparation for reuse), and prevented in accordance with national objectives and European framework conditions provided in legislation and policies such as the Circular Economy Action Plan. If this were to succeed, it would represent the first successful transition of its kind by an industrialized community. Currently, approximately 75,000 metric tons of waste on Bornholm is treated annually, of which 7% is landfilled, 28% is incinerated, and 65% is sent for recycling.

This chapter details the waste management situation on Bornholm in terms of infrastructure and waste flows, while also showing the different innovative projects and initiatives that are planned and underway to achieve the waste-free 2032 vision and reaching more circularity. A particular emphasis in the chapter is on the higher-order steps in the waste hierarchy, i.e. waste prevention through environmental awareness raising, preparation for reuse and reuse.

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The case of Bornholm shows that through a focus on unlocking green minds and an innovative partnership and experimentation approach, it is possible to waste prevention and strengthen preparation for reuse and thus, the inner circles in a circular economy are complied with. This may be affected by the current COVID-19 pandemic which has had global effects on waste streams including Denmark, but in the longer timeframe the actions involved with achieving the waste-free 2032 vision is expected to be resilient to outside conditions. By fostering good working relationships with civil society through projects and challenging norms about the municipal leeway to operate in, e.g. waste planning, Bornholm can lead the way for others.

Keywords

Denmark · Circular economy · Islands · Bornholm · Reuse

13.1 Introduction

The amount of municipal solid waste is estimated to grow from about 2 billion tonnes worldwide now to about 3.4 billion tonnes by 2050 (Kaza et al. 2018). By 2022, all Danish waste authorities will have to abide by the requirements in *"Denmark Without Waste"*—the latest national waste and resource management plan (The Danish Government 2013) which has as its primary goal, that 50% of household waste from 7 specific fractions (glass, plastic, metal, wood, paper, cardboard, and food) must be recycled by 2022.

Additionally, EU legislation (European Commission 2018) will require recycling of 55% of all municipal waste (defined differently from household waste and may also include commercial waste, with no limitations of waste fractions), increasing to 60% in 2030 and 65% in 2035. To complicate the issue further, the 2022 requirements are based on gross measurement (i.e. materials sent to recycling), while the EU demands net measurement (materials actually recycled).

A successor to the Danish national waste and resource plan, *"Denmark Without Waste"* has been expected since 2018 but has yet to be presented by the Danish government. In the meantime, climate change is a high-priority policy area for the Danish government, which has launched 13 industry-led "climate partnerships" (State of Green 2019a), which are multi-partite working groups tasked with providing recommendations for a number of sectors, including for waste, water, and circular economy. Following in the wake of these recommendations, a politically negotiated agreement for a *"Climate Plan for a Green Waste Sector and Circular Economy"* was announced in the summer of 2020 underpinning circular economy as a growth driver for Denmark. The main points are (a) Climate neutrality for the waste sector by 2030, (b) 80% of plastic to be diverted from waste incineration in 2030, and (c) Decoupling of the waste curve – less waste, less wastage, and more recycling (State of Green 2020).

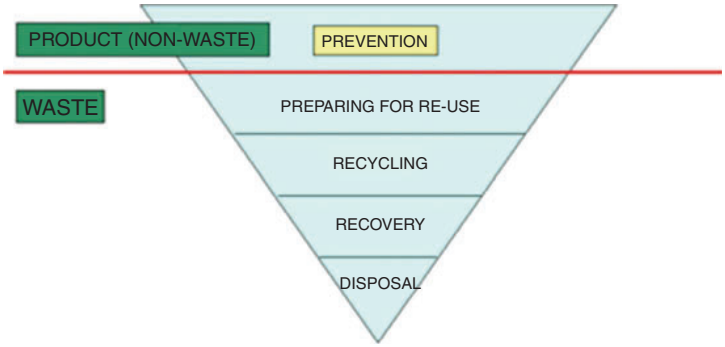


Fig. 13.1 EU Waste Hierarchy showing how reuse and recycling takes priority over landfill (disposal) and incineration (recovery) (European Parliament and Council 2008)

At the European level and influencing these national developments in Denmark, the EU has launched its *"Circular Economy Action Plan – for a cleaner and more competitive Europe"* (European Commission 2020), building on the European Green Deal and its action plan of 2015 which was part of the circular economy legislative package (European Commission 2015). In the new Circular Economy Action Plan, waste collection schemes and product labelling are sought harmonized by 2022 and non-recyclable waste is to be halved by 2030.

There is a long way to go for Denmark. According to the OECD (2019), Denmark is facing the challenge of achieving higher household waste recycling rates and implementing meaningful waste prevention measures while having one of the highest municipal waste generation rates per capita in the entire OECD, as high as 785 kg per inhabitant.[1] A high waste incineration capacity is seen as having created a "path dependency" effect in Denmark:

> Heavy public investment in incineration for municipal waste treatment has created a path dependency featuring high levels of municipal waste generation and limited domestic recycling infrastructure. Municipalities, the main owners of waste incineration plants, face excess waste incineration capacity.
>
> (OECD 2019)

Although there are no negative health effects from a modern incineration plant which undergoes a strict environmental and occupational health and safety oversight regimen (de Titto and Savino 2019), incineration is contrary to the circular economy and should be replaced by handling strategies higher in the waste hierarchy, shown in Fig. 13.1.

[1]This is far above the OECD average of 524 kg per capita but is partly explained by methodological approach to the statistics, in which Denmark has included 127 kg of garden waste in this category in 2017. Subtracting garden waste, Denmark, however, remains in the top six municipal waste generators per capita in the OECD (OECD 2019).

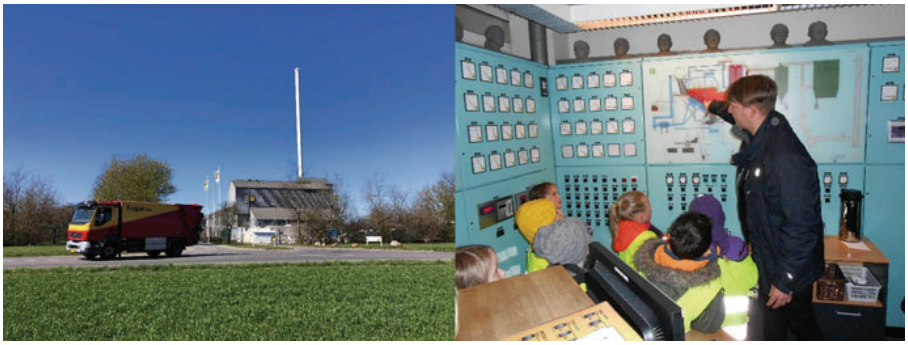


Fig. 13.2 Bornholm's waste incineration plant (Left), run by BOFA, the municipality's waste management entity, and children (Right) being shown the control room of the waste incineration plant

The EU and national requirements are minimum levels, but the Danish island of Bornholm has chosen a more ambitious path with the decision to close its waste incinerator by 2032 and prevent, reuse or recycle all waste irrespective of origin and fraction (BOFA 2019). Bornholm is a unique setting. It is a Danish island in the Baltic Sea, and its vision sets the foundations for furthering circular economy in the country. The vision is detailed in the following.

13.1.1 The Vision for Waste and Resource Management on Bornholm

The Island of Bornholm with 40,000 inhabitants often has difficulty in reaching a critical mass for public services. Whether it is a hospital, an international airport or even a police station, the Danish society is organized with larger populations in mind. The remoteness of the island, however, means that these and many other services are provided for its citizens. This includes a waste incineration plant (See Fig. 13.2), a landfill, and recycling centers, all run by the municipality's waste management entity, BOFA. This situation has often caused the need for dispensations from national waste legislation.

Currently, approximately 75,000 tonnes of waste on Bornholm is treated annually, of which approximately 7% is landfilled, 28% is incinerated, and 65% is sent for recycling (See Fig. 13.3). With the technocratic and somewhat complicated goals and targets from EU and Danish legislators, respectively, it was not possible to communicate these issues to citizens in a simple and understandable form. Something else would be required to create enthusiasm or even understanding and acceptance of the proposed measures.

Inspiration for addressing the waste-related challenges on Bornholm was found in the works of Professor Mark Moore of Harvard University. Professor Moore has developed the concept of public value in the public sector as a parallel to the

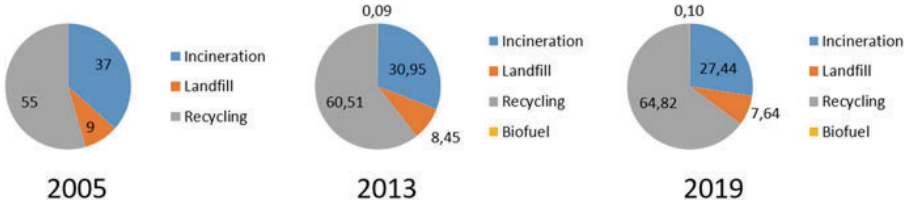


Fig. 13.3 Progression of how waste is treated on Bornholm in percentages in 2005 (estimates from best available data), 2013, and 2019

well-known concept of shareholder value in the private sector. Moore stresses that managers in the public sector should be "... *initiating and reshaping public sector enterprises in ways that increase their value to the public in both the short and the long run"* (Moore 1995). Their roles are not as *"... passive servants to their political masters, but as steward of the public assets, who have an important role to play*" (Benington and Moore 2011).

Another source of inspiration was the Norwegian sociologist John Elster, who argues that individuals or organizations may benefit from constraints and limitations to their choices. The classic example is that of Ulysses who lets himself be tied to the mast in order to safely hear the sirens' song (Elster 1979).

Based on the above mentioned it was clear that a radical solution must be found, and this was developed in the form of the vision, titled *"Bornholm showing the way - without waste 2032."*

The vision's main goal is to eliminate incineration as a waste treatment option, and recycle or reuse all waste by 2032 (BOFA 2019) but there are a number of other goals as the vision encompasses all of society-at-large on Bornholm. These goals, along with three different timeframes and the scopes of action encompassed by the vision, are shown in Table 13.1.

This chapter elucidates circular economy in Denmark with a focus on Bornholm. The chapter shows different innovative initiatives throughout that are planned and underway to achieve the waste-free 2032 vision and reaching more circularity. A particular emphasis is on the higher-order steps in the waste hierarchy, i.e. waste prevention and preparation for reuse.

Section 13.2 highlights circular economy opportunities within waste and secondary resource management, energy, water, and climate change and sustainable development in Denmark in general and on Bornholm. Section 13.3 explains the framework conditions for unlocking circular economy in Denmark in terms of legislation and policies and initiatives put in place by the Danish government. Section 13.4 details the main case studies in the chapter, dealing with Bornholm's efforts within education for environmental awareness raising, and with partnerships with civil society organization, both driven by BOFA. Finally, Sect. 13.5 illustrates future plans for strengthening waste prevention and preparation for reuse.

Table 13.1 Goals, timeframes, and scopes of action in the vision, "Bornholm showing the way - without waste 2032"

Goals	Timeframes	Scopes of action
Children will receive **education** in sustainability and waste-related topics **Repair cafes** will prevent usable products from being discarded **Tourists and visitors** to Bornholm will participate actively in the first waste-free society A **waste and resource cluster** will be established with new and established businesses to serve as a knowledge center and an international showroom for Danish waste solutions, technologies, and knowhow In collaboration with a university Bornholm will establish its first **education and research center** for green transition and circular economy	**Near future 2019–2022**, where we know the requirements and measures **Slightly distant future 2023–2026**, where we have some knowledge of legislative requirements and available technologies **Distant future 2027–2032**, where we cannot predict new legislative requirements and technological developments	Prevention Collection Treatment and outlets Learning and knowledge Communication and dialogue Organization Economy

13.2 Opportunities for Circular Economy

As opposed to waste management, which has a focus on waste streams held up against the waste hierarchy, circular economy is a broader systemic concept defined by Geissdoerfer et al. (2017) and Ghosh (2020) as:

> . . . a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling.

> . . . a systems-level approach to economic development and a paradigm shift from the traditional concept of linear economy model of extract-produce-consume-dispose-deplete. . . to an elevated echelon of achieving zero waste by resource conservation through changed concept of design of production processes and materials selection for higher life cycle, conservation of all kinds of resources, material and/or energy recovery all through the processes, and at the end of the life cycle for a specific use of the product will be still fit to be utilized as the input materials to a new production process in the value chain with a close loop materials cycles that improves resource efficiency, resource productivity, benefit businesses and the society, creates employment opportunities and provides environmental sustainability.

