Linköping University | The Department of Management and Engineering
Master's Thesis, 30 credits | Master of Science – Energy – Environment – Management,
Specialization in Sustainable Business Development
Spring Semester 2026 | LIU-IEI-TEK-A--26/05312--SE

From Incineration to Recycling: Closing the Loop for Bonded, Short-Lifecycle Products

– A case study on recycling the plastic frame of comfort air filters

Hugo Järnbrink
Anton Lindberg

Supervisor: Johannes Matschewsky
Examiner: Jelena Kurilova - Palisaitiene

Linköping University
SE–581 83 Linköping, Sweden
+46 13 28 10 00, www.liu.se

Abstract

Over the past decades, the circular economy has developed around products with either high material value or large, uniform waste volumes. However, many other products are still locked in to the linear economy of take–make–dispose. Few products illustrate the logic of the linear economy as clearly as product category of bonded, short-lifecycle products with examples such as comfort air filters. Comfort air filters are manufactured to improve air quality, protect human health and machines, and they require frequent replacement as their efficiency declines when they become saturated with dust and particles. This frequent replacement generates substantial end-of-life waste, which is typically sent to incineration. Climbing higher in the waste hierarchy, from incineration with energy recovery to material recycling, would allow the embedded material value to circulate rather than be lost, easing pressure on virgin resource extraction and aligning the product category with the broader transition toward a circular economy.

This master's thesis investigates why incineration persists as the main end-of-life pathway, how a manufacturer of bonded, short-lifecycle products can implement a take-back system, and what value arises from closing a material loop. This is done through a case study of the company Camfil AB, a market-leading manufacturer of comfort air filters, with the main empirical collection constituting of semi-structured interviews, primarily with employees and customers.

The thesis highlights that incineration persists for several mutually reinforcing reasons. Sweden has developed one of the most extensive waste-to-energy systems with incineration being deeply integrated with the district heating networks. Regarding the material recycling, infrastructure is built around either high-volume single-material products or high value materials. Large recycling companies deem the volumes of these products as insufficient for a dedicated processing line to be economically viable to operate. The material value is also too low to motivate them to acquire the necessary machinery for separation of the bonded materials. Customers handling spent products are influenced by several types of operational frictions – all leading the filter handling towards the path of least resistance, which is incineration. Additionally, the study concludes that an internal take-back system is preferable to outsourcing for a market-leading manufacturer of bonded, short-lifecycle products. An internal system secures control over material, the economic value of the recovered material, and the communicative benefits of a closed material loop. Companies should leverage existing local presence and prioritize locations where customer and product-density is sufficient. Implementation should proceed incrementally, starting where conditions are most favorable, rather than as a full-scale rollout. Finally, the findings show that the economic viability of a take-back system need not rest on material value alone. Value is realized indirectly through won procurements where circularity has become a qualifying criterion, through strengthened relationships with actors throughout the value chain, through a strengthened sustainability position that limits competitors' ability to compete on environmental claims, and through first-mover advantages such as customer lock-in and influence over emerging regulation. For a market-leading manufacturer, the greatest value lies in maintaining its market position and failing to act puts this position at risk. The risk from inaction is greater than the risk from early investments, as brand position and customer trust are difficult to rebuild once lost.

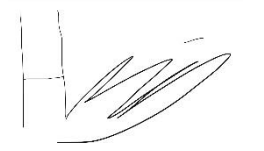
Acknowledgements

This Master's thesis was conducted during the spring semester of 2026 and marks the end of our five year journey at Linköping University, resulting in a Master of Science in Energy – Environment – Management, with a specialization in Sustainable Business Development. The Master's thesis has been a collaborative effort between Camfil AB and Linköping University, where a case study has been conducted. We would like to extend our sincerest gratitude to all who decided to contribute to this project. We had the honor to speak to so many incredible people who took time away from their daily activities to assist us in producing this thesis. A special thank you goes to the case company Camfil, who generously welcomed us into their organization for the duration of our thesis, and specifically to Jenny Groth and Erik Lans for this cooperation and valuable discussions.

We would like to direct a big thank you to our supervisor from Linköping University, Johannes Matschewsky, for all the guidance and great discussions throughout the thesis. Your knowledge, optimism, and inputs have been most valuable. The same is extended towards our examiner, Jelena Kurilova-Palisaitiene, for your expertise, valuable insights and guiding this thesis , and valuable insights in throughout the thesis. We would also like to thank our opponents, Emma Sjöndin and Lydia Trygg for their constructive feedback and valuable reflections.

Lastly, we would like to thank each other. We complemented each other greatly and this is an experience both of us will cherish for a long time forward. Five fantastic years together in Linköping culminating in a Master's thesis we both can be proud of, thank you.

Linköping, June 2026



Hugo Järnbrink



Anton Lindberg

Table of Contents

1. Introduction **1**
1.1 Objective and Research Questions 2
1.2 Delimitations 2
2. Background **5**
2.1 Case Company 5
2.2 Filters and Ventilation 5
2.3 Product Recyclability 6
3. Theoretical Foundation **9**
3.1 Circular Economy 9
3.2 Circular Business Models 11
3.3 The BECE Framework 12
3.4 Reverse Logistics 13
3.5 R-Strategies: Narrowing, Slowing, and Closing the Loop 14
4. Methodology **17**
4.1 Research Process Overview 17
4.2 Case Study 18
4.3 Literature Study 18
4.4 Document Study 19
4.5 Interview Study 19
4.6 Research Quality 23
5. Results **25**
5.1 Filter Handling 25
5.2 Logistics, Density, Geography and Costs as Deciding Factors. 28
5.3 Customer Value, Sustainability and Willingness to Pay 29
5.4 Technical Solutions and Process Innovation 32
5.5 Roles, Responsibility and Ownership 35
5.6 Positioning, Competition and First to Market 36
6. Analysis and Discussion **41**
6.1 Barriers for Circular Economy Implementation 41
6.2 Commercially Viable Take-back Systems 43
6.3 Competitive Advantages from Closing the Loop 48
7. Conclusion **53**
7.1 Contributions 54
7.2 Recommendations for the case company 54
8. Future Research **55**
References **57**
Appendix **69**
Appendix A: Sales 69

Appendix B: Logistics....71
Appendix C: Purchasing....72
Appendix D: Marketing....73
Appendix E: Legal Advisor....74
Appendix F: Recycling....75
Appendix G: Public Purchasing....76
Appendix H: Facility Managers....78
Appendix I: Questionnaires....79

List of figures

Figure 1: Example of a comfort air filter, made from the producer Camfil AB. **6**
Figure 2: The waste hierarchy: six steps for managing waste. **15**
Figure 3: Illustration of the ten different R-Strategies and which categorization each strategy falls within. **15**
Figure 4: General design of the research process for this thesis. **17**
Figure 5: Image of used air filters that did not fit in the waste compaction container. **33**

List of tables

Table 1: Themes and keywords used in the literature study. **18**
Table 2: Comprehensive list of all interviewed actors with descriptions **21**
Table 3: The six themes chosen to present the results from the interview study.....**22**
Table 4: Selection of descriptive statements made by respondents and what these quotes imply **27**
Table 5: Selection of descriptive statements made by respondents and what these quotes imply **38**

Terms and abbreviations

EU	European Union
R-Strategies	A framework consisting of ten strategies to increase circularity, condensed into three overarching categories: Narrowing -, Slowing -, and Closing the loop (Bocken et al., 2016).
HVAC	Heating, Ventilation, and Air Conditioning
CE	Circular Economy
BECE	Backcasting and Eco-Design for the Circular Economy
RL	Reverse Logistics
HIPS	High Impact Polystyrene
LCA	Life Cycle Assessment. A method for calculating and evaluating the total environmental impact of a product or service (Baumann & Tillman, 2004).
EPD	Environmental Product Declaration. A third-party verified document that discloses a product's environmental impact throughout its life cycle (Acampora et al., 2026). Based on an LCA, an EPD is a communicative, comparable document that allows for informed decision-making of products (Acampora et al., 2026).
AI	Artificial Intelligence
EoL	End-of-Life
FM	Facility Management. A company that handles the daily operations of a building, including ventilation and procurement of air filters.
CO_2e	Carbon dioxide equivalent. Converts different greenhouse gases into the equivalent amount of CO_2 with the same global warming potential.
Take-back system	Used to describe the method of moving materials backwards in the supply chain.
Closed loop	A self-sustaining system where outputs (waste) are continuously fed back in as inputs (new raw material). Used in the context of circular economy.

