# Preparing for Reuse

*Towards Cooperation for the Inner Cycles and the Local Loops*

Moalem, Rikke Marie

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# PREPARING FOR REUSE

COOPERATION FOR THE INNER CYCLES AND THE LOCAL LOOPS

**BY**
**RIKKE MARIE MOALEM**

DISSERTATION SUBMITTED 2022

AALBORG UNIVERSITY
DENMARK

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Dissertation submitted 2022

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| Dissertation submitted: | April 2022 |
| PhD supervisor: | Professor Arne Remmen<br>Aalborg University, Denmark |
| Assistant PhD supervisor: | Senior Advisor Stig Hirsbak<br>Aalborg University, Denmark |
| PhD committee: | Professor Johannes Brezet (chairman)<br>Aalborg University, Denmark |
| | Associate Professor Rebeka Kovacic Lukman<br>University of Maribor, Slovenia |
| | Associate Professor Thomas Lindhqvist<br>Lund University, Sweden |
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| Department: | Department of Planning |

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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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# ACKNOWLEDGEMENTS

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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 II**

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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

**Moalem, R.M.**, Hirsbak, S., Butzbach, M.T., Johansen, B., 2021. *Bofas samarbejde med det civile samfund omkring genbrug 2018-2021*. Final report. FUTURE. Published: https://www.gate21.dk/wp-content/uploads/2021/09/Case-7_BaggrRapport_BOFA-1.pdf

**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.

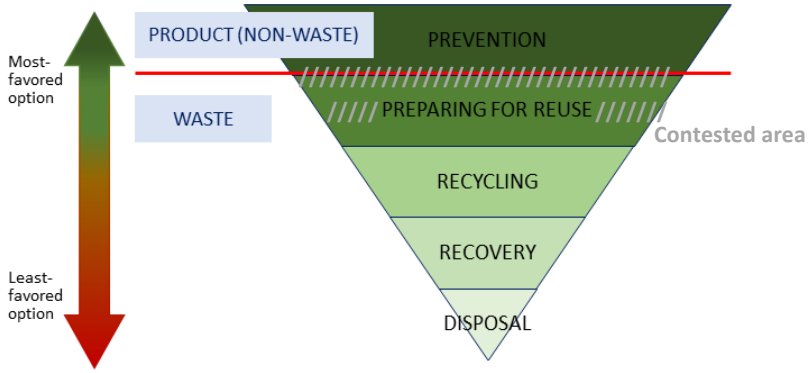


**Figure 4** Positioning of thesis in the contested area of preparing for reuse (based on Directive 2008/98/EC, Art. 4)

## 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.

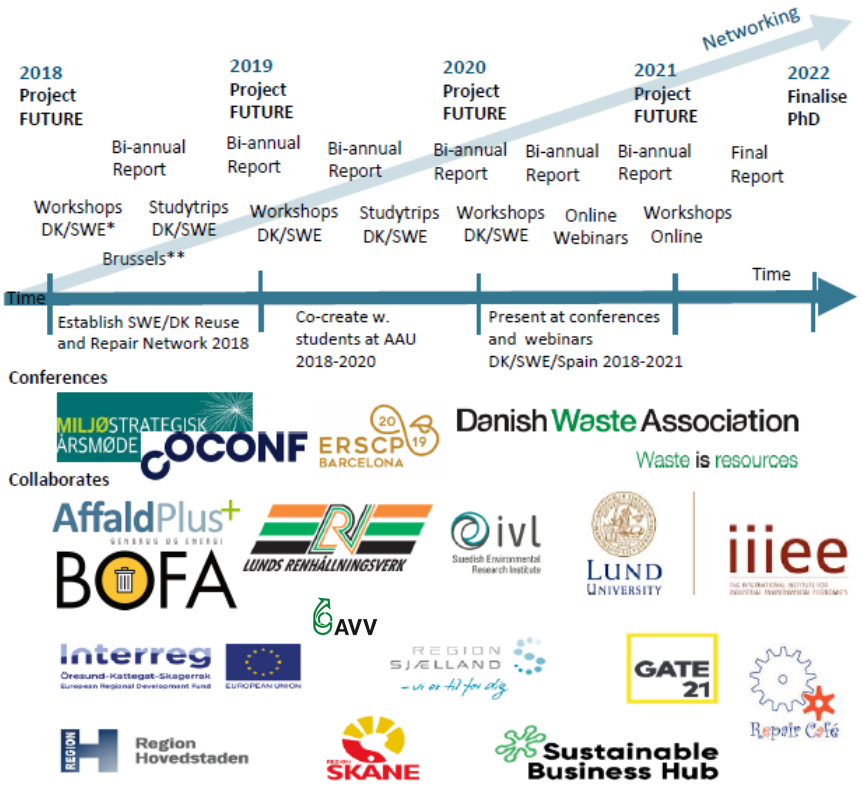


**Figure 5** Research activities, partners, and network in the PROJECT future

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.

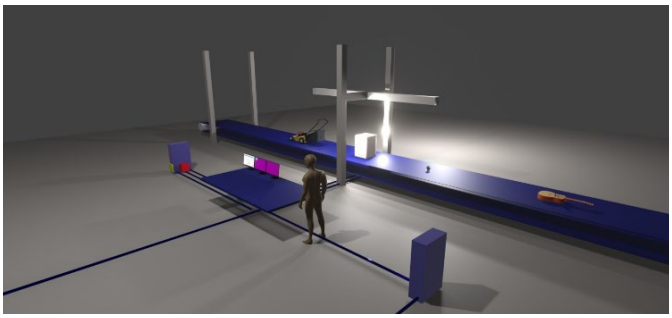

**Figure 6** Preparing for reuse registration platform, Affald Plus

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.

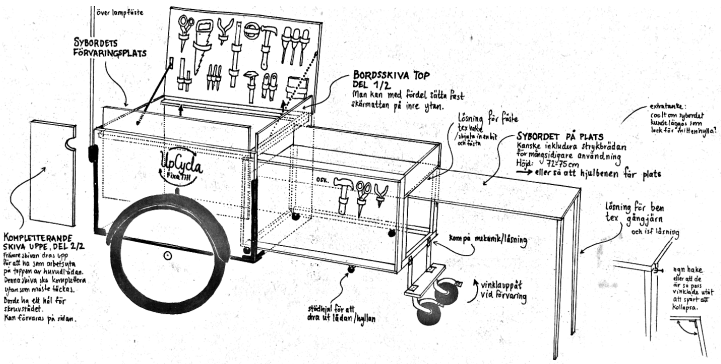


**Figure 9** Sketch of the mobile variant of the repair shop 'UpCykla'. Reprinted with permission. Lena Wallin, Lund Renhållningsverk.

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.

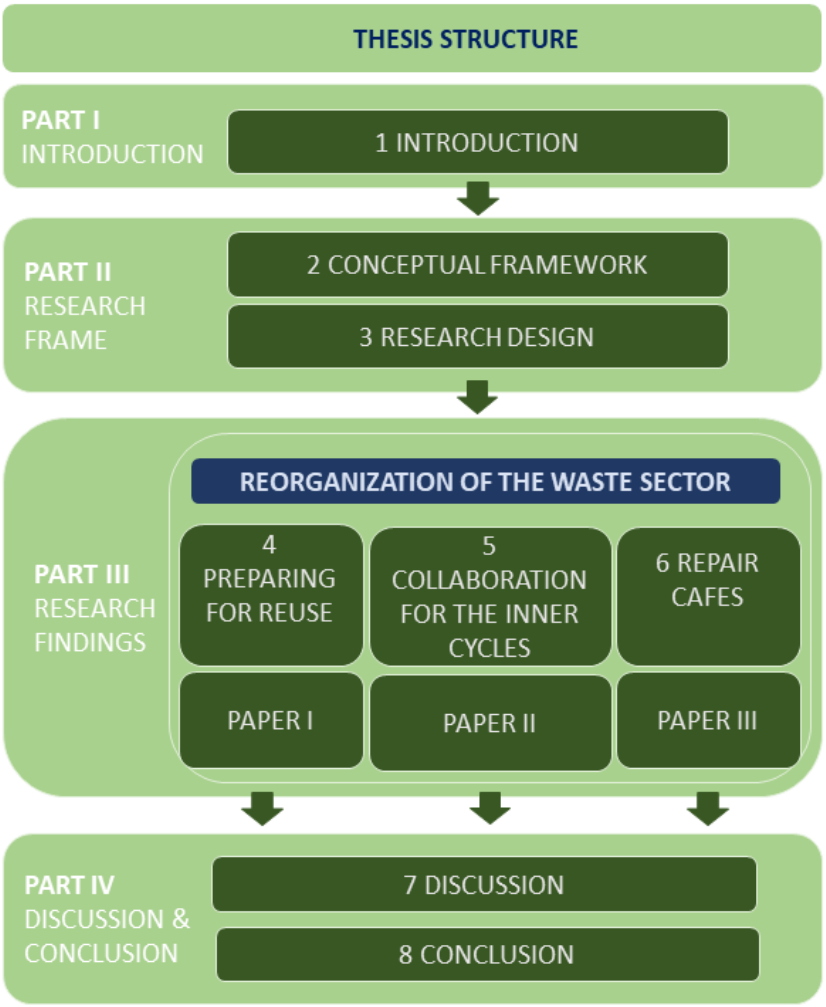


**Figure 11** Thesis structure

# 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.

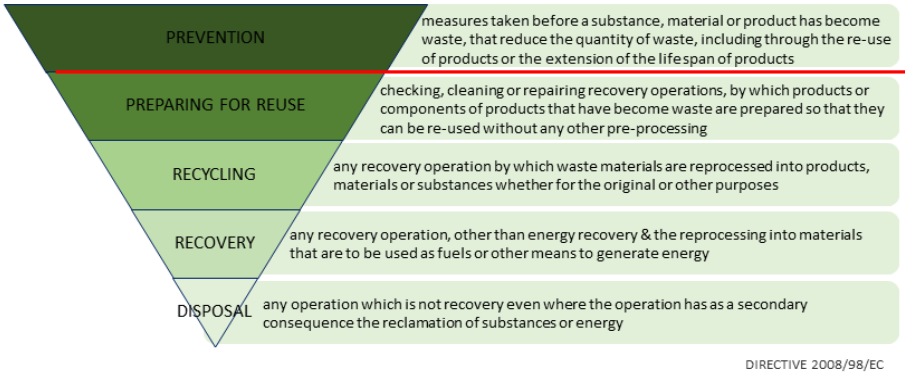


**Figure 12** The European waste hierarchy (EU, 2008)

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).

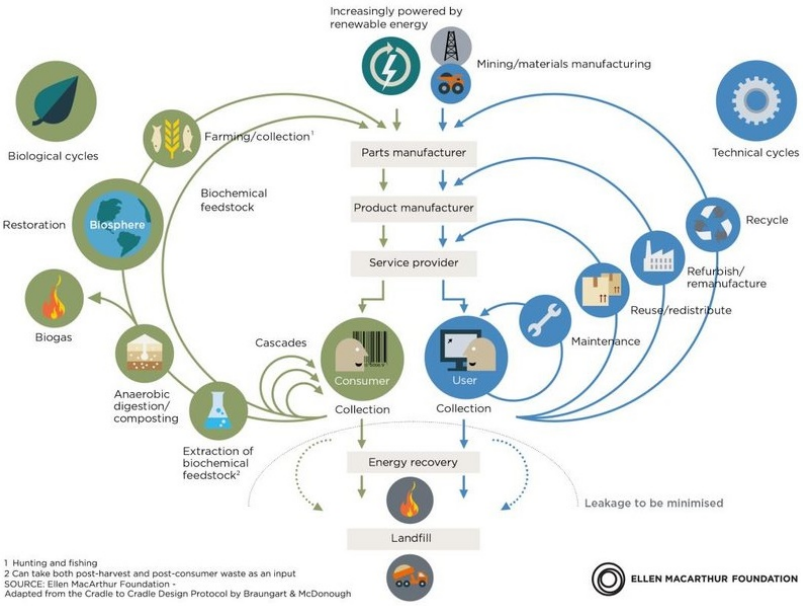


**Figure 13** CE systems diagram (EMF, 2019)

### *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.

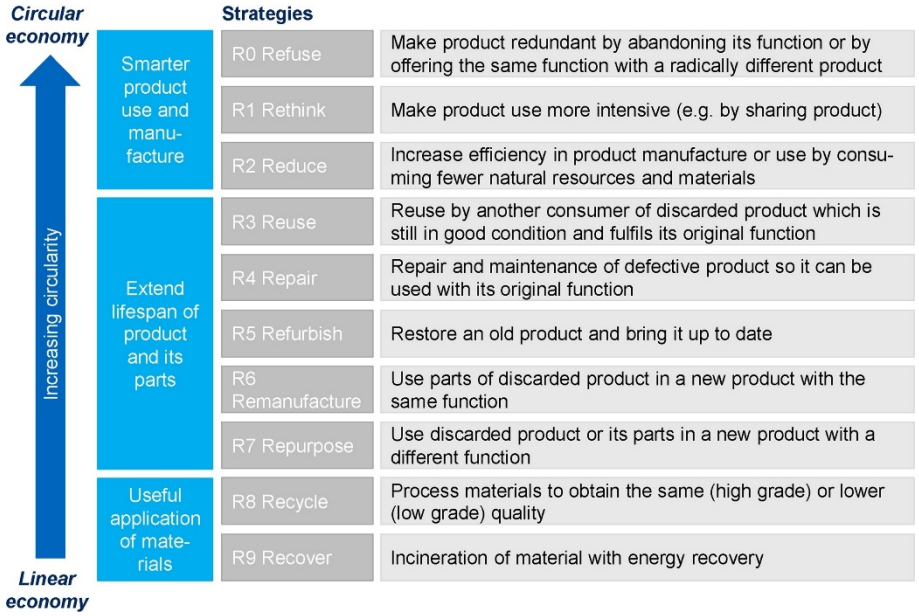


**Figure 14** The 9R Framework (Kirchherr et al., 2017)

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.

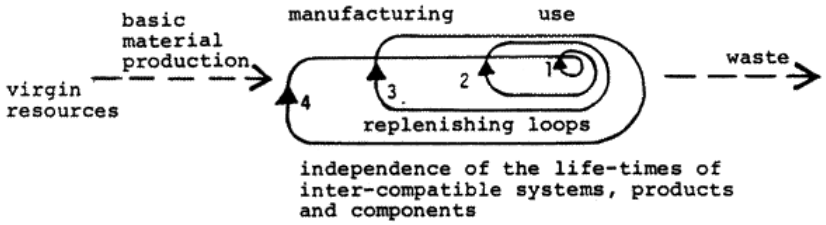


**Figure 15** Product life extension (Stahel, 1984, p. 74)

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).

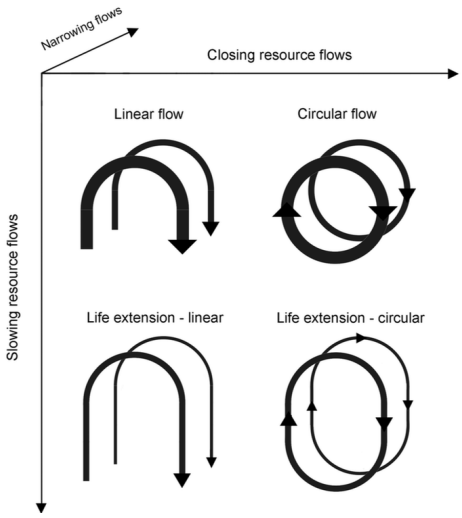


**Figure 16** CE framework of slowing, closing, and narrowing (Bocken, de Pauw et al., 2016).

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.

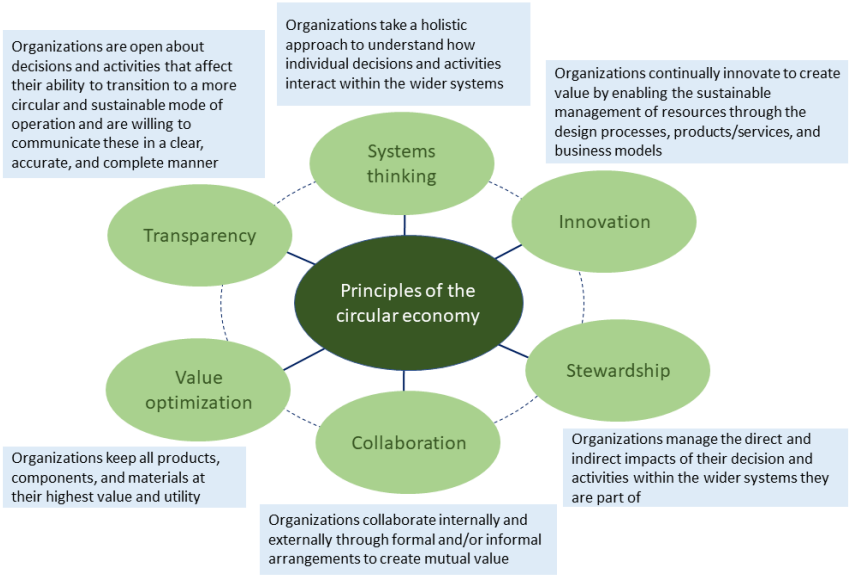


**Figure 17** Principles of the CE and corresponding definitions (BSI, 2017)

### *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.

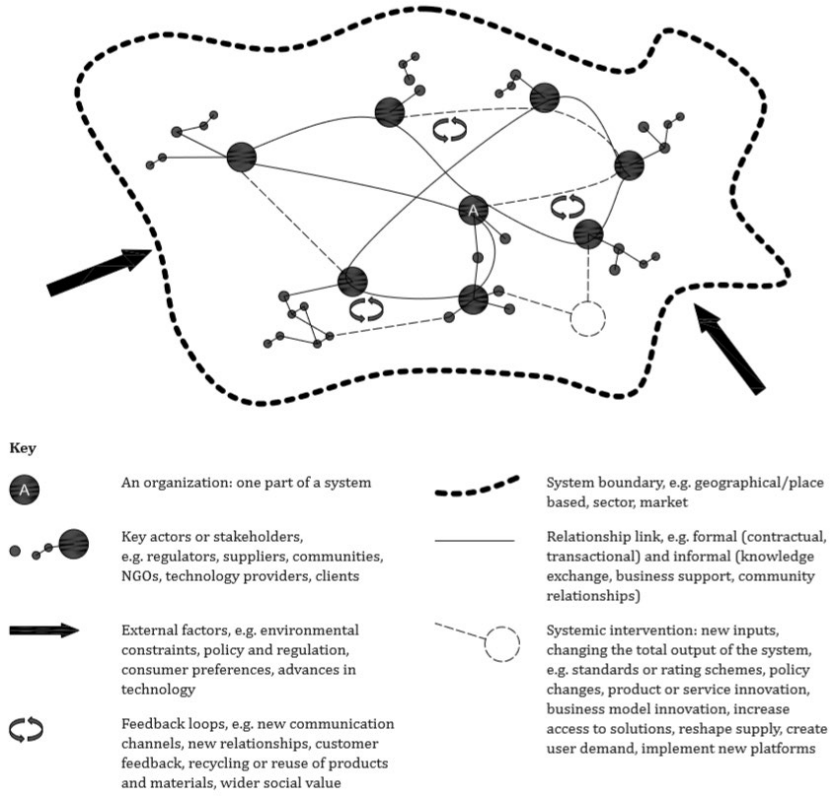


**Figure 18** Organizational system with interventions highlighted (BSI, 2017)

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.

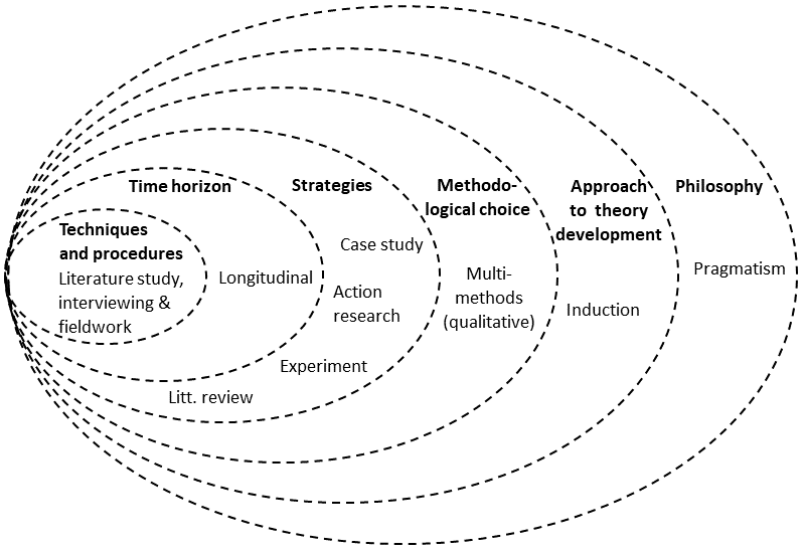


**Figure 19** The research onion applied to this thesis (based on Melnikovas, 2018; Saunders et al., 2016)

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.

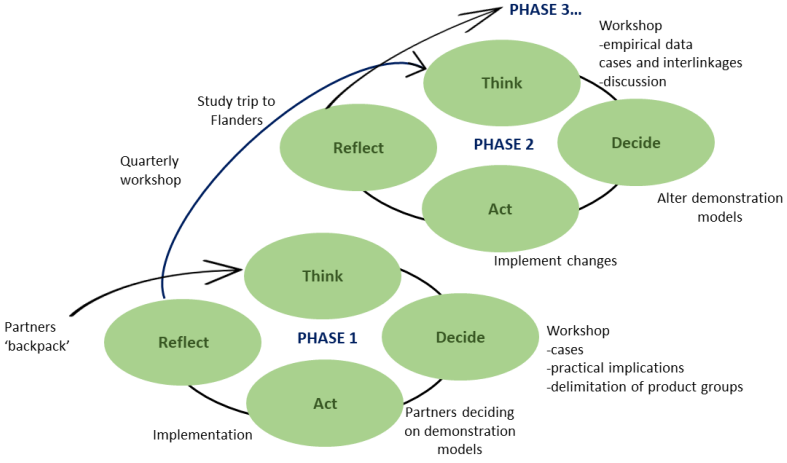


**Figure 21** Loop learning facilitates processes of change (inspired by Kolb, 1994).

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 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).

# Struggles over waste: preparation for reuse in the Danish waste sector

**Rikke Marie Moalem[1], Arne Remmen[2], Stig Hirsbak[3] Søren Kerndrup[4]**

[1, 2,3] Department of Planning, University of Aalborg, A.C. Meyersvaenge 15, 2450 Copenhagen, Denmark
[4] Department of Planning, University of Aalborg, Rendsburgade 14, 8000 Aalborg, Denmark
Corresponding author: Rikke Marie Moalem. Department of Planning, University of Aalborg, Campus Copenhagen, A.C. Meyersvaenge 15, 2450 Copenhagen, Denmark. Email: rikkekr@plan.aau.dk

## Abstract

The circular economy model conceptualizes waste as intrinsically valuable. Further, following the waste hierarchy, preparing for reuse (PfR) is regarded as a better waste management option than recycling. Nevertheless, too many products with a reuse potential end up as waste. This includes residuals from products that have no major value and are therefore not demanded by the current system. As a result, products are prematurely recycled. This contrasts both the hierarchical order of the European waste hierarchy and the principles of a circular economy. This paper investigates the potential of and constraints to reusing products that are disposed of at reuse sites. It aims to improve our understanding of these issues and offer possible solutions that could enable municipal waste companies to transition from waste to resource management and reach the upper levels of the waste hierarchy, preparing waste for reuse. Interviews with relevant stakeholders, desk studies, and knowledge obtained from participating in waste conferences over the past three years are all used to analyse PfR practice at five municipal waste management companies in Denmark. Pioneers with respect to circularity in the waste sector, which have been experimenting with and initiating PfR schemes concerning a range of products, including building materials, furniture, white goods and bicycles, are considered because they support the inner cycles of the circular economy. However, the current transition consists of complex processes with an ambivalent legal framework and struggles over access and rights to resources.

Thus, challenges to achieving higher reuse rates seems to go beyond engaging in strategic partnerships, creating financial incentives, and setting separate targets for reuse. Consequently, a comprehensive investigation seems to be needed, to deepen the understanding of processes of resource management, use and contestations around these. Furthermore, a wider mapping of actors operating in the tension area between prevention (reuse) and PfR, including their willingness to cooperate, as to finding solution to negotiating future orders, beneficial for both practitioners and policy developers.

**Keywords:** preparation for reuse; waste management; European waste hierarchy; circular economy

## Introduction

Challenges related to waste management is one of the drivers in a circular economy (Ghisellini et al., 2016), and waste is perceived as a resource (Ellen MacArthur Foundation, EMF, 2015). The European Waste Framework Directive (WFD) (Directive 2008/98/EC), later amended by Directive 2018/851, sets the frame conditions for waste management planning in the European Union (EU). The central principle is the 'waste hierarchy', formulated in Article 4, which shall 'apply as a priority order in waste prevention and management legislation and policy' (EU, 2018). The first option is a) 'prevention', followed by b) 'preparing for reuse' (PfR), (c) 'material recycling', (d) 'recovery' and finally (e) 'disposal'. When applying the waste hierarchy, Member States shall take measures to encourage the options that deliver the best overall environmental outcome (2008/98/EC). Once products have become waste, PfR is – in most cases – the preferred waste management option over recycling, as reuse is often environmentally preferable to material recycling and the manufacturing of new products. PfR is defined in the WFD as 'checking, cleaning, or repairing and recovery operations by which products or components of products that have become waste are prepared so that they can be reused without any other pre-processing' (2008/98/EC). Nevertheless, waste management has moved steadily upwards in the waste hierarchy (Williams, 2015; Milios & Dalhammar, 2020), contradicting the downward prescription formulated in the WFD. Moreover, the waste hierarchy lacks clarity in terms of overlap between measures (Gharfalgar et. Al., 2015). In the case of Denmark, the overall focus within municipalities is on the challenge of implementing separate collections and increasing the amount of collected waste fractions for recycling rather than on PfR. This was the clear result of a review of the waste plans of the 28 municipalities in the capital region of Denmark (Remmen, 2019).

The amendments of Directive 2018/851 were an element of the circular action plan communicated by the Commission in 2015. The aims of these amendments were for waste management to be 'transform[ed] into sustainable material management' and 'promote[ing] the principles of the circular economy…focusing on the whole life cycle of products in a way that preserves resources and closes the loop' (Consideration 1). These statements indicate that measures for prevention and PfR should be expanded. On the other hand, the amendments also increased ambitions concerning collection rates for separated waste for recycling and expanded the numbers of waste fractions for separate collection in households (e.g., textiles from 2025). In other words, the amendments in 2018 indicated the beginning of a transition from traditional waste management (where most attention is paid to the bottom of the waste hierarchy) upwards, by increasing separate collections of more waste streams for 'real' recycling and by giving more attention to PfR and the circular economy. The Directive encourages repair activities through the notion of 'reuse and repair networks', both as non-waste in Article 9 and as waste in Article 11 (EU, 2018). Therefore, PfR can be considered a 'new' focus area and thus the core focus of this paper. Nevertheless, only a few case studies in the existing scientific literature have investigated the potential for PfR in reuse sites or recycling centres (Milios & Dalhammar, 2020).

In this contribution, we investigate PfR at municipal reuse sites in Denmark, building on previous research on PfR at reuse sites and recycling centres (Hultén et al., 2018; Ljunggren Söderman et al., 2011; Messmann et al., 2019; Milios & Dalhammar, 2020; Zacho et al., 2018a).

Our analysis aims to assess the experimental development of PfR by progressive, pioneering waste management companies in Denmark, including access rights and legal framework conditions. This will enable a better understanding of the possibilities for and constraints to PfR playing a larger role in future waste management for the circular economy (CE), as suggested by Zacho et al. (2018a) and the revised EU framework directive.

## Background: The transition from recycling towards preparing for reuse

### *Circular economy and the inner cycles*

CE entails a resource cycle understanding, proposing five circular strategies: narrow, slow, close, regenerate and inform material and energy flows (Konietzko et al., 2020). The two circular strategies most directly related to the scope of this article are: 'slowing' strategies (inner cycles), which pertain to product life extension and increased utilization of products by extending their use (e.g. PfR activities); and 'closing' strategies (outer cycle), which entail material recycling (Bocken et al., 2016). Based on environmental and economic benefits, a key principle in CE is that loops principally *decrease* from the inner cycles of reuse and repair to the outer cycle of recycling (EMF, 2012; Kirchherr et al., 2017; Stahel, 2010). This corresponds to the descending principles of the waste hierarchy. Thus, the time that resources are spend in the inner cycles should be maximised (Kohornen et al., 2018).