This does not preclude that high-order aspects of the waste hierarchy can be synonymous with *slowing*, *closing,* and *narrowing* in a circular economy perspective.[2] There are overlaps. In this respect, what is particularly interesting is to set the state-of-the-art in terms of Danish practices on waste prevention, preparation for reuse and recycling. According to Blomsma and Brennan (2017), the concept of circular economy functions as an umbrella concept representing new ways to organize reuse and recycling. Several Danish municipalities have undertaken a number of circular economy-related initiatives through sector planning and project initiatives and experimentation, influenced by national waste strategies and EU legislation. The island of Bornholm, being a municipality of its own, is positioned uniquely in this setting as the first to publicly declare, and get political backing for, its intention to phase out waste incineration by 2032 through its vision, "*Bornholm showing the way - without waste 2032."* In the following sections, opportunities for circular economy in Denmark are highlighted and include state-of-the-art examples in the fields of (a) Waste and Secondary Resource Management, (b) Energy, (c) Water, and (d) Climate Change and Sustainable Development- showcasing Bornholm's actions and innovation potential along the way, focusing on the upper levels of the waste hierarchy where pertinent.

13.2.1 Waste and Secondary Resource Management

In a Danish context, municipal waste management companies take action at all levels of the waste hierarchy. In addition, a range of both private entities, NGO's and citizens work with reuse related activities and thus help reduce waste. Zacho et al. (2018) found that preparing products for reuse has the potential to produce environmental, social, and economic benefits. Furthermore, Messmann et al. (2019) found that between 13% and 16% of waste streams of waste electric and electronic equipment (WEEE), used furniture, and used leisure goods stemming from 61 waste collection points, could immediately be prepared for reuse, depending of the type of waste. In addition, 13–29% had a potential to be unlocked if the mode of collection, storage, and the overall treatment of wastes at the collections points were changed.

From a circular economy perspective, the three levels of prevention, preparation for reuse and recycling also represent different levels of circularity with prevention as the most preferred option, followed by preparation for reuse (inner circles) and with recycling as the least preferred option as it represents the most outer cycles of the circular economy. However, from an environmental perspective, reuse is only beneficial over recycling, *"if the impacts that arise during a certain usage duration of a reused products are smaller than those of a new product"* (Boldoczki et al. 2020).

[2]Bocken et al. (2016) define three strategies for the move towards a circular economy: Slowing loops (reuse), closing loops (recycling), and narrowing loops (efficiency).

13.2.1.1 Waste Prevention—Extending the Lifetime of Products Through Reuse

In relation to waste prevention in Denmark, one finds a range of actions and actors. In this section we present some of those, including secondhand shops, swapping schemes, and actions taken on social media.

13.2.1.2 Secondhand Shops

Sale of secondhand clothes, books, furniture, toys, and small kitchen appliances from secondhand shops are probably the most common activity when it comes to preventing waste through reuse. In a Danish context, reuse shops are primarily run by charity organizations like the Red Cross. However, there are also commercial secondhand shops. In some cases, municipal waste companies have opened reuse shops in which they sell items recovered from their own reuse sites and waste collected from bulky waste. In a Danish context around 50 municipal reuse shops have been established against 1076 charity shops. In 2015, the Danish Red Cross received 7600 tonnes of reused clothing and the generated turnover was DKK 57.3 million. In 2016, this had grown over DKK 60 million. In comparison, the Danish municipal waste management company AffaldPlus, which runs two secondhand shops and two reuse building warehouses, sold 1300 tonnes of goods in 2018, including building materials, and generated a turnover of DKK 7.9 million.

13.2.1.3 Swapping Schemes

As another attempt to reduce waste, some municipal waste companies establish swapping facilities on the premises of the reuse sites where citizens can donate reusables for other citizens. Often this is with restrictions such as "only two visits per," to avoid commercial businesses taking advantage of the scheme. The municipal waste management company AffaldVarme Aarhus has gone a step further, developing a reuse station named REUSE where the whole site is designed around waste prevention, allowing for citizens to pick up items that others do not need, free of charge. In addition, citizens can also hand over used items for others to enjoy. Items for REUSE are collected on site where citizens can hand over usable items during opening hours. In addition, citizens can donate usable items at all of Aarhus' six traditional reuse stations. Here citizens can find two containers for reused items. One container is for items donated and sent directly to REUSE. The other is for the donating reusables to an association named "Brugsting," where items are sold in flea markets. If there are items in the container that "Brugsting" estimates they cannot sell, these are sent to REUSE where citizens can find them for free.

13.2.1.4 Facebook Groups

In addition to the more formal schemes and business models, there is growing interest from Danish citizens to engage in local Facebook groups as platforms for swapping, selling or donating reusables. One popular Facebook group based on Bornholm has named itself "Last stop before BOFA," sending a strong signal that everyone on the Island of Bornholm should think twice before they discard waste.

Preparation for Reuse: Extending the Lifetime of Products Through Reuse and Repair

13.2.1.5 Municipal Reuse Shops and "Green Tracks"

Municipal waste companies have, in some cases, opened reuse shops in which they sell items recovered from their recycling centers, and waste collected from bulky waste.[3] A definition of waste does exist, however in practice, we found that this is interpreted differently amongst different actors in the waste sector. Thus activities related to reuse are in some cases interpreted as either preparation for reuse or activities supporting waste prevention. In other cases a mix of both. As an example, some waste management companies establish "green channels" in which customers are guided to sort reusable products from recyclable, etc. at recycling centers. Reusable products are then "donated" by the customer and thus interpreted as "non-waste" and sold in a municipal secondhand shop or donated for charity. In the area of Copenhagen, the municipality has recently built a new reuse station "South Harbor Reuse Station." This reuse station has a space where circular startups can apply for a space, free of charge for periods of 6 months. Visitors arriving to the recycling center enter a green channel in which they are guided to donating specific waste products, product groups or materials which have been requested by, and sold to, the circular startups. Products vary from men's shirts which are made into girls dresses, to specific types of wood made into garden furniture, to DVDS made into lamps.

13.2.1.6 Marketplace for Reuse

The Danish company "Genbyg.dk" has created a business around reuse. They specialize in the purchase and resale of used building materials. A few years ago the company expanded their business model to also include an online sales platform, genbyg.dk which is Denmark's largest such platform for reuse of construction materials and products including doors, windows, lamps, floors, door handles, timber, and bricks. This platform attracts more than one million visitors annually from all over the world and presents 127,000 products for sale (www.genbyg.dk visited on the 10th of June, 2020). Genbyg buys used materials from private customers.

13.2.1.7 Partnerships and Collaboration around Secondary Building Materials and Appliances

Some Danish waste management companies such as Vendsyssel Affalds Selskab (AVV) and AffaldPlus have expanded their shops to also consist of larger storage spaces where they sell reused garden and building materials and appliances. Public–

[3]Products prepared for reuse and sold in the approximately 50 Danish municipal reuse shops mainly consist of clothes, household items (porcelain, glass, cutlery, etc.), small electrical appliances, bicycles, and furniture.

private partnerships have been built around reuse, including appliances and building materials, i.e. old bricks.

As a unique case, we have the Danish reuse appliance company named DeGrønneHvidevarer which can be translated into "The Green Appliances," which has made a business case based on appliances prepared for reuse. Common to all products in their online sales platform is that they are all discarded prematurely and therefore would have been processed for recycling, i.e. materials separated, re-melted, and included in the production of new ones. This company thus extends product life and supports the inner cycles of the circular economy, avoiding the environmental impacts associated with the production of new products (energy use, virgin materials extraction, etc.).

13.2.1.8 Recycling: The Bottle Deposit Scheme and Collection and Treatment of Household Organic Waste

Denmark has a long tradition for recycling bottles. In fact, the introduction of the deposit scheme on bottles dates back to 1942, see Sect. 13.3. The long history of collecting and recycling bottles has helped develop and optimize the return scheme. At present, it is the Danish company "Dansk Retur System" that is responsible for running the scheme. The Danish Return System, the English translation, collects and sorts empty cans and bottles so that they can be recycled. It is a Danish non-profit company that has a monopoly on collecting bottles and cans in Denmark through the Danish Bottle Bill which passed through parliament in 2000 (Andersen n.d.). The company was founded in 2000 by the breweries in collaboration with the grocery industry, and has since been regulated by the Ministry of the Environment. In addition to running a bottle deposit fee and recovery scheme, The Danish Return System works to reduce the grocery stores' costs by receiving and sorting packaging. The costs of operating the system are funded by fees paid by producers and importers of beer and soft drinks.

However, the system only works because both consumers, breweries, grocery shops, and private companies contribute to the recycling of cans and bottles. Thanks to the cooperation of those players, the Danish Return System is among the best in the world. At present the Danes are quite good at returning empty cans and bottles, and 9 out of 10 bottles and cans sold are returned.

The organic fraction of household waste in Denmark, i.e. food waste and other biodegradable waste (excluding garden waste), is not always collected separately among Danish municipalities. As a result, the organic fraction is part of residual waste, and ultimately incinerated. However, separate collection of the organic fraction is growing increasingly commonplace. In 2017, 22 out of 98 Danish municipalities collected the organic fraction of households waste separately at curbside, and this figure increased to 31 in 2018 (Danish EPA 2018). As of the end of 2019, this figure has now reached 51 of 98 Danish municipalities.

Danish households' garden waste is often composted after being deposited at municipal recycling stations, with the end product made available to citizens free of charge. The organic fraction of household waste that is collected at curbside, on the other hand, consists of approximately 40% of household waste and is sent for a

variety of recycling treatment options (Kreilgård and Jørgensen 2015). In 2015 the Danish EPA identified a total of 148 different facilities across the country that could potentially receive and recycle organic waste from households and services, namely 8 pretreatment facilities, 31 biogas plants, 48 farm biogas plants, 57 wastewater treatment plants, 3 composting plants, and one "dry" biogas plant with combined composting and biogas production (Kreilgård and Jørgensen 2015). This recycling infrastructure for household organic waste is undergoing continued expansion and has so far favored biogas (anaerobic digestion) as a treatment option over composting.

To sum up, in a Danish context, there is a range of action taken on the reuse scene, see Table 13.2. This has resulted in the development of a range of different models on reuse, at local level. In Sect. 13.4 we explore more in detail how BOFA, as a waste management company, works in practice to achieve the waste-free 2032 vision. This is provided by giving two practical examples on waste prevention schemes run by BOFA.

13.2.2 Energy

Within energy production and consumption, circular economy opportunities in Denmark should be seen in light of the overall energy transition effort. After World War II, Denmark's energy production ramped up and became based on oil and coal, which were significant for underpinning consumerist lifestyles and for developing the Danish modern welfare state (Poulsen and Rüdiger 2020).

As environmental consciousness began to emerge from the 1970s onwards and as awareness about climate change has taken root in recent times, the government of Denmark has decided upon transitioning from this fossil fuel legacy. The current adopted policy target is nothing less than the complete phase out of fossil fuels in the heating and power sectors by 2035 (GWEC and IRENA 2012), and all sectors of the energy system by 2050 (Krog and Sperling 2019). This can pave the way for integrated, decentralized solutions and synergies constructed close to the consumer.

Identifying circular economy opportunities in Denmark in a fossil fuel-free 2050 energy context is therefore not always straightforward. For instance, expanding electric vehicle infrastructure may mean substantial challenges with ELV (End-of-Life Vehicles) down the road, when waste management systems will have to address the complexity and large amounts of car batteries often classified as hazardous waste today. One of the main circular economy potentials with respect to Denmark's fossil free energy transition is the matter of dealing with wind turbines. Wind energy is a mature renewable energy technology in Denmark and has seen high levels of penetration in the Danish energy system despite high levels of fluctuation (Hvelplund et al. 2017), supplying 20% of electricity demand as early as 2004 (Hansen and Hansen 2007) and roughly 50% today, in compliance with a adopted policy target to achieve 50% wind energy in electricity consumption by 2020 (GWEC and IRENA 2012).

Table 13.2 Summing up Danish "best practice" examples on actions taken to "prevent," "prepare for reuse," and "recycle" products and materials (Based on Moalem, 2021).

Action taken on waste and secondary resource management, including prevention (non-waste)	Products/Categories (primary)	Actor position (public, private, NGO, Citizen)	Level of circularity (inner/outer circles) and action taken
Prevention (non-waste)			
Teaching waste prevention to school kids (common practice in Denmark) -BOFA	Knowledge	Municipal	Inner cycles
Secondhand shops Red Cros, Blus cross, AVV, Affald plus	Clothes, shoes, kitchen utensils, furnitures	NGO, commercial, municipal	Inner cycles/slowing the resource loops / product life extension (resale)
Swapping facilities -on the premises of the municipal reuse sites e.g. REUSE	Furniture, building materials,	Municipal	Inner cycles/slowing the resource loops / product life extension
Facebook groups promoting reuse -'Sidste stop inden BOFA' (Last Stop Before BOFA)	All products but some specialize in ex. Women's fashion, children clothes	Citizen	Inner cycles/slowing the resource loops / product life extension (platform for dissemination of reused products)
Reuse building market -genbyg.Dk,	Building products	Commercial	Inner cycles/slowing the resource loops -product life extension (repair, upgrade & resale)
Preparation for reuse (PfR) (waste)			
Reuse shops -AVV, Affald plus, ARGO	Clothes, shoes, kitchen utensils, furniture, bicycles, building materials (only few)	Municipal	Inner cycles/slowing the resource loops -product life extension (PfR & resale)
Reuse building market -AVV, Affald plus, -Gamle Mursten	Building and construction products and materials (wood, bricks)	Municipal, Commercial	Inner cycles/slowing the resource loops / product life extension (PfR & resale)
Company selling "prepared for reuse" appliances online -DeGrønneHvidevarer (DGH)	Washing machines Dryers, dishwashers Washing/drying machines, stoves / ovens, industrial machinery	Commercial	Inner cycles/slowing the resource loops -product life extension (PfR + upgrade & resale) -resource recovery?