1. Introduction

Indoor air quality has become a growing public health concern in densely populated urban environments, where people spend the majority of their time indoors and are continuously exposed to airborne pollutants (Li et al., 2025). Long-term exposure to particulate matter and other contaminants has been linked to respiratory illness, cardiovascular disease, and cancer, and air filtration is one of the most widely deployed technical measures used to mitigate these health risks in buildings (Li et al., 2025). Comfort air filters are therefore manufactured and replaced in large volumes across commercial, institutional, and industrial buildings worldwide. However, these filters share a defining characteristic that makes them environmentally problematic. They are bonded, multi-material products with a short operational lifespan, and are typically replaced once or twice every year. Each replacement cycle generates substantial volumes of waste that are most commonly handled through incineration with energy recovery – a route that recovers some embodied energy but destroys the material value entirely (Ashby, 2021). The combination of high replacement frequency, complex bonded construction, and end-of-life (EoL) infrastructure that is not designed for recycling make comfort air filters a particularly relevant, yet understudied, case for circular economy (CE) research.

This problem is symptomatic of the broader logic of the linear economy, in which resources are extracted, transformed into products, used, and discarded in a one-directional take–make–dispose flow that treats finite resources as if they were infinite (Esposito et al., 2018). CE, in contrast, is defined as an economic system that replaces the EoL concept with strategies for reducing, reusing, recycling, and recovering materials in production, distribution, and consumption processes, thereby keeping resources in use for as long as possible and retaining their value (Prieto-Sandoval et al., 2018). Mobarakeh et al. (2022) further demonstrate that achieving substantial emissions reductions in industrial sectors requires, among other measures, the adoption of CE approaches. For bonded short-lifecycle products such as comfort air filters, linear material flows result in losses from both a societal and business perspective. This is through avoidable waste and environmental impact, as well as through missed opportunities for material retention, cost reduction, and value creation (Esposito et al., 2018; Lüdeke-Freund et al., 2019). By adjusting and closing material flows it could be possible to substantially reduce virgin material input and waste generation across the value chain, thereby improving resource efficiency without shifting environmental burdens elsewhere (Brändström & Eriksson, 2022). Realizing this potential of a closed loop, however, requires not only the technical feasibility of product recycling and disassembly but also business models and organizational structures that support circular solutions in practice (Geissdoerfer et al., 2018).

Life cycle assessments (LCA) and EoL management of air filters remain underexplored, with Li et al. (2025) calling for future research to address the product's full lifecycle and emphasizes the EoL handling. They argue specifically that lifecycle approaches should "*encourage the adoption of circular economy principles, wherein used filters are recycled or repurposed into new products*", for example by remolding thermoplastic-based filters into construction materials or other industrial applications (Li et al., 2025). Despite this recognition, the subset of CE research concerned with material recovery and EoL management focuses predominantly on sectors such as construction, products with longer operational lifespans, or products made from homogeneous materials – such as those found in packaging – where sorting and recycling processes are comparatively well-established. Bonded, short-lifecycle products that are replaced frequently remain comparatively understudied, despite representing a significant and recurring source of industrial waste (UNEP, 2023). The gap between the current linear handling of these products and the potential for circular material flows motivates the need to explore how circularity can be implemented in practice within the air filtration industry.

This thesis addresses this gap by examining the implementation of CE principles within the context of an industrial manufacturer of bonded short-lifecycle products. To do so, Camfil AB is studied as a case company, providing access to employees, customers, and operational data through which the closing of the material loop can be analyzed in practice. As proved for in the case description, responsibility for managing the waste generated from used air filters in Sweden typically falls on the customer or a sub-contractor. This leads to limited data and insight regarding EoL handling. As a result, material flows

beyond the point of use remain largely unmanaged from the manufacturer's perspective. Additionally, as one of the largest actors on the comfort air filter market, Camfil AB has the financial reality of implementing circular solutions – leading to more concrete opportunities to investigate how this waste stream can be managed and create value for different stakeholders, including competitive advantages for themselves.

1.1 Objective and Research Questions

The objective is to advance the understanding of how EoL handling of bonded, short-lifecycle products can be improved through material recycling, and identify the forms of value this generates. This requires identification of the organizational, business-related, and technical prerequisites needed to realize circular products and services. By questioning if incineration of bonded, short life-cycle products is the only disposal method through the case company Camfil AB – a large producer of comfort air filters – the opportunity is given to examine the interactions between manufacturers, suppliers, customers, end users, and waste-handling actors.

The research questions are as follows:

Research Question 1: **What barriers for circular economy currently sustain incineration as the default end-of-life pathway for bonded, short-lifecycle products?**

The first research question aims to establish the primary barriers that hinder material recycling of bonded, short-lifecycle products. This will provide a description of the current state and help explain why is incineration is the default EoL pathway.

Research Question 2: **What considerations should be made when designing a take-back system of bonded short-lifecycle products to make it compelling for a market-leading manufacturer to develop?**

The second research question aims to lay out the considerations a market-leading manufacturer should make when designing, or choosing a design, of a take-back system of bonded, short-lifecycle products. There are a few prerequisites that need to be addressed before development can begin. As this Master's thesis is a case study, the preconditions of the case company will be used to try to extrapolate the results to the broader audience of market-leading manufacturers of bonded, short-lifecycle products so other companies in a similar position may utilize the findings.

Research Question 3: **What competitive advantages are created for a market-leading manufacturer by closing the material loop of bonded, short-lifecycle products?**

The third research question aims to identify competitive advantages that market-leading manufacturers stand to gain from closing their material loop of bonded, short-lifecycle products.

1.2 Delimitations

The master's thesis has placed emphasis on the Swedish HVAC industry with some input from Norwegian actors. This is due to the limitation of data collected outside the geographical area. Influences from the company's own characteristics and specific market conditions affect the thesis. The aim here however is that the insights gathered from this work are not restricted to the Swedish, or even Norwegian markets, rather they can apply more broadly. Since this has been a case study with a specific product in the segment of comfort air filters, the desire and ambition has been to generalize the findings to make it applicable to other types of bonded, short-lifecycle products in other industries. The results may not be universally applicable for market-leading manufacturers of all bonded, short-lifecycle product categories, yet much can be utilized. As long as the manufacturer produces a bonded, short-lifecycle product with low material value and density, some aspect of the master's thesis should be applicable.

This thesis does not address product redesign as a means of improving recyclability. While a redesign of bonded, short-lifecycle products could enable easier disassembly and promote material recycling, such an investment presupposes that customers see value in take-back and that closing the material loop

is technically and economically viable. These preconditions are what this thesis investigates, and redesign is therefore left outside the scope of this work.

2. Background

This chapter covers the background of the thesis. The chapter begins with an introduction to the case company Camfil AB. After that, the function of comfort air filters in ventilation systems is described, along with the performance parameters and market trends shaping current product development. Finally, the recyclability of the main filter materials is discussed, with a focus on HIPS plastic and its potential for mechanical recycling.

2.1 Case Company

Camfil AB (Camfil) is a leading producer and developer of air filters and clean air solutions, headquartered in Stockholm, Sweden, with approximately 5,700 employees worldwide and an annual turnover of around 14.3 billion SEK (Camfil, n.d.). The company operates across several business units, and this thesis is conducted within the filtration solutions unit, focusing specifically on plastic-framed comfort air filters. As one of the largest incumbents on the market, Camfil has the financial capacity to implement circular solutions, creating concrete opportunities to investigate how this waste stream can be managed and create value for different stakeholders.

Key customer segments include data centers and facility management (FM) companies, both of which face growing sustainability requirements regarding EoL handling of products. As comfort air filters are not effected by producer responsibility, material flows beyond the point of use remain largely unmanaged from the manufacturer's perspective. FM companies in particular function as intermediaries between filter manufacturers and facility owners of commercial properties, schools, and hospitals, playing a vital role in decisions related to filter selection, replacement intervals, and waste handling.

2.2 Filters and Ventilation

Air filters are a critical component in ventilation systems, protecting people's health, instruments, and processes while enabling energy-efficient operations across a range of applications, from offices and residential buildings to hospitals, data centers, and industrial facilities (Fact.MR, 2025). These are bonded products, consisting of a frame and a dust-holding bag, also known as filter media. In Camfil's case, this consists of a frame made by post-consumer HIPS plastic and filter media from glass fiber. An example of a comfort air filter can be seen in Figure 1, which comes from Camfil.