Reuse brings benefits of an environmental, social and economic character (Milios & Dalhammar, 2020). Since 2009, interest has been increasing in reuse-related issues of waste electrical and electronic equipment (WEEE) (Pérez-Belis et al., 2015) due to their environmental benefits (Bakker et al., 2014; Coughlan & Fitzpatrick, 2020; Deng et al., 2011; Hampus et al., 2019; Prakash et al., 2016; Zacho et al., 2018a), which can increase where collection takes place at the closest possible location to the user (Casey et al., 2019). Reuse can bring about social and economic growth (O'Connell et al., 2013), including local job creation, training opportunities for unemployed and disadvantaged people, and providing reused products for those of low income (Gusmerotti et al., 2019). Furthermore, reuse operations are often environmentally preferable over material recycling and the manufacturing of new products. For example, Ljunggren Söderman et al. (2011) have measured the environmental impact of reusing end-of-life (EOL), their results confirming that the greatest environmental benefit of reuse is due to the replacement of new production.

However, implementing slowing rather than closing strategies can prove a challenge for companies, as reuse processes are more labour-intensive than those of material recycling (Messmann et al., 2019), require additional coordination efforts (Hansen & Revellio, 2020), and involve market demands that can act as bottlenecks (Rizzi et al., 2020). Further, legislative barriers and a lack of financial incentives can limit reuse (Kissling et al., 2013. Thus, 'even a small target is necessary to encourage PfR' (Seyring et al., 2015, p. 73; REEUSE, 2012). Another significant difference is in the point of departure from traditional linear waste management, where waste should be managed 'safely and cheaply', to reuse and resources, which are kept in the system for 'as long as possible' (Williams, 2015, p. 241), demanding a change of mindset.

### *Potentials in waste in the waste system and how to exploit these through preparing for reuse*

Waste is perceived as a resource in CE (Ellen MacArthur Foundation, EMF, 2015), but only a few scientific scholars have conducted case studies on the subject of assessing the potential for PfR of end-of-life (EOL) products, disposed at reuse stations (Milios & Dalhammar, 2020; Zacho et al., 2018a). One study has analysed the theoretical potential of PfR of bulky waste in Germany (Messmann et al., 2019), a second has used a Danish case study of municipal PfR and recycling of waste (Zacho et al., 2018a) and a third has investigated the potential of PfR EOL products at private recycling centres in Sweden (Milios & Dalhammar, 2020).

In the case of Germany, Messmann et al. (2019) conducted a case study investigating the potential of PfR at collection points in the state of Bavaria. Their aim was to quantify the *theoretical* potential of PfR of WEEE, used furniture and used leisure goods. Their results revealed that 13–16% of used furniture, leisure goods and WEEE products could immediately be prepared for reuse (Messmann et al., 2019), indicating significant potential for reusing EOL bulky waste. A further 13–29% could be unlocked through changes in, for example, the model of collection, storage, and overall treatment of waste. For instance, 86% of damage caused toWEEE is attributed to a lack of sufficient weatherproof roofing.

Milios and Dalhammar (2020) investigated the reuse potential of EOL products disposed of at private recycling centres in Sweden. The aim of their study was to assess the type and the quality of waste in the waste streams of two sorting facilities at private operators in Sweden and to examine whether the waste could have been reused instead of recycled. Their results revealed significant potentials to collect and PfR products that are currently being recycled, as about one-quarter of the total waste collected could be commercially or functionally reused. That was particularly true for the product groups of building materials, furniture and white goods (Milios & Dalhammar, 2020). However, the results also revealed that it was not economically viable for private recycling centres to repair and sell these products with the current set-up (Milios & Dalhammar, 2020).

Zacho et al. (2018a) assessed the size and the characteristics of the potential value to be captured from the resources embedded in waste (cardboard, plastic, waste, wood, and items for reuse) at a municipal reuse site in Denmark. A municipal reuse shop and a workshop in which PfR could be conducted were part of the set-up. The results revealed a limited economic value creation potential for waste collectors when collecting for recycling, and that preparing waste items for reuse offered a greater potential both in terms of local employment and economic prosperity. The sales of reusable items covered the costs of the labour and logistics required for sorting out and PfR processing, and employment included nine contracted full-time workers and six employees on the fringes of the labour market. For this reason, Zacho et al. (2018a) suggested that the management option 'prepare for reuse' plays a larger role in future waste management for a circular economy.

However, PfR rates remain low (Coughlan & Fitzpatrick, 2020), and too many products that can still be used end up as waste (Dansk Affaldsforening, Danish Waste Association, DAF, 2017a,b; Hultén et al., 2018; Affaldskontoret, 2019). As a result, there is a large 'residual' of reusable products at reuse sites, i.e. things that are actually of good quality and could be used, but which have no major value and therefore are not in immediate demand by, for example, current (non-profit) reuse shops, and which also cannot be sold by the private sector (Affaldskontoret, 2019, p. 5). Although designing out waste is an integral part of a CE concept, waste is persistent and waste management companies have a critical role to play in terms of returning waste to the highest value (Directive 2018/851). Therefore, this paper focuses on constraints and possibilities for waste management companies to 'transform' and return products from the waste phase to the inner cycles of the technical metabolism, added with red in Figure 1.

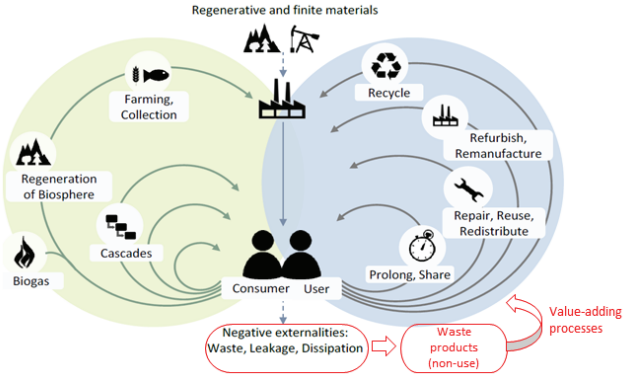


Figure 1. The biological metabolism (products of consumption) and the technical metabolism (products of use). Reprinted with permission from "Reflections on Sustainability Concepts: Aloha 'Āina and the Circular Economy" by Beamer et al., 2021.*Sustainability*, 13(5), p.2984. Copyright [2021] Creative Commons.

This research seeks to investigate and learn from the experimental development of PfR by pioneers with respect to circularity in the waste sector, which have been experimenting with and initiating preparing for reuse (PfR) schemes concerning a range of products, including building materials, furniture, white goods and bicycles, which are considered because they support the inner cycles of the circular economy.

Based on the literature, this paper aims to investigate different models for PfR activities that illustrates how PfR may expand and consist of different activivites in the chain – from waste to use. The papers take point of departure in Dalhammar et al.'s (2021) visualization of PfR in a chain perspective. As can be seen from Figure 2, PfR is embedded in a chain that recreates the product functionally to enable a use in the market but without integrating the product's value for use and market opportunities into the model.

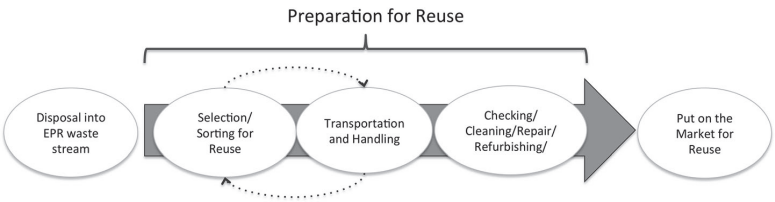


Figure 2. Elements included (and not included) in the preparation for reuse process. Reprinted with permission from Dalhammar et al., 2021. Enabling Reuse in Extended Producer Responsibility Schemes for White Goods: Legal and Organisational Conditions for Connecting Resource Flows and Actors. *Circular Economy and Sustainability,* 1(2), p.675. Copyright [2021] Creative Commons.

Therefore, we have sought to investigate different models that integrate PfR into a chain that includes use and market to understand how use becomes the focal point of PfR activities. Moreover, we have sought to investigate barriers that may hinder PfR practices from expanding.

The paper is outlined as follows. Section 2 presents the methodology, while sections 3 and 4 present the results and discuss these in relation to the concrete experiences as well as the existing literature. Section 5 presents the conclusion, limitation and suggested future research.

## Materials and methods

This paper is based on collaborative research which is part of a larger study – the EU project 'Intelligent Energy and Resource Systems of the Future' (FUTURE), spanning (Feb. 2018 to Aug. 2021) – which provided waste companies the opportunity to experiment and test new practices promoting CE and the inner cycles through preparing waste for reuse.

Two research questions set the frame for the empirical work:

RQ1: How are barriers and possible solutions regarding PfR reflected in the pioneers' practices with respect to circularity in the waste sector?

RQ2: To what extent does the legal framework support a change from traditional waste management with a focus on the inner cycles of CE?

The empirical work for this paper rests on selected case studies related to the project FUTURE, in which anthropologic-inspired field studies combined with desk studies were used to explore different types of PfR practices. In particular, solutions were examined in which waste products were reused instead of recycled and assessed through traces of narratives, documents and activities that transformations had deposited through the development from idea to implementation and operation.

### *Case study*

This paper adopts a case study approach to understand fundamental elements and issues characterizing the PfR practice. Case studies are instrumental in addressing 'how' and 'why' type questions, and when there is a need to analyse a complex phenomenon in-depth in its real-life context (Yin, 2003). Moreover, since case studies are rooted in actual practice, they can be further linked to action and thus help to change practice. The aim was to learn from pioneer waste management companies implementing or experiencing CE inspired solutions that support the inner cycles.

Case selection for this paper sprung out of work in the project FUTURE as experiences from these cases showed a tendency for some waste companies to break (more) with existing (linear) solutions compared to others (henceforth, frontrunners). Moreover, companies can be regarded as frontrunner companies because they have an innovative reputation (Zwetsloot, 2001), particularly with respect to conducting PfR activities, as well as their tendency to think beyond and challenge the framework in which they operate. That included new ways of doing things and examples supporting the inner cycles of a circular economy compared to recycling. Extreme cases expose ideas not seen in average cases and thus allow us to gain new knowledge about PfR development in waste companies (Flyvbjerg, 2006). For this purpose, five municipal waste management companies were selected as extreme cases (Flyvbjerg, 2006; Neergaard, 2007), from which eight PfR schemes were singled out to illustrate the diversity of PfR solutions. See Table 1.

Table 1 Municipal waste management companies and selected schemes

| Companies | Schemes |
|---|---|
| Vest Forbrænding (VF), Affaldsselskabet Vendsyssel Vest (AVV), Amager Ressourcecenter (ARC), Affald Plus (A+), ARGO, | Municipal reuse shops, Green tracks, White goods; WEEE (PPP), Bike repair, Reuse from a value chain perspective (PPP), Storage and sale of reuse building products (PPP), old bricks |

All companies were typical municipal waste management companies in the sense that they are serving the same purpose: to manage waste from their owner municipalities. Their activities include the operation of reuse sites where citizens can bring their waste and sort it for reuse, recycling or incineration, rendering them comparable.

### *Data*

The data collection aimed to follow the development of PfR schemes in the five case companies by tracing their activities over three years and between actors. Documents and materials were collected through a literature and document search, but also through snowballing in connection with our interaction with the key actors and stakeholders and field studies (Biernacki & Waldorf, 1981). Thus, a range of interviews, desk study research, and site visits complemented the study. Un-and semi-structured interviews were chosen due to their flexibility, allowing interviewees to disclose important yet unexpected information (Qu & Dumay, 2011). By applying mixed methods (Creswell & Plano Clark, 2011), we were able to combine a variety of interviews and non-intrusive methods (Brewer & Hunter, 2006) as well as compile a dedicated data archive (Larsen, 2014). Due to the strengths of each method, we could conduct analyses of practices and legal aspects from different angles, providing us with new insights (Frederiksen et al., 2014) and revealing appropriate practices, attitudes and perceptions on the topic as well as individual meanings and experiences. As an example, we also include the analysis to triangulate the knowledge obtained from the fieldwork, document studies of legal and state administrative documents, and a media analysis of a broad swathe of news stories. The complete list of applied methods corresponding to the paper's research questions is provided in Table 2, Appendix A. Moreover, a list of interviewees is presented in Table 3 Appendix B.

## Results

In our study, we have followed the work of waste companies in meeting the circular economy's objectives of developing and exploiting the potential for reuse, which sets the stage for some fundamental changes in the way waste(s) is included in the waste cycle. These initiatives are based on fundamental challenges in converting products and materials that have been classified and handled as waste to a form in which they can be reused in the same way as they were initially intended. These challenge, which have been the subject of only a limited number of academic and practical studies, are promoted through initiatives in the waste regulations' directives and guides on 'RfR'. Initiatives play an essential role in exploiting the potential for reuse, but also impose several limitations on exploiting the potential for reuse, which is linked to the understanding of 'reuse' that underlies the concept and more fundamentally the separation between product development and market development (see theory section).

The result section consists of two parts: first, PfR practices are investigated. Secondly, the practical implications of legal framework conditions for PfR and the development of public waste companies' activities and 'room for manoeuvre'.

### *Results part I: Preparing for reuse practices and value-adding processes among pioneers*

By following waste companies' experiments in developing solutions that promote the exploitation of PfR potentials, results reveal the emergence of a number of innovative solutions, which will be discussed in the following.

These initiatives help promote opportunities for the development and exploitation of reuse potentials and contribute to developing our understanding of how PfR and market development should be seen as integrated processes if waste is to transform to reuse.

The results show that waste companies develop solutions alone, and as network-based solutions concerning specific challenges that converting waste to reuse poses. Challenges relate to the technical, economic, organizational and institutional conditions that affect the product/material, its use and the market context.

Moreover, results reveal that the complexity of challenges and solutions presented here relate to both the innovative and the organizational complexity. The innovative complexity moves from incremental solutions, where minor changes occur within the existing mental, technical, organizational, market and institutional frameworks, to more radical changes where new ways of thinking are provided to one or more of the aforementioned frameworks. Organizational and institutional complexity can be understood as a more or less

complex landscape of actors and institutions that requires interaction and cooperation across current and future stakeholders. An overview of the various PfR experiments and practices presented in this result section is provided in Figure 3.

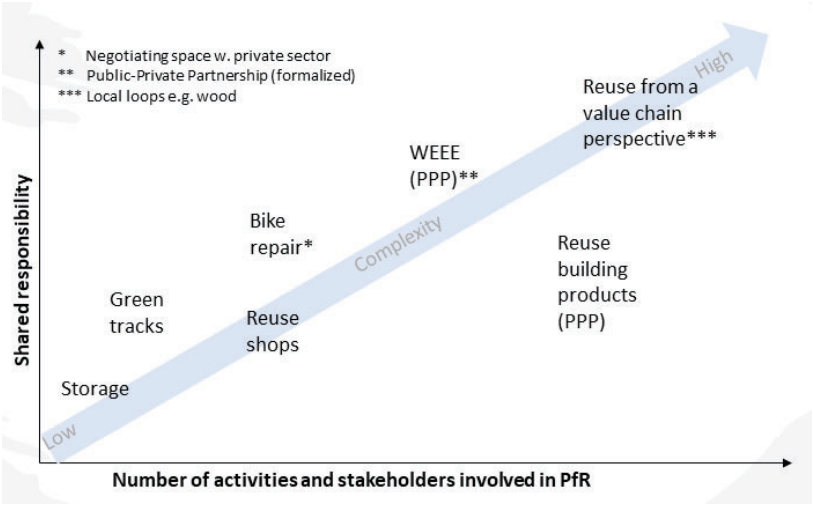


Figure 3 Solutions of varying organizational structures.

The review of the various experiments presented in this result section examines the following.

1. How to 'PfR': which reuse processes and relevant actors are involved/required, with particular emphasis on the three dimensions: selection/sorting for reuse, transport, and handling as well as checking, cleaning, repair and refurbishing.
2. How to create a market: which market formation processes and relevant actors exist, with particular emphasis on the interaction between actors, the framework for interaction and market processes.
3. How do experiments/activities contribute to changing waste actors' and the network's practices towards reuse, business and the environment?

## I Incremental preparing for reuse activities

*Municipal reuse shops – a gateway to the market*

Municipal reuse shops are an old initiative that the waste company AVV launched 30 years ago as part of an employment programme (Interviewee #4). Waste reuse is considered a residual product 'too good to throw away' and as a means of creating social activities in the form of employment and availability of 'cheap reused goods' through in-store sales located on the reuse site. The items sold in the municipal reuse shops are derived from bulky waste, donations and items 'saved' from waste containers by staff at the reuse site.

The AVV store was not originally a natural part of "prepare for reuse." No special activities were associated with taking residuals out of the waste stream but instead bringing product/material that had the original functionality on the market when sold (Interviewee #4).

Thus, the concept is considered a means of bringing the product to market rather than a market-creating activity. One could also argue that the store acts as a gateway to the market, a self-organized mechanism that will automatically ensure reuse.

The store plays a limited direct role in PfR and market formation. The store, however, is becoming increasingly important due to a large increase in turnover and employment, which is linked to changing consumption patterns (trendy with use), more dynamic profiling of reuse, and its value in local communities. As an example, AVV annually sells 1,000 tons of items that have been prepared for reuse in its store and employs fifteen people, nine of whom are contracted full-time employees, while the other six are workers on the fringes of the labour market, employed on special conditions
Those elements influence how reuse is included in the company's practices. Thus, the company becomes aware of the business value of reuse, which helps to motivate increased sorting and control (PfR) and increased marketing activities, including online action of valuable products, the development of collaboration with charity shops concerning delivery/donation of clothing, as well as an increasingly better understanding of usability - and not just reuse.

*Green tracks optimizing potentials for preparing for reuse*

'Green tracks' focus on the optimization potentials that lies in the first part of PfR by involving citizens and employees in sorting the usable waste. These are commonly situated at the entrance of the reuse site, where citizens are guided to sort out reusable items which are then prepared for reuse (checked, cleaned and/or lightly repaired) and sold in one of the shops (Interviewees #2,3,4, 5, 10).

Thus, green tracks function as an incremental development of PfR. The focus is primarily on optimizing the dominant practice of keeping the usable waste separate from the heterogeneous mix waste streams, ensuring a more significant amount of reusable products of better quality – with minimum effort. In addition, the focus is on maintaining the quality of the waste and avoiding it deteriorating in the process.

Green tracks do not directly affect market formation but support the waste company's ability to deliver waste as reused products to a 'waiting market'. Moreover, green tracks function to motivate and support the delivery of reused products.

Green tracks are an incremental development that primarily optimizes the waste company's resource consumption (work, cost) for reuse and helps support the internal anchoring and organization of reuse as part of practices at the reuse sites and down through the organization. Experiments with green track separation reduced the amount that went to incineration and increased clothes for reuse by 300 per cent; in one case (interviewee #2) and elsewhere, 24 per cent more were collected for reuse (Interviewee #5). In addition to increasing efficiency, it reduces the cost of this by allowing citizens to sort and make recycling more visible to both citizens and employees, which has a learning effect on the groups mentioned and their behaviour. In addition, 'Green tracks' contribute to a change of mindset.

## II Upgrading of preparing for reuse and market creation

*Preparing WEEE for reuse*

The WEEE directives challenge waste companies' linear practices and competencies and provide new opportunities to develop and exploit reuse potentials. Challenges include requirements to 'prepare for reuse' activities concerning re-establishing waste as usable products but also challenge the idea of an existing market.

PfR of WEEE products entails the development of PfR activities to include all three elements: sorting, handling and repair, which requires the development of the product's usability and competence.
In this case, the concept of usability is extended to include the product's material functionality and the functionalities that make the product usable for the user in use-situation access to service, spare parts certifications, and standards. The intangible parts are essential for the product to be experienced as attractive. The new activities mean that the company must explore new opportunities for partners and employees to develop the right capabilities that can ensure the product's usefulness.

Market formation plays a crucial role in the marketing and reuse of the product. Therefore, the physical functionalities are not sufficient for the product to become available on the market. Market availability depends on the product having a character that makes its use-value sufficient for customers to buy it. The immaterial parts of the product, such as guarantees, insurances and certifications, play a crucial role. These elements help support the buyer's belief that the product is usable. A complete set-up consisting of distribution and service systems that can guarantee a product quality that is competitive with existing product and service systems must be created around the product.
For example, a prerequisite for collecting a sufficient number of good-quality appliances for reuse is to develop a collection method that complies with WEEE rules, does not destroy the reuse value of the products during transport and is cost-effective. For testing and refurbishing, AVV collaborates with a local one-person business, the local job centre and a collective scheme called Elretur (Interviewee #4, 5). Once the products have been tested and refurbished, they are put up for sale in AVV's second-hand shop, alongside a product information sheet and the terms of trade. Products are also sold with a six-month warranty followed by an additional eighteen-month 'right of complaint'. (Interviewee #4, 5).

WEEE for reuse is a radical innovation that challenges practices and capabilities in the company. It is, therefore, necessary to develop new capabilities in the form of new routines and competencies, recruit employees with these competencies, and cooperate across markets and institutional frameworks to provide the business, market and institutional basis for the development of activities.

*Bike repair*

Bicycles hold great potential for reuse, as many bikes end up as recycling material, even though they could be prepared for reuse and sold. However, the existing structure of professional repair has hampered the waste companies' development and exploitation of the reuse potential. This has led to a negotiation structure in which only the highest price/quality bicycles are attractive to the private operators, or bikes are sold as 'scrap metal' (price/kilo) (Interviewees #8, 9). Interviews revealed that developing this reuse potential as a business area requires dialogue and collaborative PfR, market formation, and legitimacy (Interviewee #4).

Preparing bikes for reuse requires a framework for the waste companies to participate in these activities, consisting of dialogue with stakeholders in the repair ecosystem (Interviewees #4, 9). For example, dialogue makes it possible to create a division of labour in preparing activities that will upgrade bicycles to market and regulatory standards. In the case of AVV, the company is responsible for preparing activities that restore the functional characteristics of the bicycle, as repairing the bikes would be too costly and time-consuming for bike dealers, while dealers upgrade the bikes to the regulatory standards by applying reflectors and locks. Upgrading, the functional standard of the bicycle, requires that AVV has established a bicycle repair shop and hires employees who can handle these activities in cooperation with the other employees (Interviewee #4).

Market availability requires cooperation that enables services, guarantees and insurances to be obtained, allowing bicycles to be sold in a market. Activities require cooperation with local dealers and repairers of bicycles and other stakeholders, such as insurance companies, authorities, etc. Cooperation impacts the institutional framework for delivering PfR in this area. It requires legalization (approval) for a municipally owned waste company to enter the market, which also requires that the price of bicycles prepared for recycling reflects the market price.

The waste company's development of reuse potential is thus a disruptive innovation that breaks with the existent linear waste practices.
Institutional innovation, which breaks with the municipal waste management practice, made possible through dialogue-based practices with the local bicycle ecosystem's stakeholders, opens up the possibility of exploitation without entering private market domains.

However, these measures place demands on the capacity of waste companies to be institutional entrepreneurs and the development of cooperation and repair capabilities.

**Upgrading preparing for reuse to market creation and industrial use**

*Development of supplier systems/chains for the reuse of bulk wood*

Large volumes of waste wood, for example, stemming from construction and demolition, pose an environmental and reuse challenge concerning PfR, market formation and business development (Interviewee #2, 9, 10). Wood is bulk material with a large volume and many reuse options, but also a material that, as a waste, has a low value and where the industrial requirements place requirements for availability of the material on the market and particular specifications and qualities (Interviewee #2, 8, 9,10).

Preparing for use activities include all three dimensions concerning preparing activities, emphasizing sorting and storage. The challenge is that wood waste comes in many different types, qualities, and sizes mixed, and it can therefore be much work and costly to separate, sort and store, not least given the low-value content that most waste has. Intangible activities such as administrative systems are also labour-demanding and cost-demanding.

These challenges place demands on the development of market and business networks, which is why waste companies such as Affald Plus have taken the initiative to build up local business networks to help create a framework for e.g. wood to be part of one or more business cycles. See Figure 4


Figure 4 Potential local wood value chain (illustration based on Niras, 2017).

In these local cycles, industrial producers play a key role in the way the wood is reused. The waste company is, in this case, an intermediary between waste collection and industrial circuits, governed by companies whose business base is built on wood reuse, emphasizing inner circles. The major obstacle proved to be meeting the private sector's demand, guaranteeing *flexible access* to resource flows (Interviewees #2, 3). However, supplies (waste) fluctuate over time. Thus, to accommodate demand, a storage space was needed, both to build up volume until the products/materials are demanded by collaborators, and to protect these products/materials from being damaged by rain (Interviewees #2, 3, 9). In addition, this set-up requires an online registration and communication system to communicate the types and amounts of products available to the private sector actors. On this basis, a market system linked to investment in a warehouse building can act as a marketplace for players seeking reused materials but requires significant investments (Interviewees #2,3).

*Reused Bricks*

The municipal waste companies see the reuse of building materials such as old bricks as a significant challenge for promoting circular principles of reusing locally (Interviewee #2, 4, 9). Usually, most construction waste is crushed and recycled. However, the waste company AVV sees it as a critical task to contribute to local, sustainable development by transforming construction waste into reuse and has therefore established a company that produces reused bricks (Interviewee #4). The business idea is based on a patent developed by the company "Gamle Mursten," [Old Bricks] making it possible to recreate functional bricks by separating, sorting, and cleaning old bricks at an industrial plant. " Old Bricks " has spent 15 years building documentation and knowledge that makes

brick reuse commercially possible. To provide the necessary technology, knowledge, and experience that lies outside the municipal waste companies' technology and business competencies, the company started a collaboration with " Old Bricks " as co-owner and renamed “Genbrugssten” [Reuse Bricks]. (Interviewee #4).

The starting point for this transformation of waste for reuse is an investment in patented technology, access to knowledge, and competence to build the necessary prerequisites and relationships for using reused brick. The latter access is crucial for AVV to see business opportunities in the project.

The reuse of bricks in the form of functional bricks is within the traditional functional technical focus in PfR. However, the reuse potential is utilized in interaction with market players and research and development institutions, as functionality alone does not live up to market requirements. An advanced industrial market requires documentation for several properties for reused building materials. Requirements include documentation of quality and environmental certification, including EDP, which means that products meet stakeholders' construction requirements: builders, architects, financing, insurance, and authorities. Requirements that have taken "Old Bricks" fifteen years to live up to through the development of experiments, tests, and dialogues with construction stakeholders in collaboration with research, development, and consulting institutions.

Especially the knowledge-intensive documentation of technical and environmental properties has been crucial for reused bricks to gain access to the market. On the one hand, market access has been crucial for utilizing the reuse potentials. On the other hand, market access also limits how significant a potential could be due to asymmetric competition in existing markets with well-established products.

'ReuseBricks' seeks to solve this dilemma by transforming the reuse history (externalities) from a cost to an income. The scientific documentation is combined with cultural and aesthetic documentation and stories, making it possible to make reused stones unique by connecting them with specific buildings, events, and places, making them attractive to specific market segments and uses. It requires collaboration with actors throughout the construction chain. Architects can use the stone's unique cultural and aesthetic value to create value. The builder can create value in construction and residents/citizens to experience and maintain cultural/local values.
For the PfR activities, value is created through collaboration with actors in the entire construction ecosystem, which extends beyond actors in the construction waste chain and its markets. Counseling and knowledge institutions play a central role in enabling potentials to be unfolded by creating unique markets and needs.

Thus, the frontrunners related to circularity in the waste sector have brought about innovative changes, adopting new reuse approaches. Although some solutions are achieved by developing activities under the regulatory ‘radar’ while others are developed to challenge legal framework conditions, examples have provided the inspiration for various solutions. A range of key insights obtained from different types of solutions is presented in Table 4.