(continued)

Table 13.2 (continued)

Action taken on waste and secondary resource management, including prevention (non-waste)	Products/Categories (primary)	Actor position (public, private, NGO, Citizen)	Level of circularity (inner/outer circles) and action taken
Recycling (waste)			
Dansk Retur system A/S	Bottles (plastic) and cans	Non-profit[a]	Outer cycles/ take-back system/ closing the resource loops
Pretreatment facilities, biogas plants, farm biogas plants, wastewater treatment plants, composting plants, and "dry" biogas plant	Organic fraction of household waste (food waste and other biodegradable waste excluding garden waste)	Commercial	Outer cycles/ closing the resource loops

[a]The fees are calculated each year based on the expenditure of Dansk Retursystem versus the income. The fees are required to solely reflect the exact costs of operating and administering an efficient deposit and return system (https://danskretursystem.dk/)

Large companies such as Vestas and Siemens Wind Power are at the forefront of developing wind power technology domestically in Denmark, and internationally. Wind turbines are complex pieces of machinery that consist of, e.g. foundations, tower, nacelle, and blade elements with advanced electronic control systems, and composite materials utilized for turbine blades. Research and practice related to wind turbines in a circular economy relate to extending wind turbine lifetimes (Jensen 2015) and understanding the environmental impacts, challenges, and potentials for wind turbine recycling in a circular economy (Jensen 2019; Jensen and Skelton 2018).

According to Jensen (2015), extending the product lifetime of a wind turbine has a beneficial impact on its carbon footprint, and different strategies can be taken to maintain high performance over time. This can involve a service/maintenance strategy, a reuse/redistribution strategy (relocation of wind turbines to e.g. developing countries), or remanufacturing/refurbishment (relevant in locations where there for instance is a height constraint). With respect to recycling options, Jensen (2019) further finds that there are significant environmental benefits to recycling once a wind turbine reaches its expected lifetime of approximately 20–25 years, since the materials used for manufacturing a wind turbine accounts for 70–80% of the impact seen in a life cycle perspective. Examining the wind turbine decommissioning process, a number of materials may be recovered from components and most studies assess 80–90% recyclability which covers, e.g. ferrous metals, aluminum, composite materials, lubricating oil, copper, and various plastics (Jensen 2019). Jensen and Skelton (2018) examine, in particular, how circular economy may be applied in the case of wind turbine blades, which are often glass fiber-reinforced plastics (GFRP) composites. They find that different strategies can

be used for handling wind turbine blades at end-of-life: They can be be reused/redistributed elsewhere, resized, and used in e.g. playgrounds and furniture, recycled and used as filler material or sent for recovery or conversion (fibers, oils and chemicals) through e.g. pyrolysis or solvolysis (Jensen and Skelton 2018). Each strategy has their own pros and cons.

13.2.2.1 Energy Island Bornholm

Recently, the island of Bornholm won the European Responsible Island Prize for 2019, which was awarded by the European Commission in recognition of its efforts to achieve zero emissions by 2035.

While the RESponsible Island prize is a recognition of the efforts made in delivering climate-friendly energy infrastructure and delivery in an affordable way using a mix of technologies in a challenging, rural and isolated environment, Bornholm has also been at the center of national energy governance and planning. In 2019 Denmark formally adopted a Climate Act, which includes a legally binding target to reduce greenhouse gas emissions by 70% by 2030 relative to the 1990 baseline. As a result of this, Denmark will be developing annual Climate Action Plans (State of Green 2019b), the first of which has been adopted in 2020 and which includes the proposal to build two energy islands in the North and Baltic Seas by 2030 (Skopljak 2020). These energy islands will be offshore wind farms built on existing or artificial islands. The energy island in the North Sea will have a capacity of 3 GW while the other energy island in the Baltic Sea will be developed at Bornholm and have a 2 GW capacity (Durakovic 2020). For Bornholm, the implications of the energy island project are that the island's largest port will need to be upgraded to accommodate the offshore wind industry including area expansion, depth increase, installing a new external wave breaker, building a new multi-purpose terminal and Ro-Ro facilities (Buljan 2020). As well, Bornholm is set to accommodate new Power-to-X technologies to transform renewable energy from the offshore wind farm into hydrogen from electrolysis. Power-to-X technologies enable storage of energy in chemical form for, e.g. further biogas upgrading or other forms of upgraded gas production for injection in gas grids (Nielsen and Skov 2019). While Bornholm has no gas grid, there are potential applications of Power-to-X technologies in terms of boosting methane production from the island's single biogas plant or for use in the transport sector through hydrogen fuel cells.

The energy island project on Bornholm involves a number of circular economy opportunities. Firstly, the port expansion itself involves a massive construction project in which circularity can be built-in as early as the design stage with respect to choice of materials and with respect to demolition waste from renovating activities. Additionally, building on the previously-cited research on application of circular economy on wind turbines (Jensen 2015; Jensen and Skelton 2018; Jensen 2019), there are potentials in terms of offshore wind turbine decommissioning once the turbines have reached the end of their technical lifetimes. Finally, the envisioned implementation of Power-to-X technologies are themselves circular, in the sense that hydrogen is produced from water via electrolysis using a renewable power source, and water is produced once more via energy conversion in hydrogen fuel cells. If the

Power-to-X technologies are used to boost methane production from Bornholm's biogas plant, then this can also improve upon the biological loops (circular bioeconomy) if the biogas plant is upgraded to be able to handle organic household waste, and equivalent waste from commercial businesses, as a feedstock.

13.2.3 Water

In water resource management, circular economy potentials can be found in, e.g. resource and energy recovery from wastewater sludge (Gherghel et al. 2019). There are specific opportunities involved in extracting and utilizing nutrients such as carbon (C), nitrogen (N), phosphorous (P), and micropollutants, in energy production via anaerobic digestion, and in some cases production of bio-based high-value products (Nielsen 2017). Gherghel et al. (2019) report that one of the promising technologies in a circular economy perspective in general with a high TRL (Technology Readiness Level) is phosphorous recovery with anaerobic digestion, while urban biorefinery concepts and technologies are under development for cellulose and nutrient extraction as well as bioplastics production, amongst others.

Nutrient removal of C, N, P, micropollutants, and pathogens in wastewater is common in many wastewater treatment plants in Denmark through the activated sludge process (Nielsen 2017). In addition, pre-settled sludge and surplus activated sludge is commonly fed to anaerobic digesters for energy production. This has resulted in some wastewater treatment plants achieving energy neutrality or even becoming net energy producers (Nielsen 2017).

However, there are a number of strict restrictions[4] on recirculating treated sewage sludge as a fertilizer for agriculture, in the interest of protecting human health through direct or indirect contact. The legal framework provides strict limit values on, e.g. heavy metals (cadmium, lead, mercury, nickel, chrome, zinc, copper) and other human health and environmentally harmful substances (DAKOFA n.d.-a). Denmark has historically set limit values lower than EU Directive provisions (Kelessidis and Stasinakis 2012), though despite this, more than 50% of sludge in Denmark was used in agriculture in 2010 (Gherghel et al. 2019). Other final disposal options for sludge include incineration and landfilling. According to Kelessidis and Stasinakis (2012), Denmark is one of few countries that has increased landfilling of sludge from 2000–2009 marginally (4%), while incineration has declined (−22%).

While it is possible to add solid urban biowaste from households to anaerobic digesters that treat sewage sludge, the legal framework provided by the Danish Water Act only allows this if there is excess capacity and if necessary for optimization of the process (Roskilde Municipality et al. 2016). This means that addition of

[4]In particular the "Danish statutory order on waste products for agricultural and related purposes" which implements EU legislation, namely "Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture."

urban biowaste can only be secondary to sludge as a primary feedstock for anaerobic digesters attached to wastewater treatment plants. In practice, if urban biowaste is added as a secondary feedstock for a wastewater treatment plant, this will rarely count as recycling.

13.2.3.1 Water Management and Circularity on Bornholm

Wastewater management on Bornholm does not fall under the immediate purview of the island's vision, *"Bornholm showing the way – without waste 2032"* which focuses on solid waste streams instead. Urban biowastes from households on the island are currently not mixed in for treatment at any wastewater treatment plant on the island, and no biorefinery concepts are currently being tested. Neither does any wastewater treatment plant on Bornholm have an anaerobic digester attached to it. However, the strict limit values on utilization of sewage sludge for agricultural purposes does not prevent that 100% of sewage sludge is recirculated on the island for this purpose, which is the case today.

At the level of certain sectors and some individual businesses, circular economy with respect to water management has been the focus of a few studies and initiatives. A project named CIRTOINNO[5] has focused on increasing the innovativeness of small- and medium-sized enterprises (SME's) within the tourism and hospitality sector by integrating elements of circular economy into services, products, and business models (Manniche et al. 2017). In-house systems for re-utilization of "gray water" (wastewater streams without fecal contamination) are seen as pivotal for immediate application of circular economy principles for instance within spa and wellness centers, while broader circular water systems at regional scale are envisioned for black, gray, and potable water systems (Manniche et al. 2017).

13.2.4 Climate Change and Sustainable Development

In Denmark, there is broad political backing to actively seeking synergetic opportunities for circular economy within climate change and sustainable development, see Sect. 13.3.

In general, Bornholm's vision *"Bornholm showing the way – without waste 2032"* supports the Sustainable Development Goals (SDG's) to a large extent, in particular Goal 9.1, 9.4, 11.6 and 17.17[6]. The benefits, however, go beyond aligning with SDGs. If solutions are found in the small scale setting of Bornholm, these solutions could be replicated in large scale in many parts of the world and contribute

[5]Circular economy tools to support innovation in green and blue tourism SMEs, see: https://cirtoinno.eu/

[6]Goal 9.1 *"Develop quality, reliable, sustainable, and resilient infrastructure."*
Goal 9.4" *Upgrade infrastructure."*
Goal 11.6" *Reduce the adverse* per capita *environmental impact of cities."*
Goal 17.17" *Encourage and promote effective public, public–private, and civil society partnerships."*

to real change that will strengthen both the move towards a sustainable society and quality of life of the affected population. From a Triple Bottom Line perspective, sustainability in Bornholm's circular economy transition would need to fulfill the following criterion (Elkington 1997):

- Economic: Provide reduced costs or at least lower cost increase with added activities, both for waste management entities and for waste generators.
- Social: Provide, at least, the same level of social acceptance as current practice with respect to waste collection and treatment solutions. Increased social cohesion, acceptance, etc. is a desired outcome.
- Environmental: Reduced impacts viewed through a life cycle perspective.

Bornholm has actively worked with implementing sustainability long prior to adopting its zero waste 2032 vision. Since 2008, Bornholm has been strategically working to make the island a green and sustainable future, an initiative termed *"Bright Green Island"* (Bright Green Island Bornholm, n.d.). This transition is a matter of wisely and sustainably utilizing and safeguarding the shared resources on Bornholm. The goal is to be a 100% sustainable and climate-friendly island community by 2035.

As part of this goal, Bornholm formally adopted the target of achieving 100% CO_2-neutral energy production by 2025, aligning well with the Danish government's energy island plans as part of its 2020 Climate Action plan which will enable offshore wind turbines to cover the island's own electricity consumption as well as exporting excess power to Denmark ad surrounding countries.

By 2032, all waste on Bornholm is to be treated as resources, i.e. the zero waste 2032 vision (Bright Green Island Bornholm n.d.).

By 2035, the goal is to achieve a zero-emission society (Bright Green Island Bornholm n.d.). This entails that locally, Bornholm aims at reducing total emissions of CO_2 and other sources of pollution through changed production and consumption patterns. The ultimate goal is—in "popular speak"—that the island's citizens do not cause adverse environmental impacts more than they can remediate afterward.

Aside from the above 2025, 2032, and 2035 targets for energy production, waste and production and consumption patterns, Bornholm has also transposed the SDG's into 8 locally adapted versions of the goals under its *"Bright Green Island"* framework. The 8 Bornholm Goals is presented in Table 13.3.