Selecting an appropriate air filter for a specific application requires careful evaluation of several interrelated performance parameters. *Filtration efficiency* describes the ability of a filter to remove particles of different sizes and is increasingly expressed using particulate matter fractions (PM_1, $PM_{2.5}$, PM_{10}), which better reflect real indoor air quality conditions (Yit et al., 2020). *Pressure drop* is a critical parameter as it directly influences heating, ventilation, and air conditioning (HVAC) energy consumption, while *dust holding capacity* determines filter service life and maintenance intervals (Yit et al., 2020).



Figure 1: Example of a comfort air filter, made from the producer Camfil AB. The image has been sourced from their EPD for HI-FLO XLT ePM1 60% filters.

Current market development in the ventilation and air filtration sector is characterized by lower pressure drop, energy efficiency and extended operational lifetime (Technavio, 2025). This development is largely driven by increasing awareness of the strong link between filter-induced pressure losses and the overall energy consumption of HVAC systems, as well as by rising operational cost considerations over the system lifecycle and minimize total cost of ownership (Camfil, 2025). These trends reflect a broader transition from product-centric evaluation toward system-level and life-cycle-based optimization of air filtration performance (Fact.MR, 2025).

Maintaining a low drop in pressure to reduce energy consumption while simultaneously ensuring operational safety requires timely replacement of air filters as they become loaded with particles and subsequently lose performance (Kwon et al., 2025). However, this practice creates a secondary challenge in the form of substantial residual material flows from spent filters, which must be managed in a sustainable way.

2.3 Product Recyclability

In order to develop a recycling system for a product, it is important to define the feasibility of recycling said product. Camfil's comfort air filters are not produced to be recycled and as stated in section 1.2, redesigning a product before investigating recycling possibility and interest is not advised. As stated in section 2.2, comfort air filters are bonded products with a limited lifetime, making waste hard to prevent and reduce. The filter media is filled with dust and particles, making it challenging to recycle and even harder to reuse. Many particles are chemically bonded to the glass fiber, making alternatives such as filter washing and cleaning impossible. The cost of recycling processes, including mechanical, thermal, and chemical methods for glass fiber is often high, discouraging large scale recycling even further (Shehab et al., 2023). From a product circularity perspective, this implies that the glass fiber component has a limited potential to contribute to material recirculation and thus offers minimal opportunity to substitute virgin material inputs in future production cycles (Boyer et al., 2021). However, the second main material polystyrene, more specifically high impact polystyrene (HIPS), has good properties for recycling (zu Castell-Rüdenhausen, 2025). HIPS is a type of thermoplastic. This means that it can be melted and solidified repeatedly, allowing it to be recycled multiple times (Vilaplana et al., 2006). Closed-loop recycling systems for polystyrene, can ensure a pure stream for efficient reprocessing into new products (Forrest & Mack, 2005). Pure, recycled HIPS shows comparable impact strength to virgin HIPS, with quality decreasing as the concentration of impurities increases (Perrin et al., 2016). This implies that HIPS can be recycled without dramatic loss of mechanical performance, as long as it is reasonably clean. Internal experiments at the case company have also shown positive results. No

impactful decline in material properties has yet been identified. LCAs have shown that mechanical recycling generally has a lower environmental impact than producing virgin plastics, regarding parameters such as climate impact (CO_2 emissions), fossil resource use (oil) and overall resource depletion (Gu et al., 2017). Recycling plastics is environmentally beneficial, especially when it replaces virgin plastics. However, the benefits depend on efficient, centralized processes and careful use of energy and additives (Gu et al., 2017). Closed-loop recycling systems for polystyrene, can ensure a pure stream for efficient reprocessing into new products (Forrest & Mack, 2005). There is a substantial untapped potential to increase polystyrene recycling if collection is expanded beyond packaging, but better data and collection systems are needed (zu Castell-Rüdenhausen, 2025).

3. Theoretical Foundation

This chapter establishes the theoretical foundation for examining the circular transition of a bonded, short-lifecycle product. The chapter starts with an explanation of how the chosen theories operate on three different levels of analysis and is followed by an explanation of Circular economy and barriers for its adoption. This is followed by Circular business models, including enablers and barriers for their implementation. Thereafter, the BECE framework is examined, and the chapter concludes by explaining Reverse Logistics and three overarching R-Strategies.

The theoretical foundation is structured across three complementary levels of analysis: System, Firm, and Operational. Rather than treating these as discrete categories, the theories selected span and overlap across these levels, as circular transitions are rarely confined to a single systemic, organizational, or operational domain. CE theory operates primarily at the system level, mapping the structural conditions, policy frameworks, and market dynamics that shape how material flows close across industries and societies, while also providing a background for firm-level responses to those conditions. CBMs and the BECE framework sit primarily at the firm and operational level – CBMs examine how companies organize their value creation, delivery, and capture logic to support circularity, while BECE connects long-term strategic ambition to concrete design, product architecture, and EoL decisions. R-strategies and reverse logistics operate at the firm and operational level, providing structured guidance on how firms can retain products and materials at their highest possible value through design decisions, take-back schemes, and EoL handling. Together, they form a structured theoretical foundation capable of capturing why circular transitions stall and what conditions are required for them to succeed in the context of bonded, short-lifecycle products.

3.1 Circular Economy

CE has been defined in numerous ways across literature, reflecting its broad application across sectors and scales. For the purposes of this thesis, CE is understood as an economic model that aims to decouple growth from virgin resource extraction by keeping materials, components, and products in productive use for as long as possible through strategies such as reuse, repair, remanufacturing, and recycling (Geissdoerfer et al., 2017; Stahel, 2016).

Empirical research points to substantial environmental, economic, and social benefits from circular economy (CE) strategies, spanning reduced resource use, lower emissions, economic gains, and improved well-being for affected communities. LCAs consistently show that circular strategies reduce demand for virgin materials. The Circularity Gap Report estimates that scaling CE practices could cut global material extraction by roughly one third, while sector-level LCAs in construction and electronics report virgin-material reductions exceeding 30 percent with up to 55 percent in closed-loop systems (Circle Economy Foundation, 2024; Marrucci et al., 2025). A European Environment Agency synthesis of more than 130 studies finds an average 33 percent reduction in greenhouse gas emissions from CE strategies relative to business-as-usual, with a sectoral potential of 52 percent in waste management (EEA, 2026). Firm-level evidence indicates that CE innovation is associated with positive growth and employment effects, and macroeconomic modelling points to substantial GDP and job-creation potential through remanufacturing and service-based business models (Horbach & Rammer, 2020; Stahel, 2016). Effective adoption of CE practices can also help organizations achieve social sustainability in terms of "*employee satisfaction and welfare*" and "*improved working conditions*" (R. Singh et al., 2022).

Despite the substantial estimated gains of implementing CE, progress remains slow, and the interdependent nature of many barriers is a major reason for this (Ellen MacArthur Foundation, 2013; Grafström & Aasma, 2021). Grafström and Aasma (2021) categorize these barriers into four overarching domains: *technological*, *institutional, market* and *social.* These four types of barriers are deeply entangled in each other, such that even a single unresolved barrier may be enough to prevent a circular market from forming altogether (Grafström & Aasma, 2021). The four barrier domains are outlined below.

Technological barriers to CE adoption, operating primarily at the system and firm level, span product design, waste management infrastructure, material quality, and digital capacity (Grafström & Aasma, 2021). Inadequate product design remains a foundational obstacle where firms consistently deprioritize designing for reuse, remanufacturing, and recyclability in favor of practices with faster financial return (Masi et al., 2018). Current design practices also tend to address environmental problems incrementally rather than at the source (Wautelet, 2018). Design choices at early development stages are carrying long-lasting consequences for circularity potential and is a large barrier for CE (Grafström & Aasma, 2021). At least 70 percent of a product's environmental impact is determined by its design, meaning this has a decisive impact on a product's life cycle (Kong et al., 2022). Esposito et al. (2018) make a similar point that bad design is a fundamental reason why companies stay locked into linear models. The design choices made early on whether a product can be taken apart, reused, or recycled will determine what happens to it at the end of its life.