Table 4. Schemes and key insights

| Scheme | Key insights from solutions to increase reuse (PfR) potential |
|---|---|
| **Municipal reuse shops** | ● allow for the sale of low value ‘waste’ products (high volume)<br>● minimize premature recycling or incineration of reusable (high volume)<br>● create local jobs (ordinary and for people with special needs)<br>● challenged by-access rights and legal framework conditions<br>● push for policy changes |
| **Green tracks** | ● Support function:<br>  ○ mindset changes amongst citizens<br>  ○ minimize the risk of reusable product/material ending up in recycling/incineration<br>● distinguish between waste and non-waste<br>● allow for incremental change |
| **White goods; WEEE (PPP)** | ● strengthen relationship links with formal contractual public–private partnership (PPP)<br>● a prerequisite for creating a sustainable business model that supports the triple bottom line |

| | |
|---|---|
| | ● facilitates alliances with experts in the field<br>● in a purely public set-up, the quality control would be missing<br>● in a purely private model, there would be a lack of incentives to develop a model with the same environmental goals and secure local jobs for people on the edge of the labour market<br>● difficult to invest in sufficient sales channels when supply is fluctuating<br>● careful collection and logistics cannot be secured unless municipal waste management companies are actively involved<br>● create jobs locally |
| **Bike repair** | ● aligning PfR with existing local repair solution<br>● dialogue with local business to find common solutions<br>● increase reuse as repairing is too costly and time-consuming for bike shops<br>● creating jobs for people on the fringe of the labour-market e.g. learning new (repair) skills<br>● feedback loops e.g. new communication channels and wider social value |
| **Reuse from a value chain perspective (PPP)** | ● support systemic thinking<br>● allows for systemic intervention e.g. business model innovation, increase access to solutions, reshape supply<br>● increased cross-sectoral collaboration<br>● costly and time-consuming:<br>● mapping potential local partners and conducting local market screening is a core element<br>● meeting the private sector's demand calls for development and investment in a new system that would guarantee that the private sector has flexible access to resource flows i.e.<br>o storage space to build up the volume<br>o a comprehensive registration and communication platform which (with minimal manual effort) can register and communicate waste prepared for reuse to partner companies<br>● change of mindset i.e.<br>o greater consideration of value chains and how local companies can be weaved into them<br>o break down silos (internally and externally) |
| **Storage and sale of reuse building products (PPP)** | ● prevents products/materials (e.g. building materials) from being incinerated/prematurely recycled, including waste from the private sector<br>● costly and time-consuming (e.g. constructing storage, justifying the value chain model)<br>● a reuse market for construction waste is 'troublesome' e.g.<br>o products and materials are large, long, and take up a lot of space, or else they are heavy<br>o there is only a small profit margin<br>● challenges the EU waste framework directive and access rights<br>● storage (support function) a prerequisite for creating a business model based on local value chain thinking (PPP)<br>● saves time on logistics; companies deliver to 'the doorstep' |

*Summary*

The increasing demands for a transformation to circular waste treatment have encouraged waste companies to initiate experimental development initiatives that open up for rethinking both content and relationships in the PfR concept.

PfR, in the traditional form, focuses on recreating products and implicitly assumes that there is a market for this. The market mechanism is considered to work if the product's functionality corresponds to the original product. PfR activities in this segment often consist of 'sorting' and 'selection,' as 'repair' gives costs and therefore must be

financed, which ten happens through sales. See model 1 in *Figure 5*. The line below figures 4-7 illustrates how PfR activities expand from PfR in the original form. The eclipses illustrate how the waste companies' ownership relationship changes with the PfR models

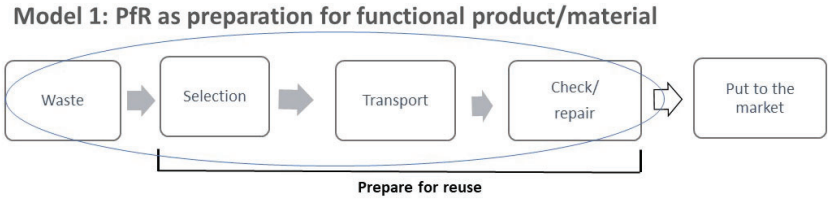


Figure 5: PfR in the original form

The first types of initiatives aimed to develop practices based on the companies' linear waste practices. Focus is primarily on optimizing the handling of incoming waste in its original form through "Green track" and bringing products to the market by opening for sale through "second-hand shops and auctions."
Thus, PfR focuses on preserving and restoring the product's original value. Emphasis is on the PfR activities sorting and selection. However, it may also include a limited range of minor "repair" activities, as sales provide an opportunity to reduce costs. The value in these activities thus lies in making the reuse potential visible, contributing to a mindset change, not only for visitors at the reuse site but also for employees and the company. See Model 2 in Figure 6.

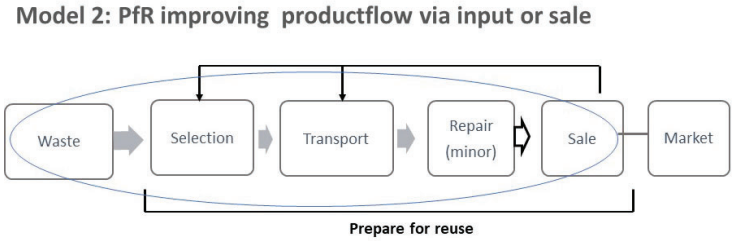


Figure 6: PfR extended to include sale activities

The types of PfR consisted of several initiatives to promote reuse by focusing on product restoration through repair activities for sale in own stores (whitegoods and bicycles). Repair activities developed from lighter repair activities, which ensured the functional properties of the products to include services related to sales, i.e., increasingly, include services such as warranty, service and insurance. Sales and thereby access to the market was made possible through negotiations with local business organizations

The functional upgrade required the waste companies' "repair competence and facilities", which required investments in facilities, employment of qualified employees, and the development of new business and collaboration models that went beyond the traditional forms of business models (whitegoods and bicycles). See Model 3 in Figure 7.

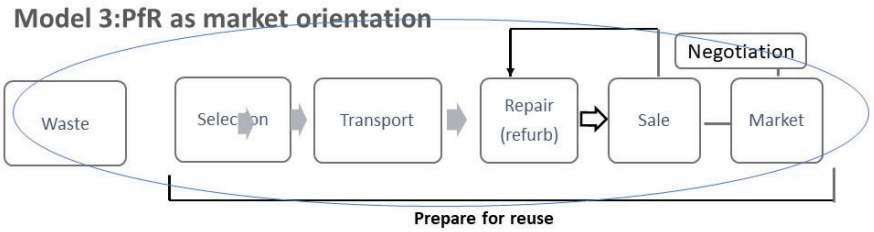


Figure 7: PfR activities extended to include sales and market activities

Bringing reusables into the industrial market posed significant challenges for waste companies, with the market formation and customer requirements coming to the fore. PfR operations were no longer just a matter of establishing a product whose properties had been upgraded to newer use requirements (refurbished). It also required that products were designed for the socio-technical context an industrial market constituted, i.e. that there was a stable relationship between supply and demand, e.g. building materials and reused bricks, and an adaptation to the socio-technical and regulatory requirements from stakeholders (reused bricks).

Market creation becomes crucial for reuse, and the market is thus crucial for the way reuse is prepared. The preparation is primarily preparing for a market that plays back on the entire chain. Thus, the PfR is based on the requirements for the development of the market. This requires upgrading repair to refurbishing and upgrading the supply-chain relations. Model 4, see Figure 8.

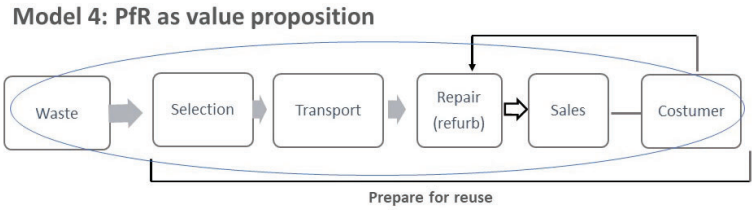


Figure 8: PfR activities extended to include market formation and costumer requirements

### *Results part II: Practical implications of legal framework conditions for PfR and the development of public waste companies' activities and 'room for manoeuvre'*

Under the revised EU Waste Framework Directive, all European countries will have to recycle and PfR at least 65 per cent of municipal waste, by 2035 (EU 2018/851). This includes implementing CE business models that encourage extended use of products, components and materials.

In Denmark, the municipal council is in charge of handling waste, as stipulated in the Environmental Protection Act (LBK nr 1218 af 25/11/2019, §45, Art. 1). Municipal waste management must take place in accordance with the EU's waste hierarchy, where PfR is the priority, as stated in the Danish Waste Order (BEK nr 2159 of 09/12/2020, §13). Thus, there are new insights to be gained from the CE concept, but it also puts pressure on the waste sector, governed by the waste hierarchy.

However, according to the Danish National Board of Appeal [Ankestyrelsen], a municipality can only carry out an activity to the extent that there is a municipal interest in the activity (Ankestyrelsen, 2017). Moreover, it is generally assumed that municipalities cannot conduct trade or financial activities without legal authority. The

background for this is the consideration of avoiding distortions of competition with the private sector (Ankestyrelsen, 2017). However, the ban on municipalities conducting trade has been modified in several ways (Ankestyrelsen, 2017). Moreover, according to the municipal power of attorney rules, municipalities and municipal communities have access to make certain dispositions without actual legal authority (Ankestyrelsen, 2017). Thus, the municipality has a general obligation to prepare waste for reuse. However, there are no exhaustive rules on how exactly this should be done (Ankestyrelsen, 2017). Moreover, items that are handed over for direct reuse are not regulated by the Danish Environmental Protection Agency's rules, as they have not become waste (Ankestyrelsen, 2017). This has led to some disputes between actor-related access rights and to defining waste/nonwaste, discussed in the following.

Our document analysis of registry data revealed that, in 2015, three municipal waste management companies were accused of acting in violation of the legislation by receiving items from citizens, preparing them for reuse and reselling them (Ankestyrelsen, 2017). Trial documents from the state administration indicated that the representative Confederation of Danish Industry (DI) sent a complaint to the Danish Appeals Board questioning whether municipal reuse sites can be allowed to set up reuse shops. Further, it claimed that municipalities have 'no legal authority to sell items delivered at the reuse site' and disputed whether 'products sold in the shops [were] in fact, waste' (Ankestyrelsen, 2017). The accused companies acted differently from the accusations. As an example, AVV stated that at the time of the case, some waste management companies took a stand:

> We are not doing any activity [that] can be interpreted as an illegal act from our side; [this includes] VF, the largest municipal waste management company in Denmark.

Following this statement, VF sought juridical assistance on the legal matter from two different law firms, one of which was supportive whereas the other was not, leaving the company in a 'legal grey zone'. During the trial, the media presented a negative picture, stating that it was 'not OK' for municipal waste companies to run second-hand shops and that municipal waste management companies 'stole' usable materials from charities. Our media analysis provided further insights into some of those controversies. One example of a local news story had the heading, 'Put an end to the public task theft', in which the DI's marketing manager commented on the establishment of municipal reuse shops as follows:

> What we see here is an example of public task theft. Unfortunately, in many cases, we see that the municipalities intervene and offer services that undermine business and industry…The problem is that it is getting a lot harder for charitable institutions to make money. (Århus Stiftstidende, 2016).

As a result, VF closed its largest and most successful reuse shops. However, AVV stated:

> Although it was a stressful time, not least for the 15 employees at the second-hand store [who listened] to the radio accusations using words like 'it is forbidden', 'cheating', 'task theft', we chose to continue. But, we chose to stay in the grey zone for two years until the decision came from the Appeals Board, because we believed that what we did was in line with the waste hierarchy.

The decision of the Danish Appeals Board stated that municipal waste management companies may prepare waste for reuse if products are sold at market price (Ankestyrelsen, 2017). From a legal perspective, however, lawyer Henriette Soya argued that the answer received from the Board was not sufficiently clear and left room for interpretation by both parties. For example, how does one define when something becomes waste? Moreover, how does this relate to preparation for reuse and waste prevention?
From a legal perspective, Soja stated:

> This is a good question, because is an item 'discarded' if a citizen places it in a special reuse container at the reuse centre, or is it not waste already when the citizen delivers it to the reuse station or as bulky waste?

Therefore, municipal waste management companies were left to operate in a legislative 'grey zone', compelling them to navigate a 'not clearly defined' framework (Soya, personal communication). As VF claimed:

> It is not allowed without 'bending some rules'. However, we acknowledge that others do it. Take, for instance, A+. They are innovative and great at coming up with new ideas and solutions whenever they,

> in legal terms, 'hit the wall'…The legal framework promotes neither prevention nor preparation for reuse and therefore should be challenged.

Court documents and consultation responses revealed that the case opened a procedural conflict over waste products involving a range of actors. An overview of actors playing a role concerning progressive waste companies room for manoeuvre is provided in Table 5.

Table 5. Actors that play a role concerning frontrunners' room for manoeuvre

| | |
|---|---|
| Regulation | - EU Waste Framework Directive (2008/98/EC) as amended by Directive 2018/851, including the waste hierarchy and definitions of 'waste' and 'PfR'<br>- New Danish Green Deal on Waste and CE |
| Other actors | - Confederation of Danish Industry (DI)<br>- Confederation of Voluntary Organisations (ISOBRO)<br>- Danish Appeals Board<br>- A law firm (HORTEN)<br>- Danish Waste Association (DAF)<br>- Denmark's largest waste company (VF) |

Interviews revealed that the decision, combined with the negative press, made most companies distance themselves from conducting PfR, but a few waste management companies saw the decision as a window of opportunity to experiment or expand existing PfR schemes and challenge the legal framework, reflected in the schemes presented in Figure 3.

However, in June 2020, a new climate plan for a green waste sector and CE for Denmark, was reached by a broad political agreement and included visions for reuse:

> The objects [reusable at reuse sites] must first be available for private actors, including voluntary organizations and citizens. Objects not wanted by these players, the municipalities may sell in municipal second-hand shops or to socio-economic enterprises" (Regeringen 2020, pp.13–14).

Consultation responses revealed that the agreement met critique by the Danish Waste Association DAF and progressive waste management companies because they fear the agreement will cause a negative environmental impact (Energistyrelse, 2021). Moreover, the government's law draft for the reorganization of the waste sector goes beyond what a parliamentary majority agreed with the Climate Plan for the green waste sector and circular economy from June 2020 (Regeringen, 2020). This is at least the main message in the Danish Waste Association's consultation response (DAF, 2022). For example, although the climate plan explicitly states that the municipalities are obliged to offer compulsory tender requirements on recyclable household waste only, the compulsory tender requirement in the law draft is extended to PfR. Thus, the law draft 'over-implements the climate agreement', including more bands regarding PfR, than agreed politically (DAF, 2022, p.1). This narrowed room for manoeuvre, combined with uncertainty is considered a barrier to PfR amongst actors.

## Discussion

The analysis shows that there is limited knowledge and research within the specific challenges that the transition to a circular economy poses to the transformation of materials and products that have ended up as waste. The limited knowledge and research point to

1. Waste holding an essential potential for reuse, exploited only to a limited degree, which is both an environmental and economic challenge (Messmann et al., 2019; Milios & Dalhammar, 2020).
2. The organization of the waste sectors (municipal waste companies) collection, management, and treatment methods plays a vital role in exploiting these potentials (Milios & Dalhammar, 2020).

This paper contributes with examples of how waste can be redefined as products and transformed into reuse based on the waste collected, handled and processed by municipal waste companies.

Over some years, we have followed waste companies' experimental approach to solving the challenges of converting waste for reuse after users have disposed of it (Moalem, 2022). The experiments show challenges in understanding and practising the transformation of waste products for reuse. The process seems more complex, innovative and interactive than what is laid out within the dominant CE-based paradigm (Moalem & Kerndrup 2022; Moalem 2022). That also implies methods and the opportunities that municipal waste companies hold to solve the complex, innovative challenges inherent in transforming waste into products that have usability and value for future users.

Against this background, we will discuss the following:

1. *The basic paradigms* underlying the transformation of waste for reuse consisting of a critical assessment of the key concept of '*PfR'* which, despite important guidelines for restoring product functionality, is a concept that imposes several limitations in restoring the product's usability and its market.
2. The *opportunities that municipal waste companies* hold to redeem the reuse potentials of waste in interaction with stakeholders.
3. The *challenges posed by the current initiatives* on the development and conversion of waste, including the transition towards a CE in Denmark.

## *The basic paradigms behind the transformation of waste into reuse*

The EU amendments of Directive 2018/851, which were an element of the circular action plan communicated by the Commission in 2015, are crucial to the ongoing transformation of waste paradigms and actions (See introduction for additions). Specifically, it is expressed in the definition that reuse concerns the recreation of a product to its original form. Moreover, the concept of 'PfR' concerns the activities ensuring that waste is transformed into original form through various activities (Messmann et al., 2019; Milios and Dalhammar, 2020; Dalhammar et al. 2022, Kemi, 2022). See Figure 2.

As described in the result section, prepare for reuse activities are limited to those that can maintain and restore the functional characteristics of the original product. This, however, reflects a limited understanding of the importance of 'usability' related to the concept, including the ability to recreate the material/product as a product that has value to the user and, more fundamentally, the framework needed to recreate a product and put it back into service, which requires the establishment of a transaction and user infrastructure.

Our study on waste companies' work to reuse waste shows that through their experimental activities, they have understood the importance of 'usability' to recreate a product by relying on the use-and-market situation. Thus, the case of hard white goods shows how the material and intangible aspects are taken into account when the product's value is restored (quality, aesthetics, service, insurance, certification, job creation). As a result, market relations and 'value proposition' are developed in which the intangible parts play an essential role in establishing distribution, service, and repair activities.
Market creation also plays a decisive role in establishing market relations, such as in the case of bike repair. The example of reused bricks shows that within the B2B market, intangible parts of the product are essential for it to have value for the industrial users in the construction chain; and for the development of market segments.

Our study of waste companies' experiments with preparing waste for reuse thus helps to critically examine some of the basic concepts and methods used to promote waste reuse that are essential for creating reuse and the reuse of these products. This implies that products must contain use-value and channels established to allow interaction and market exchange (Moalem & Kerndrup, 2022).

Another challenge to the basic requirements for PfR is *an environmental condition*, where the experience of the white goods indicates that a selection of white goods is based on their energy label in order to avoid sending products for reuse that the environment, and to avoid greenwashing (Bolldocski 2021, Messmann et al 2020, Milios & Dalhammar 2020). This is initiated on the company's initiative and points to the importance of developing criteria that make it possible to differentiate products for reuse based on environmental criteria. Here, the eco-label served as a guideline for the waste company so that only 'A' branded white goods were reused.

Several reports, including Kemi's (2022): Regulatory for remanufacturing, Delgado et al., (2009): End of waste criteria, The EU commission (2015): Study on WEEE recovery targets, as well as articles (Dalhammer et al. 2022;

Milios & Dalhammmar 2020) support our empirical analyzes of how reuse of waste is not reduced to include the product-oriented PfR activities only, but also include activities up and down the waste chain. Despite the many empirical facts, these are not used to develop a more coherent conceptual understanding of PfR, which integrates PfR activities into an overall understanding of the waste ecosystem.

### *Waste companies' role in developing potentials for reuse*

The development work of waste companies, e.g. experiments with new solutions, is central to developing potentials for reuse, not only restoring the products physically but by restoring the value of the waste through a focus on what makes the product experience as having value for the user and at the same time differentiating the product from other products (Zacho et al., 2018 a, b; Milios & Dalhammar, 2020, Christensen, 2021).

Developing new productive capabilities has been necessary to restore and upgrade waste products. For example, the repair of white goods and bicycles has made it necessary to develop specific functions and competencies, *competencies developed in the company and in collaboration with external actors*, such as in the white goods example where there is a collaboration with an independent entrepreneur employed part-time in the waste company. This can also be achieved by developing new business companies, such as dealing in reused bricks, which started in collaboration with another company and became a self-ignition part of the waste company AVV.

The development and creation of the market are essential prerequisites for successfully reusing the recreated products. In the PfR concept, the market is taken for granted, which may be linked to the assumption that a market exists. This may be why the potential for PfR is only solved to a limited extent or not resolved. However, the assumption that there is a market contains several pitfalls. First there *is no market* for the recreated products. Secondly, the current market offers only limited opportunities, as recreated products are perceived as 'secondary' to existing products. Third, a market based on the product's unique qualities is created.

1. There is no market because the product does not meet what users need, and market players do not consider the product suitable for existing product markets.

2. The existing market is based on new products and the technologies, qualities, prices and usability, which is why reused products are classified and perceived as being of low quality. Therefore, they are sold as products aimed at specific social groups that are market segments. The white goods example is an example of the product being given less value and thus a lower price, making the product attractive to social groups who find it difficult to pay the average market price. It is often highlighted as a quality but, in many cases, can be seen as an inability to incorporate other values into the product. (It may therefore be essential to consider that social washing, in some cases, shifts the focus from environmental internalization to social internalization.)

3. Reused products can have a unique character based on the value inherent in the reused products/materials history, internalization of environmental/climate effects, and aesthetic dimensions. The example of reused bricks is an example of how to manage to internalize the history, culture, environment and aesthetics of the value proposition, which allows the product to be differentiated from other bricks. The value can be captured by the company selling the reused bricks by taking a higher price (Moalem & Kerndrup 2022)

The analysis shows that municipal waste companies can play an essential role in developing and exploiting the potential for reuse. However, those waste companies are challenged by the market policy conditions they are subject to. As public companies, there is a very narrow framework for how they can be involved in the development and exploitation of PfR potential. Thus, proactive waste companies are constantly struggling to make their reuse activities legitimate, opening up conflicts whenever they try new initiatives. This discourages many waste companies from considering or starting new activities that lie in the tension between public and private. At the same time, the entrepreneurial companies try to rise to the challenge, despite requiring many resources to get it legitimized. For example, AVV managed to start up the reuse of white goods and bike repair because the waste company views PfR as essential for the company to live up to the mission of waste companies: to minimize the environmental effects of waste. For this reason, AVV has invested a great deal of effort in building alliances across

sectors, companies and stakeholders, as well as investing resources in building up the necessary legal expertise for these political and legal conflicts to test and circumvent.

An essential driver of the waste companies studied is that they see the environment as crucial to their mission, which impacts the importance they attach to the environment in developing business models and partnerships. For white goods, this is reflected in the apparent prioritization of only white goods with energy class A that were prepared for reuse and the choice of potential reused products that require excessive transport distances.

The waste companies' challenges in the form of a cross-pressure between the CE requirements for reuse and the minimal room for maneouver set by the public regulation are also seen in several analyses by Dalhammer et al. (Millios & Dalhammar 2020, Dalhammar et al. 2022, Kemi 2021, Zacho et al. 2018a). The analyses show how the cross-pressure limits opportunities to utilize the vast potentials and thus limit the environmental consequences of waste. Therefore, there is a need to improve the framework for reusing waste and develop the capabilities of companies and partnerships.

### *The policy framework conditions for exploiting preparing for reuse potential*

The analysis shows that the policy framework conditions play a crucial role in exploiting the potential of reuse and the actors involved. We have previously mentioned the central importance reuse has in the EU's circular economy actions/policy as a critical element of plans to meet environmental and climate objectives and the concrete methods for identifying, assessing and exploiting PfR potentials. However, we have also seen how municipal waste companies have had a very narrow scope to develop and exploit reuse potential, as justified by the legislative tasks and the very narrow possibilities that the companies have concerning cooperation and competition in markets (Ankestyrelse, 2017).
Despite these limitations, individual waste companies have developed initiatives that contribute to a better understanding of how PfR potentials can be developed and how to achieve reuse through innovation, collaboration and partnerships. However, these experiences seem to be reflected only to a limited extent in the latest waste and circular economy action plans, which call for a rethink of regulation and organization in this area.

The analyses show that once products are discharged and collected, reuse is much more complicated than for products that have not passed the waste threshold. Moreover, transitioning from recycling towards reuse includes establishing effective systems for legal frameworks (Williams, 2015).

However, due to the unclear legal framework and definition of waste, actors are unaware of who has the right to explore present reuse potential and who is responsible for this to happen. This issue has led to a legal debate concerning municipal waste management companies that engage in, for example, reuse shops, raising questions like, 'Are the products sold in the shops in fact waste?' However, waste is a generic concept, defined differently by authorities (Pires et al., 2019). From a legal perspective, Luciano Butti (2012p.1621) has pointed to this same challenge, stating, 'One of the most distinctive features of waste is that it creates legal problems at both its "birth" and "death"'. He also points to the first problem by asking, 'When does waste come into being?' and furthermore, 'the apparently simple definition of the concept of waste, seems to be "impossible" to outline in regulatory terms' (Butti, 2012, p. 1621), highlighting the unfortunate linkage between this ambiguity and the EU waste hierarchy. As a result, companies conducting PfR seek to legalize their actions either verbally (e.g. 'I define everything that comes inside my fence [reuse site] as waste') or by establishing green tracks to define 'non-waste'. This indicates that entrepreneurial waste companies want to work with PfR but they feel the framework is too narrow and they feel they will be penalized if they do so, i.e. that there is a narrowing of initiatives and so they seek to increasingly withdraw from the PfR tasks. On the other hand, the grey zone is also a window of opportunity and the possibility of interpretation that makes companies try out new approaches in the search for finding new solutions.

Results show how waste practices change when institutional conditions change, and the broad political agreement is an excellent example of how waste is conceived, including PfR, as a process decoupled from the market. So, for example, 'use' is for others to take care of. However, this contradicts our results that point to the importance of getting 'user' and 'usability' coupled more strongly to PfR, which means a heightened awareness of the systemic contexts and 'couplings' rather than decouplings.

*Summing up the discussion*

PfR schemes result from public innovation and may support incremental change as well as the transition from recycling towards reuse. Schemes increase the number of reusable items and in turn create jobs and valuable knowledge for different EU Member States, regardless of where they are in the sustainable waste management transition process. Directing waste practices away from recycling implies a range of challenges, including the development of partnerships. In Denmark, the case companies have brought about innovative changes, conducting experiments focusing on PfR rather than recycling. These companies are characterized by their tendency to collaborate, network and work across systems, enabling them to gain important insights into innovation within current practices. As Gray and Stites (2013) argue, working across systems is a particularly important action for unlocking sustainability.

## Conclusion

The development of the circular paradigm and its implementation in the EU waste action plans have put pressure on the waste system, including pressure on waste-generating activities in production and consumption and how the waste treatment is institutionalized. From being an externality and cost reduced through public regulation in the past, waste has increasingly become a valuable and sought-after resource, subject to increased competition and rivalry.

The development of the circular paradigm and its demands for transformation of production and consumption has been the subject of increasing research and practical measures to reduce waste and close the waste streams up until the waste chain (see Figure 1), achieving this by integrating the various 'cycles' into companies' business models. However, research and practices in waste transformation after reusables have 'exceeded the waste limit' have been limited – cf. method sections. The primary knowledge and method of promoting the upper stages of the cycle (reuse) have been defined primarily through the EU's work on developing principles and guidelines for circular waste strategies.

Therefore, the article took a point of departure from the concepts of 'prepare for reuse' developed by the EU for promoting the potential for waste reuse and the limited research on this, to examine how the paradigm shift has initiated experimental activities in the most innovative municipal Danish waste companies.

Results in this paper identify challenges and limitations in the understanding and concepts for how waste can be transformed into reuse. This includes what the innovative companies' experimentation with waste transformation into reuse can contribute with knowledge and learning and the challenges it poses to developing an institutional and regulatory set-up.

Concerning the paradigm shift and methods of transforming waste into reuse, our studies show that the current understanding of 'PfR' has too narrow a focus on restoring the material product functionality to ensure that the restored products are reused. Therefore, there is a need for 'prepare for reuse' to focus on usability for the user and not just the product, combined with initiatives that make it possible to create a market that brings the product and user into dialogue. The importance of market creation and sustainability is a growing issue in research into entrepreneurship and marketing studies. Thus, there is a need to develop a dynamic and systemic concept covering the entire journey from idea to value in the user.

Concerning municipal (and private) waste companies, the study shows that it is vital to develop the business aspects of reuse (PfR) so that the value of reuse is clarified and developed. Transformation to reuse should not be understood in a narrow monetary perspective but developed to include unique benefits in product and use situations. Empirical examples given in this paper illustrate how values linked to reuse may also be articulated and staged in the dialogue between the waste companies, business networks, and customers (Moalem & Kerndrup 2022, Christensen et al 2021). The innovative nature of the transformation processes means combining individual and collective development of capabilities and competencies, in which networks and partnerships are ideal forms of organization. This is also consistent with experience from analyses of circular initiatives in manufacturing companies.

The regulatory set-up has been central to the transition to a circular paradigm in waste. The EU's work on developing concepts for waste (zero waste) and concrete methods of preparing waste for reuse has been important for the steps taken within the waste sector, including a framework to experiment with new forms of transition at

the company, network and sector level. A development is accelerating, which is why the European Union and national actors face some critical choices in the coming years. In a Danish context, the struggles over waste as a resource have intensified, and a discussion is ongoing about the interaction between public and private actors. Our analysis points to the importance of developing the regulatory framework, which supports forms of organization that promote transformations that provide an environmental benefit for the effort.