The 8 goals were developed in participatory fashion involving a diverse crowd of inhabitants on Bornholm, partly through a so-called Bornholm Day in 2017, where 230 inhabitants participated, and partly through a series of meetings and workshops. In 2018, the municipal council of Bornholm adopted the goals as the *Bornholm Goals*, which now serve as the common benchmarks for the implementation of "*Bright Green Island."* Each *Bornholm Goal* contains several specific objectives and efforts.

While the 8 Bornholm Goals form the framework for achieving the *"Bright Green Island"* vision, the political leadership at Bornholm has specifically chosen to work from four lighthouse initiatives, which are areas that need special focus. The

Table 13.3 The 8 Bornholm Goals (the vision "Bornholm showing the way - without waste 2032" is included in Goal 3)

The 8 Bornholm Goals	
1. Business	To make sustainability a good business
2. Fact-based sustainability	To document and keep track of our green transition
3. Carbon neutrality	To be a model, climate-friendly community at all times 2025: 100% CO2 neutral energy production **2032: All waste on Bornholm treated as resources** 2035: 0-emission society
4. Mobility	To make all land-based transportation green
5. Housing	To make sustainable housing part of our cultural identity
6. Food products	To be a pioneer within sustainable Danish food products
7. Nature	To make the protection of our natural resources vital to everyone's bottom line
8. Inclusion	To ensure that everyone on Bornholm is part of bright Green Island

four lighthouses are (a) CO_2-neutral electricity production, (b) Waste-free in 2032, (c) 20% Organic agriculture, and (d) Green mobility.

Thus, working with circular economy on Bornholm and its vision *"Bornholm showing the way – without waste 2032"* is not only embedded within the *"Bright Green Island"* vision and its associated 8 Bornholm Goals, but is also one of the lighthouse initiatives currently prioritized at highest local political level.

13.3 The Role of Government in Unlocking a Circular Economy in Denmark

The operating space for zero waste and circular economy transitions in Denmark is closely directed by policy initiatives and legislation at the EU level. Denmark is often regarded as a frontrunner country in terms of sustainability and technological innovation, but as mentioned in Sect. 13.1, Denmark is facing challenges in the waste sector due to the lock-in effects of having invested in a highly developed waste incineration infrastructure. Denmark correspondingly has one of the highest waste generation rates per capita (OECD 2019).

Nonetheless, government initiatives in Denmark over the past years have been drivers for restructuring of the waste sector. In the following sections, the legislative framework for circular economy is explained, as well as softer measures such as policy initiatives and national action plans.

13.3.1 The Legislative Framework to Support a Circular Economy in Denmark

The legislative framework supporting circular economy in Denmark is historically linked with environmental legislation in general. Denmark passed an environmental law in 1973 as one of the first countries in the world, and further passed the world's first law on recycling in 1978 which stated that at least 50% of all paper and beverage packaging should be recycled (DAKOFA n.d.-b). A 1990 amendment to this obliged authorities to organize separate collection of paper and glass. Thus, the circular economy aspect of *closing* has a relatively firm entrenchment in Danish legislation as regards these waste streams. An example of a common method of glass waste collection in municipalities is shown in Fig. 13.4.

Voluntary take-back schemes for glass bottles in Denmark have existed as far back as the 1940's (See Fig. 13.5). Today this has developed into a widespread, visible and successful bottle deposit fee and take-back system for plastic and glass bottles and aluminum cans at Danish supermarkets, overseen by Danish Return System (see Sect. 13.2.1).

Different acts and circulars regulated waste in the 1980's but from 1989 Denmark implemented an actual Statutory Order on Waste, which established the Ministry of the Environment and provided the mandate for local authorities (municipalities) to

Fig. 13.4 Shared waste collection point for glass packaging waste not covered by Denmark's bottle deposit fee and take-back system

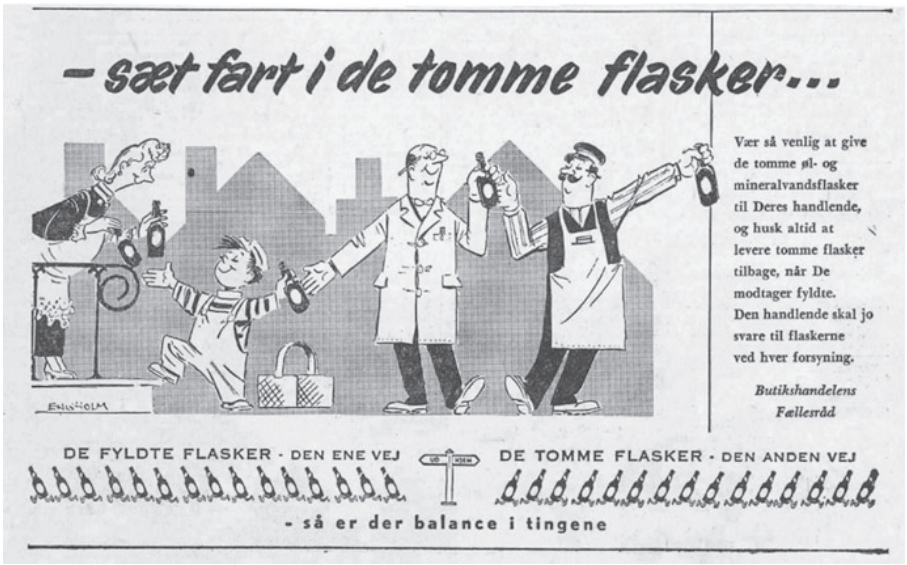


Fig. 13.5 Newspaper advertisement printed in Berlingske Tidende in 1957 by illustrator Kaj Engholm encouraging recycling of glass bottles (voluntary deposit fee scheme implemented in 1948)

be the main competent authorities to decide how to collect and manage waste (DAKOFA n.d.-b).

Denmark revised and extended the Statutory Order on Waste in 1993. Municipalities became obliged to carry out waste planning, collect data and provide supervision on waste collection and management (DAKOFA n.d.-b). Municipal waste plans have been prepared since 1993. Amendments to the Statutory Order on Waste have taken place in 2012, 2015, and in 2019, sometimes to align with changes in the EU legislative framework, sometimes (as in the latest amendment) to align with re-ordering of ministerial areas of authority.

While commercial waste for recycling is handled and part of a liberalized market, municipalities are obliged to receive commercial waste for incineration and landfilling (DAKOFA n.d.-b). Many municipalities in Denmark co-own and operate waste companies with incineration plants. The installment of waste incineration capacity to divert waste from landfilling was one of the earliest government strategies to move up the waste hierarchy. Additionally, Denmark introduced a landfill tax in 1987. Denmark further amended this in 1997 to ban landfilling of waste otherwise suitable for recycling or incineration. However, waste incineration capacity has now expanded to the extent that it has proved a hindrance to move even higher up the waste hierarchy (OECD 2019).

13.3.1.1 A Note on Bornholm

Bornholm is unique in the sense that it is the only municipality in Denmark that has voluntarily chosen to decommission its waste incineration plant and adopt a zero

waste vision. The vision, *"Bornholm showing the way – without waste 2032"* and its incineration plant decommissioning decision has been enacted ahead of any top-down legislative or other formal requirement at the national level.

While many municipalities co-own waste companies with incineration plants, Bornholm is an example of an exception as a municipality with waste management, including treatment of commercial waste, directly controlled by the municipality itself. This is unusual but explained by the fact that as an island with no fixed link to the Danish mainland, Bornholm and other similar islands have legislative exemptions.

The waste management entity on Bornholm, called "BOFA" began as a company co-owned by a number of smaller municipalities on the island. The law on recycling in 1978 was one of the major driving forces behind establishing a bottle recycling plant that was one of the predecessors to BOFA. BOFA became formally established in 1987 (BOFA 2012). A structural reform in 2007 led to the merging of the smaller municipalities on the island, and BOFA became incorporated into the Regional Municipality of Bornholm.

13.3.2 Government Support Towards Implementing a Circular Economy

As per the Danish Statutory Order on Waste, The Danish government is required to prepare national waste plans (or strategies) at regular intervals. These national waste plans set out the direction for the waste and resources sector to develop, and it is clear that circular economy has become more visible in these plans as the concept has become more prevalent internationally and more firmly entrenched in EU legislation.

The Danish waste strategy for the period 2005–2008 focused on pollution control and prevention, e.g. by banning certain types of packaging materials and use of particular substances and materials that are problematic from a waste treatment perspective (Basse 2020). The waste strategy for the period 2009–2012 aimed to ensure minimum 65% recycling and maximum landfilling of 6% by 2012. The latest Danish waste strategy is a 2-part strategy covers the period 2013–2018, in which one major ambition is to increase recycling of household waste from 22% to 50% by 2022 (Basse 2020). This covers the fractions organic waste, paper, cardboard, glass, wood, plastic, and metal, and as mentioned in Sect. 13.1, this is different from the EU definition of municipal waste and what the EU-level targets cover, which are described in the previous section.

There is as of yet no updated national waste strategy since the ones that covered 2013–2018 period. A new Danish waste strategy is being prepared for release late 2020. One of the delaying factors has been the EU's circular economy package and the subsequent changes to the different EU waste directives, which the Ministry of Environment and Food of Denmark has sought to understand the contents of better prior to preparing the new Danish national waste strategy (Basse 2020).

Table 13.4 Overview of Danish government support to municipalities through 80 projects in the period 2014–2016 covering waste management aspects and themes (Danish EPA 2017)

Waste management aspects	Themes
• Source separation	• Information and behavior
• Waste containers	• Children and youth
• Sales and marketing channels	• Technologies
• Communication	• Analyses
• Citizen participation	• Apartment buildings
• Education	• Waste collection points and summer cottages
• Planning	• Organic waste
	• Recycling centers

Municipalities are seen as a key actor for implementation of the 2013–2018 national waste strategy, and one of the enablers of this has therefore been a formalized agreement between the Danish government and the association and interest group representing all of Denmark's 98 municipalities in 2014 called *KL – Local Government in Denmark* (Danish EPA 2014). The agreement has sought to coordinate efforts aimed at source separation, collection, and treatment of waste in a cost-effective manner through many different initiatives (Danish EPA 2014). In other words, closing loops with respect to households waste is a multi-partite domain area that the Danish government has entered into partnerships to support. As part of the agreement with Danish municipalities, the Danish government also set up a financial support instrument for municipalities that co-financed all kinds of experimentation of practical solutions for realizing the 2013–2018 resource strategy. In 2014, 32 projects were supported, followed by 35 in 2015 and 13 in 2016. The 80 projects are too numerous to detail here, a summary of aspects and themes are collected in Table 13.4.

Thus, aside from the formal Danish national waste strategies, the government also supports implementation of circular economy through, e.g. partnership agreements and project support funding.

A support initiative specifically dealing with circular economy had to do with private sector involvement in 2016. Here, the Danish government established an Advisory Board for Circular Economy with broad representation among a number of Danish companies ranging from multinationals to SME's and with the CEO of the renowned Carlsberg Foundation as Chairman (Ministry of Environment and Food of Denmark n.d.). The Advisory Board was tasked with providing the Danish government with recommendations for a circular economy strategy, and these recommendations were sent in and published in 2017 (Advisory Board for Circular Economy 2017).

Following the recommendations from the Advisory Board for Circular Economy, the Danish government adopted a Strategy for Circular Economy in 2018 through the Danish Ministry of Environment and Food and the Danish Ministry of Industry, Business and Financial Affairs. The strategy covered 15 initiatives clustered in six thematic areas, and released 116 million DKK for their implementation in the period

Table 13.5 Themes and initiatives in the Danish government's 2018 Strategy for Circular Economy to be implemented 2018–2022 (European Circular Economy Platform n.d., The Danish Government 2018)

Themes	Initiatives
1. Strengthening enterprises as a driving force for circular transition. 2. Supporting circular economy through data and digitalisation. 3. Promoting circular economy through design. 4. Changing consumption patterns through circular economy. 5. Creating a proper functioning market for waste and recycled raw materials. 6. Getting more value out of buildings and biomass.	1. Promoting circular business development in SMEs. 2. Setting up a single point of entry to the authorities for enterprises with circular business models. 3. Expanding the access to financing of circular business models. 4. Supporting digital circular options by commercial use of data and challenges. 5. Incorporating circular economy into product policy. 6. Boosting Danish participation in European work on circular standards. 7. Promoting circular procurement. 8. Increasing focus on total cost of ownership in public procurement. 9. Promoting more harmonized collection of household waste. 10. Creating a level playing field on the market for waste and recycled raw materials. 11. Liberalizing WEEE management. 12. Establishing a fund for the handling of regulatory barriers to circular economy. 13. Developing a voluntary sustainability class. 14. Propagating selective demolition. 15. Getting more value out of biomass.