Waste management infrastructure is underdeveloped in many contexts, generating quality concerns around recycled materials (Grafström & Aasma, 2021). Recycled inputs are often lower in quality and less reliably available than virgin materials, leading many producers to favor virgin alternatives instead (Kinnunen & Kaksonen, 2019; Milios et al., 2018). Research consistently points to infrastructure missing for an effective management of waste. Grafström & Aasma (2021) argue that since recyclables are often not separately collected, sorting becomes more difficult. Milios et al. (2018) adds to this by demonstrating that the capability to handle bundled collected waste in the Nordic countries is insufficient. Despite available enabling technologies, a persistent gap in practitioner know-how restricts adoption of CE solutions who often fall outside the existing areas of expertise (Agyemang et al., 2019; Rizos et al., 2015; Tura et al., 2019).

Institutional barriers to CE adoption stem from path-dependent regulatory frameworks designed for linear economic models that have yet to adapt to circular principles (de Jesus & Mendonça, 2018). Policy heterogeneity across national jurisdictions increases compliance costs and investment uncertainty, particularly for firms operating in internationally integrated supply chains (de Jesus & Mendonça, 2018; Tura et al., 2019). The premature legal classification of by-products as waste transfers ownership from private actors to the public sector, restricting entrepreneurial entry into circular markets, while high administrative burdens and weak policy implementation further slow adoption (de Jesus & Mendonça, 2018; Milios et al., 2018). Innovation capacity remains constrained by insufficient R&D investment and inadequate support structures, especially for small and medium-sized enterprises (SME) lacking access to reverse logistics infrastructure and CE management tools (Masi et al., 2018; Milios et al., 2018). Policy design can also produce counterproductive outcomes, as energy-efficiency incentives may accelerate product replacement in ways that offset environmental gains (de Jesus & Mendonça, 2018). Globally, the Basel Convention, a multilateral environmental treaty, was designed to reduce the movement of hazardous waste across international borders which primarily went from developed to less developed countries (Lin et al., 2025). The convention has been criticized for only seeing the negative aspects of global waste trade between wealthy and less wealthy nations, and not accounting for the economic value embedded in this waste stream trade (Krueger, 1999). These critiques are supported by recent empirical findings showing that waste streams continue to function as economically valuable inputs in developing countries recycling economies despite increased regulatory restrictions (Lin et al., 2025).

Market barriers are closely tied to the fundamental economics of virgin versus recycled materials. The market for product recovery fails due to quality uncertainty, creating a classic "lemons problem" where buyers cannot distinguish quality, suppressing demand (Akerlof, 1970; Tura et al., 2019). This is compounded by low virgin material prices, which remain deceptively low as negative externalities are not internalized into the price, resulting in recycled alternatives being perceived as less economically attractive (Kirchherr et al., 2018). The negative externalities created by companies products are instead paid for by society (Biglan, 2009). As Biglan (2009) illustrates, tobacco companies market an addictive product that leads to disease, yet "*healthcare providers, employers, governments, smokers, and their families bear most of these costs*". Similarly, society bears the environmental and social costs that comes with extraction of virgin materials. Beyond this pricing distortion, recycled supply is less elastic and more price-volatile, further deterring investment (Åkesson, 2014; Blomberg & Söderholm, 2009).

Finally, high upfront switching costs from renegotiating contracts, adapting technology to redesigning products all pose a particularly significant barrier for companies (Masi et al., 2018; Rizos et al., 2015).

Social barriers are the primary obstacles to CE adoption, according to Kirchherr et al. (2018). The authors argue that especially the lack of consumer interest and hesitant company culture are the most pressing barriers for CE, followed by market barriers like low virgin material prices (Kirchherr et al., 2018). Social barriers to CE adoption cluster around three dimensions: resistant organizational culture, low consumer awareness, and weak supply-chain cooperation (Grafström & Aasma, 2021). At the firm level, upper and middle-management frequently oppose circular initiatives when these conflict with existing incentive structures, and where CE efforts do exist, they tend to operate in isolation from core business functions with little strategic integration or measurable goals (Agyemang et al., 2019; Mangla et al., 2018).

Consumer psychology and purchasing habits persist as barriers for CE, where consumer engagement remains limited by physical product ownership, social norms, and consumeristic culture, which collectively foster negative attitudes towards transiting to a CE (P. Singh & Giacosa, 2018). Many customers lack environmental awareness of their purchases, rendering sustainability a low priority in their companies decision-making (Rizos et al., 2015; Wycherley, 1999). At the supply-chain level, confidentiality norms restrict industrial symbiosis and by-product exchange, while inter-firm cooperation is broadly perceived as intrusive and competitively threatening (Agyemang et al., 2019; Masi et al., 2018).

3.2 Circular Business Models

Closely related, and discussed in concert with CE, is the concept of circular business models (CBM) (Geissdoerfer et al., 2018). Regular business models can be used as a tool to explain how a firm conducts its operations and creates value (Bocken et al., 2014). It can be divided into four different areas, namely value proposition, value creation, value delivery, and value capture (Richardson, 2005). They describe a firm's competitive strategy, the design of its products or services, cost structures for both production and customers, and how the firm differentiates itself (Bocken et al., 2014). Business models also give insight to how a firm can integrate its own value chain with other actors within a broader value network to create value (Bocken et al., 2014). A CBM operate primarily at the firm level and is defined as a business model whose value creation, delivery, and capture logic relies on narrowing, slowing, or closing resource loops (Geissdoerfer et al., 2018). CBM keeps the four building blocks of any business model, but reconfigures each according to circular principles (Richardson, 2005; Geissdoerfer et al., 2018). The customer value proposition is "*a strategic tool facilitating communication of an organization's ability to share resources and offer a superior value package to targeted customers*" (Payne et al., 2017, p. 472). It is the strategic core of the business model and describes what is offered, to whom, and why customers should prefer it over alternatives (Richardson, 2005). Within a CBM, the value proposition is extended to environmental and social value, often by shifting from product ownership to function- or result-based services (Geissdoerfer et al., 2018; Bocken et al., 2016).

CBMs are key enablers of this transition, as they integrate mechanisms that close resource flows (Castiglione et al., 2025). Through such mechanisms, firms can reduce virgin resource inflows while simultaneously limiting waste and emissions to the surrounding environment (Geissdoerfer et al., 2018). The Swedish Environmental Protection Agency (Naturvårdsverket) defines CMB's as "*business models that create value by extending product lifetimes and reducing environmental and climate impacts*" (Naturvårdsverket, 2025). However, the implementation of CMB's may face several barriers that inhibit firms from successfully creating, delivering, and capturing value (Frishammar et al., 2025). Understanding these barriers is essential, as they often become more pronounced when firms attempt to scale their circular initiatives beyond initial pilots (Frishammar et al., 2025).

3.2.1 Barriers for Circular Business Models

Digital technologies such as AI and IoT are central for enabling CBMs at the firm level, through catalyzing value creation by tracking materials, optimizing maintenance, and improving resource flows (Ranta et al., 2021). However, many firms fail to leverage these technologies in practice due to low

digital readiness, unclear data-sharing guidelines, and difficulties integrating new technologies with existing systems (Frishammar et al., 2025). Limited customer involvement is the second barrier for value creation where customers may be cautious to share sensitive company data and to sign long term agreements (Kanda et al., 2021). To overcome these barriers, Das and Teng (2001) argue that both goodwill trust and competence trust are complementary and jointly necessary to build the foundational trust needed for sustained ecosystem collaboration. Goodwill trust reduces relational risk, while competence trust reduces performance risk, and neither can substitute for the other (Das & Teng, 2001).

To implement CE at the firm level, companies must be able to create value within an ecosystem of new and existing partners (Kanda et al., 2021). The difficulty lays in the transition from a firm-centric value creation toward ecosystem-based collaboration, where multiple interdependent actors jointly create environmental and socio-economic value (Kanda et al., 2021; Todeschini et al., 2017).

For value delivery, transitioning from a linear product selling company towards delivering services requires new competence and structure that many companies struggle to build (Parida & Frishammar, 2023). Additionally, when creating CBM's, problems regarding intellectual properties and an imbalance in negotiating power between larger and smaller companies may cause hinders in cooperation (Benoliel & Salama, 2010). To overcome these frictions and form ecosystems where value from co-creation is reached depends on the active engagement of all parties (Viglia et al., 2023). This means that each stakeholder must perceive that enough value is gained from participating in the ecosystem to sustain collaboration (Viglia et al., 2023).