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## Appendix A

Table 2 Research design and corresponding methods

| RQ & Aim | Method |
|---|---|
| **RQ1:** How are barriers and possible solutions regarding PfR reflected in the pioneers' practices with respect to circularity in the waste sector?<br><br>**Aim**: Investigate frontrunners and practices related to circularity in the waste sector, incl. conflicting interests. | Fieldwork<br>- site visits to five municipal waste management companies' reuse sites<br>- passive observations and informant interviews with project leaders/heads of reuse at the sites<br>- long-duration stays (1–4 days) at three municipal waste management companies focusing on reuse/PfR-related activities |
| | Interviews<br>- ten un- and semi-structured interviews with waste managers, developers and directors on potential benefits of and barriers to reuse/PfR |
| | Non-intrusive methods<br>- document analysis of feasibility studies on reuse/PfR.<br>- participation in nine Danish waste conferences on reuse/PfR with actors on the reuse scene (public, private, non-governmental organization) |
| **RQ2:** To what extent does the legal framework support a change from traditional waste management with a focus on the inner cycles of CE?<br><br>**Aim:** investigate legal framework conditions for PfR, incl. legal issues and implications regarding roles and constraints for municipal waste management companies in the act of PfR | Fieldwork<br>- participation in two conferences on legal issues concerning PfR (DAKOFA, AVV)<br>- informal interviews with lawyer Christina Soya, law firm HORTEN<br>- study trip to Brussels, including meeting with RREUSE to discuss legal issues, including potential benefits of and barriers to PfR |
| | Interview<br>- semi-structured interview with Dir. of DAF |
| | Non-intrusive methods<br>Document analysis of:<br>- state administration documents on the trial/conflict around PfR against three municipal waste management companies<br>- legal documents from the law company HORTEN assisting the case<br>- political documents<br>- framework around waste<br>Media analysis<br>- review of a broad swathe of news stories on PfR |

## Appendix B

Table 3 List of interviews

| # | Company name | Type of company | Interviewee title | Purpose of the interview |
|---|---|---|---|---|
| **1** | VF | Waste management | Project Leader | Identify: |
| **2** | A+ | Waste management | Deputy Dir., Head of Reuse | -current reuse practices |
| **3** | A+ | Waste management | Waste Consult. | Examine: |
| **4** | AVV | Waste management | Business Developer | -the role of the company in a CE |
| **5** | AVV | Waste management | Waste & Sustain. Spec. | transition |
| **6** | BOFA | Waste management | Director | -the extension of experimentation |
| **7** | BOFA | Waste management | Information Officer | and |
| **8** | BOFA | Waste management | Chief for the Environment | innovation around PfR |
| **9** | ARGO | Waste management | Director of Reuse* | -drivers and barriers to reuse/PfR |
| **10** | ARC | Waste management | Project Leader | |
| **11** | DAF | Waste association | Director | Examine:<br>-the role of municipal waste authorities in a CE transition<br>-drivers and barriers PfR |
| **12** | HORTEN | Law firm | Lawyer | Examine legal perspective on:<br>-trial documents<br>-drivers and barriers to PfR |

# 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

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

# The Entrepreneurial role of waste companies in transforming waste streams to value streams. Lessons from a Danish Municipal waste company

**Rikke Marie Moalem[1], Søren Kerndrup[2]**

[1]Aalborg University of Copenhagen, Department of Planning, A.C.Meyersvaenge, 2450 Copenhagen, Denmark, rikkekr@plan.aau.dk

[2]Aalborg University of Copenhagen, Department of Planning, Rendsburggade 14,, 9000 Aalborg, Denmark, sk@plan.aau.dk

**Abstract**

The Circular Economy (CE) gives rise to paradigm shifts in the understanding, practice, and regulation of waste, challenging a waste sector built for the linear waste paradigm of waste streams rather than value streams. We examine how a waste management company developed value streams, caught between increasing competition for waste types with high market value, and rigid regulation limiting the development of new streams. This cross-pressure necessitates new knowledge and practices to not only transform waste streams into value streams, but to prioritise the inner circles prescribed by the CE paradigm. There is potential for increasing reuse of products that have been collected as waste or handed in at municipal reuse sites. However, if the product value is not sufficient to be attractive for the existing market, then value must be added and a market created. There is a great deal still to learn about what it takes to create value out of waste products and what the role of municipal waste companies is in that process. Our findings indicate that unlocking the potential of waste (in this case, old bricks and WEEE) has been far from straightforward. Value must be created through several activities, requiring collaboration between a range of actors as well as new knowledge and business competencies. This contribution aims to open discussion on what it takes for waste management companies to navigate the new complexities in the transition from waste to resource management.

**Keywords:** waste valorization, municipal solid waste, case study, preparation for reuse, waste streams, value streams

## 1. Introduction

Waste is perceived as intrinsically valuable in a circular economy (Perey et al., 2018). Nevertheless,over 2 billion tons of municipal solid waste are generated globally each year, and this shows no signs of slowing (World Bank, 2021). In the EU, municipal waste generated has increased by 7.4% from 1995-2019 , with 502 kg of municipal waste per capita generated in the EU in 2019, of which approximately 60% was neither reused nor recycled (Eurostat, 2021). Due to fast depletion of natural and primary resources, it is highly desirable to find a way to manage waste that minimizes the environmental impact and leads to sustainable use of resources.

Nevertheless, scientific waste management literature mainly focuses on municipal solid waste management from a traditional, 'linear business model perspective' (Puntillo et al., 2021 p. 968), in which waste is perceived a burden (Puntillo et al., 2021) imposing a cost on organizations (Perey et al., 2018). However, some case studies have investigated the reuse potential at reuse and bulky waste sites (Milios & Dalhammar, 2020), agreeing that there is a great potential for increasing reuse. A case study quantifying the potential for preparation for reuse (PfR) of bulky waste in the German state of Bavaria (Messmann et al., 2019) concluded that between 13% and 16% of the waste streams (furniture, leisure goods, and electric and electronic equipment (WEEE)), could immediately be prepared for reuse, depending on the product type, and a further 13% - 29% could be unlocked through changes in the model of collection, storage and overall treatment of waste. Similarly, Milios & Dalhammar (2020) identified significant potential for increasing reuse operations in private recycling centers in Sweden, particularly for building materials, furniture, and electrical equipment (mainly white goods). A third case study of a PfR project in a municipal waste management company in Denmark (Zacho et al., 2018) revealed that, from the perspective of the municipal waste management authority, 'the largest value creation potential (economic, social, and environmental), lies in preparing waste for reuse'. As an example, in comparison to recycling, PfR processing employed nine contracted full-time employees and an additional six employees at the edge of the labor market, and the amount of reusable material collected out of the combustible waste stream doubled. On this basis, 'it is fair to assume that a similar potential exists in other municipalities that do not yet provide separate collection for reuse' (Zacho et al., 2018, p304).

However, as the market for reuse has increased, so has competition, affecting prices in a downward direction (Norfors, 2019). Norfors further notes that due to the growing interest in reuse, most items of good quality and condition are being reused, but there is a large residual at reuse sites of items that could be reused, but have low value and therefore are not taken by charity-run second-hand shops or saleable to the private sector. This implies that there is a large potential for increasing reuse of products that have been collected as waste or handed in at municipal reuse sites. However, where the product value is not sufficient in itself to be attractive to the existing market, value must be added and a market for these products must be created.

Waste valorization, 'the process of converting waste into more useful products', is increasingly catching attention as a potential alternative to conventional solid waste disposal, including the development of environmental strategies to process solid waste (Abdel-Shafy & Mansour, 2018). The idea is not novel, but has gained renewed attention due to fast depletion of natural and primary resources (Abdel-Shafy & Mansour, 2018). This has led to a growing interest in waste valorization and the potential for processing large amounts of waste to create useful materials (Kabongo, 2013). Particular attention has been paid to the field of bio-waste (Abu Yazid et al., 2017; Venkateswar Reddy et al., 2020). However, according to Kabongo (2013), there is a lack of understanding of the different ways that companies are trying to implement waste valorization practices. Thus, little seems to be known about the actual waste valorization process: what does it take to create value out of waste and what might be the role of municipal waste companies in that process?

According to Kabongo (2013), important knowledge on the success of waste valorization initiatives can be hidden in the underlying social or socio-technical layers of the processes. Success can therefore not be attributed exclusively to environmental engineering progress and should be investigated more broadly. Thus, there is a need to look 'beyond' technology. This creates demands for new research, particularly, there is a need to understand the many ways different ways that companies are trying to implement waste valorization practices (Kabongo, 2013).

In this contribution, we build on previous studies that have identified the potential for increasing reuse of municipal waste (Zacho et al., 2018, Messmann et al., 2019, Milios & Dalhammar, 2020). Unlike these studies, we are investigating how potentials for reuse may be realized. We examine how a municipal waste company develops innovative (entrepreneurial) value stream solutions by building and launching activities to transform waste streams into value streams, and through a series of experimental processes make the product or service meet the relevant economic, technical and regulatory requirements. We follow two different waste streams in a waste business, bricks and white goods, through the complex and uncertain transformation process, involving a long and complex series of interactions between internal and external stakeholders.

The paper is outlined as follows. Section 2 provides the theoretical background for understanding the transformation of waste streams and the entrepreneurial processes that underlie it. Section 3 presents the methodology on which the analysis is based, while section 4 presents the case company and the two transformations of waste into value streams. Sections 5 and 6 present the results and discuss these in relation to the concrete experiences as well as the existing literature and knowledge. Section 7 presents the conclusion, limitations, and suggestions for further research.

## 2. Conceptual framework of waste valorization beyond technology.

In this section, the core concepts in the transformation of waste into value from a valuation perspective are introduced. We build on Kabongo's argument that waste valorization goes beyond technology and focuses on the challenges to unlocking value potentials in waste, and on Yang et al.'s (2014, 2017) and Zacho et al.'s (2018) analysis of uncaptured value in the product's life cycle and revalorization of waste. Secondly, we combine those theories with concepts from Doganova & Karnøe (2015; 2017). Finally, stressing that value is a dynamic socio-material process in which value is created through waste actors' work in developing and combining different value components (economic, social, environmental), and engaging stakeholders in collaborative value creation processes (Doganova & Karnøe, 2015; 2017).

### *Waste as value*

Research into waste as value is sharpened on two key points by a number of research projects at Cambridge University (Yang et al. 2014,2017), which aim to develop the understanding of waste value as part of the development of sustainable business models and methods to support this.

The first contribution lies in the development of an understanding of how waste arises through the life cycle of products, and the challenges associated with the localization of waste in the life cycle process, as a basis for organizing sustainable business models (Yang et al, 2014; 2017). Against this background, a methodology is developed to identify the untapped potentials throughout the life cycle by examining which value is captured and which is not, and therefore constitutes a value-adding potential for business models.

The value potential of waste and the opportunities for revaluation cannot be understood independently of the material and social history of waste. To understand these potentials, Yang et al (2014, 2017) have developed a method for understanding, mapping and assessing these possibilities. The purpose of the method is to capture the potential that a product or material creates throughout its life cycle. Value capture depends on the dominant culture of production, use and waste management. A distinction is made between 4 types of uncaptured value: value surplus, value absence, value missed and value destroyed.

The second contribution lies in the concept of value, seen in the light of sustainability (Yang, 2014,2017), which incorporates the value potential of waste through direct and indirect social and environmental effects, for example, the creation of local employment and social enterprises. A new and broader understanding of the value potential of waste is opened up, which is important not only for companies' and industries' business models, but also for the development of value and business models in the waste sector.

Zacho et al. (2018) use the concept of uncaptured value in an understanding of value as consisting of the three dimensions to build a more detailed knowledge and understanding of the potential values that can be captured in the waste sector. The article provides an important insight into the particular challenges associated with exploiting

the value potentials of waste companies' different waste strategies: reuse, remanufacturing, recycling, and incineration. The research from Zacho et al. (2018) helps us to understand the problems associated with the location of waste in the life cycle, the challenges associated with waste companies' opportunities to create value and earnings through various waste strategies, and the potentials and limitations of social inclusion and environmental aspects.

Based on the value capture model by Zacho et al (2018) & Ordones Pizarro (2016), (Figure 1), the challenges are visualized by creating value flows through waste management in waste companies. The model depicts that household waste has a negative waste value, as a consequence of the way household waste is collected, which follows the tradition of linear waste management. The waste has been through extraction, production and use processes, which are both materially and socially embedded in the waste and actors' understanding of its value. A great deal of value has been lost in the process, but how can value can be regained?

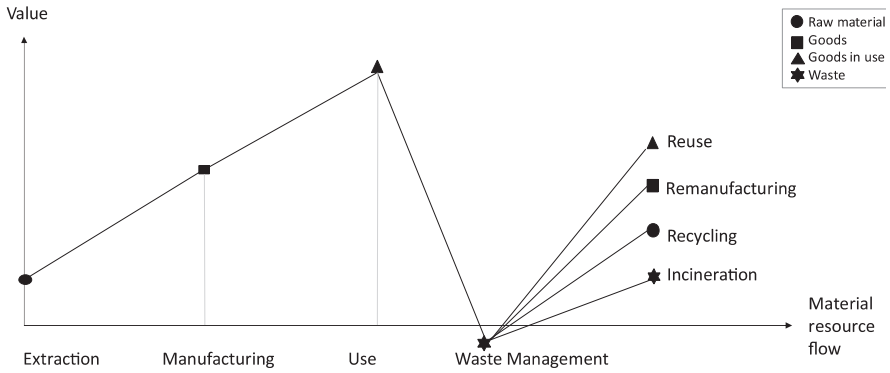


**Figure 1:** Value levels in the flow of materials. The choice of recovery route made by the waste management company creates different potentials for extracting value. Reprinted from "Capturing uncaptured values — A Danish case study on municipal preparation for reuse and recycling of waste" by Zacho et al., 2018. *Resources Conservation and Recycling, 136*, p.299. Copyright [2018] Elsevier B.V.

Zacho et al. (2018) focus on the specific challenges for waste companies' in revaluing household waste through processes such as sorting, testing, cleaning, transporting and networking. For most waste streams, the opportunities for creating financial value for the waste company are limited, while it can, to some extent, succeed in creating social and environmental value. Zacho et al. (2018) point to the need to create regulatory and market mechanisms to increase the possibility of capturing value for the company, as well as to exploit the potential that lies in uniting the various forms of value (business, social and environmental), as well as creating local value.

***Waste as valalorization processes – from waste stream to value streams***

We now apply a valorization perspective and shift focus from 'what' to 'how' value streams can be created from waste streams through entrepreneurial activities, combining different forms of value, providing knowledge and documentation, and building networks.

The valorization perspective focuses on value in making and understands waste as value not as something 'that is' but something 'as becoming'. The theoretical background is actor network theory (Latour 2006, Callon 1986, Law & Hassard 1998, Michael 2017), action net (Czarniawska 2004, 2015, Corvallec & Czarniawska 2017), and valorization (Doganova & Karnøe 2012, 2017, Callon et al 2002).

The valorization approach focuses on the processes through which actors co-create technology and networks. Within the environmental area, Doganova & Karnøe (2012, 2015, 2017) explain how value-creating processes create the basis for transforming waste streams into value streams. Valuation is understood as concerning how actors develop solutions in networks. Solutions are constantly created and recreated through activity and

interaction, and framing, development of knowledge, information, and documentation temporarily stabilise value and value flows.

The central starting point is to see the *transformation process as an entrepreneurial process,* where the entrepreneur, in this case the waste company, creates opportunities rather than discovering them. That is

> "This means that there is not a pre-given environment "out there" visible to the entrepreneur; the environment becomes visible "in the company/for the entrepreneur" through the work of representation. The work of representation creates the business opportunity and makes it visible in the business case through a process of construction, whereby the entrepreneur enacts, collects, and arranges data (e.g., regulations, assumptions about user problems), and makes calculations (e.g., estimated price/cost structures) to form a view of the world." (Doganova & Karnøe 2012, p.5).

This entrepreneurial approach means that value potentials are not seen as pre-existing, but as created and assembled. It is therefore important to understand how to waste company and stakeholders may

> "co-evolve and become assembled as a new network supporting the new product. When it comes to innovation of new products, both stakes and their holders are emergent; hence, assembling the stakes and holders is a critical job for the innovator." (Doganova & Karnøe 2012, p.6).

Framing, in the form of knowledge-information and documentation work, plays a central role in transforming waste and waste streams into value and value streams. It is thus important that waste is framed as value and that this value concept is seen as a link between economic, environmental, and social value, where "externalities" are internalized and give the product extra value and create distinct products.

Our conceptual journey has provided an opportunity to develop a framework for investigating the processes through which public waste companies can create entrepreneurial activities that enable waste and waste flows to transform into value and value streams. The framework is used to map and assess the processes and activities through which the waste company transforms waste streams into value streams. To visualize the complex journey of converting waste into more valuable products, we use the term 'black box' as a metaphor for the unknown or hidden processes involved when 'unlocking' potentials (Figure 2).


**Figure 2:** A black box metaphor for waste valorization processes (Based on Dononova and Karnøe, 2012; Kabongo, 2013).

### 3. Methods and materials

This study is based on collaborative research, which is part of a larger study (PhD) of how waste companies in Denmark can change from a linear to a circular waste and business paradigm. The study is based on a collaborative research framework (Van de Ven 2007) and inspired by innovation and entrepreneurship research approaches (Van de Ven et al.,1999, Doganova & Karnøe, 2012, 2019, Pedersen et al. 2020), where emphasis is placed on following processes in real time.

The scope of the study derives from the strategic ambition of the European Union (EU) for waste management in the EU to transition from waste to resource management as stated in the European Waste framework directive (2008/98/EC, as amended EU 2018/851). In this effort, municipal waste management companies have particularly important roles to play. However, due to fast depletion of natural and primary resources, private actors are also expected to be keen to explore new ways of reusing end of life products.

The study is based on an abductive research design, where theory and empiricism are developed in interaction. Initially, the research for this paper began with an understanding of the transformation of waste into value from a value framework perspective (Yang et al 2016, Zacho et al. 2018) combined with an understanding of experimentation in the transition to CE (Bocken et al. 2018, 2020, 2021) but this was challenged through the empirical work on the process. Thus, the dominant approach was changed to a valorization perspective based on (Doganova & Karnø 2012, 2019) as well as staging collaborative design by Pedersen et al. (2020).

The empirical work is based on selected cases and was strongly inspired by anthropological fieldwork, which was used to follow the transformation process from waste to value through traces in the form of stories, narratives, documents, materialities and activities that transformations had deposited through the development from idea to implementation and operation.

***Case study***

To collect empirical evidence on waste valorization practice, this paper adopts a case study approach. This approach enables us to obtain a better understanding of fundamental elements and issues characterizing the waste valorization process, networks and the reframing of waste as an asset. Interviews, desk study research and site visits complimented the study. Case studies are especially useful in addressing 'how' and 'why' type questions, and when there is a need to perform an in-depth analysis of a complex phenomenon in its real-life context (Yin, 2003). A case study is rooted in the individual's experiences and practice and can help to uncover complexity. Since case studies are rooted in actual practice, they can be further linked to action and thus help to change practice.

Case study research is a "linear, but iterative process, consisting different steps; planning, designing, preparing, collecting, analyzing, and sharing, in which each step requires the researcher to review and re-examine former decisions" (Yin, 2003). In the context of this article, this includes planning and designing case-study design and methods and preparing the collection of data by identifying niche waste valorization projects within the waste sector in Denmark. Data collection and analysis is examined through the lens of niche projects, outside the traditional split of public or private, with a focus on the key issues in delivering new value propositions within the context of the waste sector: how value is created and the type of value.

The case study is an embedded case study of two entrepreneurial business developments in a public waste management company. The aim was to learn from a front-runner in experimentation with and implementation of CE inspired solutions. For this purpose, the municipal waste management company AVV was selected as an extreme case (Flyvbjerg, 2001, Neergaard, 2007). AVV is famous in the waste sector for its reuse shop and for experimentation with CE inspired solutions. Thus, the company is a front-runner within public waste companies (Moalem, et al. 2021) and the two chosen business initiatives are strategic entrepreneurial business developments, which is why the case study is an extreme case (Flyvbjerg, 2001). An extreme case exposes ideas not seen in average cases and thus provides the opportunity for us to gain new knowledge about entrepreneurial business development in waste companies (Flyvbjerg, 2006).

The fact that the two cases are embedded means that they are not seen as isolated business initiatives, but as initiatives embedded in the waste company's relational context.

The selected cases are also strategic cases as they provide an opportunity to follow the innovation journey of the transformation from waste to value. This journey cannot be understood in isolation from the individual company (AVV) but must be seen as a result of a longer journey over time and between actors. The first case concerns how value can be created by reprocessing brick waste from demolition and reuse stations by cleaning, sorting, and selling waste bricks for new building. By transforming waste into a product and creating a market for it in a collaboration between actors who are already active in this field, AVV was able to start up its new business. The second case concerns how value can be created based on refurbishment of white-good waste (WEEE) by collecting, sorting, refurbishing, and selling prepared-for-reuse appliances, and whether it is possible to build stakeholder acceptance of this business method based on local and social value. The refurbished appliances stem from white goods disposed of at municipal reuse sites or as bulky waste. (Section 4).

The choice of the two strategic cases makes it possible to examine the special challenges associated with converting waste streams into value streams.

***Data***

The data collection aims to follow the transformation process by tracing the transformative activities over time and between actors as they are deposited in the form of stories, narratives, documents and in the form of physical traces in the form of activities and artefacts.

*Desk study research*

The literature and document analysis were an important part of mapping and evaluating the two transformation processes, as transformation processes had left traces in the form of documents and literature. Thus, documents played an important part in the work of transforming old bricks into value. A documentation that consisted of technical analysis of how bricks' physical properties were affected by their product life, of their durability and quality, as well as of their environmental effects. In addition, there were articles and documents about the dismantling, production and use of old bricks, as well as marketing material. (Doganova and Karnøe 2012, 2018).

Documents and materials were collected through a literature and document search, but also in connection with our interaction with the key actors and stakeholders, as well as in connection with our field studies.

*Interviews*

The aim of the interview was to follow the activities (Czarniawska & Corvellec 2015, Latour 2005), which meant that the selection of interviews took place on the basis of a mapping of the journey through which the idea of preparing old bricks for reuse had flourished. This process turned out to have taken over 15 years before AVV launched their business development project. This careful selection of stakeholder interviews was very important to understand the complex value-creating activities and processes that underpinned the success of converting waste into value. An overview of interviews is provided in Table 1 (Appendix A).

Semi-structured interviews were chosen due to their flexibility, allowing interviewees to disclose important, yet unexpected, information (Qu & Dumay, 2011).

To bring interviews from oral to written form, interviews were transcribed, creating, as accurately as possible, a fair written version of the verbalizations generated in a research encounter with participants (Cope, M., 2009; Kvale & Brinkmann, 2009).

*Field visits and observation*

Visits to sites that had played an important role in the innovation journey were important for mapping the tracks that the transformation leaves in the specific materialities and activities in the new business areas. Observation and dialogue provided an opportunity to track the transformation processes in physical and social activities as they were practiced at the individual business units and gave us a deeper understanding of the actors in the business units. The examined field sites included the municipal waste management company, an appliances company, and a brick company, located in the northern region of Denmark.

*Triangulation*

The case study methodology provided a rich opportunity to gain detailed insight and understanding of the diverse and complex micro-processes that were the basis for waste to be transformed into value. It required a disciplined coding process of events, activities and actors, as well as triangulation data and information.

Interviews, documents, and research field notes were coded according to the main themes; entrepreneurship, investments, value, value proposition, mobilizing stakeholders, knowledge development in applying the strategies, and understanding solutions as models in which value is created.

**4. Cases**

AVV is a public waste company in North Jutland, which is known as an innovative and entrepreneurial company (Methodology section). The company consciously works to develop "private and public entrepreneurial" initiatives that can benefit the company's overall goal and to reduce waste through reuse, recycling and disposal, and contribute to the development of the local area (Interview #2).

The waste sector is facing extensive changes. Shifting to a circular economy has heralded a major structural change in the Danish waste sector, where the value of waste is translated into price formation, with markets and private actors as driving forces. In contrast to the dominant passive trend among public waste companies, AVV is actively trying to create new opportunities to turn waste into value through experimental measures in a political landscape that is very restrictive of public companies' value creation in relation to markets. (Moalem et al 2020)

In this paper, we take a closer look at two selected transformation initiatives, which have some special potentials for understanding what and how transformation from waste to value can be understood as valorization processes. Such processes are often understood as simple supply and demand mechanisms, where actors, interests, markets and prices are seen as given rather than as something created through entrepreneurial processes in which actors create activities, products, value propositions, and markets through development and transformation of knowledge and information between stakeholders.

The first case examines challenges associated with transforming old bricks from demolition sites and reuse stations into a value stream.

The business idea is based on an existing patent developed by the company Gamle Mursten (meaning Old Bricks) which was initially included as co-owner of the newly established business unit. In 2018, the waste management company AVV opened a production line in the region. Today the company has changed its name to ‘Genbrugssten’ (meaning reused bricks) and is owned by a fond. There is a potential for reusing bricks worth DKK 47.3 million per year, which at present mainly go for recycling in road filling (Miljøprojekt, 2018).

The municipally owned waste company saw a strategic and operational need in the region to transform waste into value within the construction industry in North Jutland if the region is to live up to the goals of sustainable regional development. Hence, AVV established a new business area through engagement in a company that could transform old waste bricks into reusable bricks in competition with traditionally produced bricks. By following the case from the establishment of the former company ‘Gamle Mursten’ to ‘Genbrugssten’, a unique insight is gained into how the original contractor company has enabled realization of the idea that waste bricks can be transformed into value through the development of production and product technology through collaboration with many different actors. Knowledge and factual understanding has been crucial for creating potential value throughout the construction chain. This collaboration has been underway for 15 years and included many different controversies, actors and activities, and is still under development, but now seems favored by the requirements for developing a circular economy.

The second case concerns a business based on refurbishment of white-good waste (WEEE) by collecting, sorting, refurbishing, and selling prepared-for-reuse appliances. The challenge in this case is to create the market conditions for such business development under the existing regulatory regime, which limits the ability of public corporations to create value by creating goods and markets. It not only places demands on the company's technical and business capabilities, but also on its ability to navigate both the political and the market landscape.

The business idea builds on a concept original developed by the company De Grønne Hvidevarer. The company is stationed both in the northern and southern part of Denmark. Preliminary investigation to test the potential for preparation for reuse (PfR) showed that 25% of discarded white goods were suitable for PfR, of about 140 thousand tons WEEE per year in Denmark alone. A local initiative based on that of De Grønne Hvidevarer’ concept was seen as a means to create value for AVV and at the same time contribute to the regional goals of environmental and social development.

The two entrepreneurial initiatives at AVV allow us to follow the many transformative processes that underlie AVV's success with their initiatives, which goes beyond the individual business development process. A success

that would not have been possible if they had not built on a chain of activities, actors and institutions that had been created over time, space and across stakeholders.

In the following, we investigate varying issues related to the turning of waste products into a value. What characterizes the journey from waste to product? What is the special value and how is value created so that products are able to be sold in a market? How is value created through discovering and disseminating facts to make it possible to turn waste streams into value for users?

## 5. Results

### Waste valorization of old bricks

*Entrepreneurship-business development*

The first element that we will point out in this valorization journey is the entrepreneurial uncertainties associated with establishing a business basis so that technology that makes it possible to reuse bricks is valued by the construction sector. What does it take for old used bricks to be considered a valuable resource and not just a cheap substitute product for peripheral tasks? What does quality mean in this context, and how can quality be used to create value from waste blocks? Is there a market for reused bricks, or can a market be created for this? If there is a market, how can it be secured? It was a partial solution to these entrepreneurial uncertainties that AVV "bought" by collaborating with the company Gamle Mursten and engaged in their technology and competences.

*Investment*

Second, the results showed that the return on investment in production facilities, technology, and patents depended on investment in the "qualification" of the product concerning both market and institutional requirements. Achieving the CE marking cost more than DKK 2 million initially and approximately DKK 0.5 million annually in maintenance and salary for a permanent laboratory technician. However, the CE marking was crucial to enter the market in line with construction products of other manufacturers: without it, it would be difficult to document the uniformity and parameters for engineering calculations. The CE marking refers to the manufacturer and thus gives the company a supplier responsibility.

*Value propositions*

Investments in quality, documentation, and deliveries mean that the old bricks' value proposition develops from documenting and certifying the existing market's norms for quality in the form of physical properties, to incorporating the bricks' history into the value formation process. From being a matter of physical qualities and deliveries, the value of the bricks is increasingly based on their environmental and climatic effects and their cultural and aesthetic value. This shift is made possible through the development of climate policy, as described by one architect and materials specialist, who reflects on the environmental value in the following way:

> "Denmark has signed the Paris Agreement, and in 2030 we must achieve a saving of 40% in CO2 emissions compared to the level in 1990. As architects in Denmark, we, therefore, have a great responsibility, and we must contribute to the solutions of the future. We assess our materials carefully through life cycle analyses that map their environmental impact from extraction, production, use, and disposal. When we compare new bricks with reused bricks, we see a marked difference in CO2 emissions and energy consumption." (Interviewee #10)

The increasing focus on "old bricks" as unique quality materials initiated a positive development spiral, where the unique benefit gave rise to the creation of new value through the collaboration with the client and architects, multiplying the value. Diversity of value was also increased through the development of complementary services in the form of training and advice from actors in the construction chain on more gentle demolition, aesthetic cultural potentials, etc.