2018–2022. The six thematic areas and 15 initiatives are too numerous to detail here, but Table 13.5 provides an overview. What can be is the recognition of the necessity to support business development, and the recognition of the importance of enabling conditions on the market and of financing, product design, consumption patterns, and public procurement.

Most recently, the Danish government has carried out a broad private sector involvement strategy in the field of climate policy. 13 so-called 'climate partnerships' with business were launched in 2019 in which CEO's of different companies of various types and sizes were appointed as chairpersons to lead working groups to work on climate policy recommendations. Each partnership involved a working group of various business actors, led by the appointed CEO. Among the partnerships was one dealing specifically with *waste, water and the circular industry.* This partnership handed in their policy recommendations early 2020. In this manner, government led climate policy initiatives have involved businesses in the private sector and this has crossed over to the waste and circular economy domain area.

The policy recommendations included a vision for Denmark to be the world's leader in circular economy by 2030 in support of climate neutrality by 2050, and further included a vision to achieve 90% recycling of waste by 2030 (Climate Partnership on Waste, Water and Circular Economy 2020). Seen from a climate perspective, achieving the 90% recycling target by 2030 was calculated by the partnership on waste, water, and circular industry to generate CO_{2e}-savings equivalent to seven to nine million tonnes held up against a baseline of 27.5 million tonnes. This would be the expected result of increased and improved recycling of waste, longer product lifetimes and increased reuse, increased use of recycled materials, circular business models, substitution to use of new materials, and less wastage. The climate partnership on waste, water, and circular industry identified 94 initiatives in total within 14 strands of action in their published report (Climate Partnership on Waste, Water and Circular Economy 2020). Thirty-nine initiatives were specific to circular economy and 29 were specific to waste. Table 13.6 shows the keys points in the Danish government's "Climate Plan."

Following a *modus operandi* of adapting policy recommendations into national strategy, the Danish government announced a broadly backed political agreement in June 2020 on a *"Climate Plan for a Green Waste Sector and Circular Economy."* The ambition is to make the waste sector climate neutral by 2030, and divert 80% of plastic from waste incineration by 2030 as well. This is the latest development in Denmark within circular economy, which has significant ramifications for the way that the waste sector is structured today. The key points in the agreement are (State of Green 2020).

In summary, the legislative framework in support of a circular economy in Denmark has a long history with strong interplay with EU legislation and EU-level Circular Economy Action Plans in recent times (both the first and second). Circular economy at the national level is driven by preparation of national waste strategies. In recent times, the Danish government has supplemented this through private sector involvement in advance of formulating a national strategy on circular economy for 2018–2022 and a wide-reaching political agreement on a green waste sector and circular economy ensuring climate neutrality in the waste sector by 2030, and 80% recycling of plastic instead of incineration.

13.4 Unlocking Green Minds for a Circular Economy: Bornholm Showing the Way

As cornerstones of Bornholm's *"Bornholm showing the way – without waste 2032"* vision elaborated on in Sect. 13.1, learning and participation of citizens are crucial for innovation and the transition towards a circular economy. This section sets out to show how BOFA engages in sustainable education activities such as "The Waste Tower" and in experimentation with civil society organization partnerships.

The research employs a mixed-method approach, simultaneously employing a range of research styles allowing for analysis from different angles. The research follows two practice tracks, exploring how BOFA engages in waste prevention and

Table 13.6 Keys points in the Danish government's "Climate Plan for a Green Waste Sector and Circular Economy"

Increased and streamlined source separation of waste	Danish citizens are to sort waste the same way at home and at work, regardless of the municipality in which they live. This means that ten different types of waste must be sorted in all Danish households, and that sorting will follow the same guidelines and waste pictograms.
Flexibility for solutions	The types of waste that can be mixed without degrading the quality can be placed in the same waste bin. The agreement will provide flexibility for municipalities—a standard detached house shall have no more than 2–4 waste bins with several compartments for the ten waste types. The agreement also provides the opportunity to establish a technical solution, if it can ensure comparable quality in recycling, and the same low level of waste that separate collection involves
More recycling of plastic waste	A requirement of 60% actual recycling of plastic will be put in place. Furthermore, the agreement requires close sector collaboration with the hospitality industry, agricultural and construction sectors, and in the national implementation of extended producer responsibility with respect to packaging, that have to have financial incentives to make packaging recyclable
A strong recycling sector	Household and commercial waste needs to be collected and organized more consistently and uniformly. The framework conditions for the waste sector must be coordinated so investments are put in recycling rather than incineration. The municipalities are required to treat all recyclable waste. Supply obligations do not change the environmental requirements for waste management. Municipalities must be able to document where and how citizens' waste is recycled. Existing municipal recycling facilities can continue to be owned by municipalities for a transitional period of 5 years, but must otherwise be incorporated into the new agreement (i.e. liberalized)
Less incineration and less import of waste for incineration	The capacity of the Danish incineration plants must be reduced to match the Danish waste volumes, which will decrease as the Danes sort more, so more waste is recycled. Therefore, a capacity ceiling is set corresponding to the Danish waste volumes, which in 2030 is expected to be reduced by approximately 30 per cent compared to today. It has been agreed that the waste sector will henceforth comply with the State's ownership policy

reuse: through education (see Sect. 13.4.1) and through partnerships with civil society (see Sect. 13.4.2). The research design consists of four dependent steps: Identifying cases for the case study, applying the mixed-method approach to the case study, building the empirical research design, and finally integrating and interpreting results. This research is a case study conducted in one waste management company. Case studies are suitable for investigating phenomena within a real life context (Yin

2003). The case is a typical case as BOFA serves the same common goal as other municipal waste management companies in Denmark.

Applying mixed methods allows for integrating different aspects of the research object and thus allows for new forms of insight (Frederiksen 2014). Brewer and Hunter (2006) suggest methods placed into four groups or research styles: *fieldwork*, *interviewing methods*, *experiments,* and *non-intrusive methods* (Brewer and Hunter 2006). Mixed methods consist of mixing two or more of those research styles (Frederiksen 2014). Studying Danish waste handling practice, using a mixed-method approach, enables gaining of new, and possibly more holistic, insights to potentials, and constraints in the current transition from a linear to a circular economy, focusing on the inner cycles.

13.4.1 Preventing Waste through Education for a Circular Economy and Fostering Green Civic Responsibility

Education is crucial for environmental awareness raising and for achieving sustainability. The United Nations attested to its importance by declaring the years 2005–2014 as the Decade of Education for Sustainable Development (UNESCO n. d.), and in more recent times education has been provided an SDG unto itself, SDG 4. For circular economy, the educational potentials of waste have hitherto received only little consideration in environmental and sustainability education practice and research (Jørgensen et al. 2018). Conventional waste-related education is expert-driven and behavioral change-oriented, but research suggests there are further potentials in waste education (Jørgensen et al. 2018). These potentials pertain to fostering deeper reflections about socio-material relations (the relations between, e.g. children and parents and wider communities) and waste practices (the social practices relating to waste that are part of a broader waste management system). BOFA's approach to education for sustainability is hoped to play a role in this.

13.4.1.1 The Story of Waste Education on Bornholm

Over the past 20 years, BOFA has focused on teaching children and youth about good waste sorting practices. Initially, an employee of the operations unit of the organization set aside 30 min to tour school classes around the facilities. Later, a trained waste consultant had the task, and directed focus towards the environmental benefits of waste sorting.

In 2009, BOFA opened its first dedicated visitor's reception and dissemination center in an older refurbished water tower, see Fig. 13.6. This was named the Waste Tower. The center is dedicated to teaching activities for citizens of Bornholm in general and children and youth in particular, free of charge. An employee is tasked solely with receiving these guests at the Waste Tower and providing a better understanding of resource management on Bornholm.

Fig. 13.6 BOFA's Waste Tower

Fig. 13.7 Children of different age groups being given tours of BOFA's facilities

13.4.1.2 How Is Waste Education Carried Out at BOFA?

It has always been an important part of teaching at the Waste Tower that guests must have the opportunity to see, smell and feel waste. It quickly becomes too theoretical if waste is only encountered through a book or on a screen. A visit therefore always includes a tour of BOFA's facilities, where guests are shown around the recycling center, the waste incinerator plant, and the landfill site, see Fig. 13.7. For the sake of clarity, the waste tower has chosen to divide the teaching into different topics, or offerings. All offerings are targeted at different grades and ages.

A very popular teaching offering in the Waste Tower is "smash the mobile." Here, guests, typically young people around 13–15 years old, separate old mobile phones that have reached the end of their useful lifetimes, into small pieces, and then sort the many small parts consisting of different types of metal, printed circuit boards, and plastic, etc. When the phones are separated into fragments and the many piles, lying on a table, then the teaching on the many resources of the phone starts and the importance is highlighted of remembering to hand over your old mobile phone at the local recycling center. This ensures that elements and other important materials are recycled in the best possible way.

To complement the above exercise, students have the opportunity to revisit the Waste Tower after a few weeks to play the interactive and web-based game "The

Fig. 13.8 The making of "Waste Rascals" at the Waste Tower

Hunt For Resources." Here, the students build on their knowledge of resources, such as rare elements and environmental impacts of mining.

Another very popular offering in the waste tower is for the smaller children, typically 7–10 year olds, called "Waste Rascals," see Fig. 13.8. Here the young guests are tasked with bringing some household waste with them. This could, for example, be it a metal lid, a shampoo bottle, or a worn wooden spoon. From the materials brought, students make their very own "Waste Rascal." This is an imaginary character they must give a name to and invent a story about, with respect to how it and the materials it is made of have ended up on Bornholm. The "Waste Rascal" must be made so that it can be easily disassembled as it is composed of different kinds of materials, e.g. metal, plastic, and wood.

As the Waste Rascals course nears its end, the class, their teachers and the Waste Tower employee holds a small closing session. The children give a presentation about their Rascal and what its mission is on the globe. It ends with a solemn vow that they promise to separate the materials from which their Waste Rascal is made and sort them at their school, or local recycling center.

In the process of turning waste materials into a tangible and "valuable" creation, students gain a greater knowledge of the origin and properties of resources as well as a basic idea of what circular economy is all about.

BOFA's teaching activities have, in addition to the various educational offerings, so far led to the publishing of two textbooks that introduce the concepts of Upcycling, Downcycling, and Circular Economy for children and youth. Waste Book 1 is for the youngest (6–10 years), Waste Book 2 is for a slightly older audience (11–13 years) and Waste Book 3 is for the eldest schoolchildren (14–16 years).

13.4.1.3 Why Carry Out These Educational Offerings?

BOFA, seeing itself as a responsible Danish waste company, must accept waste and ensure that it is treated in the best way with the least possible environmental impact.

However, the company BOFA has also chosen to take responsibility for the education of future generations. There is no legal requirement for a Danish waste

company to take part in supporting the formation of green civic responsibility among children and youth. However, at BOFA it only makes common sense to teach future generations about resources in waste, the UN's Sustainable Development Goals and the circular economy—both at the near level of their own waste bin, nationally and in a global perspective.

It is precisely at the local waste company that children and youth can see these matters when it comes to waste management. Students can gain an insight into waste and relate it to climate, consumption, and energy. Here you get a unique opportunity to delve deeper into your own resource consumption and look at how the right treatment of waste can help support a sustainable development.

Teaching is related to the class and students' everyday lives, and students experience what happens to, for example, aluminum soda cans or empty peanut butter jars that they deposit for recycling and their impact on the environment.

It is also an important point during the visit to go into what happens to the waste that has not been recycled or recycled so far. Therefore, BOFA's incineration plant and landfill are also under scrutiny. What to do with the smoke and flue gas residue? Why is some of the waste landfilled, and will it remain there forever? Why should any waste be specially treated, and what happens next?

BOFA is convinced that when students get a sensory and educational experience with the many tonnes of received waste, all the operating equipment that is used to treat it, and gain an insight into what happens with the waste that the students may themselves have thrown away, a foundation is laid for the individual student to become far more conscious of its own role in the greater circular system.

13.4.1.4 Supporting the Formation of Green Civic Responsibility

BOFA's work on waste and increased resource awareness is in line with the educational ideal that is being pursued in both kindergartens and schools in Denmark. The goal is to make children more aware of waste in their local environment and in the world and thereby strengthen their sense of place and responsibility. The idea is for children to learn to care for each other, for themselves and for the world they are a part of.

BOFA seeks to create a framework in which to contribute to the formation of green civic responsibility and provide opportunities to ask new questions related to the future of resources, reuse and recycling.

At BOFA, it is believed that with increased knowledge of waste and the handling of waste, children and youth are given the opportunity to understand their own role as a consumer and thus better be included in the circular economy.

BOFA is not alone in Bornholm to spread the idea of green formation and greater climate awareness. Several educational institutions, schools, and experience centers work with BOFA to make the children and youth of Bornholm a part of the most enlightened generation on climate and the environment of all time.