Value capture is challenged by the high upfront investments required and the difficulty of selecting a revenue model that fits both the offering and the company's operations. To transition towards circularity, substantial investments in new infrastructure and technology is required to help transform the corporation (Sousa-Zomer et al., 2018). This may then impact the price and make it more expensive, which can make circular offerings less attractive in the initial stage (Jaeger & Upadhyay, 2020). The CBM literature frames the investment decision for circular solutions as a cost-benefit calculation where the primary risks are the substantial upfront capital expenditure required for new infrastructure and technology, and the uncertainty of whether customers will adopt offerings that may come at a higher price (Sousa-Zomer et al., 2018; Jaeger & Upadhyay, 2020).

Problems can occur when companies design, develop, and launch circular products or services. Early on, many industrial firms choose the wrong way to make money from the circular offering (Tabares et al., 2023). It is important to select a revenue model that fits how the company operates. When the business model and daily operations do not match, serious problems can arise. The right choice depends on the type of circular solution, how well customers understand it, how digitally prepared the company is, and how well it works with partners in the digital ecosystem (Tabares et al., 2023).

Subscription models often lead to more predictable smaller, recurring revenue streams compared to lump-sum payments from direct sales. This can create cash flow gaps, especially if upfront investments are required (Gyulasaryan et al., 2025). Shifting to a subscription model requires strategies to attract and retain customers, which can be challenging if customers are accustomed to direct purchase models (Kumar & Sethi, 2009; Pauwels & Weiss, 2008).

From a risk perception perspective, CBMs may increase uncertainty not only about economic outcomes but also about customer and partner behavior, which are key sources of perceived risk (Mitchell, 1995). Risks are not always negative for the long run. With proper risk management, risks can present opportunities to generate additional revenues managing them through a diverse and strategic approach (Tukker, 2004).

3.3 The BECE Framework

The Backcasting and Eco-Design for the Circular Economy (BECE) framework integrates future-oriented backcasting with product-level eco-design to support the practical implementation of circular economy principles in industrial contexts, operating at the firm and operational level by connecting long-term circular ambitions to concrete design, product architecture, and EoL decisions (Heyes et al.,

2018; Mendoza et al., 2017). The framework addresses the central limitation of other circular economy approaches and instead connects long-term circular ambitions to concrete design and business decisions. Circular strategies are often developed at a strategic level, while implementation efforts focus on isolated technical improvements, creating a risk of incremental optimization within fundamentally linear systems (Ellen MacArthur Foundation, 2013, 2015).

Backcasting is used to define a normative, long-term circular vision that serves as a reference point for present-day decision-making. Rather than extrapolating existing practices, the approach starts from an ambitious future state, aligned with circular economy principles and works backwards to identify necessary transitional steps (Heyes et al., 2018; Mendoza et al., 2017). This future-oriented logic reduces the risk of short-term improvements that lock firms into sub-optimal linear trajectories and allows corporations to proactively shape their transition pathways instead of reacting to externally imposed regulatory or industry requirements (Ellen MacArthur Foundation, 2015; Heyes et al., 2018).

Eco-design constitutes the operational core of the BECE framework. Through systematic analysis of existing products; such as material composition, product architecture, disassembly, and EoL handling, eco-design identifies design-related constraints and opportunities for circularity (Mendoza et al., 2017). These insights are continuously evaluated against the backcasting vision, ensuring that design changes contribute to long-term circular objectives rather than isolated efficiency gains (Mendoza et al., 2017).

A key strength of the BECE framework is its structuring of circular transition across multiple time horizons (Mendoza et al., 2017). Short term, actions tend to focus on low-risk design improvements within existing systems like standardizing screw types or making repair and replacement parts clearly defined and accessible to improve disassembly and EoL handling (Mendoza et al., 2017). In the medium term, BECE points towards more system-changing interventions, such as introducing take-back schemes, increasing the share of recycled content, and piloting service-based models like product-as-a-service, which can imply substantial shifts in value capture and responsibility across the life cycle (Mendoza et al., 2017). In the long term, actions move beyond optimization of the current design and instead question the product concept itself such as exploring alternative material pathways and asking whether the current solution remains the most appropriate way to deliver the intended function in a future circular system (Mendoza et al., 2017). This staged approach supports gradual capability building while managing technical and organizational risk (Mendoza et al., 2017).

Circular solutions typically require collaboration across value chains, alignment between strategic ambition and operational capability, and willingness to engage in new forms of cooperation (Heyes et al., 2018). Cooperation and stakeholder engagement as key drivers for overcoming implementation challenges, with improved supply-chain relationships as a co-benefit (Mendoza et al., 2017). Early adoption of CE principles can build internal capabilities and develop suitable systems ahead of future regulatory requirements, allowing firms to shape their transition rather than adapt to externally imposed solutions (Mendoza et al., 2017).

3.4 Reverse Logistics

Reverse logistics (RL) operates at both the firm and operational level, is similar to traditional logistics in many ways. Most of the principles are the same but applied in a different way. Here, upstream material flows are in focus rather than downstream (Agrawal et al., 2015). A widely accepted definition of RL is that it is the "*process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal*" (Rogers & Tibben-Lembke, 1999, p. 2). Put differently, it is the process of moving goods backward through the supply chain, from the end consumer to the goods manufacturer, seller or a designated recovery point for purposes like repairs, refurbishment, resale, recycling, or disposal (Agrawal et al., 2015).

A choice of internal development and external partnership is to be made for RL. This is mainly a decision between competence and maintaining control (Uhrenholt et al., 2022). If the firm possesses specialized knowledge of take-back systems, has operational expertise in managing returns, and can utilize these flows effectively, there are few arguments for not developing an internal RL system (Meade

& Sarkis, 2002). However, these are skills and capabilities that most companies lack (Meade & Sarkis, 2002). If this is the case, consideration should be made towards partnering with an external actor. The third-party logistics provider could take many different forms. The cooperation could be in the form of a temporary service, a long-term partnership, or a strategic alliance (Agrawal et al., 2015; Meade & Sarkis, 2002). With their specialized knowledge, reverse logistics suppliers play a crucial role in helping organizations in closing the loop for products and promoting so-called closed-loop supply chains (Agrawal et al., 2015).

Reducing waste and increasing material recovery and recycling is important for several different reasons. It can help companies both capture more value from their products while also promotes environmental initiatives as it is actively used to decrease waste (Meade & Sarkis, 2002). Subsequently, RL is an essential part of a circular economy (Benitez-Fuentes, 2016). One of the main barriers for CBMs is the economic viability of the take-back system (Uhrenholt et al., 2022). A take-back system is an operational set of processes of RL and includes the collection of EoL products, transportation, sorting and disassembly, requalification, and re-engagement of the recovered material, components or products in the forward supply chain (Uhrenholt et al., 2022). The success of the take-back system is dependent on three interrelated dimensions: context, supply chain, and company (Uhrenholt et al., 2022). The context-dimension constitutes the external factors that influence the organization, such as regulation and legislation, maturity of recovery technologies, market conditions, and customer behavior (Uhrenholt et al., 2022). Even a well-designed take-back system may fail financially if the external context is unfavorable (Uhrenholt et al., 2022). The company-dimension measures internal factors related to both the product and the operations required for a reverse logistic system. This includes product design choices influencing the ease of value recovery, upper management's commitment, as well as the organizations capabilities (Uhrenholt et al., 2022).

For collection system design, the number of collection points and the assurance of sufficient return volumes critically affect economic viability, with profitability dependent on optimizing both. The evidence shows mixed but informative findings. Zhang et al. (2013) found that "*expanding the reverse logistics network, i.e. increasing collection points, will lead to profit up to a point,*" indicating a non-linear relationship where excessive collection infrastructure becomes uneconomical. The economic viability of reverse logistics is contingent on achieving sufficient return volumes, as fixed costs must be distributed across enough units to reach break-even (Fleischmann et al., 1997; Kant-Hvass & Pedersen, 2019). To achieve sufficient return volumes the level of consolidation of a company´s goods is also an important factor to consider. Less consolidation of products results in more frequent shipments with lower quantities, ultimately leading to higher costs for the take-back system (Uhrenholt et al., 2022). This consolidation applies to when products are located over a large geographical area as well as when there are many, small collection points (Uhrenholt et al., 2022).

Although reverse logistics is a well-established field, sources provide limited specific data on low-value, high-volume consumables. Dev et al. (2020) noted that "*collection investment*" is a governing parameter for product returns, while Abdallah et al. (2012) identified the "*value of recovered products*" as a major factor in the economic feasibility. The evidence suggests design must balance collection infrastructure costs against return volumes and recovered product value, but quantitative guidance specific to consumables is absent from these sources.