*Mobilizing stakeholders*

Stakeholder identification, selection, and involvement are central in ensuring that old bricks can be developed from waste to valuable bricks in a standardized market. In the first phase, the central development collaborations were focused on documenting and certifying the bricks to meet the physical requirements of the market, which was done by collaborating with consulting firms, certification institutions, and quality and environmental experts. This collaboration was crucial for old bricks to be considered a resource in construction, but it was also a product that was pressured by competition on price, which was a dominant market requirement. Therefore, the collaboration to make the product unique by incorporating the environment and culture was crucial to developing a market that emphasized these unique qualities. These collaborations built on the work of certifying quality by focusing specifically on environmental and socio-cultural aspects that are more difficult to qualify and quantify. It requires collaboration with consultants and knowledge institutions with specific competencies and collaboration with actors throughout the chain who can identify the potential in buildings with a particular value and associated material use due for demolition.

*Knowledge development*

A transformation of waste into value and the creation of business opportunities for the utilization of old bricks has only been possible by the conscious effort over the 15 years since the entrepreneurial process was initiated to transform growing concerns about climate and waste into behaviour change. That includes transforming the way waste is treated: cleaning bricks and reusing the bricks as a resource in construction.

Initially, concerns were directed at whether waste was a resource that could live up to current and future requirements for construction (quality, efficiency, durability) so the original contractor opted to have the bricks CE-marked. In addition, the company also has an Environmental Product Declaration (EPD).

Another concern was regarding the availability and stability of the resource. There was limited knowledge about how the quality of the bricks used in construction had varied over the years. Further, obtaining consistent and timely supplies through waste collection, demolition work, and distribution required the development of knowledge and methods to ensure a stable market for old bricks. Therefore, it was essential to develop knowledge about the scope and methods of demolition, which is why the contractor was involved in projects and activities that could capture the necessary knowledge and established advice and training for demolition companies to develop selective demolition.

A third and growing concern was with the environment and climate, which was further addressed through the UN Climate Conference (COP) negotiations on climate and circular economy (CE) requirements. In the first period, these concerns were translated into facts through projects concerning life cycle assessments of old bricks versus new ones, which showed environmental and energy improvements. These facts were essential preconditions for creating old brick as a unique product. This had only limited value to the customers in the first part of the period. However, with the challenges posed by COP agreements and CE, it was transformed into value for customers who were increasingly required to document their climate and environmental accounts. The COP agreements have thus created a situation where one has gone from old bricks as 'nice to have' to something that is important to have to live up to the requirements of reducing climate pressures.

COP climate agreements have provided an essential incentive for facts to be transformed into value for the end-user and are also the driving force for AVV's interests in old bricks as a business area. The production of facts gives rise to the development of new value in the old bricks through a collaboration between stakeholders in construction. One of the end-users frames it this way:

> At Hennig Larsen Architects, this difference in environmental impact weighs heavily in our choice of old bricks. Another way we work with the stones is from a micro-climatic perspective. In one of our projects, we have placed the brightest bricks at the top to reflect the light and send it down to street level. Conversely, we have laid the darker bricks on the lower part of the facade. They absorb heat and make it more comfortable to stay in the outdoor areas at street level, says Peer Teglgaard Jeppesen, architect and partner (Interviewee #9)

**Waste valorization of post-consumer white goods**

*Entrepreneurship-business development*

The first element to note in this waste valorization journey is the large degree of uncertainty concerning the feasibility of the business model for remanufacturing post-consumer products.

Some of the initial barriers for developing a business and setting up a workshop for remanufacturing consisted a range of elements spanning uncertainty concerning the local market demand, the quality of the supply as this entailed of post-consumer products collected at the recycling center, potential resistance, or cooperation from retailers, producers, or other actors. Further, the company was uncertain of the extent of the resources needed for developing the business: the time it would take to test and refurbish the products, and the tools, facilities, labor, and skills needed. Finally, there was uncertainty how to market the post-consumer products. Due to this wide range of uncertainties about the ability to bring the refurbished products to the market, capturing value to outbalance the investments, AVV applied for funding.

*Investments*
Secondly, a shift from material recycling to preparing for reuse demanded a practice change which entailed new activities, new routines, and new investments. Some of the most important costs inherent in this business model included setting up a workshop space with new inventory, tools and rents, administration, market analysis, advertising, communication with citizens, and finally salaries being the largest expense. Further, in the first 4 months of the project, it was found in practice that the presumed potential of collecting, refurbishing and sale of 100 items a month, could not be realized solely by asking citizens to donate reusable appliances at the reuse sites.

*Value propositions (beyond economy)*
For the waste company, value creation takes place within the existing valuation framework, where value is created through labeling and guarantee schemes, as well as by expanding the value concept content by ensuring local management of local resources, improving the environment and local CO2 accounting, and upgrading the skills of citizens who lack a connection to the labor market and creating local jobs, proving that CE is relevant and sustainable.

The company thus develops a more diverse value proposition that integrates traditional externalities and that can strengthen the value of products for customers, not least the opportunities for cheapening through the use of eligible labor. How the value is converted into value for customers depends on the customer segment and its experience of products. Customer segments are people with lower income, local newcomers and holiday home owners (niche market). Thus, the multiplication of value creates limited extra value in certain customer groups but may not translate the softer values as product value. Thus, the value structure is on the one hand a cost-driven, low price value proposition, but on the other hand value-driven, focused on value creation.

*Mobilizing stakeholders*

Navigating the political landscape was an essential part of this case as preparation for the reuse of white goods is sensitive and concerns the division between public and private matters. Challenges to navigate included organizing the legality of marketing reused second-hand appliances. Thus, central to this case is to develop networks that create and support legitimacy for the local stakeholders, emphasizing the need for stakeholders to develop new competences.

One element entailed the dealing with resistance from the authorities and ambiguity in the regulation which posed a need for legitimization of the project. To acquire a formal seal of approval, several applications were made to the environmental protection agency funds program. A first attempt was declined, setting the workshop on hold for two years. A second attempt entailed a new project description and application, this time with support from two collection schemes in which one is the legal owner of the WEEE products. The agreement entailed that AVV should ensure high quality, environmental benefits, monitoring and registering of products in the WEEE system, and that the refurbished post-consumer products should be sold solely to the local market.

To ensure high quality repair and environmental benefits, the company entered a public-private partnership with a one-man enterprise with the electrical and technical skills to refurbish large household appliances, as those skills were not present at the waste management company.

Finally, the waste company went into a dialogue with the local job centre concerning the employment of socially disadvantaged people, as activities related to reuse of products are more labour intensive than recycling. Short of companies willing to engage in this type of collaboration, the job centre agreed, as long as the jobs were meaningful. The two parties agreed that the job centre would be responsible for developing a suitable training program as the waste company did not have competencies in this field. This agreement also limited the financial risk for the waste company. The negotiation process, especially the mobilization of the various stakeholders, was a key regarding the creation of local acceptance of the project.

*Knowledge development*

The development of factual knowledge was crucial for the company to be able to deal with concerns about transforming discarded white goods into valuable products. Concerns centred on economy and efficiency and the necessary capabilities and competencies.

To accommodate future scenarios of scaling up the business model, a key activity for the company was to develop standardized methods for separating products with reuse potential and preparing them for reuse. To ensure positive environmental effects, safety and quality, a procedure for selection, deselection, and repair of appliances, was conducted. The test and repair process were based on a translation of the British standard for white goods repair, PAS 141. Nevertheless, it turned out that unskilled labourers could not make repairs, even from a manual based on the standard. It required a skilled technician to perform testing and repair. Another important learning was that citizens and staff on the reuse sites lacked the skill to assess which appliances have reuse potential. This also required professionally trained experts.

Concerns about the products value for users required testing. The establishment of systematic procedures allowed for the waste company to sell the recovered products with a six-month warranty followed by an additional eighteen-month warranty, to comply with the rules of the Purchase Act (LBK nr. 140 of 17/02/2014).

To meet concerns about legitimacy in relation to regulatory pressures, the collaborative entrepreneurial company developed an electronic registration system for data handling and reporting the remanufactured post-consumer products to the WEEE system.

Translating concern into concrete facts is thus crucial for the company, users and stakeholders to develop the business concept for reusing white goods. If AVV had not been able to find and document the necessary facts, such a development would not have been possible

*New practices and future*

The waste management runs a physical and an online second-hand shop which serves as a sales channel for the refurbished appliances.

In relation to upscaling and future scenarios however, it very much depends on the local context and on the company's ability to navigate the political landscape, the division between public and private matters and the legality of marketing reused second-hand appliances, and to gather local support.

*Summing up results for bricks and WEEE*

Results revealed that converting waste bricks and WEEE into more valuable products is a complex process consisting of several entrepreneurial activities, beyond supply/demand mechanisms and price formation. Secondly, creating value out of waste requires collaboration between actors. Thirdly, new competencies are needed, including knowledge and business competencies. A visualization of key elements in the waste valorization process of the waste streams of bricks and WEEE, in the case of Denmark, is illustrated in Figure 3 (below), 4 & 5 (Appendix B).

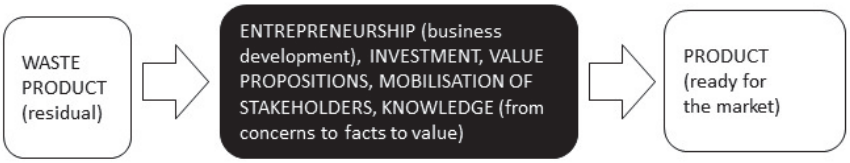


**Figure 3:** The waste valorization processes for solid waste bricks and WEEE, in the case of Denmark.

**6. Discussion**

Transitioning to a Circular Economy challenges the waste sector and its practices by requiring waste streams to be converted into value streams in the last stages of product and material life cycles. Systemic and organizational capabilities have been developed to optimize the linear waste system, focusing on the lowest levels of the waste hierarchy: recycling, incineration, and landfill.

Transformation to CE has primarily focused on developing business models where the most significant economic potentials lie and where the forms of waste are less complex and to a greater extent can be converted to integrated and "closed" circuits in the value chain. However, challenges are more significant in the last stages, where waste has achieved a negative value through use, handling, and disposal in many cases (Zacho et al., 2018). See Figure 1.

Circular initiatives, therefore, put the operators of waste systems and their practices under tremendous pressure to develop innovative processes and capabilities which can transform waste streams into value streams. That requires systemic and organizational entrepreneurship. We have analysed challenges associated with establishing and building waste streams as value streams based on two entrepreneurial initiatives. First, activities require an innovative shift in the way waste is reconstructed as value. That also includes activities, relationships, and competencies that are needed to establish such a transformation. Thus, the transformation requires an entirely new regenerative paradigm. Products and materials are no longer perceived as the last part of their life phase but rather as parts of a dynamic, regenerative process.

The elements of such a paradigm are already present in the form of ideas, experiments, and tests. However, they have difficulty unfolding within the existing institutional mental, technological, economic, and regulatory framework (Doganova & Karnøe 2012,2015). Therefore, most ideas remain ideas, dreams, desires, and "invisible" experiments. Only a few exceptional cases succeed in negotiating a space (Pedersen 2020, Moalem et al. 2021) so that ideas can be developed, as those in this paper.

***From waste streams to resource streams: innovation processes transforming waste into value***.

The analysis shows how converting waste into a product/service differs from the technical material process of recycling waste, i.e., making it into a resource by optimizing its technical material properties.

On the contrary, transforming waste into a product/service is an innovative, creative process. The idea of product/service forms the basis for activities and processes that enable the idea to transform into value.

This process is not so much about restoring the original value of the 'waste' product, for example, to achieve purity and quality that is comparable to its original value as a product or material, but rather to create a distinct value for the product.

To succeed, it requires actors to create a basis that makes the product's life cycle an integral part of the valorization process. That includes valorizing parts of the life cycle process that have been excluded from the traditional way of assessing value in the form of externalities. For example, the transformation of 'waste' bricks to 'value' illustrates how actors succeed in co-creating a valorization process. The old bricks' positive environmental and energy effect creates value for end-users and its 'use history' creates additional value. Further, the unique physical properties linked to the non-standardized "look" are transformed into a value that can be utilized in the way the bricks are included in buildings and thus create added value. This added value is crucial for the transformation to succeed

under the given conditions as there are significant investments associated with establishing the different processes for collecting and cleaning the old bricks. In addition, work is being done to create extra value by increasingly embedding old bricks in a product-service system, where advice and training can be purchased.

In the case of white goods, the valorization process occurs primarily through the externalities associated with the social dimension of sustainability. The inclusion of people on the fringe of the labour market, creating social and local jobs, plays an essential role for the actor in negotiating acceptance for recirculating the white goods as Danish legislation is rigid concerning what products and services public companies may provide in the market. For end-users, the value is primarily related to functional products at a low price, and to a lesser extent, the circulation of materials as a value proposition. For AVV, however, the latter is the decisive force.

The transformation of the value concept is crucial for the waste actors to create a productive activity that transforms waste streams into value streams in both cases. Either by creating a value proposition that provides extra value for the end-users as in the case of old bricks or extra value for stakeholders, which is decisive in enabling the activity to be established.

***Valuation of waste as co-creation processes***

Results further reveal that the transformation of waste into value cannot be isolated to a single actor or process. Instead, it is a dynamic co-creation process where co-creation occurs throughout the journey from idea to product of value. Development paths consist of experimental processes where different possibilities are tested through the involvement of different actors during the development process. Actors who are getting involved have different ideas and interests in opportunities. Interests and ideas, however, change along the way according to who and where they are involved.

The co-creation processes in the development process of "old bricks" aimed to establish value in the existing market for bricks through the engagement and involvement of stakeholders who ensure that waste bricks can be attributed a value in the market. Transactions in the market require that the buyer and seller, respectively, can mutually guarantee that the bricks have a value that makes them attractive sales and purchase objects, that have the character of a commodity and live up to the requirements of the buyers.

Therefore, it was crucial for AVV to enter into cooperation with actors who could 1) provide knowledge and documentation of techniques and processes for cleaning the bricks and 2) guarantee that the bricks had a quality and physical durability that lived up to the requirements of building regulations and processes, and thereby could be marketed. The latter was provided through development and documentation cooperation funded by the Ministry of the Environment and the EU.

For the waste company, collaboration with the private entity Gamle Mursten meant that it was possible to gain knowledge and competencies about technology and markets, documented and tested both in production and on the market. That provided AVV access to rapid exploitation of the start-up potentials that were important in the company's attempts to position themselves in the rapidly growing area created by the demands for circularity in the construction sector. To provide scientific knowledge and document the old bricks' environmental and climatic effects, it was necessary to complement the collaboration with more scientifically based collaboration, as Gamle Mursten could not provide the necessary knowledge for LCA documentation. This co-creation process is vital for the waste company's role in regional waste streams. AVV has the environment and the climate as their strategic value proposition in a changing market. The collaboration with Gamle Mursten was an integral part of the initial start-up process to ensure rapid skills building. To further AVV's strategic aims to develop regional collaborations and potential they subsequently bought out the private entity.

However, the exploitation of entrepreneurial potential has been a complex process, and to be able to provide the necessary entrepreneurial competencies, the company has had to focus more on internal capacity-building than first assumed. That demonstrates the importance of co-creation processes in transforming waste streams into value streams, which in most cases are far from the notion that waste is gold simply waiting to be collected.

In the case of white goods, co-creation processes also played an essential role concerning building the necessary capabilities to transform waste into products that have value on the market. A collaboration with a private entity

[De Grønne Hvidevarer] was crucial to ensure productive and distributive capabilities that could turn waste into goods. In addition, there was a challenge in ensuring the quality of the white goods, partly solved by reorganizing the transport to "gentle collection" and by guaranteeing the necessary quality and right of return. Finally, there is the importance of collaborations in ensuring that production could occur despite national regulation on return schemes. That illustrates the importance of engaging with legitimizing stakeholders as emphasized by Mitchell et al. (1997). In the co-creation process, it was important for AVV to navigate the local political landscape and to have the skills to negotiate and design a collaboration that was accepted locally.

***Navigation and negotiation as key transformative capabilities***

Case results reveal some of the challenges that underlie the ongoing transformation process and the extraordinary demands on the individual public waste actors and their ability to innovate and navigate the changing landscape. First, the transformation processes are more comprehensive and transformative than current analyses describe. The transformation from waste to value is perceived as a straightforward socio-material process that can be achieved with relatively simple means such as marketing in the form of privatizations, pricing, and competition, or through changes in the mode of collection (Messmann, Boldoczki et al. 2019)

Secondly, most analyses have focused on the cycling of waste types in the productive parts of the production cycle rather than on the waste sector's challenges to handle end of life products where the value has been degraded through activities such as waste management and disposal. In regards to the latter, only a few real life examples exist (Zacho et al., 2018, Messmann et al., 2019, Milios & Dalhammer, 2020).

For public waste companies, systemic and regulatory embedding means that the actors' options for action are limited partly due to the regulatory framework and partly due to the lack of relevant competencies and knowledge development as those have been built for the linear system.

The analysis reveals how even entrepreneurial public waste companies such as the case company AVV have limited capabilities to navigate under the new conditions, which hamper opportunities for actors to develop experiments and practical solutions to the challenges that CE poses to the waste system.

Waste companies have limited capabilities to develop and experiment with initiatives that can promote circularity in the waste sector. Only a few pioneering companies such as AVV, which has built up unique business development competencies, may hold the competency and knowledge to oversee and initiate new circular activities supporting the inner cycles and local loops of the CE. AVV has gained insight and knowledge that has made it possible to initiate activities outside their traditional technology and knowledge base under their tradition of collaborating with knowledge institutions, participating in development projects, and screening development potentials in broader terms. Others without these development capabilities have more limited ability to undertake such work.

The limited development capabilities of waste companies will be challenged by the increasing complexity and speed of development, which means that no player can solely base circular solutions on their competencies. The analysis thus shows how circular solutions that transform waste into value are based on the actors' ability to collaborate and engage stakeholders in development processes outside the traditional waste system. Therefore, there is a need for the waste actors to have knowledge and insight that enables them to collaborate across organizational and professional boundaries. The analysis shows how the waste company AVV has the ability and competence to collaborate across economic, technical, organizational, and institutional boundaries. That has made it possible for the company to carry out the complex transformative processes necessary for the 'from idea to value' development journey. That journey consisted of development paths that offered challenges in technical and financial value, and organisation and where new problems, solutions, and interactions arose throughout the process. We claim that these competencies do not exist in many waste management companies, as a linear mindset has locked in certain delimited functions and relationships. As a result, opportunities to develop and experiment with different ideas and collaborations have been limited.

The waste management companies' limited ability to navigate is challenged in an increasingly complex world. We can assume that demands for circularity, sustainability and to identify relationships and partners will only increase. The analysis shows that it is not sufficient to identify issues and cooperate in strategic public-private partnerships

as suggested by Milios and Dalhammer (2021); it is also essential to identify and navigate between the various stakeholders in the innovation process. Identifying the different stakes concerning ideas, activities, and collaborations is crucial to develop and experiment in a world of constant change. Taking the example of the old bricks, the results revealed the importance for waste companies to navigate between the various stakeholders to build knowledge about the environmental effects and, through cooperation with authorities regarding planning and implementation of demolition projects, to ensure the supply not only of blocks, but of stories and value. Concerning the development of recirculating white goods, the project's establishment depended on the ability to navigate the waste policy landscape and create the necessary alliances and cooperation to establish a project within thresholds acceptable to national actors.

## 7. Conclusion

Turning waste streams to value streams is a key component in a circular transition. The aim of this paper was to investigate and gain improved understanding of the underlying processes and interactions of waste valorization and how waste companies position themselves as mediating actors in these value creation processes.

Results reveal that such a transition challenges the waste system and individual actors in the system. The waste sector seems to be at a cross-roads. There are growing demands for waste management companies to turn the "waste hierarchy" upside down and thereby transform waste practices away from organizing and managing waste streams to activities in which value creation is central. However, companies are in an institutional grip, which maintains individual public actors and systems in the existing linear economic, technical, organizational, and institutional logics and mechanisms. That hampers actors' opportunities to develop and experiment with new solutions and to navigate in the new landscape.

With this contribution, we wish to open a discussion and raise awareness of what it takes for waste management companies to navigate the new complexities in the transition from waste to resource management. First, results emphasizes that value must be created through several activities, rather than something that awaits to be revealed. Second, creating value out of waste requires collaboration between actors. Thirdly, new competencies are needed, including knowledge and business competencies. Throughout, there is a need for the waste actors to have knowledge and insight that enables them to collaborate across organizational and professional boundaries.

For future research we suggest a further examination of which specific competencies are needed and how to develop them to support the transition to a circular economy. That applies to public and private waste companies, as both must adjust to the new situation.

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**Appendix A: List of interviews**

**Table 1:** List of interviews

| Interview | Stakeholder type | Interviewee role | Sector |
|---|---|---|---|
| #1 | Waste Management | Waste and sustainability specialist | Municipal |
| #2 | Waste Management | Business developer | Municipal |
| #3 | Waste Management | Waste collector | Municipal |
| #4 | Brick company | Director | Business |
| #5 | Brick company | General Manager | Business |
| #6 | Apliances company | Director | Business |
| #7 | Demolishion | Demolisher | Business |
| #8 | Authorities | Officials | Municipal |
| #9 | Architectural firm | Architect and partner | Business |
| #10 | Architectual firm | Architect and Specialist | Business |

**Appendix B Key elements in the waste valorization processes**

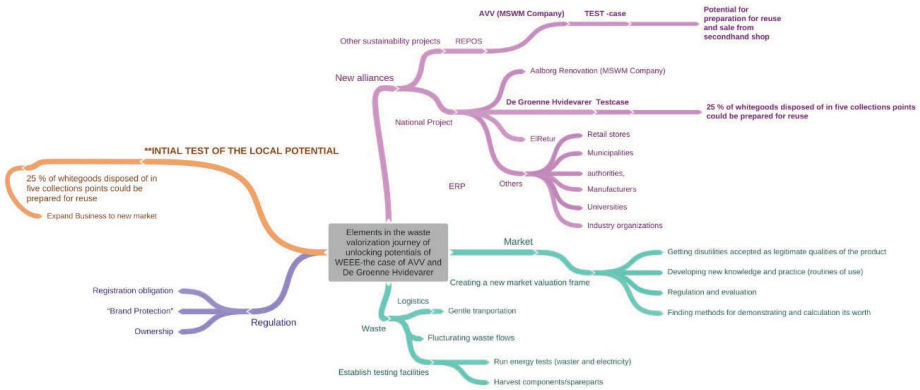


**Figure 4** Elements in the waste valorization process for the case of WEEE

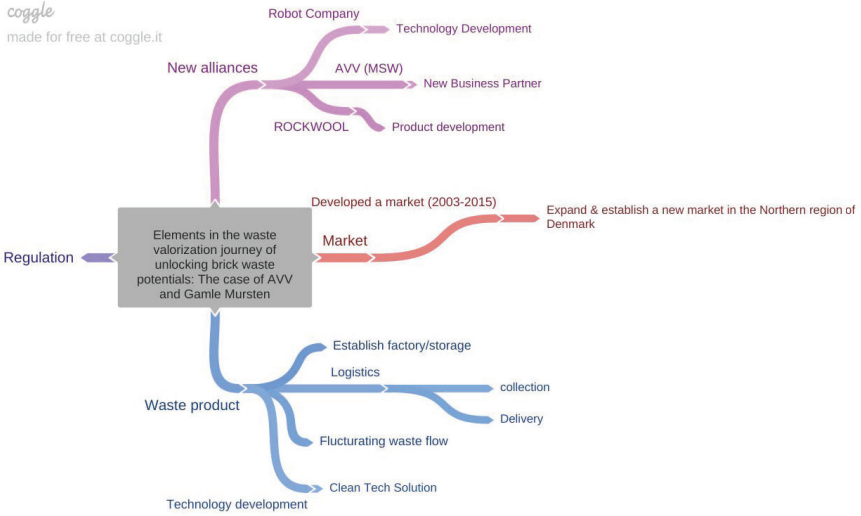


**Figure 5** Elements in the waste valorization process for old bricks

# 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

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

*sustainability*

MDPI

*Review*

# A Critical Review of the Role of Repair Cafés in a Sustainable Circular Transition

**Rikke Marie Moalem [1,*] and Mette Alberg Mosgaard [2]**

[1] Department of Planning, Aalborg University, 2400 Copenhagen, Denmark
[2] Department of Planning, Aalborg University, 9000 Aalborg, Denmark; mette@plan.aau.dk
* Correspondence: rikkekr@plan.aau.dk

**Abstract:** Extending the useful life of consumer products is a critical element in the circular economy. Although commercial repair is an established part of the global economy, the repair is often conducted informally. This means that non-commercial repair ecosystems exist, including the international network of repair cafés, spreading worldwide to over 2000 repair cafés in 37 countries (April 2021). As the first review on this topic, this article investigates and gains more knowledge about repair cafés, 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 descriptive and content analyses. The bibliometric data revealed an increase in the number of publications on repair cafés, particularly over the last four years, indicating that repair cafés as a research topic have started to gain attention, and this is likely to grow in numbers. However, the significant number of different places of publication indicates that this is not (yet) a well-established field with defined research channels. The content analysis revealed that the concept has spread to a range of different contexts, beyond the original scope, influencing the mindset and acts of a broad field of practitioners. This indicates a wide range of possibilities for the expansion of the concept of repair cafés, bringing different expectations on calling into question the future role of repair cafés. However, the aims of the people involved in repair cafés span from the altruistic and strategic, over personal gains, to critical consumer, financial and educational aims. This may challenge repair cafés' future role(s), i.e., ambitions set by the international organisation of repair cafés. Notably, the ambition for actors at the micro-level is to feed in data on repair and achieve 'collaborative repair', as the aims of the people involved are complex, and their expectations lack alignment, both vertically and horizontally.

**Keywords:** repair café; actors; product repair; sustainability; circular economy



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## 1. Introduction

The repair of broken and faulty products that would otherwise end up as waste can help keep materials in use for longer, making repair a key element in a circular economy strategy [1–3]. Furthermore, repairing an item uses less energy than new production [4]. In addition, repair is the preferable option compared to remanufacturing or refurbishment, as it uses less energy and material [2].

Repairing is defined as a 'correction of specified faults in a product' [5] (pp. 259–260). Thus, repair activities are performed at the product level, and rather than the entire product being discarded into a waste or recycling stream due to a worn or damaged part, repair activities enable the continuance of the product's life [2].

Although commercial repair is an established part of the global economy [6], repair can be conducted informally [2]. This contrasts with other value-retention processes, such as remanufacturing or refurbishment, which are typically conducted formally in industrial settings [2].

A range of different actors, spanning from industrial repairers (mostly B2B), manufacturers, retailers and after-sales services to independent repairers (small/local scale SMEs)

at the consumer level, can conduct repairs. Examples of the latter include repair cafés, 'self-repair', and internet solutions, e.g., iFixit [7]. Thus, repair is and can be conducted both formally and informally, e.g., through self-repair and in repair cafés.

In Europe and in the United Sates, there has been a decrease in the number of repair enterprises, e.g., for consumer electronics as well as personal and household items, and only recently has it seemed that a slight reversion has occurred in the EU [8]. However, the global crisis has, together with an increased environmental awareness, led to an increased interest in repair in industrialised countries [9]. As an example, over the last ten years, community repair movements have expanded [10], including a growing grassroots movement to support the repair of consumer products [11]. This has created ecosystems of non-commercial repair, including repair cafés; however, those non-commercial repair activities are less well-documented [6].

From a historical perspective, the first repair café came to life in 2009, initiated by Martine Potsma, who organised the first repair café in Amsterdam in 2009. Prior to this, the founder had applied for funding from the Dutch Ministry for the Environment—a subsidy for environmental activities aimed at fostering innovative environmental thinking [12] (pp. 64–65). These funds enabled Martine Potsma to establish the Repair Café Foundation, a non-governmental organisation that provides information and guidance to local groups setting up repair cafés in their own neighbourhoods [12]. After one year, Martine Potsma helped to develop twenty repair cafés not only in the Netherlands but also across Europe and the United States [12]. Since then, the success has grown to include 2125 repair cafés in 37 countries (https://repaircafe.org/en/visit/) (accessed on 29 April 2021), meaning that the concept is still growing.

According to Rosner [12], the concept of repair cafés can be traced back to responses to the financial crisis in 2007–2008. However, according to the founder, 'it all started with the Repair Manifesto of Joanna van der Zanden of Platform21' (the anniversary symposium celebrating the ten-year anniversary of the Repair Café, October 2019, Amsterdam). The establishment was an attempt to 'reduce waste and actively engaging the public in sustainability' at the local level [13] (p. 210). According to the international organisation of repair cafés, repairs tend to be smaller jobs that people could do at home but never get around to doing. These include jobs too insignificant or unattractive to take to a professional seamstress or bike repair shop, for example, raising the saddle of a child's bike, fixing a loose reflector, mending a tire, or even work a seamstress has rejected (https://repaircafe.org/wpcontent/uploads/2013/09/Information_package_Repair_Cafe_USA.pdf) (accessed on 13 March 2021). Thus repair cafés assist users in performing simple repairs that are not to be confused with professional repairers. The international Repair Café Foundation has the following goals: (a) to bring back repairing into local society in a modern way; (b) to maintain repair expertise and to spread this knowledge; (c) to promote social cohesion in the local community by connecting neighbours from very different backgrounds and with different motives with each other through an inspiring and low-key event (https://repaircafe.org/wpcontent/uploads/2013/09/Information_package_Repair_Cafe_USA.pdf) (accessed on 13 March 2021). Thus, repair cafés are examples of community repair in which the community aspect is in the foreground [10] and the drivers to repair are based on shared value creation or sustainable thinking [14].