A concrete example of a green partnership focusing on the formation of green civic responsibility is BOFA's collaboration with the island's local natural history experience center, NaturBornholm and the University of the German City, Warnemünde, by Dr. Sven Hille. The three parties have jointly developed a teaching

course in which the elder pupils from the island's schools go to the coasts of Bornholm and collect plastic waste and, if possible, microplastics from the seawater. The plastic waste must then be divided into various fractions such as cigarette butts, packaging and fishing nets. Once the plastic waste collected is categorized and examined further, the students take it to BOFA's Waste Tower. Here, the plastic waste is sorted and divided into the different types of plastic, such as PET, HDPE, PP, and PVC.

Afterwards, the students are taught the composition, advantages and disadvantages of the plastic materials, as well as climate impact. Finally, the plastic types are put in a circular economy context and the possibilities for reuse and recycling are discussed with the students. The teaching process ends with the collected plastic being delivered to the recycling center near the Waste Tower.

13.4.2 Preventing Waste Through Partnerships With Civil Society Organizations

Collaboration is one of the keys for unlocking sustainability (Gray and Stites 2013). This is also reflected in the SDG17 "partnerships for the goals" which refers to the need for cross sector and cross country collaboration in pursuit of all the goals by the year 2030 (UN.org, 2020).Thus there is a wide acceptance that partnerships do play an important role in the transition to a more circular economy. Partnerships can help innovate new ideas and thus produce new solutions to complex challenges. Research found that the use of partnerships to address sustainability challenges has grown exponentially (Gray and Stites 2013).

13.4.2.1 BOFA's Partnership Activities With Civil Society Organizations

A general challenge in relation to transitioning to a more circular economy is that products that can still be used end up as waste, which is not compatible with the vision *"Bornholm showing the way – without waste 2032."* Therefore, BOFA is working on testing different models on how to prevent waste and increase reuse, thus supporting actions at the inner cycles of the circular economy. This section describes and elaborates on two models in which BOFA collaborates with two local sports associations on the aspect of reuse. The sports associations are named, respectively, *Hasle Sports Association (HIF)* and *Aakirkeby Sports Association (AAIF)*. Both cases are part of a 3 year long project named FUTURE which is supported by the EU's Interreg program (regional development support).

13.4.2.2 The Hasle Sports Association (HIF) Reuse Model

In the spring of 2019, BOFA entered into a collaboration with HIF on reuse, where BOFA makes a container available for HIF so that they can collect items for their annual flea market. HIF is then responsible for emptying the container when filled. Hasle Reuse Station therefore today houses a 40-foot container, see Fig. 13.9.

HIF has a long history of running flea markets. The flea markets play an important role for the local community as they gather people and contribute to keeping

Fig. 13.9 Donation container at Hasle Reuse Station (Moalem, 2021)

communities in Bornholm alive. However, BOFA was also aware that in recent years there has been a challenge for the island's sports clubs to recruit volunteers for the flea markets, including collecting items for donation. Therefore BOFA invited the sports club to be part of the reuse experiments to be tested in FUTURE. BOFA could thus test the model and thus do something good for the environment, while at the same time a local sports association could test to see if this cooperation could help facilitate the work prior to the organization of the flea markets. HIF agreed to cooperate and was appointed to manage the "donation container" at Hasle Reuse Center.

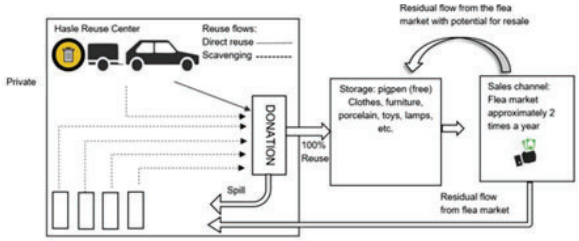
HIF's collaboration with BOFA's has helped the association develop a new model for collecting items for reuse and sold through their flea markets, which are held approximately twice a year. The models are described here. As seen in Fig. 13.9, BOFA has donated a 40-foot container for donating reusable items to HIF. However, research done on-site revealed that the inflow of reusable items donated and collected to HIF is more complex and affected by a range of actions including donation process, logistics, and storage capacity. HIF's reuse model is illustrated in Figs. 13.9 and 13.10.

13.4.2.3 Aakirkeby Sports Association (AAIF) Reuse Models

Apart from BOFAs cooperation with HIF's, BOFA also collaborates on direct reuse with AAIF. Here as well, BOFA has made a donations container available so that AAIF can collect donated items for their annual flea market. This time, at a different reuse site in Aakirkeby. AAIF is responsible for emptying the container when filled. The reuse site houses a 40-foot container where the items for reuse are collected, see Fig. 13.11.

13.4.2.4 Aakirkeby Reuse Model Prior to Cooperation with BOFA

In contrast to the HIF model, it was the chairman from AAIF who contacted BOFA as a reaction to a story in the local newspaper about the donation container for the HIF project. At the time of contact, AAIF had a collection model that was highly dependent on a large number of volunteers. This included driving around the island



Donation process	Logistics - emptying of container (storage) and sales channels
1. Visitors at the reuse site donate items to the sports association by placing them on a shelf located outside the donation container (this is to avoid visitors at the site scavenging donated items from inside the container). 2. The BOFA site worker plays a major role: a. The site worker informs visitors about the possibility for direct reuse (donation). b. The site worker identifies items in the containers for recycling or for combustible waste that are suitable for reuse, and places these in the donation container instead (allowed on Bornholm since there is a general rule allowing for scavenging that is not allowed otherwise on the Danish mainland). c. The site worker transfers donated items from the shelf outside the donation container into the container itself. d. The site worker ensures that visitors do not scavenge donated items for reuse from the donation shelf, or from the donation container itself. The site worker often locks the container to avoid the latter from occurring.	Volunteers pick up effects once a month and drive them to a storage. Furniture, grill and other major effects are transported on a trailer. Smaller effects are transported in a regular car. Storage: Effects collected are stored in the old dairy in Hasle. The storage is not heated but is dry. The storage is about 2 min drive from the reuse site. Sales channels consist of a flea market held twice a year.

Fig. 13.10 HIF's model for direct reuse in collaboration with BOFA (Moalem, 2021).

Fig. 13.11 Donation container at Aakirkeby Reuse Site (Moalem, 2021)

collecting from private homes. Apart from those smaller donations, townspeople also regularly contacted the sports association if a relative died and asked AAIF to empty the house in return for keeping reusable items. AAIF stored the items at an old barn (free of charge) until their annual flea market.

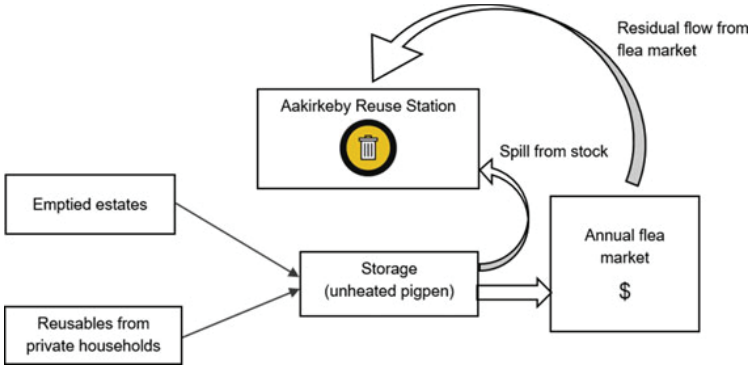


Fig. 13.12 AAIF reuse model prior to the cooperation with BOFA (Moalem, 2021)

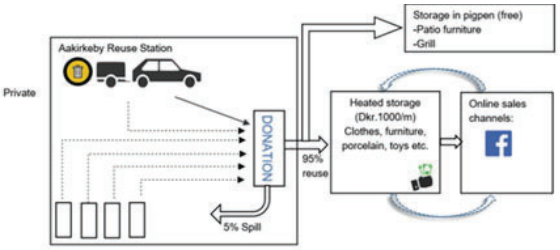
The challenge was that storage was cold, humid, and susceptible to moisture damage, or came to smell of the pig shed when stored for up to a year. This meant that AAF had to discard a large part of the reusable items. Additionally, items not sold on the day of the flea market were also discarded. The flea market required about 40 volunteers for 3 days prior the flea market and on the day itself. Revenue from the annual flea markets reached around DKK 20,000 per year. Summed up, this model demanded a large number of volunteers (logistics). From an environmental perspective, the unheated storage created a large material loss but from an economic point of view, a heated storage would create a money loss for AAIF. However, the annual flea markets are almost like a part of the DNA on Bornholm, including AAIF. AAIF's model prior to BOFA cooperation is illustrated in Fig. 13.12.

13.4.2.5 Aakirkeby Reuse Model in Cooperation with BOFA

After AAIF entered into collaboration with BOFA, it developed a new model for collecting, selling, and storing reuse effects for their annual flea market. As in the case of HIF, BOFA has provided a 40-foot container for AAIF where visitors at the reuse site can donate reusable items to AAIF. The container is located strategically at the reuse site for every visitor to see when entering the reuse site. A model of the reuse model is illustrated in Fig. 13.13. Figure 13.14 shows how the AAIF chairman plays a role in collecting reusable items.

In addition to the warehouse that AAIF had access to prior the cooperation with BOFA, AAIF has been able to rent a centrally located storage room owned by the municipality. Furthermore, the chairman of AAIF operates a hotel within walking distance of the storage. This means that AAIF can easily access the storage site, categorize deposit items for storage. In addition, the storage room is heated (dry), see Fig. 13.15. According to the chairman *"the room is the key to success!"*.

AAIF is overwhelmed by the amounts of reused items donated to AAIF at the reuse site and according to the chairman, only 5% of what is donated at the container is refused. The remaining 95% is sold. A key to this success is digital media. According to the chairman, AAIF has earned approximately DKK 60,000 in the



Donation process	Items for recycling are collected through several channels at the recycle bin: a) Visitors to the reuse site donate items to AAIF by placing them on a shelf located outside the container (this to avoid scavenging inside the container). b) The BOFA site worker informs citizens about the possibility of donating to AAIF if he spots reusable items on their trailer or car that can be beneficial to AAIF. c) The BOFA site worker identifies items in the containers for recycling or for combustible waste that are suitable for reuse, and places these in the donation container instead (allowed on Bornholm since there is a general rule allowing for scavenging that is not allowed otherwise on the Danish mainland). d) The BOFA site worker transfers donated items from the shelf outside the donation container into the container itself. e) The BOFA site worker ensures that visitors do not scavenge donated items for reuse from the donation shelf, or from the donation container itself. f) The chairman of AAIF also identifies items in the containers for recycling or from the combustible waste container that are suitable for reuse, which are brought to the donation container.
Separation Process	a) AAIF (the chairman) discards 5% of what is collected in the container if it is considered that it cannot be sold. For example, an office chair missing a wheel. The BOFA site worker helps by placing these items in the right container for either recycling or in the combustibles container for incineration. b) Preparation of items. AAIF (the chairman) packs fragile effects into blankets and bags so that they are ready and do not break when volunteers come and empty the container.
Logistics (emptying of container)	Volunteers pick up effects each week and drive them to a storage*. Furniture, grills and other major effects are transported on the trailer. Other items are transported in regular cars.
Storage- two types	a) Seasonal goods such as garden chairs and barbecue that can withstand cold / moisture are stored at the "pig barn" warehouse. b) Furniture, clothing, toys, crockery and small accessories etc. are driven directly to a heated storage at the center of Aakirkeby
Sales channels	Online sales (9 Facebook groups and a local reuse platform: Bornholmermarked.dk)

Fig. 13.13 AAIF's reuse model in cooperation with BOFA (Moalem, 2021)

Fig. 13.14 The chairman of AAIF "inspects" whether visitors hold reusable items which could benefit AAIF and scavenges reusable items out of the metal containers for recycling. Reusable items are placed in the donation container and later on sold by AAIF

4 months the project has run. This should be held up against the old model in which AAIF obtained an annual revenue of DKK 20,000 from flea markets.

13.4.2.6 Summing Up AAIF Models on Reuse Prior- and in Cooperation With BOFA

Annual flea markets are part of the Bornholm DNA and a strong AAIF tradition. However, if AAIF is to gather items for a whole year, costs can outweigh income. The "flexible" model AAIF developed in collaboration with BOFA (with ongoing

Fig. 13.15 Heated storage in the town of Aakirkeby. With the new model AAIF has increased sale and reduced waste (Moalem, 2021).

Table 13.7 Main differences in the two reuse models prior AAIF's collaboration with BOFA and AAIF in cooperation with BOFA (Moalem, 2021).