3.5 R-Strategies: Narrowing, Slowing, and Closing the Loop

R-strategies operate at the firm and operational level, providing structured guidance on how firms can retain products and materials at their highest possible value through design decisions, take-back schemes, and EoL handling. The management of products and materials that have reached their EoL or end of use in Europe is governed at the policy level by the EU waste hierarchy, which ranks treatment options by environmental preference (European Parliament, 2018). The hierarchy prioritizes prevention above all, followed by reduction, reuse, recycling, energy recovery, and finally disposal (European Parliament, 2018; Pires & Martinho, 2019; *Waste Hierarchy - EUR-Lex*, n.d.). This ordering reflects the principle that strategies which avoid waste generation are environmentally superior to those that manage it after the fact (Pires & Martinho, 2019). In practice, advancing to higher levels of the hierarchy

requires both appropriate product design and functioning collection and treatment infrastructure, as the costs associated with waste collection, transportation, and processing are substantial and must be justified by the value recovered (Grafström & Aasma, 2021; Jiang et al., 2024).



Figure 2: The waste hierarchy: six steps for managing waste, from most preferred (prevention) to least preferred (disposal). Figure is made by authors.

R-strategies translate this hierarchical logic into a product-level design and business framework, providing structured guidance on how products and materials can be retained within the economy at their highest possible value (Bocken et al., 2016). While various formulations exist ranging from three to ten distinct strategies, the literature converges on a core hierarchy ordered by environmental preference, where strategies that avoid resource consumption altogether are prioritized over those that recover value after use (Potting et al., 2017). Bocken et al. (2016) synthesize these into three overarching categories; narrowing, slowing, and closing the loop. They are not mutually exclusive but represent different points of intervention across a product's life cycle, each with distinct preconditions for applicability (Bocken et al., 2016).

	R-Strategies
Narrowing the loop:	R0 - Refuse R1 - Rethink R2 - Reduce
Slowing the loop:	R3 - Reuse R4 - Repair R5 - Remanufacture R6 - Refurbish R7 - Repurpose
Closing the loop:	R8 - Recycle R9 - Recover

Figure 3: Illustration of the ten different R-Strategies and which categorization each strategy falls within. Figure is made by authors.

Narrowing the loop targets resource efficiency at the design and production stage, reducing the amount of material and energy required per unit of output (Bocken et al., 2016). It is applied early in product development and is primarily a strategy for producers rather than downstream actors in the value chain (Bocken et al., 2016). These strategies often provide the greatest environmental benefit as the prevention of emissions is in focus (Bakker et al., 2014). This focus on resource efficiency has already been applied successfully within the traditional linear economy as the business models do not require change in order to provide value (Bocken et al., 2016).

Slowing the loop extends the productive life of a product through repair, refurbishment, reuse, and remanufacturing (Bakker et al., 2014). Its applicability is contingent on whether a product retains sufficient residual value after use to justify recovery and reprocessing (Bocken et al., 2016). Products with longer operational lifespans, modular architectures, and easily disassembled components are generally better candidates for slowing strategies, as these characteristics reduce the cost and complexity of returning products to service (Bakker et al., 2014; Bocken et al., 2016).

Closing the loop focuses on the EoL phase, recovering materials through recycling and reintroducing them as secondary inputs into production, thereby substituting virgin resource extraction (Bocken et al., 2016). It is particularly relevant when slowing strategies are technically or economically unfeasible, for instance when products are functionally exhausted at EoL, when disassembly is impractical, or when operational lifespans are inherently short (Potting et al., 2017). The effectiveness of closing strategies depends significantly on material composition. Homogeneous materials are generally easier and more economically viable to recycle, while composite or bonded materials present greater challenges as overlapping density distributions complicate separation and limit both the purity and yield of recovered fractions (Peeters et al., 2014; Thomason et al., 2016). Even where closed-loop recycling is technically achievable, the recycled quality is typically reduced relative to virgin material and may require dilution with virgin inputs to meet performance requirements (Peeters et al., 2014). While material characteristics constrain what is technically recoverable, the realization of closed-loop recycling depends on the logistical structure of EoL processes, which in turn shapes the associated economic trade-offs (Uhrenholt et al., 2022). Logistically, the choice between disassembly and size-reduction based treatment is a central design decision. Disassembly yields higher recycle quality but is cost-intensive, while shredding is more scalable but produces lower purity outputs and, in both cases, sufficient collection volumes and well-developed sorting infrastructure are prerequisites for viability (Grafström & Aasma, 2021; Peeters et al., 2014). Economically, the residual value of recovered materials is a major determinant of feasibility, alongside the volume and predictability of return flows, as low or volatile return rates undermine the business case even where technical recycling is achievable (Abdallah et al., 2012). Product design choices further shape economic outcomes, as the degree to which a product facilitates disassembly or refurbishability directly affects profitability (Bhattacharjee & Cruz, 2015). It should be noted, however, that the empirical evidence underpinning these determinants derives predominantly from electronics and durable goods with relatively high material value; their applicability to bonded short-lifecycle products of lower unit value remains comparatively understudied.

4. Methodology

This chapter begins with an overview of the research process, followed by a brief description of the case study. After that, the gathering of the thesis' empirics is explained. Finally, the quality of research and analysis are discussed.

4.1 Research Process Overview

A research process is needed to solve a problem systematically (Kothari, 2004). Kothari (2004) means that several unique challenges arise in a project, and this leads to a demand for tailored solutions. The research in question can be quantitative or qualitative in nature. A quantitative research method involves collecting and analyzing numerical data to identify patterns, averages, trends, and causal relationships (Borrego et al., 2009). Key methods include experiments, surveys with closed-ended questions, and analysis of existing data sets, utilizing statistical tools to test hypotheses (Goertz & Mahoney, 2012). Quantitative research methods typically require large sample sizes which enable generalization of findings to larger populations (Goertz & Mahoney, 2012). Qualitative research methods on the other hand are characterized by its collection of non-numerical data (Borrego et al., 2009; Kothari, 2004). By using interviews, observations, and conversational analysis, a qualitative research method can assist in explaining the reasoning behind why certain events occur, and how behaviors, attitudes and motivations affect other aspects (Kothari, 2004). This thesis has primarily utilized qualitative research methods to gain a deeper understanding of a specific area and gather valuable insights. Given the exploratory nature of the research questions, a qualitative approach is particularly well suited for this study, as it allows for the exploration of processes and relationships that cannot be adequately captured through quantitative measures alone. To structure this inquiry, a single embedded case study was conducted where one organization was examined across multiple units of analysis (Yin, 2018). This design enables an in-depth examination of circular economy implementation in a real industrial context, generating empirically grounded insights that can inform broader understanding of CE adoption among manufacturers of short-lifecycle products (Yin, 2018).

A few elements of a quantitative research method were included, namely a small survey. For more information, see subsection 4.5.1. This thesis's methodological approach follows a proposal for qualitative studies by Bell et al. (2019), and has been an iterative process until the results were collected, see Figure 4 below.

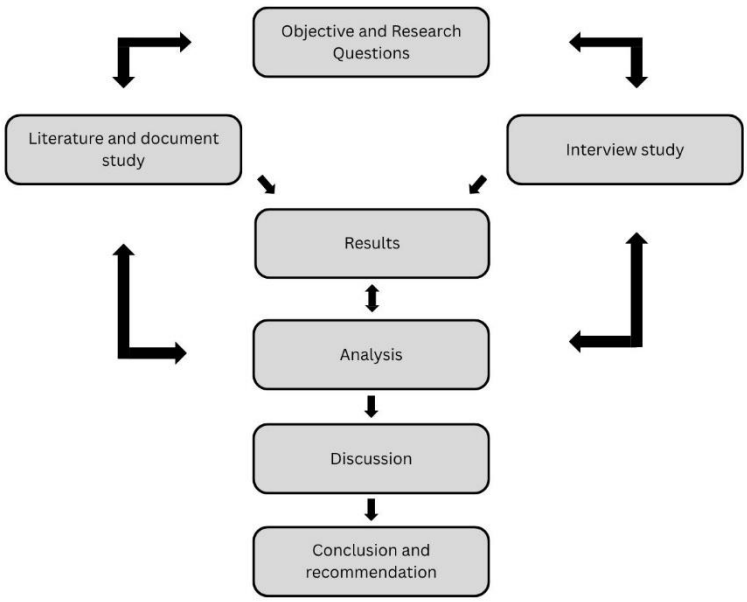


Figure 4: General design of the research process for this thesis. Inspired by the process Bell et al. (2019) recommends for a qualitative study.