*Product Repair, Sustainability and Circular Economy*

Circular economy (CE) is viewed as being an alternative to a traditional linear economy of 'take-make-dispose' [15]. Furthermore, CE is often presented in 'discourses' in relation to a sustainable future, with an aim to the accomplishment of sustainable development [10,16]. The term 'sustainable development' is a guiding principle for development containing three aims to be accomplished simultaneously: environmental quality, economic prosperity and social equity [17]. The concept of CE is connected to sustainability and sustainable development [18,19], and is important for its ability to attract both business and policy communities to sustainability work [20].

In a CE, repair is one of the main environmental strategies for achieving 'stock optimisation and waste prevention', as it supports product lifetime extension [21]. For example, a successful repair can bring a product back into use [10]. Within a CE, the term 'slowing resource loops' is used to describe slowing effects achieved through long-lasting products and the extension if product life, e.g., through repair [22]. One barrier to achieving product life extension through repair is planned obsolescence. This term is used for 'purposely designing' a product that 'stops working, works less well, or cannot be repaired before the end of its expected lifetime' [23] (p. 1). It occurs in consumer products, such as washing machines, and also in smaller consumer goods, such as flat-screen TVs and consumer electronics, contributing to resource inefficiency [23], linking to the degrowth debate in terms of decoupling consumption and resources [24]. Furthermore, repair as a CE initiative has a local dimension to it [25]

From a CE perspective, 'design for disassembly' is a strategy for improving product reparability in which the need to disassemble products for repair, refurbishment and recycling is already considered in the product design phase [21]. In relation to this, repair data is an important resource in a circular economy because data can enable and support product reparability, and can thus accelerate the adoption of CE [26]. Data can be used to improve reparability, e.g., by informing product design and CE policies in regard to the durability and repairability of products [10]. Some community repair initiatives collect and share data, including Repair Café International [10]. The aim of the collection of data is to 'identify what needs to be done to make products more repairable, so they will contribute to a circular economy' [27] (p. 3).

However, the decision concerning whether to repair or not is initiated by the users of the products, making consumers' repair behaviour key to a sustainable transition [28,29]. At the consumer level, drivers and barriers to repair are affected by a variety of factors stemming from technical, emotional and value aspects [29], including a lack of financial means to buy new products, saving money [30] and increasing environmental awareness [14]. This has led to the emergence of consumer groups living less wasteful lifestyles, including 'self-repairers' [31].

With regard to developing CE solutions successfully, attention should be given to all three dimensions of sustainability [18,20,22]. With regard to this, van Buren et al. [32] use repair cafés as an example to illustrate that circularity is vivid in civil society, and not only in industry. Nevertheless, environmental concerns are often found to be favoured over environmental and social ones [16], including indicators for measuring CE at the micro level [33]. Further, consumers are rarely outlined as enablers of the CE, although the CE operates at the micro-, meso- and macro-levels [16]. In addition, or maybe due to this, 'little is known about consumers' willingness to participate in [a CE]' [34] (p. 1), leaving behind a research gap regarding consumers' perspectives on CE [16] (p. 220).

This article sets out to investigate and gain more knowledge about repair cafés as a local sustainability initiative, and, on this basis, to critically assess the role of repair cafés in a circular sustainable transition. The latter includes a discussion on the ways in which local repair initiatives match the wider sustainability objectives formulated by the international Repair Cafés Organization.

This paper is organised as follows: Section 2 explains the methods used. Section 3 holds the descriptive analysis of the bibliometric results obtained in the review. Section 4 presents the content results, including a critical analysis of the results obtained in the literature review (as seen in the light of repair cafés and their role in a circular sustainable transition). Section 5 offers a critical discussion about the results, and Section 6 concludes the literature review.

## 2. Research Methodology and the Framework of the Analysis

The study presented in this article consists of a review of the literature on repair cafés. This literature review aims to create an overview of the scientific research on repair cafés that has been performed so far, including the identification of the themes and patterns in the

literature [35]. Different approaches to literature reviews exist, and review methodologies include systematic, semi-systematic or integrative approaches [36]. The chosen method for conducting this study is systematic, which provides a summary of previous studies in the area [37]. According to Knapp [38], librarians possess important qualifications in interdisciplinary research in terms of identifying information and bridging different perceptions of qualified knowledge. Furthermore, library staff possess great professional insight into the use of search engines and relevant databases, and in organising knowledge, which qualifies them to take on roles in interdisciplinary research [38]. Thus, librarians assisted with this literature review, particularly with regard to the development of a strategy to obtain data in a systematic way, supporting an iterative process. In order to secure a systematic review, the research process was designed with inspiration from Snyder [36], Fink [39], and Briner and Denyer [40]; see Figure 1.

| Steps | Research |
|---|---|
| 1. Strategy to obtain the data | Development of a search strategy supportive of a systematic review |
| 2. Initial review | What defines repair cafés? Who participates? What is repaired? What is gained from a sustainability and circular perspective? |
| 3. Objective | Obtain an overview of the scientific research on repair cafés and on this basis, critically asses the role of repair cafés in a circular sustainable transition |
| 4. Criteria for considering studies | Develop criteria for considering studies, including databases, words and search strings |
| 5. Data collection | Collecting data and exclusion of repeated articles |
| 6. Quality assessment | Screening/reading (ensuring that all the obtained studies meet the search criteria) |
| 7. Analytic framework | Analysing material to develop an analytical framework. |
| 8. Preparation of results | Preparing results for the descriptive analysis of the bibliometric results obtained for the systematic review and content analysis |

**Figure 1.** The research process inspired by [36,39–41].

In the following is a short description of the eight steps in the research process, including the criteria for the consideration of the studies. This also includes the words used in the search string, and examples of how this resulted in different hits and made the process iterative. The word search was undertaken in four academic search engines (Scopus, Web of Science [WoS], EBSCOhost, and Google Scholar).

The first step in the process included the development of a systematic search strategy to obtain data in which the overall aim was to create a strategy which allowed for the repeated running of cycles and the securing of documentation of the process. This process resulted in a search strategy template supporting an iterative process. The second and third steps in the review process included the initial review and the definition of the research problem to be studied, the objectives, and the criteria for considering the studies. This resulted in framing the study: What defines repair cafés? Who participates? What is repaired? What is gained from a sustainability and circular perspective? The objective of obtaining an overview of existing peer-reviewed studies on repair cafés includes addressing the role of repair cafés from a sustainability and circular perspective. Thus, the 'what, who and why, drivers and barriers to repair' guided the content analysis. The criteria for considering the studies were that the papers should include 'repair café*', 'repair café*' AND CE OR sustainability OR waste. The fourth step included setting up the search criteria to obtain the data (see Figure 1). This step included predefining the search criteria, such as databases, words, search strings, document type, the time span for articles in the search and the language. The literature review was confined to scientific peer-reviewed articles, books, book chapters and proceedings. The keywords used in the search included

'repair café*', 'sustainab*', 'circular economy*' and 'waste'. These words were combined in different ways and search strings (Block 1: word **OR** word **OR** word **AND**, Block 2: word **OR** word **OR** word **AND** Block 3: word **OR** word **OR** word, etc.), e.g., 'repair café*', 'repair café*' AND 'sustainab*', 'repair café*' AND 'circular econom*', 'repair café*' AND 'waste*'.

Search strings were used to create different search blocks in which we could narrow or broaden our search, e.g., by combining different search strings to different levels of searches in the databases. As an example, our initial search (Block 1) included only one search string (Scopus S1: 'repair café*'Abstract, title, keyword). This resulted in only eight articles. In order to obtain more articles, we expanded the search string to also include 'all fields' (Scopus S2: 'repair café*' 'all fields'), resulting in 26 articles. In another example (Block 2), we initiated the search to include one search string (WoS S1: 'repair café*'), providing us with only eight articles. In this case, the expansion (WoS S2: 'repair café*' 'all fields') only provided us with one extra article (9). The search template established a search structure, which allowed for spiraling out from databases covering broad and umbrella databases. The fifth step in the process included the initial search ('repair café*' AND sustainab*' OR circular econ*' OR 'waste*') in each of the three databases (Scopus, WoS, EBSCOhost), using the combination of 'repair café*' AND ('sustainab*' OR 'circular econom*' OR 'waste*'), which resulted in a total of 95 papers. Eliminating repeated articles across all of the databases resulted in a total number of 62 articles. Step six included a quality assessment to ensure that all of the papers fell into the category of peer-reviewed articles or proceedings, which resulted in a total number of 45. A final read of the full paper (excluding those not meeting the established criteria) resulted in a total number of 41. Reasons for not meeting the criteria at this final stage included only the abstract being in English, and the term 'repair café' only occurring in the reference list and not in the main text.

In order to ensure that the review had come to completion, a final search was performed in the search engine Google Scholar, thus repeating steps five and six. This included combining the broadest search string ('repair café*') with a search on an umbrella search engine (Google Scholar), resulting in 943 hits. Excluding the repeated papers and articles not meeting the search criteria resulted in a total number of three articles (2 + 1 early release 2021). Inserting relevant papers (3) that were not included in the initial search left us with a total number of 44 articles (Scopus, WoS, EBSCOhost 41; Google Scholar 3). In order to supplement the search, the cited references in the already-identified articles were checked, as recommended by Webster and Watson [37]. This did not lead to any additional publication being included in the review, indicating that the existing peer-reviews on repair cafés had been obtained.

Inspired by Zacho and Mosgaard [41], the seventh step in the process included the development of an analytic framework for organising, classifying and analysing the literature. The framework resulted in two main categories—descriptive elements and concept categories—and six subcategories; see Table 1.

The first category concerns descriptive elements encompassing the number of publications distributed over time; the journals in which the articles were published; the countries in which the articles were published, including countries with the greatest number of publications; and finally, the publications' dispersal according to the subject area. The second category concerns the content of the literature. Based on Webster and Watson [37], this part include themes and concepts for the organisation and analysis of the data. The process of defining the categories and subcategories was iterative, going back and forth during the reading of the literature [41]. The themes and patterns for the content results and analysis were identified using a matrix organizing the content of the 44 articles, searching for themes and patterns. The results from this categorization are provided in the Appendix B.

Thus, the analysis is divided into two parts. The first part constitutes a descriptive analysis of the bibliometric results obtained in the review, including basic statistics. The second part constitutes the bibliometric results obtained, forming the basis of the analysis of the content of the articles included in the literature review, critically assessing the central

elements of the repair cafés in the light of the goals of their own organization and in relation to their role in a sustainable development transition.

**Table 1.** The analytical framework guiding the analysis.

| Categories | Subcategory |
| --- | --- |
| Descriptive analysis of the bibliometric results obtained in the review | • Number of publications distributed over time<br>• Journals in which publications are published<br>• Countries in which the greatest number of articles were published<br>• Publications dispersal according to subject area |
| Content results and analysis | • What constitute repair cafés<br>• Repair cafés—who and why |

## 3. Descriptive Analysis of the Bibliometric Results Obtained in the Review

In this section are the basic statistics of the years and sources of the publication, and the countries of affiliation, including the countries with the greatest number of publications and the publications' dispersal according to their subject areas.

### *3.1. Dispersal over Time*

The first bibliometric analysis investigated how publications related to repair cafés are dispersed over time (Figure 2).

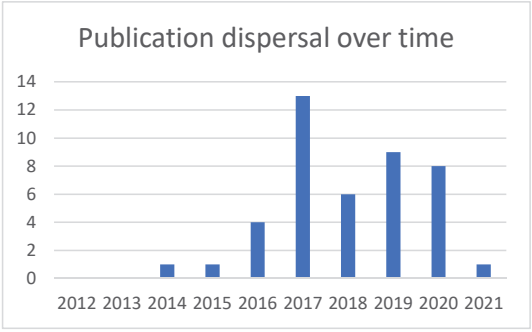


**Figure 2.** Repair café literature dispersal over time (indexed in Scopus, WoS, EBSCOhost, 2010–2020).

In the graph, one article from 2021 occurred in the search (indexed 2010–2020). The explanation is that this article appeared in the search, as it was a 2021 forthcoming article.

The graph illustrates an increase in the number of articles published, especially in the last four years (2017–2020), in which 40 out of the total number of 44 articles were published. This indicates that the repair café as a research topic has started to gain attention, and is likely to grow in numbers. The Action Plan adopted by the European Commission in 2015 led to increased attention on repair, which could have influenced the number of articles published.

### *3.2. Source of the Publications*

The second analysis investigated the source of the publications (Appendix A: Figure A1). What catches the eye is the great number of different places of the publications. Forty

different publishers published the 44 articles. Only four journals had more than one publication. The greatest sources of publications were Energies (2), European Planning Studies (2), the Journal of Cleaner Production (2) and publications in the Handbook of Sustainable Product Design. This indicates that this research field is not a well-established one with fixed research channels yet.

### *3.3. Countries of Affiliation*

The third bibliometric analysis investigated how the countries of affiliation are dispersed geographically (indexed in Scopus, 2010–2020). From a geographical point of view, it can be noticed that most of the articles came from Germany (13%) and the United Kingdom (12%), which dominated the field, followed by Austria 5%, the United States (4%), China and Finland (3%), and the rest were below 2% (Netherlands, Romania, Austria, Belgium, Canada, Greece, Italy and New Zealand).

### *3.4. Documents by Subject Area*

The fourth bibliometric analysis investigated how the publications are dispersed according to their subject area (Figure 3). Sixteen types of subjects were retrieved, with the most frequent being social science, representing 27% of the total publications indexed in Scopus. This was followed by environmental science (13%), business management and accounting (12%), engineering (9%), economics, econometrics and finance (8%), the arts and humanities (7%), and energy (7%). The rest of the subject areas had insignificant shares: mathematics (2%); medicine (2%); and finally nursing, agricultural and biological sciences, decision science, earth and planetary sciences, materials science and psychology, each with 1%.

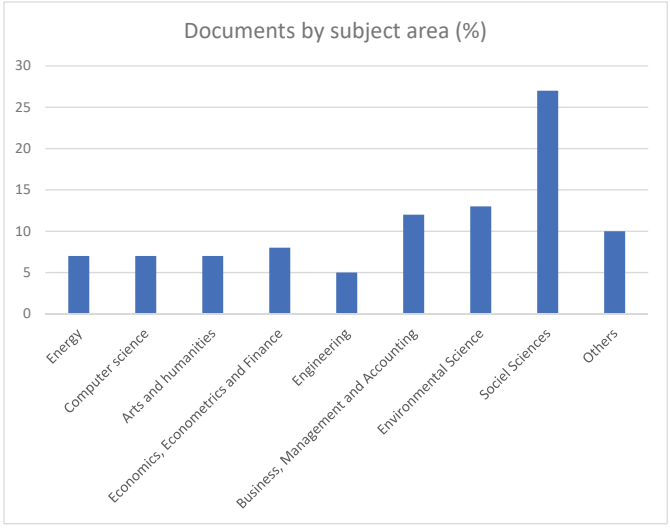


**Figure 3.** Number of documents according to their subject area (indexed in Scopus, 2010–2020).

## 4. Content Results and Analysis

This section presents, and critically asseses, repair cafés and their role in a circular sustainable transition, based on the results obtained in the literature review. The themes and patterns were identified using a categorisation matrix on the 44 articles obtained in this literature review. The content analysis is divided into two parts. First, it investigates how the literature presents the more organisational and structural elements of repair cafés (what constitutes repair cafés?), such as the format of repair cafés, the products brought for repair, and the location and geographical distribution. The second part of the content

analysis investigates (a) how actors are presented, including a critical view on the actors and their reasoning as to why (not) they engage in repair at repair cafés, and (b) how the purpose(s) of repair cafés are presented in the existing literature. Those elements lay the foundation for the discussion, critically assessing the role of repair cafés in a circular sustainable transition. In particular, this includes the ways in which local repair café initiatives match the wider sustainability objectives formulated by the international repair cafés organization. Appendix B provides an overall overview of the content results which lay the foundation for the content analysis.

### *4.1. What Constitutes Repair Cafés—Organisational and Structural Characteristics*

The first analysis of the content examined what constitutes repair cafés, including the format, the products brought to repair cafés, and their location and geographical distribution; see Appendix B, Table A1: Content results—What constitutes repair cafés?

#### 4.1.1. The Format of Repair Cafés

Six articles addressed the format of repair cafés in different ways, but primarily in relation to the set-up and procedures, the time and frequency of the events, and social elements.

##### Set-Up and Procedures

Seven articles addressed the format of repair cafés in relation to the set-up and procedures. The format of repair cafés is viewed as 'quite straightforward' [42], including seating and table arrangements which are 'similar' [43], and consisting of volunteers offering help sitting by tables where signs above or on the tables indicate the type of goods in need of repair [43] (p. 78). In one article, the set-up also included a reading table with books about repair, as the repair café event took place at a library [44]. One article addressed the procedural aspects of repair cafés as a 'step-by-step' procedure, with visitors explaining the problem to the volunteers before they are directed to the appropriate repair station where a volunteer expert awaits them to diagnose the problem, gives advice on how to repair the item and, if feasible, carries out the repair [42]. In addition to this 'step-by-step' procedure, it is stressed that repairing requires a 'range of gestures, tools and competences, and also emotional engagement' [45] (p. 7), as repair work often 'develops in unpredictable ways, requiring a range of capabilities'.

However, five articles also highlighted the more social aspects of repair café set-ups, including the fact that the materials, tools and know-how to fix broken consumer products are being provided to the visitors [46]. Furthermore, repair cafés constitute places where visitors can bring their broken items and attend free of charge [42,46–49], thus touching upon the more social aspects of the set-up, in particular the inclusion of people with a low income.

##### Temporary vs. Fixed

Four articles addressed the format of repair cafés in relation to time and frequency, where the latter seems to differ.

In some cases, repair cafés are organised several times a month, and sometimes weekly [48], contrasting to another case where the event was held just three times a year [44]. One article addressed that the events take place for a restricted period of time, usually three to five hours [43] (p. 78). One article addressed repair cafés as constituting 'pop-up' events, which are often held on a regular basis [42] (p. 644), thus addressing repair cafés as events that are 'temporary and unexpected' but also as something more 'fixed', contrasting with the temporal aspect.

##### Social Elements (Contributing to the Strengthening of Social Cohesion)

In addition to the more formal requirements for repair, the repair café set-up was also described as supporting the social aspects of a community [49]. One article addressed this aspect in the following way: 'Irrespective of the location, usually coffee and cake or

other beverages and snacks are provided to create a sort of café atmosphere even when not actually taking place in cafés' [43] (p. 78). As an example, there may be a refreshment table with coffee, tea and donuts [44]. This suggests that elements in the set-up contribute to the relational side of communities, supporting the social function of repair cafés. The latter was not a part of the original concept of repair cafés but rather something which became clear over time. Pesch et al. [48] stated it this way:

Originally, the concept of repair café was invented as a way to reduce waste and to extend the lifetime of products. Moreover, it was intended to revive 'forgotten' technical skills that are required to repair broken down appliances. Over time, it became clear that the repair cafés also have a strong social function. (p. 307)

Summing Up the Format

The overall format of repair cafés is described as quite 'straightforward', including the physical set-up and procedures. However, there are also variations. Firstly, the frequency of the events can vary from weekly to just a few times a year. In addition, the event format seems to constitute both 'pop-up' events and more stationary events, and at times a mix of both, thus addressing repair cafés as events that are 'temporary and unexpected' but also as something more 'fixed'. The latter contrasts with the temporal aspect. In common, the repair café set-up encompasses social elements with the potential to contribute to social cohesion and inclusion.

4.1.2. Products Brought to Repair Cafés

Sixteen articles addressed the type or age of products brought to repair cafés in varying ways.

Products and Types

Repair cafés have a general focus on electronic products [30,50,51], and receive and recover broken [42] or defective everyday objects [9,47,52]. One article indicated that the products brought for repair include items that are 'highly valued' [46] (p. 934).

In the category of electronic products, media technologies are one of the most common types of products brought to repair cafés [47]. This includes computers and computer equipment [9,47,52], laptops [52], smartphones and mobile phones [14,47,52,53], radios [47,52], and slide projectors [52].

Household items are also commonly brought to repair cafés. Firstly, these include household electrical and mechanical devices [14,45,48], in particular small domestic appliances [50] like toasters [44,53] and vacuum cleaners [44]. Secondly, clothes [30,44,45,48,53]—including shirts with loose buttons [44] and the 'hem of their trousers' [53] (p. 70)—are brought to repair cafés, which gives a glimpse of the type of repair carried out on clothes.

Finally, bikes [30,45,48,54,55], furniture [48] and toys [30,48] are repaired there.

The products brought to repair cafés constitute both old and new devices [43,52], e.g., 'They bring with them new devices such as laptops and smartphones as well as old ones like slide projectors and radios' [43] (p. 79). Whether the products brought to repair cafés are successfully repaired is only dealt with at a more general level, e.g., 'a variety of people brought defective everyday objects and devices that were (mostly successfully) repaired with the free assistance of the students and other 'experts'' [43] (p. 189).

Summing Up the Products' Types and Ages

The type of products repaired in repair cafés depends on the physical set-up, including the aim of the specific repair café and the repairer's expertise. Based on the 16 articles addressing the products brought to repair cafés for repair, there seems to be a preponderance of electronic products, including media technology and household items. However, there are examples of other products, such as clothes, bicycles, furniture or toys, as well. Two articles note that the products brought to repair cafés constitute a mix of old and new devices. Common to the articles is that none seem to address quantitative measures, such

as the numbers of products brought to repair cafés or the types or brands of products, including more detailed measures on the age of the products and whether the products are repaired or not.

#### 4.1.3. Location and Geographic Distribution

Seven articles addressed the geographical aspects of repair cafés, in particular, their dispersal over time and the type of location in which repair cafés occur.

##### Type of Location

Repair cafés constitute new and widespread events [43,52] which are often held at fixed locations in neighbourhoods [45]. The most common types of locations are makerspaces [56], cafés and community centres [43,47,52,57]. However, five articles addressed alternative examples, including the public library, hosted by the librarians, where repairing stations were set up in the library's meeting room and outside on the front lawn [44]. In addition, they were held in a pub; in an art studio [47]; in a university context [43]; in an old, temporarily unoccupied building [52]; and finally at a public school, hosted by the schoolteachers [55]. In one article, the organisers of the repair event had put some thought into the choice of location: 'We thought the idea of using buildings that were not new and that were temporarily unoccupied would perfectly fit with the idea of not throwing away goods that can still be used' [52] (p. 189), thus addressing the type of location for the repair café as both 'fixed' and 'temporary', expanding the location to also include temporarily unoccupied buildings.

##### Geographical Distribution

The concept of repair cafés originated in the Netherlands in 2009. Repair cafés are based on Netherlands experiences, and the concept is spreading worldwide [9]. Three articles specified the geographical spread to Western Europe and North America [43,47,52], including many industrialised countries [45].

In line with this, one article ascribed the trend of 'making' to a trend occurring in the West [58]. In addition, others dealt with how fast the concept is growing, e.g., that the concept is both 'new and widespread' [52], and from 2009–2017, almost one thousand repair cafés had been set up across 24 countries [42]. Thus, the geographical dispersal encompasses aspects of both scale and time, indicating that the concept is growing in popularity at a certain speed.

##### Summing Up the Type of Location and Geographical Distribution

The concept of repair cafés had its origin in the Netherlands, but is a growing concept that is spreading worldwide. However, the trend of 'making' seems to occur mainly in the West. In terms of location, repair cafés are most commonly held in cafés, community centres or makerspaces. However, a range of alternative solutions is also appearing in the literature, testifying to the fact that repair cafés can be established in a multitude of locations. Thus, repair cafés are held in neighbourhoods in existing premises, and include both public and private spaces. Seven articles addressed the geographical aspects of repair cafés, in particular, their dispersal over time and the type of location in which repair cafés occur.

### *4.2. Actors: Who, and Why (Not) Do They Engage in Repair at Repair Cafés*

The second analysis of the content investigated how actors are presented, including a critical view on the actors and their reasoning as to why (not) they engage in repair at repair cafés. The actors in repair cafés are people who voluntarily offer help in either organising the repair events or in the repairing process for visitors seeking help; see Appendix B, Table A2: Content results—Actors; who and why (not).

#### 4.2.1. Volunteers

The volunteers consist of both the organisers of the repair cafés and the repairers who do the repairs in repair cafés. The volunteers are mostly retired people [43], and are often repairers [45], but also constitute a range of other people, including artists [43], librarians [44], teachers [55] and university employees [43,47], thus constituting a broad palette. The aims of the people involved in repair cafés consist of differing motivation and ambitions [48]; they are, in fact, complex [43], and include the 'conservation of resources, waste prevention, appreciation of the apparatus, technical empowerment, having fun repairing things and economic pressure' [48] (p. 84). Kannengießer [43] notes that this complexity goes against previous studies by Charter and Kieller [57], who stated that 'volunteers act altruistically and that their personal gain is not important to them' [43] (p. 82).

##### Organisers

The organisers constitute a range of different actors from both the private and public sector, and the aims of the people involved with repair cafés are complex. The motives to engage are addressed as both altruistic and strategic, in particular in relation to the public sector. Thus, the motives seem to span broadly within the context of sustainability, and consist of both altruistic and professional gains. Eleven articles addressed the organisers of repair cafés, including their aims, roles and barriers to engagement.

Eleven articles addressed and characterised the volunteers of repair cafés, including who they are and what drives them to engage. Characteristic to the organisers of repair cafés is that they are often skilled volunteers [46] and repairers [45]. However, the organisers also include librarians from a public library [44], teachers from primary and secondary schools [55], university employees, retired teachers [43,47] and artists [43].

The motives and ambitions that underlie the activities of the people that run the cafés vary [48]. From one perspective, the underlying motives are altruistic, including a way of 'giving back' to the community and a way to encourage others to live more sustainably [46]. Others addressed motives that relate more to a 'strategic shift', particularly within the public sector, including school and education, public libraries, and city planning, as well as finding new ways of achieving school learning goals [55] and identifying future roles for public libraries, including the testing of alternative uses [44]. Furthermore, establishing a bike repair café can be part of an overall strategy to enhance a district's transformation, including an attempt to contribute to an overall improvement in the 'quality of life' in a district [54].

Finally, the organisers engage because they aim to build a network among people who know how to repair as they pursue the repairing of media technologies as an 'act of empowerment' [43]. In relation to the latter, one article addresses the role of managers or founders in such makerspaces as 'gatekeepers to circular practices' [56] (p. 283), thus emphasising that organisers may play a societal role in transitioning towards a more circular society. Despite the importance of the role of the organisers, the work done by the organiser(s) can easily be taken for granted or not noticed until it is needed [58]. Organisers face constant work to keep the initiative running [58]. The role involves a wide range of tasks, including finding a location, advertising for volunteer experts, general advertising, and conducting public relations, etc. [52]. Thus, there is the risk that the organisers will burn out.

##### Repairers

The accompanying motives for the repairers vary, but generally they build upon a range of personal gains, from learning and keeping up with skills, to having fun and socialising, to bringing a level of contentedness to everyday life for both pensioners and the unemployed. Repairers are made up of students, and retired and unemployed people with varying motivation. Although repairers constitute experts, they may also include people with varying skills and knowledge, who relate more broadly to extending the lifetime

of products, including knowledge related to product maintenance. The accompanying motives include a range of personal gains, including contentedness in everyday life for both pensioners and the unemployed.

In the literature, repairers are described as taking on two roles: one relates to the practical side of repairing (e.g., diagnosing and carrying out the repair). The other relates to the knowledge that repairers gain with regard to planned obsolescence in electronics. Six articles addressed some of the accompanying motives for the involvement of the repairers in repair cafés, including who they are, the tasks undertaken, and their roles.

The repairers include both retired and unemployed people [43] and students [52], and the tasks include diagnosing the problem, giving visitors advice on how to repair, and carrying out the repair [42]. Commonly, repairers are addressed as 'experts' [42,52] with differing expertise, including specialists such as electricians, tailors, carpenters and bicycle mechanics [48]. In some cases, the repairers in repair cafés have gone through formal training [45], thus stressing the need for competences. However, one article addressed that 'experts' or 'repairers' may also include persons who possess skills which relate more broadly to extending the lifetime of products, including specific maintenance skills. Examples from the texts include students with skills related to the maintenance of specific products, such as laptops, smartphones and radios [52], in addition to students with varying levels of skill and knowledge related to bike repair and sewing fabrics, for example [52]. Thus, repairers constitute specialists, but may also include people with varying levels of skills and knowledge about repair and maintenance. For example, the useful life of clothes can often be extended easily [59].