AAIF model prior collaboration w. BOFA	AAIF collaboration model w. BOFA
Voluntary tasks (resource demanding) – Collection from households – Empty death rows-sort out reusable – Organize the annual flea market	**Voluntary tasks (resource demanding)** – Emptying the container – Put the stock in order – Online sales by the chairman (time consuming) – Chairman coordinate volunteers to pick up reusable from the container – The chairman is present at pickup
Spill products: – Substantial amount of reusable wasted due to moisture damage/odor from pig barn – Reusable not sold ended up as waste	**Spill products:** Emptying the container takes place 1–2 times per week – 5% of reusable are sorted away as waste (on-site) – Everything else is sold on line/from heated storage
Storage and sale Storage is unheated – Only sale via flea market	**Storage and sale** Two storage facilities; one heated and one not heated – Reusables are sold online→sourced from both storage facilities
Expenses: – None. Unheated storage (free)	**Expenses:** – Dkr. 12.000kr/year. Heated storage
Earnings: – Flea market: Dkr.20.000/year	**Earnings:** – Online sale: Dkr.60.000kr./4 months. – Flea market?

sales through digital media) generates the most revenue, prevents the most waste, and activates the island's volunteers. Table 13.7 illustrates the main differences between the two reuse models; AAIF prior collaborating with BOFA and in collaboration with BOFA.

BOFA's collaboration with the civil society around waste prevention has led to the innovation of new reuse models, including models supporting local flea markets. Currently, there are no figures on quantities or types of products collected through these schemes, and therefore no data on how much and what type of waste is prevented. However, the case of Bornholm shows that through a focus on unlocking

green minds and an innovative partnership and experimentation approach, it is possible to waste prevention and reuse and thus, the inner circles in a circular economy.

13.5 Future Plans to Support Waste Prevention and Reuse on Bornholm

Bornholms Waste Company, BOFA has for many years contributed to teaching better waste management in the Waste Tower among Bornholm children, young people, parents, and grandparents, but as the circular economy occupies a larger and larger part of the waste and climate agenda, BOFA wants to develop its teaching in a more innovative and circular direction.

Therefore, BOFA is in the process of exploring opportunities to expand the Waste Tower with yet another building—a practical experience center for circular economy, with the working title, The *"Wastery."*

To further support waste prevention and reuse, BOFA has plans for combining aspects of both educational activities and partnership activities (detailed in Sect. 13.4.1 and 13.4.2) in a new circular economy "experience center," see Fig. 13.16.

The plan for this new circular economy experience center is to focus even more on the innovative and practical part of the circular economy, playing into Bornholm's sustainability strategy provided in the *"Bright Green Island"* vision and the interlinked 8 Bornholm Goals (see Sect. 13.2.4) as well as the *"Bornholm showing the way – without waste 2032"* vision.

BOFA is to build a new structure where sustainable waste culture, recycling and resources in are the central focus. In the new circular economy experience center, it should be possible to explore and test ideas that are based on waste as well as how to recycle or reuse waste in new ways.

The experience center will be located approximately 100 meters from Bornholm's main recycling center and close to the Waste Tower, where it will be a natural to extract resources for its experimentation activities directly from the

Fig. 13.16 Conceptual visualizations of how the future circular economy experience center is to look like

recycling center, for example, by scavenging an electric motor from a washing machine, a discarded wooden board or a PVC pipe.

It is also planned that the circular economy experience center will house a repair cafe where citizens of the island can come with their own vacuum cleaner or similar and have it repaired in collaboration with a volunteer affiliated with center. This also provides good opportunities to involve the center in the previously mentioned partnership activities detailed in Sect. 13.4.2. The project, which aims to have more waste recycled directly, will be able to use the site's workshop to make minor repairs, so that the resource, e.g. the aforementioned vacuum cleaner, can again become operational and possibly be sold in a recycling market for the benefit of a new user- and the climate.

The circular economy experience center is also in itself intended to be a showroom for circular building construction. The idea is that center itself is to be built out of approximately 55% recycled materials from a nearby abandoned farm. The circular history is to be visible both in the building structure, but also in the building's surfaces, as well as in the area surrounding it. The circular economy experience center is expected to be completed and ready for inauguration by 2023.

13.5.1 A Perspective on COVID-19

In light of the COVID-19 pandemic that has been scarring communities, societies, and economies the world over, it is sobering to consider what the future holds in general, and with respect to circular economy in Denmark and Bornholm. When infections spread out from the disease's European epicenter in Italy and Denmark confirmed its first case of COVID-19 in February 27, 2020, Denmark was one of the earliest countries in Europe to institute social distancing measures, closing of public institutions, and border closing. This early and hard response, as well as a widespread overall public adherence to government and health authority guidelines, meant that Denmark flattened the curve quite successfully. To date, Denmark has had 13,390 cases, of which 12,299 have recovered and 612 have died, out of a population of 5.8 million people. Restrictions to movement and travelling have been easing in the months leading up to the summer of 2020, and the Danish government has been prompt in securing economic support to companies that have been hit by the crisis. As well, Denmark has widely instituted a testing and contact-tracing infrastructure in efforts to keep the infection rate low.

What is unclear is what the implications are in the longer term on the Danish economy, closely tied with the broader European economic zone. In the short term, a number of industries have been hard hit by the pandemic, including the tourism and hospitality industry that is important to Bornholm. The impacts on waste generation and circular economy jobs are still unclear. While sectors such as these may be affected by the COVID-19 pandemic, in the longer timeframe the actions involved with achieving waste-free 2032 vision on Bornholm are expected to be resilient to outside conditions.

Ethical Statement All procedures performed in the studies involving human participants were in accordance with ethical standards of the organization and informed consent was obtained from all individual participants, if any.

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APPENDIX B

Project FUTURE: the case of Affald Plus (conceptual results)

This appendix contains the solution proposal for Affald Plus regarding conceptual results of the registration and communication platform. The solution proposal is developed by Jens Tue Olsen (JTO), waste consultant in Affald Plus and partner in the Project FUTURE (2018–2021).

The official homepage for the FUTURE project is: https://www.gate21.dk/nyhed/intelligent-brug-af-produktdata-der-fremmer-genbrug/

Solution proposal for Affald Plus, project FUTURE

Design

Capabilities

Registration platform (RP)

1. Registering all incoming items by weight, item name, and item product category. Done with Registration Platform (RP). Allows for weight distribution plots, enabling decision between automatic or manual registration, and organisation of labour.
2. Registering which of the incoming items are handed over to people or organisations and when.
3. Registering which of the incoming items are sold at which reuse shops and when.

Communications platform (CP)

1. Present all items registered in RP in an e-commerce platform enabling the immediate purchase of incoming goods.
2. Provide a means of communicating needs and wishes to AP, allowing AP to react by focussing effort where demand is expressed.
3. Provide a forum for communicating AP's actions, the benefits of reusing items and other informatics to the public and partners.

Integration

1. Reduce time required to place adds on websites, by making a direct interface between the RP and the CP. The RP registration shall be reflected immediately in the CP.

Scale

The platform suggested in the FUTURE project is designed to accommodate the needs of AffaldPlus: it is intended to be able to handle the number of items selected from the waste stream as suitable for reuse.

Assuming average weight of an item is 1 kg, the total number of items to be registered is 1,5 million. 1,5 million items to be registered per year, assuming 8-hour workdays is

$$\frac{1.500.000\ items}{1\ year} = \frac{1.500.000\ items}{8\frac{hours}{day}\times 365\frac{days}{year}\times 60\ \frac{minutes}{hour}\times 60\ \frac{seconds}{minute}} = 0{,}143\ \frac{items}{second} \rightarrow 7\frac{Seconds}{Item}$$

7 seconds per item is considered an ambitious target, given the requirement for the items to be loaded onto the conveyor belt, the manual confirmation of the A.I. type and categorization, and the lag time between uploading imagery to the A.I. and receipt of the A.I. response, and the final removal of the item from the conveyor belt.

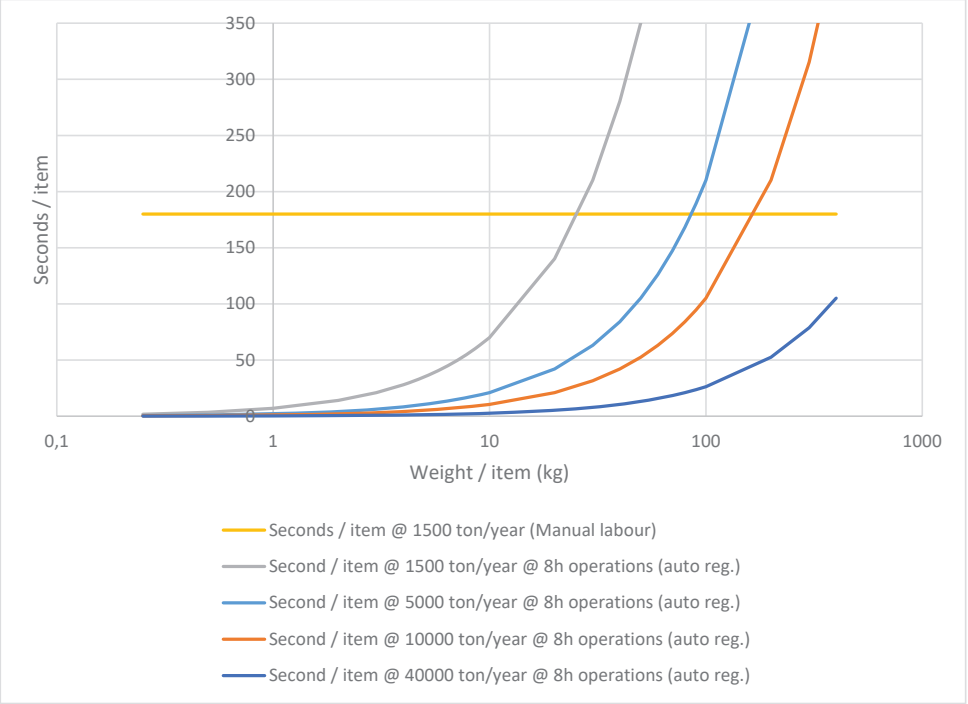

Figure 1: Automation is beneficial when time spent registering items becomes economically problematic. The more items received, it becomes more attractive to auto register still heavier/pcs items. (JTO)

Maturity levels

The EU TRL

Current

1. Pilot facility without RFID tagging and little IT effort. This is the level to which AP intends to test the solution proposal.
2. Pilot facility with RFID tagging.
3. Full scale development with RFID tagging, code optimisation, and tailor-made communications platform.

Conceptual result

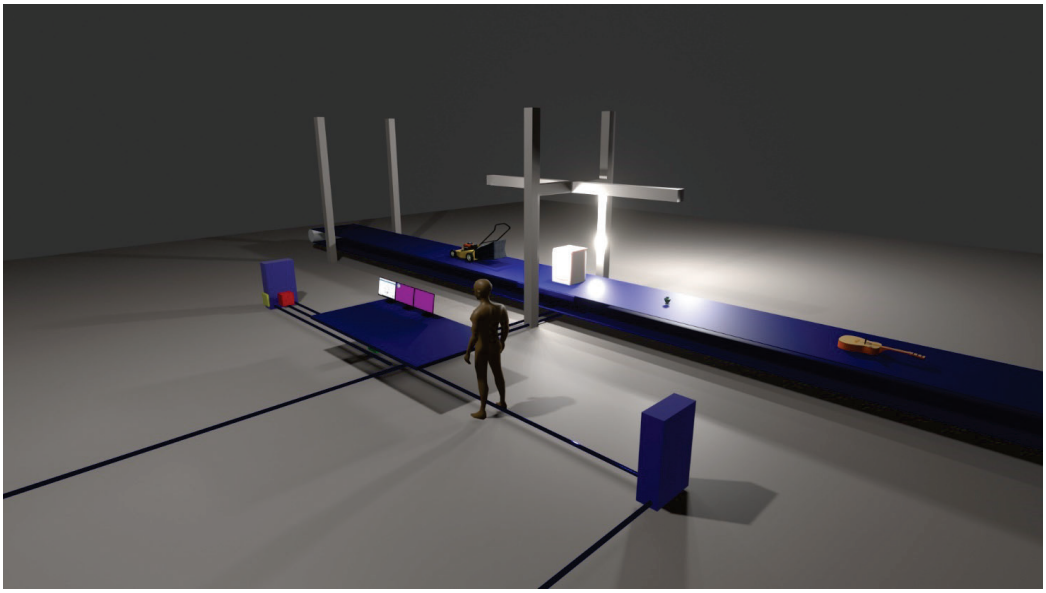

Figure 2: Illustration of the registration platform. (JTO)

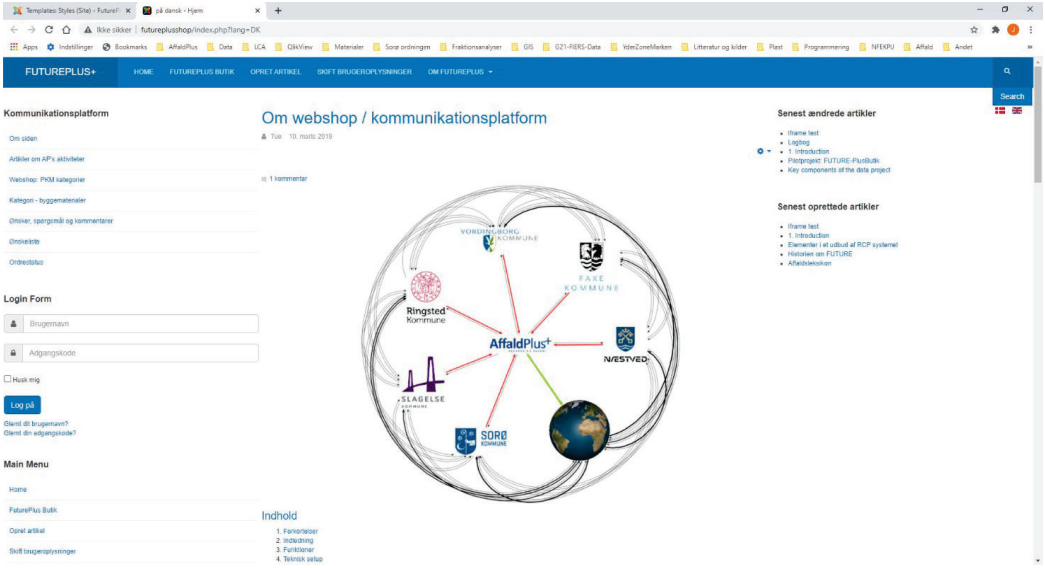

Figure 3: Frontpage of the communications platform. (JTO)

Designing for larger (or smaller) amount of registering reusable items has not been attempted.