The research process began with setting preliminary objectives and research questions. This occurred through dialogues with all supervisors, from both Linköping's University and from the case company. Following this, initial literature and document studies were conducted with the aim of finding relevant theories and gaining a basic understanding of the problem at hand. Parallel with this, an interview study was initiated. Interview objects were researched and contacted. The findings from all studies helped refine the research questions, which subsequently informed more accurate research methods and questions. The results provided a basis for analysis. Wherever gaps were discovered, additional data was collected. This resulted in an iterative process up until the discussion, as can be seen above in Figure 4.

4.2 Case Study

Camfil has been used as a case study through which, bonded, short-lifecycle products as a whole can be interpreted. The case study has been a single embedded case study, where the company enables an in-depth examination of CE implementation in a real industrial context, generating empirically grounded insights that can inform broader understanding of CE adoption among manufacturers of short-lifecycle products (Yin, 2018). Camfil is particularly relevant for this purpose due to the characteristics of comfort air filters, which have a short lifespan and therefore require frequent replacement. The plastic frames of these filters are manufactured from post-consumer HIPS plastic, yet the entire filter is currently sent to incineration as its EoL handling, representing a lost opportunity for material recirculation. A case study provides the opportunity to examine the interactions between manufacturers, suppliers, customers, end users, and waste-handling actors. These interactions capture how value is perceived differently throughout the value chain and gives insight into how circular solutions must be designed to accommodate the different interests that exist.

4.3 Literature Study

Assessing relevant and correct information is vital for academic research (Snyder, 2019). This means that much consideration has been given to the literature study in this thesis. It started with an overview, where broad scanning of the field gave the study a scientific foundation to stand on. Templier & Paré (2015) state that literature overview should start with creating research questions and defining central concepts for the subject, then proceeding with a systematic search strategy (Templier & Pare, 2015). This in combination with snowballing, both forward and backward, helped find good sources connected to the subject and theories to validate each other (Badampudi et al., 2015). Following Badampudi et al. (2015) regarding forward snowballing, relevant and recent sources were identified by starting with an initial article and screening its citations. Backward snowballing has also occurred. Here, sources used by the author are examined and so on and so forth (Kothari, 2004). This method helps find older sources that typically are more general and accepted by researchers (Goertz & Mahoney, 2012). To make the research replicable, documentation of keywords that have been used are presented in Table 1. The databases used are Linköping University´s library, Liu UniSearch, ResearchGate, ScienceDirect, Web of Science, Scopus, and Google Scholar. Access to these databases was secured through the university´s licenses.

Table 1: Themes and keywords used in the literature study.

Themes	**Keywords**
Circular economy	Circular economy, Circular business model, BECE, R-Strategies
Reverse logistics	Reverse logistics, Closed-loop, Take-back system
Recycle	Waste hierarchy, Material recycling, End-of-life, Waste

To quickly gain a general understanding or in order to find peer reviewed research for specific cases and processes, AI tools like Scopus AI and Elicit have been used as a compliment to traditional methods.

According to research, AI tools can streamline literature reviews by rapidly identifying relevant articles, mapping literature, and generating concise summaries (Agrawal et al., 2024; Granjeiro et al., 2025; Mandić, 2025). These tools enhance the efficiency and accuracy of literature searches, helping researchers uncover patterns, themes, and trends in literary works (Rani et al., 2025). However, AI tools may sometimes produce inaccurate results or exhibit algorithmic bias, which necessitates careful human oversight to ensure the integrity of this research (Agrawal et al., 2024; Mandić, 2025). The validity of AI-generated sources was thoroughly verified through a multi-step process. First, the initial database searches and AI-assisted tools generated upwards of a thousand candidate articles per area. Through reformulating search terms with tighter contextual constraints, results were condensed to approximately 100 – 150 articles per area. These were screened for peer-reviewed status and reduction of the pool to roughly 50 sources. Abstracts were then read, narrowing the selection to around 10 articles, which were read in full. Of these, three to four sources per area were ultimately selected. This process was applied across all themes and keywords in Table 1, yielding 75 peer-reviewed sources, supplemented by grey literature including industry reports and regulatory documents.

4.4 Document Study

A document study was conducted to gain technical comprehension of the case study´s product. It has filled a complementary role in this thesis. As both Owen (2014) and Bowen (2009) explain, document studies are often used in concert with other methods for qualitative studies. By analyzing internal documents from the case company, knowledge of product specifications, geographic distribution, and product density at the point of recovery can be secured. Access to these documents have been given following interviews held with the case company´s product developers, sales representatives, and through conversations with the project supervisor.

Additionally, understanding the legality of transportation of waste requires a document study. Different rules and regulations apply to actors depending on the degree of pollution, amount transported, mode of transportation and if it occurs nationally or across international borders. To a smaller extent, they will be utilized in the thesis, but only in a complementary role. Here, documents related to waste handling and transport – both in Sweden and the EU – have been analyzed.

As documents seldom are peer-reviewed, combining them with other types of data helps increase reliability and accuracy (Owen, 2014). As stated earlier, this document study has primarily been used to increase understanding of technical and regulatory conditions that affect the thesis and project. This is in line with Bowen's (2009) writings that document studies can help develop understanding and provide insights in qualitative research, not least by offering background information and deeper insight into a subject. Additionally, they can support interview studies by helping researchers ask the right questions (Bowen, 2009).

4.5 Interview Study

Semi-structured interviews have been considered suitable to this thesis and have been extensively utilized. They serve as a qualitative data collection method and have helped in gaining deep insights in respondents experiences, perceptions, as well as expertise within the subject area (Owen, 2014). Semi-structured interviews help balance structure and flexibility, allowing for both consistency across interviews whilst maintaining the ability to explore and follow up on unexpected insights (Alvehus, 2023). This type of interview is open-ended, giving greater freedom to dig deeper into different aspects of an answer (Adams, 2015). The interviewer is given the freedom to improvise follow-up questions depending on the previous answers (Kallio et al., 2016). This has been useful during the interviews since it has led to insights and revealed information that was not included in the prewritten questions. Semi-structured interviews have enabled valuable data for the thesis. With the interviewees' explicit consent, the interviews were recorded and transcribed. This ensures that all information is available for future analysis. In line with Adams' (2015) recommendation on duration, interviews have been limited to less than 60 minutes. After that time has eloped, participants tend to lose focus and provide less thought-through answers (Adams, 2015). The participants' identity was chosen to remain hidden in this thesis. The reason for this was to help ensure more truthful answers. Actors can speak more candidly if they know that the information they provide will not easily be traced back to them (Adams, 2015).

Additionally, by keeping the names of the respondents and corporations hidden, readers' own biases and assumptions should decrease. Finally, a large number of interviews have been held. The relevance of what each person says comes from the role, rather than the person's name. This helps condense the results and keep it more focused.

Interviews have been chosen to be presented in two different groups: internal actors at the case company and external interviews. The internal actors are further divided into the different business units, and the external interviews are different depending on if the respondent is affiliated with or influenced by the case company. A comprehensive list of all interviewees is presented in Table 2. In total, 21 people were interviewed, of which 15 worked at the case company and six were either customers, suppliers or experts in other fields at five different organizations. The largest interview group at the case company worked with sales. The reason why so many sales representatives were interviewed was because the case company is one of the largest globally in its field, leading to a diverse customer base with different needs and preconditions. By speaking to several different types of sales representatives, different perspectives, motivations, barriers and ideas can be identified. As this project was dependent on gathering insights from customers, getting their sales representatives onboard was crucial. Speaking to customers can be delicate. It is of great importance that the right customer is asked the right questions, otherwise it can jeopardize the working relationship between actors (Borrego et al., 2009; Kothari, 2004). The interviews with sales representatives thus assisted in finding external respondents. Two people in the business area, purchasing and logistics, were interviewed. As plastic is the main material of economic value in the air filters, gaining a deeper understanding of what that value actually is was of great importance. How the contracts for plastic frames and what influences the negotiations was relevant for both the thesis and the project. For logistics, a solution for filter recycling might include some sort of internal take-back system. Finding out what capabilities the company possesses plays a part in the final recommendation presented. The marketing director for Sweden was interviewed. This interview primarily filled gaps that were identified after an initial consolidation of the results. Here, questions regarding soft values and willingness to pay were in focus. Insight was given regarding the case company’s ability to communicate a recycling initiative effectively and what the effects presumably would be. Finally, weekly discussions with a sustainability coordinator and technical engineer were held. Parallel to the authors´ work, these two worked on related efforts. These debriefs and the insight into each other's work ensured that all participants knew what responsibility they had and could guide their efforts accordingly. As these were recurring meetings where recent findings were discussed, most did not meet a high enough standard to qualify as empirical findings. The instances where the authors felt that the information gathered was substantial enough and collected in a structured way so it could be used in the thesis, are visualized in Table 2 below.