Repair cafés provide an opportunity for retired and unemployed people to find tasks to do, as well as a space to socialise [43]. Their motives vary, but mainly consist of personal interest. Examples of this include gaining knowledge in a personal interest related to specific product groups, e.g., media technology, and having fun repairing [43]. As an additional benefit, repairing is a 'positive challenge' that may help in keeping retired people engaged [43]. Thus, valuable knowledge around repair is retained, and even updated. In relation to this, one article addressed that repairers in repair cafés contribute to identifying problems of planned obsolescence regarding electronics [60]. Thus, the role of the repairer may extend further than 'just' diagnosing and repairing. In particular, repairers may play an important role with regard to addressing specific problems concerning planned obsolescence. This may include the spotting of product weaknesses of which the producers are unaware.

#### 4.2.2. Visitors

Common to visitors to repair cafés are the variety of people from all age groups, varying social backgrounds, and the gender distribution of both men and women. Although their motives vary, they can be categorised into three broader groups, including being a critical consumer, a financial perspective, and educational motives. Five articles addressed some of the accompanying motives for the involvement of the visitors, including who they are and what motivates them to visit repair cafés.

The visitors to repair cafés constitute a variety of people [52] from all age groups [43]. The visitors include men as well as women, who come from different social backgrounds [43], and students [55]. However, one article found that it was significant that people with a migration background rarely participate [43].

One motivation factor is having the perspective of a critical consumer. In particular, participants want to prolong the lifespan of existing products in order to avoid buying new [43,52], including reducing e-waste [52]. In addition, some visitors bring items to repair cafés to have them fixed, although they have already bought a replacement for them [45]. This finding, or behaviour, goes against Pesch et al. (2019), who state that 'Repair Cafés' core function—repairing broken products—can be seen as a clear example of substitution to buying products' [48] (p. 308). However, the underlying reason for this behaviour is closely linked to everyday practices where 'the need of the object to be

able to perform daily routines often is greater than waiting for the object to be fixed' [45] (p. 8). If the object is not fixed, visitors can 'dispose of it with good conscience' [45] (p. 8). In contrast, if the object is fixed, visitors donate it to the organisers. This means that not all repairs are examples of substitutions for buying (new) products. A second perspective addressed relates to monetary motivations [43]. In particular, repair cafés provide repairs for free, allowing people with a low income to avoid costs [48]. Finally, Schulte et al. (2018) addressed education as an accompanying motive, as students visit repair cafés to achieve some of their learning goals.

#### 4.2.3. Subculture of the Repairers

Actors in repair cafés are part of a larger (sub)culture, but they also share an identity with a smaller local group.

Repair is not a new phenomenon; the novelty is that repairing (through repair cafés) has become public [52]. Repair cafés are, on the one hand, actors 'on their own', organised by and for local residents in one particular neighbourhood. On the other hand, repair cafés constitute a collective, a repair subculture, constituting a group of people within a culture that differentiates itself from the parent culture to which it belongs. As addressed in one article 'we cannot talk about sustainability without a culture of repairing' [52] (p. 187), bridging repair cafés to a 'subculture' of repair, e.g., as part of 'grassroots movement' [61], 'grassroots innovation movement' [62] and 'grassroots innovation' [63]. Other articles addressed the collective action in ways that are more specific, e.g., as part of a 'maker movement' [14,64], 'modifiers and fixers movement' [14] and 'repair movement' [42]. Thus, repair cafés are a bridge to the culture of 'making' in which some makers are 'critical makers' [43] and part of a do-it-yourself (DIY) activism [58]. Others may 'just' be DIY citizens [48] in a DIY culture [65] and a 'making culture' [58]. One may say that for the 'critical makers', repair cafés may constitute a local sustainability initiative (LSI) [48,63], and for others, repair cafés may 'just' constitute 'community workshops'or 'makerspaces' [56]. Thus, repair cafés seem to have found their way to the fulfilment of different roles in society, including the provision of a space in which both the critical consumer and the DIY citizen can partake.

#### Summing Up the Actors in Repair Cafés

The actors in repair cafés encompass a range of different actors, and the aims of the people involved in repair cafés are complex; however, there are some general characteristics. The main drivers for organisers consist of both altruistic and strategic aims, whereas the driving forces for repairers seem to relate more to personal gains. Finally, visitors are driven by critical consumer, financial and educational motives. However, repair cafés are also addressed in relation to large global movements. Thus, actors in repair cafés are part of a larger (sub) culture, but they also share an identity within a smaller local group.

#### 4.2.4. Purpose(s)

The final part of the content analysis investigates the ways in which the purpose(s) of repair cafés are presented in the existing literature. Nineteen articles addressed the different purposes served by repair cafés; see Appendix B, Table A3: Content analysis—The purpose(s) of repair cafés

#### Waste Reduction and Product Longevity

From an environmental perspective, the purpose of repair cafés is seen as 'bottom-up environmentalism' [66], motivating consumers towards product repair [67]. Repair cafés enable communities to reduce their environmental burden by offering them the opportunity to repair items [50], and in particular, a way to reduce waste [48,49], including e-waste [51], and to extend the lifetime of products [48], thus providing citizens with a 'voice' in the sense of combatting waste, environmental degradation and shared repair problems [46]. The use and support of activities like repair cafés may also serve a higher

purpose, such as influencing planned obsolescence [60] and improving product reparability and longevity [68]. Thus, initiatives like repair cafés can eventually assist consumers in achieving more independence [60].

Strengthening Social Cohesion

From a social perspective, repair cafés provide a place to meet [30,47,48,53,54]. More specifically, repair cafés are public sites of repair [42], in which people can meet to repair [52] free of charge [42,46,48], or free of any direct exchange [46]. Thus, repair cafés provide a space for freely accessible meetings, including the avoidance of costs for people with a low income [48], thus contributing to the strengthening of social cohesion [46,48]. One article addressed this particularly in relation to an improvement of social cohesion among volunteers and visitors [48]. In another case, the repair café was established at a university campus, constituting a meeting point where students, university staff and neighbouring residents can meet [54]. However, repair cafés are also addressed as places where 'people who might otherwise be sidelined are getting involved again' [42] (p. 645). Thus, in some cases, the key to social cohesion is the 'space', and repairing is secondary.

Pedagogical Aspects of Repair Movements

Repair cafés also serve pedagogical purposes, both as a phenomenon and as an activity. In particular, repair cafés are useful in environmental communication pedagogy, where they can serve as a point of departure for deeper discussion concerning production, consumption and disposal [52], in addition to examples of how environmental communication can be put into practice [52], such as being a subject in practical seminars. Partly linked to this, repair cafés are noted as places for 'testing assumptions around the connection between learning skills and long-term change' [42] (p. 644). Thus, repair cafés can serve the purpose of teaching and as a place for research [54], and thus become an extended environmental communication and research platform.

Revive Forgotten Skills and Hands-On Learning

From learning, knowledge, skill-sharing and empowerment aspects, repair cafés support the development of local socio-technical skills [14]. They do so by taking a hands-on approach to the pedagogy of repair [42]. Particularly, skill-sharing events [52,58] where people exchange, access, or transfer knowledge [30] contribute to the revival of 'forgotten' technical skills [48] and empower people to repair [51]. Thus, the purpose is twofold; learning new and reviving forgotten skills, and a matter of giving back 'the power to repair' and thus gaining (some) control over products. However, in order to reach (the majority) of those aims, both the repairer and the visitor must engage in the repair together.

Collaborative Aspects

Another element addressed relates to the 'collective' side of repair and repair cafés, particularly addressing that repair cafés are not merely a free service provider for repair, to which visitors come to sit passively while the repairers 'fix it for you'. In contrast, it is a place where people are 'invited in to learn' [65], to 'collaboratively repair' [45] and engage in 'shared repairing' [46]. From this perspective, the idea is not to provide a 'free service centre' but rather to 'help people to help themselves' [48,52], and to help each other to repair broken products [30]. In this way, people meet to repair together, to learn something together and to become conscious [52]. Thus, in some respects, there is a distinction made between visitors (in the passive form) and participants. This may help explain why some articles addressed the visitors as 'participants'.

Service Aspects

In contrast to the collaborative purpose, the articles also addressed repair cafés as 'service providers', providing materials, tools and know-how in a community space [46]. More explicit repair cafés are a non-market-based solution to repair [14], offering 'self-

repair services' [31] with 'professional assistance' [54], and workshops with experts [31]. In addition, repair cafés provide materials and tools [46], and a 'space', which together provide a valuable service to the community and the public [46,68]. In line with the service aspect, one article addressed repair cafés as a 'sharing platform' in line with, e.g., a Library of Things, Retroy and the Fixit clinic [46]. However, the article stresses that the service provided can, and should be, distinguished from other types of sharing platforms. Finally, repair cafés are addressed as 'third party service providers' and 'autonomous loop operators' in relation to CE [69] (p. 1263), particularly in relation to slowing and closing product and related material loops, as those require service operations, such as repair. However, due to the informal character of the relationship among actors in this laissez-faire architecture, a central coordinator fails to receive this feedback. This is noted as a 'lost opportunity' [69], as valuable knowledge is being lost.

Change Agents

The concept of repair cafés has found its way into a range of different contexts, from rethinking the role of community spaces and the way we plan our cities, to pedagogical aspects, political participation, and finally to broader political reflections concerning societal shifts to repair as a societal imperative, and the driving forces behind it. Feeding into this discussion of repair cafés as part of a broader network of subcultures, seven articles addressed repair cafés as 'change agents', particularly in the sense that the concept has influenced the mindset and acts of a broad field of practitioners. This includes rethinking community spaces [44], in which librarians transferred the idea of repair cafés into a public library context. The librarians took on the role of the organisers of the event, including advertising for volunteers to help others fix their broken items, and later hosting the repair event [44]. In this case, the aim was not to have more things repaired, but rather to contribute to rethinking the future role of public libraries, including alternative uses. In another example, 'the Computing Repair café' [55] involved pedagogical aspects of repairing, and more specifically a transfer of ideas to computing education [55], where the hands-on approach from repair cafés was used as a means to achieve high-level learning goals and problem-solving. As a side effect, the students began to change their view on technology, including their own use pattern, and began to see their habit of often buying a new phone in a wider ecological context [55], thus taking on a pedagogical approach to repair cafés. Pattillo [49] suggest implementing the concept of repair cafés internally in a nursing faculty, focusing on, i.e., printers, penlights, scrubs, or stethoscopes.

In addition, Graziano and Trogal [42] addressed this 'mindset shifting' ability of repair cafés: 'The Repair Café teaches people to see their possessions in a new light. And, once again, to appreciate their value' [42] (p. 645). Furthermore, the repair café helps change people's mindset, which is 'essential to kindle people's enthusiasm for a sustainable society' [42] (p. 645).

A third example involved the case of 'The Bicycle Repair Café' [54], in which the concept of repair cafés was transferred into a broader context of sustainable architecture and green mobility. The bike repair café constitutes a meeting point for cyclists, and includes professional assistance for minor bicycle repair [54]. The aim of the bike repair café is to serve as 'a place for research and teaching, as well as an object of investigation for sustainable architectural concepts' [54] (p. 1) and to 'enhance the district's transformation . . . creating a space to reflect environmental problems to be solved' [54] (p. 1), thus constituting a rethinking of the way in which we plan our cities and city districts. Other studies addressed the role of repair cafés in dealing critically with issues of materiality and (over) consumption [43,52] by referring to repair cafés as an innovative setting for environmental activism [52], in which 'people criticize the capitalistic consumer society and develop practices aimed at sustainability' [43] (p. 78). This further highlights the relevance of repair cafés for social change, including the way in which repair cafés are used to 'lobby' for environmental protection (52], thus linking to broader aspects of political participation. In line with this, others explore some of the diverging political positions, contributing to

'the shaping of the (rising) movement of repairers' [42] (p. 638), including the way in which these 'public sites of repair' [12] (p. 55) are contributing to a societal change, and more specifically 'the shift from repair seen as a family responsibility to societal imperative' [12] (p. 55), thereby addressing aspects related to the politics of collective repair.

Summing Up 'Purpose(s)'

Repair cafés serve different purposes for different people, spanning from environmental concerns, to strengthening social cohesion, to pedagogical purposes including ways to maintain repairing skills and carry out collaborative repairs, beyond repair cafés merely being a 'service' that is free of charge. In addition to this, it is impressive to find out how the concept of repair cafés has found its way into a range of different contexts, from rethinking the role of community spaces and the way we plan our cities, to pedagogical aspects and political participation, and finally to broader political reflections concerning societal shifts to repair as a societal imperative and the driving forces behind it. Feeding into this discussion of repair cafés as part of a broader network of subcultures, seven articles addressed repair cafés as 'change agents', particularly in the sense that the concept has influenced the mindset and acts of a broad field of practitioners.

## 5. Discussion

This section sets out to discuss how the concept of repair cafés speaks to the three parameters of sustainability (environmental, social and economic), followed by a critical assessment of local repair cafés' ability to meet the ambitions laid out by the international Repair Cafés Organisation. The discussion is based on the potentials and challenges for repair cafés in addressing sustainability-related issues, as addressed in the review.

### *5.1. The (Potential) Role of Repair Cafés as a Local Sustainable Initiative in a Circular Transition*

When environmental concerns conflict with the social values of community repair, consumers are rarely outlined as enablers of the CE [16], although they may be addressed from the perspective of 'community involvement' [21]. Furthermore, little is known concerning consumers' willingness to participate in the CE [70]. In this CE strategy, community involvement can be achieved through 'the involvement of communities and different stakeholders in organizing sharing platforms and providing guidance on product repair and replacement' [21] (p. 196), bringing community repair into discourses on CE. In light of this, we critically assess how repair cafés may, or may not, contribute to this discourse.

From an environmental perspective, repair cafés provide local repair opportunities, which include areas lacking places to have repairs performed. However, with the present set-up, not all types of products are repaired in repair cafés. At present, repair cafés receive and recover broken [42] or defective everyday objects [9,47,52], and some repair cafés have a general focus on electronic products [30,50,51]. The type of products repaired in repair cafés also depends on other factors, such as what is brought to repair cafés and the experience of the repairers who volunteer [10]. In particular, if products are perceived to require special skills, such as mobile phones, and none of the repairers have this experience, the particular repair café is unable to repair mobile phones [10]. Thus, the present set-up may limit repair cafés' possibilities to expand product repair and boost their environmental contribution.

However, from a social perspective, repair cafés have a strong social function [48]. Common to repair cafés is that the set-up and procedures constitute social elements with the potential to contribute to social cohesion and inclusion (see Section 4.2.4), in particular by providing a place to meet and a space for socialising [43,44], thus bringing a level of contentedness to everyday life for both pensioners and the unemployed. Furthermore, repair cafés provide places where people can bring their broken objects for repair, free of charge [42,46–48], avoiding costs for and including people with a low income [48]. However, the social function, which is embedded in the community aspect, may sometimes conflict with other core values, including those of the environment. As an example, it has

been suggested that repair cafés could repair electronics salvaged from municipal e-waste recycling, with the aim of donating the repaired products to the underprivileged [10]. The latter complies with the core aims of the CE and community repair, but it was turned down as the initiative would 'pull' repair cafés more towards being a third-party service provider and 'intervene in the community function' of the repair café [10], thus illustrating that repair cafés have the potential to expand on the original idea, but individual repair cafés may prevent a situation in which the community aspect 'moves to the background' [10].

From an environmental and economic sustainability perspective, repair cafés are also viewed as taking on different roles, pulling them more towards being a 'third-party service provider' [27,69]. Obtaining repair data is an important resource in the CE [26]. Repairers in repair cafés obtain valuable knowledge regarding weak points in product or service design, bringing community repair into discourses on the CE, e.g., as 'third-party service providers' and 'autonomous loop operators' in relation to the CE [69] (p. 1263), and particularly in relation to slowing and closing product and related material loops, as those require service operations, such as repair. As an example, autonomous repair shops collect valuable information regarding weak points in product or service design, and develop innovative solutions: 'We [third-party service provider] are better in many things. I can solve problems that an Apple employee, the entire Apple store, would not even begin to understand. We can solve these because we are much more closely involved in the matter' [69] (p. 1263). However, due to the 'informal character' of the relationship among the actors in this 'laissez-faire' architecture, central coordinators fail to receive this feedback. The latter is seen as a 'lost opportunity' [69], as valuable repair knowledge is being lost. In line with the latter, the international organisation of repair cafés plays an important role in terms of collecting and reporting data for a greater purpose beyond that at the local level, as suggested by Potsma [27], as obtaining repair data is an important resource in the CE [26]. However, there is an 'unwillingness' amongst (some) volunteers to participate in collecting and reporting data for the monitoring of repairs [10]. Reporting data often conflicts with the practice of the repairers, and it takes up 'community time'. According to van der Velden [10], this exemplifies a 'socio-material entanglement of people and things', meaning that the material and the social in community repair cannot be separated [10]. This may challenge repair cafés to take on new roles in which the community aspect of repair is not in the foreground.

On the other hand, from a collaborative perspective, community repair in repair cafés provides an opportunity for local citizens to participate in a CE [10]. For example, repairers help to improve product reparability and longevity [68] while simultaneously pursuing their passion and having fun repairing things [48] (p. 87). Furthermore, repair cafés contribute to improving societal issues, such as social cohesion and accommodating people with a low income [48], by providing a free service not only to citizens but also to society, contributing to both social and economic sustainability. In addition, collaborative repair is seen as going 'far beyond the activity itself', including social issues such as quality of life, saving natural resources and the inclusion of excluded people [71]. From this collaborative aspect of repair, Hielsher et al. [45] stressed that the repair process can become 'equally important' to 'fixing the object', as the active engagement with an object can make people value the object. Thus, Hielsher et al. [45] recommend that repair cafés 'draw as much attention to the repair process as to its outcome' in their communication. However, in support of our results, Meißner [71] stresses that, in regard to collaborative repair, interaction requires social competences for both the repairer and the visitor, which cannot always be met.

### *5.2. Local Repair Cafés' Ability to Meet the Ambitions Laid Out by the International Repair Cafés Organisation*

The International Repair Café Foundation has three goals. The findings in this review indicate that those goals are achieved to varying degrees. This is discussed in the following section.

With regard to the first goal, 'to bring back repairing into local society in a modern way', it is particularly interesting to uncover the ways in which the concept has influenced the mindset and actions of a broad field of practitioners. As an example, the concept of repair cafés has found its way into a range of different contexts, from 'rethinking' the role of 'community spaces', i.e., future roles of public libraries [44], to the way we plan our cities, i.e., the bicycle repair cafés in a district's transformation [54] and political participation [52]. The latter includes broader political reflections concerning societal shifts from repair as a 'family responsibility' to repair as a 'societal imperative' [12] (p. 55). Further examples include repair cafés serving pedagogical purposes, both as an activity and a phenomenon, particularly in environmental pedagogy as a point of departure for 'deeper discussions' concerning 'production, consumption and disposal' [52], and as a place for 'testing assumptions around the connection between learning skills and long-term change' [42] (p. 644). Thus, the concept of repair cafés seems to flourish and expand to areas which may be beyond the original purpose, including teaching, research, and rethinking community spaces.

In regard to the second goal, 'to maintain repair expertise and to spread this knowledge', repair cafés seem to provide a good foundation for volunteer repairers with respect to maintaining and upgrading valuable repair knowledge. As an example, repairer are referred to as 'experts' [52], who identify problems of planned obsolesce [60], thus making repairers attractive knowledge partners [27,69]. However, for several reasons, repairers are challenged regarding the 'spreading' of this knowledge. From a collaborative aspect, visitors sometimes lack creativity [11] or interest in learning to perform repairs [43] which reflect that repair is a marginal activity [72]. In addition, a behavioural study on consumer engagement in the CE also revealed that 'repair decisions' are easily disrupted if arranging the repair requires effort [73] (p. 10) and if the cost of the repair is higher compared to a replacement [74]. Furthermore, sharing knowledge about repair requires social competences for both the repairer and the visitor, which cannot always be met [71].

Finally, in regard to the third goal, 'to promote social cohesion in the local community by connecting neighbours from very different backgrounds and with different motives with each other through an inspiring and low-key event', repair cafés contribute to the strengthening of social cohesion, including the avoidance of cost for people with a low income [48]. Furthermore, the actors seem to constitute a range of different players, and the visitors include men and women who come from different social backgrounds; only people with a migration background rarely participate [43]. Thus, the repair café contributes a strong social aspect, as well as sustainability. However, volunteers organise repair cafés, which involves a wide range of tasks [43]. This mean that the organisers face 'constant work' to 'keep the initiative running' [58]. The work performed by the organiser(s) can, however, easily be taken for granted or not noticed until needed [58]. Thus, there is a risk of organisers eventually burning out, even in a low-key event set-up as at present. Despite this, not much attention has been paid in the literature to how repair cafés can sustain themselves in the future.

## 6. Conclusions

The main goal of this paper was to provide an overview of the current academic literature on the topic of repair cafés. In total, 44 articles were included in the review for the period 2010–2020. The concept of repair cafés is addressed in a variety of ways in the reviewed literature, which has provided a unique opportunity to obtain a broad understanding of how the concept of repair cafés has developed up until now, particularly by providing us an opportunity to, on a broad foundation, to holistically assess and get a glimpse of where repair cafés may head in the future. This particularly concerns the role of repair cafés as a sustainability initiative and how the concept may translate into a wider sustainability context.

### *6.1. Bibliometric Analysis*

The bibliometric data revealed that there has been an increase in the number of publications on repair cafés, most significantly over the four years from 2016 to 2020, during which the number of published papers more than doubled. This indicates that the repair café as a research topic has started to gain attention, and is likely to grow in numbers. However, what really catches the eye in the bibliometric data is the great number of different places of publication. This indicates that this is not (yet) a well-established field with defined research channels. It further indicates that the concept of repair cafés contains a large variety of facets, which can be translated into a number of different contexts.

From a geographical point of view, it can be noticed that most articles came from Germany (13%) and the United Kingdom (12%), which dominate the field, followed by Austria 5%, the United States (4%), China and Finland (3%), and the rest below 2% (Netherlands, Romania, Austria, Belgium, Canada, Greece, Italy and New Zealand).

### *6.2. Content Analysis*

The overall format of repair cafés can be described as being quite simple, including the physical set-up and procedures. However, the events are addressed as both temporary and unexpected, and at times more fixed. In common, the repair café set-up constitutes social elements with the potential to contribute to social cohesion and inclusion.

The products brought to repair cafés for repair vary. However, electronic products seem to be the most dominant. Other examples include clothes, bicycles, furniture and toys, and a mix of both old and new items. However, from the perspective of the repair café 'set-up', the types and volumes of products repaired in repair cafés depend on the local context, e.g., the physical set-up, the aim of the specific repair cafés, and the repairers' expertise. In particular, the latter seem to determine the types of products repaired. As noted by the international repair cafés organisation, repairs most often consist of smaller jobs which are too insignificant or unattractive to take to a professional repairer. Furthermore, repair cafés assist users in performing simple repairs on limited types of products. Therefore, repair cafés cannot stand alone, but rather serve as a supplement to home repair and the established system of professional repairers.

The concept originated in the Netherlands in 2009 and is spreading worldwide; on the other hand, however, it is also regarded as a trend of making occurring in the West. The latter indicates that repair cafés may follow economic prosperity and consumption patterns, and flourish more in industrial countries.

The actors in repair cafés constitute a range of different players with differing purposes and differing drivers to engage. Furthermore, the aims of the people involved are complex. However, there are some general characteristics. The main drivers for organisers consist of both altruistic and strategic aims, whereas the driving forces for repairers seem to relate more to personal gains. Finally, visitors are driven by critical consumer, financial and educational motives. What becomes apparent is that the actors in repair cafés share an identity within a smaller group at the local level, having both local and individual goals. At the same time, however, repair cafés are part of a broader culture of repairers, who have global goals. In that context, repair cafés constitute an innovative setting for environmental activism, contributing to a circular transition.

The purpose of the concept of the repair café is addressed in various ways, supporting all three aspects of sustainability, though the weight seems to be heavier on social aspects (i.e., contributing to social cohesion). However, the ambitions of the international organisation may be achieved to varying degrees. Particularly, the ambition for actors at micro level to feed in data on repair and the achievement of 'collaborative repair' seem more challenging to realize. One explanation is that the aims of the people involved are complex (i.e., consumers' (un)willingness to participate and repairers' pedagogical competences, or the lack thereof). Furthermore, expectations are not aligned, vertically nor horizontally.

Nevertheless, the findings also reveal the concept that repair cafés function as 'change agents', as the concept has spread to a range of different contexts, influencing the mindset

and acts of a broad field of practitioners, spanning from the way we plan our cities (i.e., mobility) to pedagogical aspects, thus spreading beyond the original scope of the concept.

Thus, repair cafés holds the potential to playing different roles in sustainable CE transitioning, spanning all three legs of sustainability, to varying degrees.

This indicates a wide range of possibilities for the expansion of the concept of repair cafés, which bring both different expectations and call into question the future role of repair cafés.

Viewing repair cafes through the lenses of peer-reviewed literature omitted non-academic experiences. Furthermore, academic publications may be lagging behind in this practice-based field. Thus, grey literature could bring exciting perspectives on the subject, i.e., strengthening the link between repair cafe experiences and product redesign.

Furthermore, investigating how the repair movement can be supported systematically may also be a critical research gap, including the ways in which future policy initiatives may support repair cafés.

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## Appendix A. Bibliometric Results

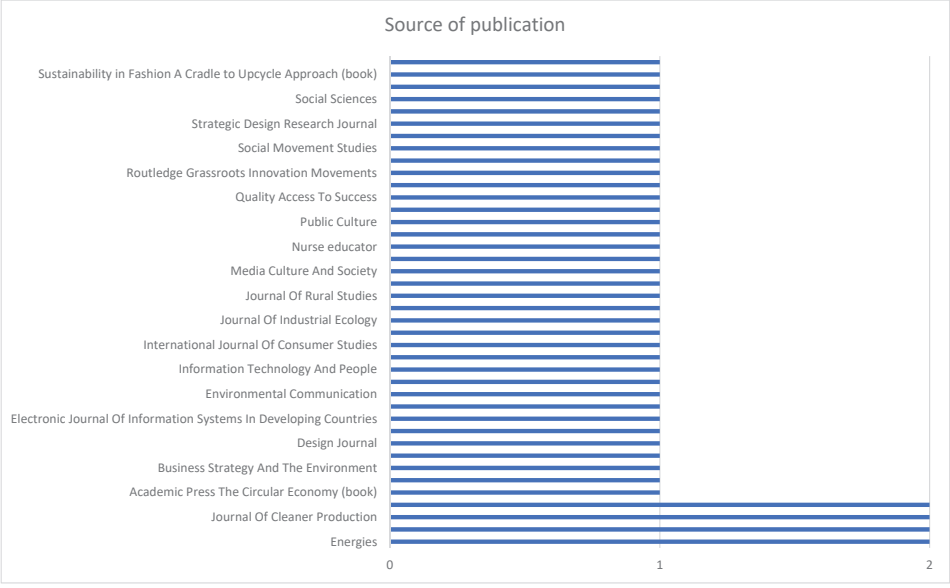


**Figure A1.** Sources of the publications. Journals that included repair café-related publications (indexed in Scopus, WoS, EBSCOhost, 2010–2020).