Platform layout

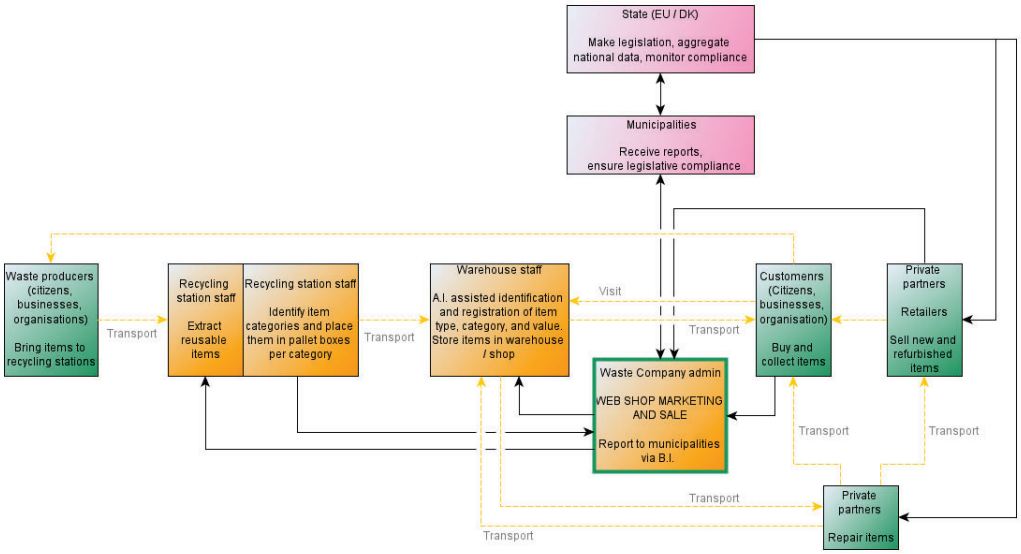

Figure 4: The FUTURE RCP. (JTO)

APPENDIX C

State of the art

This appendix contains an overview of state-of-the-art literature on ‘Preparing for reuse’ (PfR). Specific research and implementation gaps are addressed further in the papers. See Chapters 4, 5, and 6. An overview of the results from the systematic literature search, including approach and focus areas, is provided in the following.

A systematic literature search on the concept of preparation for reuse (PfR) ["prep* for reuse" (all fields)], conducted in the three search engines (Scopus, Web of Science, and Ebscohost), resulted in 137 hits on articles spanning from 2014-to 2021. Eliminating repeated articles reduced the search to 102 articles. Excluding non-peer-reviewed articles or proceedings and reading the abstracts narrowed the search to less than a third (30). The main explanation concerned that articles were related to other research fields besides waste management [microbiology, chemical science, wastewater treatment, chemical engineering, material recycling, botany, medicine & packaging material]. A final read of the entire papers (30) showed that above half the articles were on waste collection, focusing on material recycling (16) rather than preparing products for reuse. Excluding those not meeting the established criteria limited the number to 14 articles of relevance. An additional search on Google Scholar did not lead to finding additional papers.

Out of the fourteen articles, eight focus specifically on potentials and barriers to reusing ICT and WEEE (Bovea, Ibanez-Fores et al. 2016; Bovea, Ibanez-Fores et al. 2018; Zacho, Bundgaard et al. 2018; Pini, Lolli et al. 2019; Johnson, McMahon et al. 2020; Boldoczki, Thorenz et al. 2020; Coughlan, Fitzpatrick 2020). Two take a qualitative approach, focusing on advertising strategies to increase sales in PfR shops (Rizzi, Gusmerotti et al. 2020) and the upscaling of social cooperatives to compete with mainstream competitors (Pansera, Rizzi 2020). Finally, three articles investigated reuse potential of a broader product range such as furniture, leisure goods, and WEEE from bulky waste (Messmann, Boldoczki et al. 2019), cardboard, plastic, waste, wood, and ‘items for reuse’ at a municipal reuse station (Zacho, Mosgaard et al. 2018) and building materials, furniture and WEEE in private Swedish Recycling Centres, (Milios, L., & Dalhammar, C., 2020). Central to this thesis is that only a few (3) 'real life' case studies assessed PfR products that have ended up as 'waste' at reuse stations (Zacho, Mosgaard et al. 2018), recycling centres (Milios & Dalhammar, 2020) or as bulky waste (Messmann, Boldoczki et al. 2019).

Article information		Approach			Focus	
Author	Title		Qualitative	Quantitative	Products	Other
(Sorensen, Wenzel 2014)	Life cycle assessment of alternative bedpans – a case of comparing disposable and reusable devices	LCA/ sample case		x	Hospital bedpans	Assessment of alternative bedpans/ comparing disposable and reusable devices
(Bovea, Ibanez-Fores et al. 2016)	Potential reuse of small household waste electrical and electronic equipment: Methodology and case study	Experiment/sample case		x	ICT/WEEE	Propose a general methodology for assessing the potential reuse
(Bovea, Ibanez-Fores et al. 2018)	A survey on consumers' attitude towards storing and end of life strategies of small information and communication technology devices in Spain	Survey		x	ICT/WEEE	Consumers' attitude, habits and practices to store, repair and secondhand purchase
(Zacho, Mosgaard et al. 2018)	Capturing uncaptured values — A Danish case study on municipal preparation for reuse and recycling of waste	Comparative/case study	x	x	cardboard, plastic, waste, wood, items for reuse	Re-use Potential in Danish Reuse Stations (size and characteristics)
(Zacho, Bundgaard et al. 2018)	Constraints and opportunities for integrating preparation for reuse in the Danish WEEE management system	Socio-technical system		x	WEEE	Integrating PfR in the Danish WEEE management system
(Messmann, Boldoczki et al. 2019)	Potentials of preparation for reuse: A case study at collection points in the German state of Bavaria	Case study/theoretical potential		x	ICT/WEEE used furniture & leisure goods	Quantify a theoretical potential for PfR of ICT/WEEE, used furniture and used leisure goods
(Pini, Lolli et al. 2019)	Preparation for reuse activity of waste electrical and electronic equipment: Environmental performance, cost externality and job creation	LCA/scenarios	x	x	ICT/WEEE	Scenarios for decisionmakers to compare the environmental performance, cost externality and job creation of the whole life cycle of *new* and *reconditioned* ICT/WEEE
(Gusmerotti, Corsini et al. 2019)	Assessing the role of preparation for reuse in waste-prevention strategies by analytical hierarchical process: suggestions for an optimal implementation in waste management supply chain	Sensitivity analysis		x	-	Analytic hierarchy process (AHP). Waste prevention in municipal solid waste management
(Rizzi, Gusmerotti et al. 2020)	How to meet reuse and preparation for reuse targets? Shape advertising strategies but be aware of "social washing"	Case study	x		-	How advertising strategies based on emotional, functional or combining stimuli can be used to increase intention to buy items in PfR shop/social washing
(Pansera, Rizzi 2020)	Furbish or perish: Italian social cooperatives at a crossroads	Case study	x		-	Equality and democratic management. Italian social cooperatives/upscaling to compete with mainstream competitors
(Johnson, McMahon et al. 2020)	A Preparation for Reuse Trial of Washing Machines in Ireland	Sampling/quantifying theoretical potential		x	WEEE	Quantify a theoretical potential for PfR of washing machines in the WEEE stream in Ireland under current collection conditions.
(Boldoczki, Thorenz et al. 2020)	The environmental impacts of preparation for reuse: A case study of WEEE reuse in Germany	LCA		x	ICT/WEEE	The environmental impacts of PfR
(Coughlan, Fitzpatrick 2020)	Trialling the Preparation for Reuse of consumer ICT WEEE in Ireland	Experiment/sample case		x	ICT/WEEE	Potential of collecting ICT/WEEE) for PfR in workplaces in Ireland
(Milios, L., & Dalhammar, C. 2020).	Ascending the Waste Hierarchy: Re-use Potential in Swedish Recycling Centres.	Litt. review/site visits/interviews			Building materials, furniture, WEEE	Re-use Potential in private Swedish Recycling Centres. Identify product groups most suitable for PfR

APPENDIX D

Data archive

This appendix contains an overview of the data archive for research related to this thesis. In addition, publications contain a more detailed data description. See Chapters 4, 5, 6 and Appendix A.

Method	Samples
Fieldwork	
- site visits to six Danish municipal waste management companies reuse sites	Field notes and photo documentation of reuse/PfR schemes, bulky wastes, reusable that ends up in containers for recycling and incineration
- passive observation and informant interviews w. project leaders/head of reuse on the sites	
- long duration stays (1-4 days) at three municipal waste management companies focusing on reuse/PfR related activities (observation -passive and participant in DK and Sweden)	Field notes and photo documentation, and own observations (daily routines, silos, dilemmas)
- Study trip to De Kringwinkel in Brussels incl. meeting with RREUSE to discussing legal issues, potentials and barriers for PfR (general level)	Meeting minutes, notes, RREUSE materials (reports, leaflets etc.), photo documentation of De Kringwinkel
- Collaborate data collection with the Swedish Environmental Research Institute IVL (Sweden) on increasing reuse og construction and demolition materials and products (observations at Swedish recycling centers and interviews with citizens and craftsmen concerning drivers and barriers for reuse)	Field notes, questionnaires, photo documentation
- Spending time in the field with waste collectors (participant observation and shadowing)	Field notes and photo documentation (routines and dilemmas)
- engaged in the repairs in repair cafes (participant observation)	Field notes and photo documentation (routines and dilemmas)
- visited repair cafes (hidden observation)	Own observations of routines, dilemmas, behavior
Interviewing methods	
- partaking nine Danish waste conferences on reuse/PfR w. actors on the reuse scene (public, private, NGO)	Round table discussion on PfR incl. legal issues & views on PfR, access rights and values
- partaking two conferences on legal issues around PfR (DAKOFA)	Conference notes, presentation, roundtable discussions and own observation
- partaking four collaborative conferences (COOConf)	Workshops w. practitioners to develop PfR solutions to address specific problems/product groups
- fifteen un-and semi structured interviews w. waste managers, developers, directors on potentials and barriers to reuse/PfR	Notes, full minutes (complete transcription -only where needed)
- informant interviews w. lawyer Christina Soya, HORTEN to investigate PfR legal issues	Notes on follow up-question
- -unstructured interview (meeting) w. director of Danish Waste Association (DAF)	Meeting minutes (DAF perspectives on PfR, roles of WMC in relation to PfR)
- -partaking a broad swath of European online conferences on repairs	Notes, conference presentation (where possible)
Non- intrusive methods:	
- document analysis on feasibility studies on PfR	Internal reports on PfR experiments (A+ on value chains, AVV on PPP)
- document analysis on the DI trial/conflict against three municipal waste management companies concerning PfR and municipal reuse shops	State administration documents on the trial/conflict, appendixes, and legal documents from the law company HORTEN, who assisted the case and consultation responses
- media analysis	Local newspapers
- review of a broad swath of news stories to cover the PfR trial/conflict	Web news sources covering the trial/conflict

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