## Appendix B. Content Results (Analytical Matrix)

**Table A1.** Content results: What constitutes repair cafés?

| Categories and Number of Articles Addressing This | Results Obtained from the Text |
|---|---|
| The format of repair cafés #6 | *The format #6*<br>'Pop-up' events [42]; held on regular basis [42]; organised several times a month and sometimes weekly [48]; events take place for a restricted period of time (usually three to five hours) [48]; three times per year [44]; provides materials, tools and know-how [46] (p. 933); volunteers diagnose, give advice, carry out the repair [42]; refreshments and a reading table with books from the library about repairs [44] (p. 262); create a sort of café atmosphere [48,49]; seating and table arrangements are similar [48]; free of charge [42,46–49] |
| Type of products brought to repair cafés #16 | *Types of products*<br>Everyday objects [9,47,52]; 'broken items' [42]; mostly successfully repaired [52]; technical gadgets [55]; media technologies being one of the most common [47]; computers [52]; computer equipment [9]; laptops [43,52]; mobile phones [14,53]; smartphones [43,47,52]; radios [47]; old radios or slide projectors [43,52]; electronic products [30]; electronic devices [51,55]; electrical appliances [48]; broken household appliances [48]; household electrical and mechanical devices [45]; other household items [45]; household appliances [14]; small domestic appliances [50]; toasters [44,53]; vacuum cleaners [44]; clothes [30,45,48], bicycles [30,45,54,55]; toys [30]; highly valued items [46] |
| Location and geographic distribution #8 | *Location and geographic distribution #8*<br>New and widespread events [52]; at different types of location—very often in cafés [48,52] or community centres [47,48]; in makerspaces [56]; at a public library [44]; in a pub [47]; in an art studio [47]; at a school [55]; old, temporarily unoccupied building [52]; in a university context [48]; a part of a 'trend' in the West [58], spread all over Western Europe and North America [47,48,52]; based on Netherlands' experiences, spreading worldwide [9] |

**Table A2.** Content results: Actors—who and why (not).

| Categories and Number of Articles Addressing This | Results Obtained from the Text |
|---|---|
| Actors in repair cafés and motivating factors #21 | *Subculture #12*<br>'Critical makers' [43]; maker movement [14,64]; do-it-yourself (DIY) culture [65]; do-it-yourself (DIY) activism [58]; do-it-yourself (DIY) citizens [43]; community workshops [72]; modifiers and fixers movement [14]; local sustainability initiative (LSI) [48,63]; makerspace [56]; repair movement [42]; grassroots movement [61];grassroots innovation movement [62]; grassroots innovation [63]; making culture [58]; culture of repairing [52]; repairing has become public [52]<br>*Change agent #7*<br>From a 'family responsibility to societal imperative' [12] (p. 55); diverging political positions, contributing to 'the shaping of the (rising) movement of repairers' [42] (p. 638); rethinking of community spaces [44]; internal repair cafés at the nursing faculty [49];'the Computing Repair café' [55]; 'the Bicycle Repair Café [54]; district's transformation [54]; develop practices aimed at sustainability [43]; repair cafés for social change, to lobby for environmental protection, dealing critically with (over)consumption, environmental activism [52]<br>*Volunteers (in general) #5*<br>Especially retired people [43]; often repairers [45]; an artist [43]; a retired teacher [43,47]; librarians [44]; teachers [55]; university employees [43,47]; skilled volunteers [46]. *Drivers to engage*: Different motivations and ambitions [48] are complex and include: conservation of resources, waste prevention, appreciation of the apparatus, technical empowerment, having fun repairing things and economic pressure [48] (p. 84)<br>*Organisers #11*<br>Skilled volunteers [46]; often repairers [45]; librarians [44]; teachers [55]; university employees, retired teachers [47,48]; artists [48]; 'gatekeepers to circular practices' [56]. *Drivers to engage:* Educational purpose [55]; give back to their community, encourage others to live more sustainably [46]; test alternatives to uses of public libraries [44]; improvement in 'quality of life' in a district [54]; motives and ambitions vary [48].<br>*Barriers to engage:* a lot of work to keep the initiative running [58]; involve a wide range of tasks [52]; the work can be taken for granted [58]<br>*Repairers #6*<br>'Experts' [52]; identifying problems of planned obsolescence regarding electronics [60]; volunteering specialists [48]; volunteer expert [42]; retired and unemployed people [48]; students [52]; 'experts' (bike repair, sewing fabrics, maintenance of laptops, smartphones and radios) [52]; some receive formal training [45]. *Motivations to engage:* for personal interest [48]; to gain knowledge [48]; fun repairing things [48]; repairing is a positive challenge that keeps retired people young [48]; tasks to do—and possibility to socialise for retired and unemployed people [48]; to help others live more sustainably [68]; to provide service to the community [68]; to help improve product reparability and longevity [68]; to pursue their passion [48](p. 87)<br>*Visitors #5*<br>A variety of people [52]; all age groups, men as well as women, different social backgrounds [48]; students [55]; people with a migration background rarely participate [48]. *Motivations to engage:* financial [48]; to prolong the lifespan of products [48]; to achieve education/learning goals [55]; to repair things to avoid buying new—not a 'consumer person' [52]; to reduce e-waste [52]; to contribute to a sustainable society [52] |

**Table A2.** *Cont.*

| Categories and Number of Articles Addressing This | Results Obtained from the Text |
|---|---|
| Drivers to repair #8 | *Environmental and shared value*<br>Increasing volumes of waste [72]; waste reduction [48]; increasing environmental awareness [9]; growing concern for the environment [72]; resource scarcity [72]; contemporary maker movements [72]; broader behavioural change [55]; increased awareness [31]; shared value creation or sustainability thinking [14]<br>*Economic*<br>Global economic crisis [9]; business responses to economic opportunities [69]; repair as a CE initiative has a local dimension to it [25]; accommodate busy lifestyles [61]; lack of financial means to buy new products, saving money [30]; 'a business response to an economic opportunity' [14] (p. 19). |
| Barriers to repair #17 | *Material*<br>Difficult to repair [51]; planned obsolescence [51,60]; obsolete components [11]; information asymmetries with central coordinators [69]; limited access to (original) spare parts [11,43,51,69]; products are not designed for longevity or repair [11]; difficult to open [11]; high cost of repair and falling cost of replacement [67]; there's not really places you can get repairs done [61]; repair is a niche or marginal activity [72]; reparability depends on the global manufacturers' circularity choices [14]; formal relationship among actors [69]; lack or don't own the right tools [11]<br>*Competences*<br>Practical skills and know-how lacking [30,45]; repair skills are lost [19]; lack of sewing skills [59]; lack of knowledge about the spare parts required [11]; lack of talent in repairing electronic devices [48]; lack of creativity to do repair [11]; lost skills for maintenance and repair [11]; seek assistance for minor repairs [44,53,54]; useful life of clothes can often be extended easily [59]; sewing skills being taught by parents or at schools are reduced [59]<br>*Meanings*<br>The *meaning of the practice* has changed [58]; throw-away mindset [31]; products not looked after/seen as 'disposable' [11]; repair is no longer seen as a necessity, no need for it [43,58];smartphones are status symbol—the newer the better [55]<br>*Lifestyle- and warranty-related barriers*<br>Lack of time [11]; repair takes time [43]; busy lifestyles [59]; inconvenience [11]; the ease of buying a new product [11,59]; concerns about voiding the warranty [11]; concerns that product won't work anymore [11]; cost compared to replacement [74]; repair costs a lot of money [43,51,59]; the need of the object to perform daily routines [45]; lack of interest in learning how to do repairs [43] |

**Table A3.** Content analysis: The purpose(s) of repair cafés.

| Categories and Number of Articles Addressing This | Results Obtained From the Text |
|---|---|
| Purpose(s) #19 | *Waste reduction and product longevity #7*<br>A way to reduce waste and to extend the lifetime of products [48]; help improve product reparability and longevity [68]; decrease the amount of trash generated [49]; to reduce e-waste [51]; shared endeavours to combat waste, environmental degradation, shared repair problem [46]; influencing planned obsolescence [60]; 'bottom-up' environmentalism [66]; enables communities to reduce their environmental burden [50]; motivation consumers towards products' repair [12,67].<br>*Strengthen social cohesion #8*<br>Public sites of repair [42]; a place to meet [30,47,48,53,54]; improve social cohesion among volunteers and visitors [48]; free of charge [42,46,48]; avoidance of costs for people with a low income [48]; people meet to repair [52]<br>*Pedagogical aspects of repair movements #3*<br>A place for 'testing connection between learning skills and long-term change' [42] (p. 644); a place for research and teaching [54]; environmental communication pedagogy [52]; a subject in practical seminars [52]<br>*Revive forgotten skills and hands-on learning #6*<br>Revive 'forgotten' technical skills [48]; development of local socio-technical skills [14]; skill-sharing events [58]; a hands-on approach to the pedagogy of repair [42]; where people exchange, access or transfer knowledge [30]; empower people to repair [51]; to share skills [52]<br>*Collaborative aspects #6*<br>Collaboratively repair [45]; shared repairing [46]; 'the idea is to help people to help themselves' [48] (p. 78); help each other to repair broken products [30]; people meet to repair together [52]; the idea is not to provide a 'free service centre' but to help people help themselves free of charge [52]; to learn something together [52]; to become conscious, invite people to learn [65]<br>*Service aspects #6*<br>Workshops with experts [31]; offering self-repair services [31]; a service to the public [46]; a sharing platform [46]; a community space that provides materials, tools and know-how [46]; third-party service providers [69]; autonomous loop operator [69]; professional assistance [54]; a non-market-based solution [14]; a valuable service to the community [68] |

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# 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.

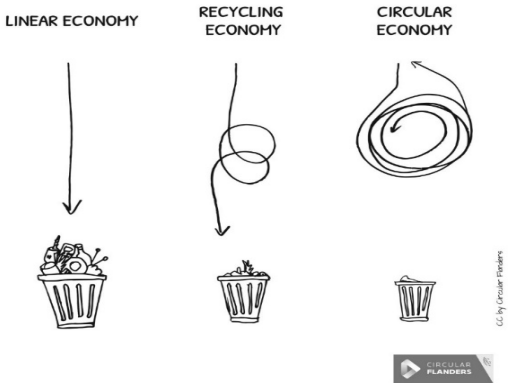


**Figure 23** Transitioning from linear over recycling to circular (Circular Flanders, n.a.)

*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).

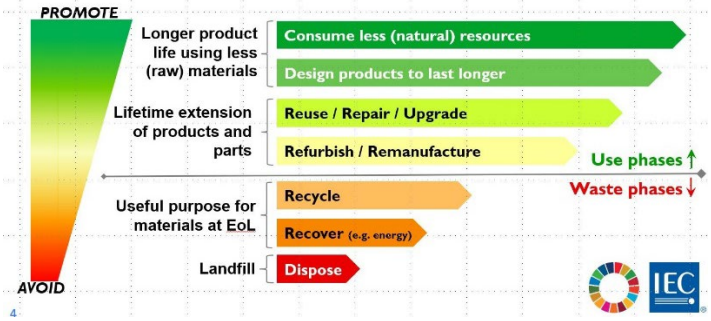


Figure 24 Use and waste hierarchy (IEC, 2022)

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.

D. Christensen (✉)
BOFA, Almegårdsvej 8, Rønne, Denmark

Aalborg University Copenhagen, Department of Planning, Copenhagen, Denmark
e-mail: dc@bofa.dk

J. Hjul-Nielsen · B. Johansen
BOFA, Almegårdsvej 8, Rønne, Denmark

R. M. Moalem
Aalborg University Copenhagen, Department of Planning, Copenhagen, Denmark





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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).

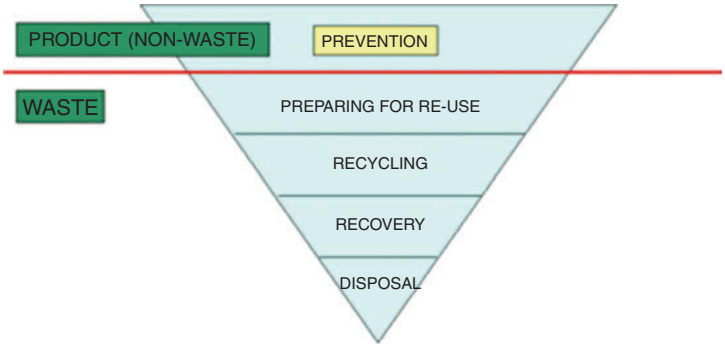



**Fig. 13.1** EU Waste Hierarchy showing how reuse and recycling takes priority over landfill (disposal) and incineration (recovery) (European Parliament and Council 2008)

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).

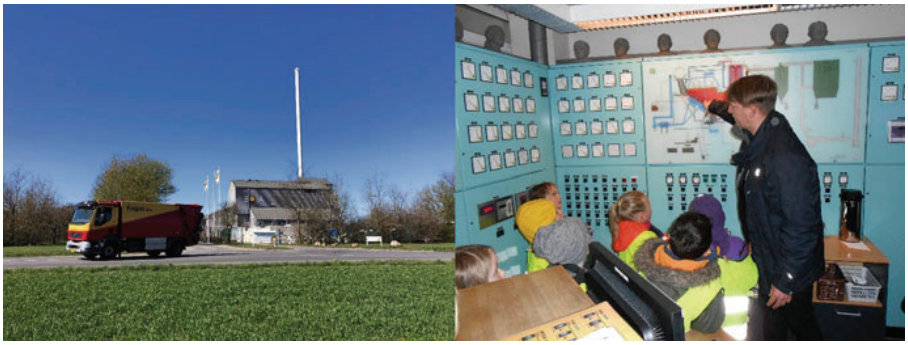


**Fig. 13.2** Bornholm's waste incineration plant (Left), run by BOFA, the municipality's waste management entity, and children (Right) being shown the control room of the waste incineration plant

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

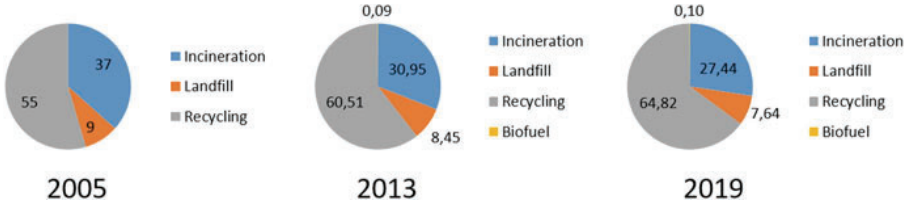



**Fig. 13.3** Progression of how waste is treated on Bornholm in percentages in 2005 (estimates from best available data), 2013, and 2019

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<br>**Repair cafes** will prevent usable products from being discarded<br>**Tourists and visitors** to Bornholm will participate actively in the first waste-free society<br>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<br>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<br>**Slightly distant future 2023–2026**, where we have some knowledge of legislative requirements and available technologies<br>**Distant future 2027–2032**, where we cannot predict new legislative requirements and technological developments | Prevention<br>Collection<br>Treatment and outlets<br>Learning and knowledge<br>Communication and dialogue<br>Organization<br>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)<br>-BOFA | Knowledge | Municipal | Inner cycles |
| Secondhand shops<br>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<br>-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<br>-'Sidste stop inden BOFA' (Last Stop Before BOFA) | All products but some specialize in<br>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<br>-genbyg.Dk, | Building products | Commercial | Inner cycles/slowing the resource loops<br>-product life extension (repair, upgrade & resale) |
| *Preparation for reuse (PfR) (waste)* | | | |
| Reuse shops<br>-AVV, Affald plus, ARGO | Clothes, shoes, kitchen utensils, furniture, bicycles, building materials (only few) | Municipal | Inner cycles/slowing the resource loops<br>-product life extension (PfR & resale) |
| Reuse building market<br>-AVV, Affald plus,<br>-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<br>-DeGrønneHvidevarer (DGH) | Washing machines<br>Dryers, dishwashers<br>Washing/drying machines, stoves / ovens,<br>industrial machinery | Commercial | Inner cycles/slowing the resource loops<br>-product life extension (PfR + upgrade & resale)<br>-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<br>2025: 100% CO2 neutral energy production<br>**2032: All waste on Bornholm treated as resources**<br>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

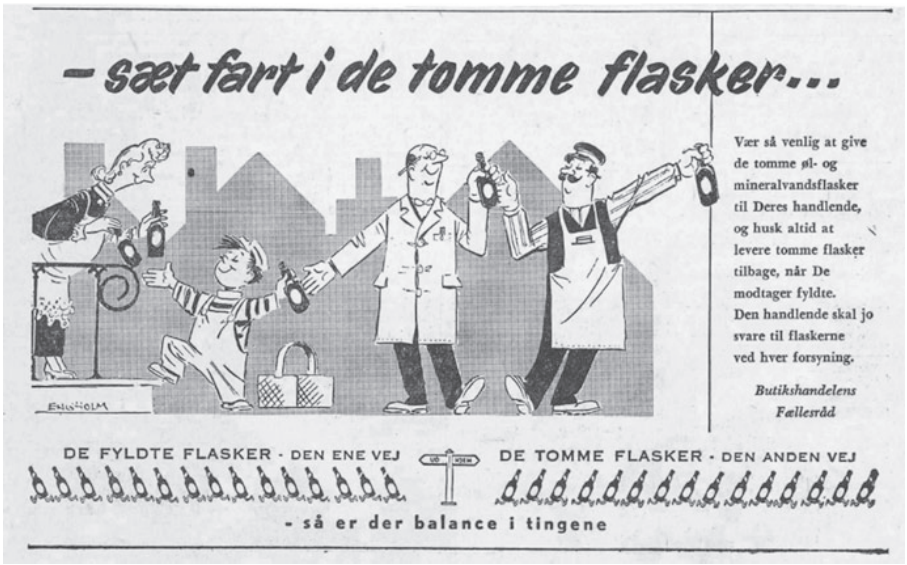



**Fig. 13.5** Newspaper advertisement printed in Berlingske Tidende in 1957 by illustrator Kaj Engholm encouraging recycling of glass bottles (voluntary deposit fee scheme implemented in 1948)

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

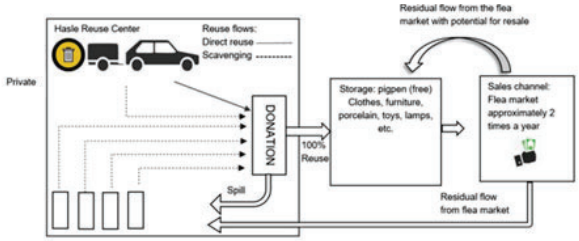
HIF's collaboration with BOFA's has helped the association develop a new model for collecting items for reuse and sold through their flea markets, which are held approximately twice a year. The models are described here. As seen in Fig. 13.9, BOFA has donated a 40-foot container for donating reusable 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).<br>2. The BOFA site worker plays a major role:<br>a. The site worker informs visitors about the possibility for direct reuse (donation).<br>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).<br>c. The site worker transfers donated items from the shelf outside the donation container into the container itself.<br>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.

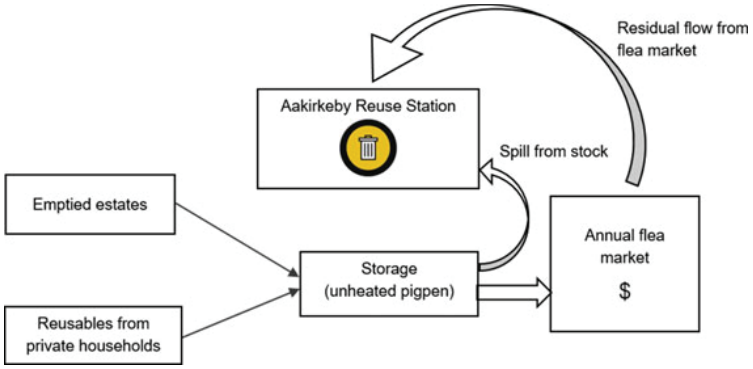



**Fig. 13.12** AAIF reuse model prior to the cooperation with BOFA (Moalem, 2021)

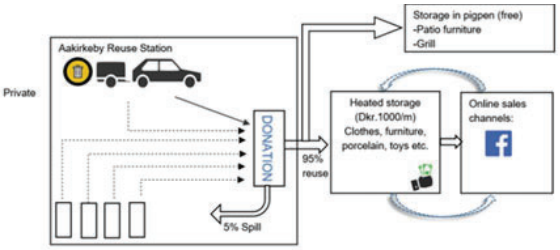
The challenge was that storage was cold, humid, and susceptible to moisture damage, or came to smell of the pig shed when stored for up to a year. This meant that AAF had to discard a large part of the reusable items. Additionally, items not sold on the day of the flea market were also discarded. The 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:<br>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).<br>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.<br>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).<br>d) The BOFA site worker transfers donated items from the shelf outside the donation container into the container itself.<br>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.<br>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.<br>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.<br>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)<br>– Collection from households<br>– Empty death rows-sort out reusable<br>– Organize the annual flea market | **Voluntary tasks (resource demanding)**<br>– Emptying the container<br>– Put the stock in order<br>– Online sales by the chairman (time consuming)<br>– Chairman coordinate volunteers to pick up reusable from the container<br>– The chairman is present at pickup |
| Spill products:<br>– Substantial amount of reusable wasted due to moisture damage/odor from pig barn<br>– Reusable not sold ended up as waste | **Spill products:**<br>Emptying the container takes place 1–2 times per week<br>– 5% of reusable are sorted away as waste (on-site)<br>– Everything else is sold on line/from heated storage |
| Storage and sale<br>Storage is unheated<br>– Only sale via flea market | **Storage and sale**<br>Two storage facilities; one heated and one not heated<br>– Reusables are sold online→sourced from both storage facilities |
| Expenses:<br>– None. Unheated storage (free) | **Expenses:**<br>– Dkr. 12.000kr/year. Heated storage |
| Earnings:<br>– Flea market: Dkr.20.000/year | **Earnings:**<br>– Online sale: Dkr.60.000kr./4 months.<br>– 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.

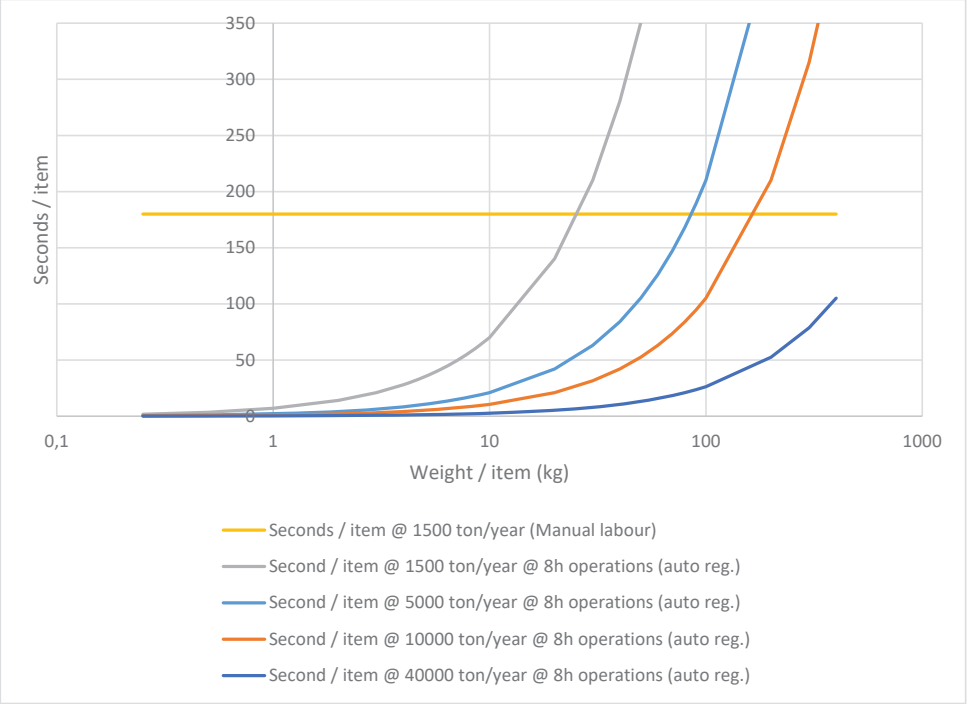


*Figure 1: Automation is beneficial when time spent registering items becomes economically problematic. The more items received, it becomes more attractive to auto register still heavier/pcs items. (JTO)*

**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

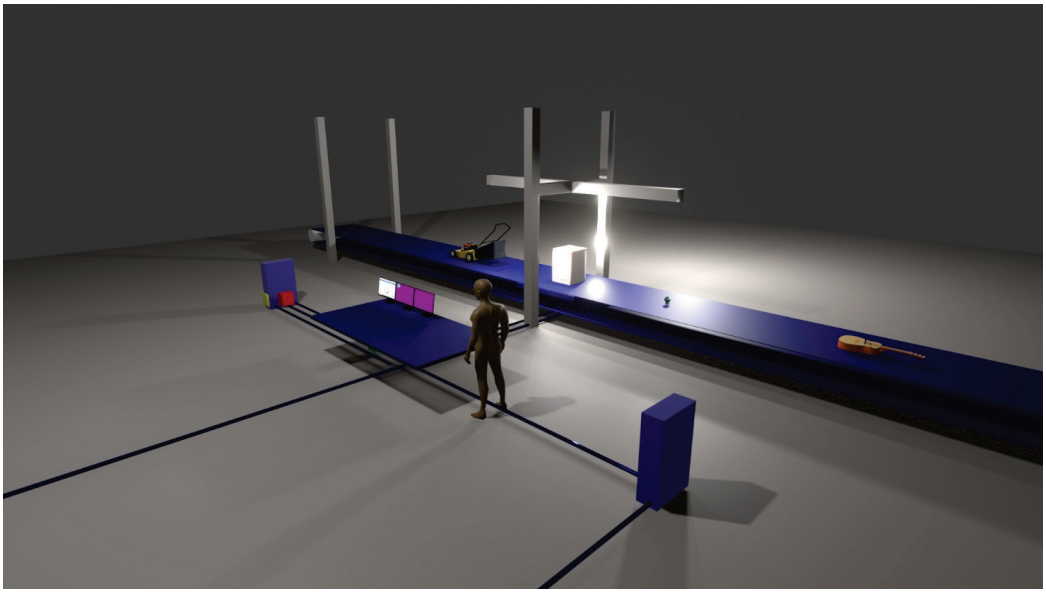

*Figure 2: Illustration of the registration platform. (JTO)*

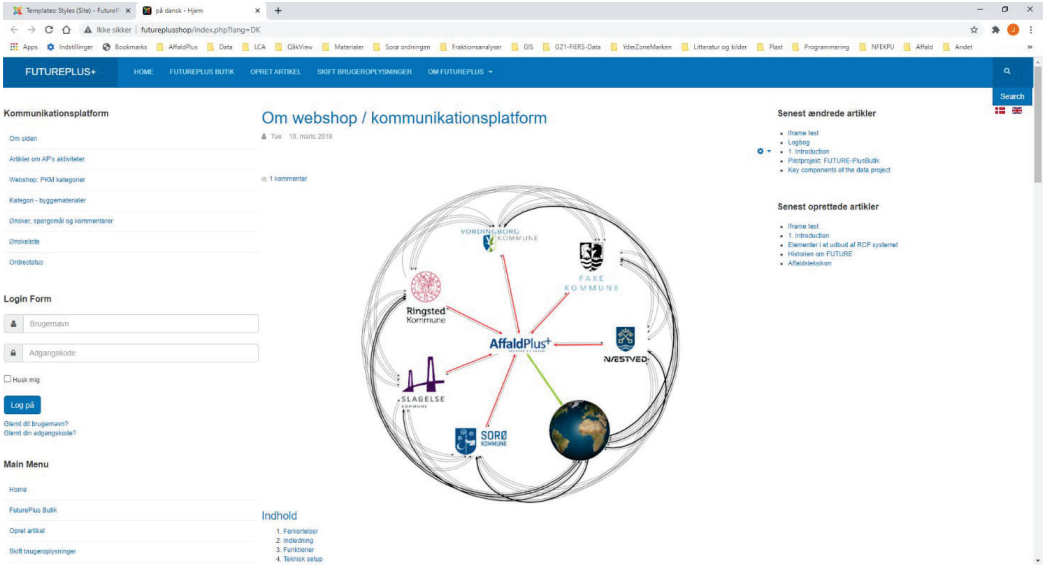


*Figure 3: Frontpage of the communications platform. (JTO)*

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

## Platform layout

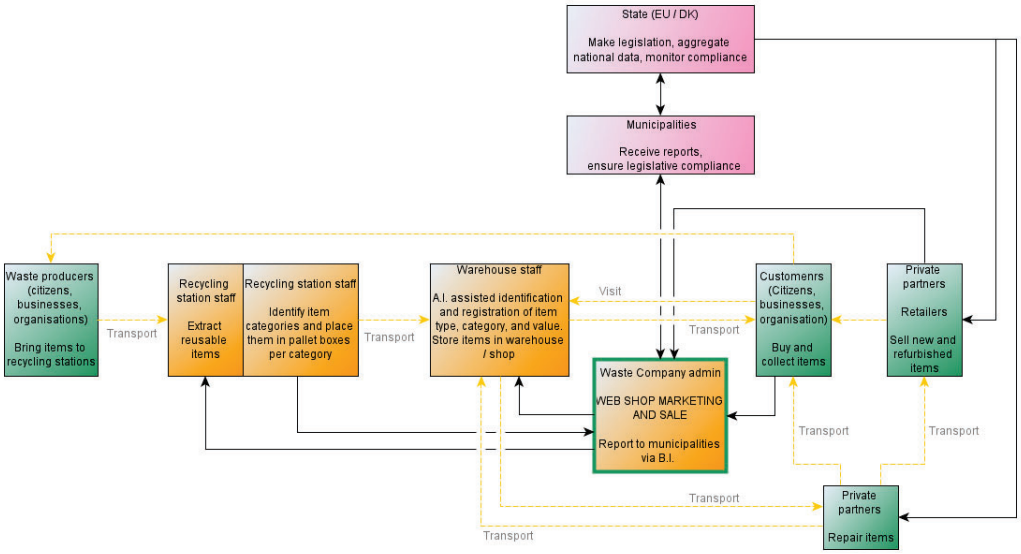


*Figure 4: The FUTURE RCP. (JTO)*

# 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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