Regarding the external actors, two customers were interviewed. One was with a sustainability coordinator for Swedens largest public purchasing organization. This interviewee provided information on how different environmental aspects of an offer are valued. A sustainability officer at a Swedish FM company was also interviewed. This discussion gave insight into the waste management of buildings and what is prioritized and important in their organizations. Service technicians were also contacted. These were not interviews, rather it was conducted as a survey. More information on this can be found in subsection 4.5.1. By interviewing both service technicians and people with managerial roles, a more complete picture of motivations, barriers and opportunities could be made out. This also made it possible to investigate differences in priorities between different roles at a facility management company, opening for a more nuanced discussion. A legal advisor was contacted and subsequently interviewed. The purpose behind this was to gain an understanding of the regulatory conditions of transporting and handling waste material. This interview also helped guide the authors in their document study. Actors within recycling were also interviewed. These can be seen as experts within their field that have the ability to speak on feasibility, both physical and financial, of separating composite products. Two interviews occurred with different companies; one with the Marketing Manager and one with a waste management consultant and Operations Manager. Nine actors in this field were contacted and the main reason for declining interviews was a perceived lack of solutions with the project's technical specifications. Most believed that either they or their company were not the right fit for what was trying to be addressed in the master’s thesis.

Generative AI such as Claude and Copilot have been utilized in making interview guides. It has been used as a devise for brainstorming relevant topics and structuring up a reasonable disposition and length of interviews. It has also played a role in language refinement and translation of the guides from Swedish to English for presentation in the thesis. All interview guides are presented in Appendix A-I. Every question in Appendix A was not posed to each participant, rather it constitutes the total number of questions for sales representatives. As this segment is quite diverse with many different types of customers – each with their own wants and needs – the questions needed to reflect this diversity.

Table 2: Comprehensive list of all interviewed actors with a description of role, date, method, and duration of interview

Nr	**Area of operation**	**Role of Respondent**	**Date**	**Method**	**Duration (minutes)**
Interviews with respondents within the case-company					
1	R&D	Senior Development Engineer	28/01–26 02/02–26 12/02–26	Digital	~30
2	Sustainability	Product & Sustainability Coordinator	28/01–26 05/02–26 12/02–26 05/03–26	Digital	~30
3	Logistics	VP Logistics & Sourcing	27/01–26	In person	30
4	Sales	Sales Director – Sweden	29/01–26	Digital	30
5	Sales	Key Account Manager – Original Equipment Manufacturer	03/02–26	Digital	45
6	Sales	Project & Service	03/02–26	Digital	40
7	Sales	Sales Director – Norway	06/02–26 26/02–26	Digital Digital	30 15
8	Sales	Key Account Manager – Central Agreements	11/02–26	Digital	60
9	Sales	Sales Manager – North	12/02–26	Digital	30
10	Sales	Key Account Manager – Public purchasing	12/02–26	Digital	50
11	Sales	Education & Experience Manager	25/02–26	Digital	45
12	Sales	Technical sales	20/03–26	Digital	30
13	Purchasing	Group Purchasing Director	13/02–26	Digital	30
14	Marketing	Marketing Director – Sweden	04/03–26	Digital	50
15	Operations	Product Manager – USA	23/04–26	Digital	60

Interviews held with external actors					
16	Waste Transportation	Legal Adviser	03/02–26	Telephone	30
17	Sustainability	Sustainability Coordinator – Public Purchasing	20/02–26	Digital	60
18	Sustainability	Sustainability Officer – Facility Management	07/04–26	Digital	30
19	Marketing	Marketing manager – Plastic Recycling	18/03–26	Telephone	50
20 & 21	Operations	Waste Management Consultant & Operations Manager – Recycling Company	23/03–26	Digital	30

Additionally to the semi-structured interviews, exploratory interviews were conducted. These occurred during the early stages of the thesis and exclusively towards people in the case company. The questions were open-ended and assisted the authors in gaining an understanding of the topic at hand and identifying key issues; both internally between different departments and externally towards the customers' wants and needs. This helped the authors develop hypotheses and guide many of the conversations that are described in Table 2. No questionnaires or interview guides were developed for these exploratory interviews. The people interviewed include product owners and developers, people who worked with the supply chain, and people who coordinate sustainability efforts.

To make the presentation of chapter 5. Results, as well as the analysis of the interviews easier, an AI-agent was built in Microsoft Copilot. It only had access to the transcriptions and notes that were taken during the interviews. The AI-agent then assisted with finding relevant quotes from different respondents for the themes chosen. These quotes could then easily be verified, validated, or discarded by listening to the recording and reading through the transcription and notes. The themes were chosen after most of the interviews had been held and certain patterns had been identified. Both the authors' and the AI-agent constructed themes independently. These were mainly corresponding with each other and refined to more accurately cover the different aspects involved in closing a material loop. The themes used can be found below in Table 3. The chosen themes represent different aspects of filter handling, recycling and prerequisites that are in effect during the implementation of a new recycling system.

Table 3: The six themes chosen to present the results from the interview study.

Theme		
Filter Handling and Operational Friction	Logistics, Density, Geography and Costs as Deciding Factors	Customer Value, Sustainability and Willingness to Pay
Technical Solutions and Process Innovation	Roles, Responsibility and Ownership	Positioning, Competition and the First to Market

4.5.1 Questionnaires and other Empirical Data Collection

In cases where an interview was not possible to conduct due to scheduling difficulty or unavailability, information was gathered through email conversations. The questions posed were similar in nature to the ones in the interview study, however they were less in-depth and not as open-ended.

Field interviews were held during a visit to the case company's sales office in Stockholm. Service technicians who arrived to collect new products and discard spent air filters were asked if they would mind a short interview. A total of five service technicians from four different facility management companies agreed. The questions were rigid and followed a clear questionnaire. An emphasis was placed on motivations, barriers, and opportunities for collaboration in the day-to-day operations of handling and discarding dirty products. Each interview averaged between three to five minutes long, with few follow-up questions asked. The reason behind this was that the service technicians were in a rush between assignments. These interviews were not recorded or transcribed. Instead, notes were taken by one of the authors whilst the other asked the questions. These questions can be found in Appendix I:1.

Appendix I:2. contains the list of questions asked to customers of the case company, more specifically, municipally owned property companies. Here, answers are collected from a sustainability coordinator, a technical advisor, and three public purchasers. These answers were gathered through email conversations.

Appendix I:3. is for Norwegian customers to Camfil who operate as HVAC contractors in Oslo. The Norwegian respondents include a sales manager and a service technician. The same questions were posed to both individuals, generating different perspectives and encompassing more diverse and accurate answers. These answers were gathered through email conversations.

Additionally, an observational study was conducted. Here, a senior service technician at a FM company gave a guided tour of a hotel and two commercial buildings in central Stockholm. The authors received a firsthand experience of the scale, obstacles, opportunities and pain points in handling filters and HVAC systems. In total, four different sizes and types of HVAC systems were visited which together gave a broader picture of how much these systems can vary. The questions and responses were not documented as this tour proceeded over several hours and was more informal in nature. Short notes were taken instead and an extensive documentation was conducted directly after the tour was finished. This was not an interview, but rather a dialog. Another formal dialog was with a product manager in the American subsidiary. Both the Swedish and the American organizations face similar challenges regarding customer requirements from data centers. This conversation was aimed to be a learning experience for both teams, where insights, experiences and solutions could be shared and discussed. It also acted as an introductory meeting for increased future collaboration between the different organizations. It was conducted digitally through Microsoft Teams and lasted sixty minutes.

4.6 Research Quality

Credibility has been strengthened through data triangulation, which Yin (2018) describes as one of the most important strategies for increasing the validity of qualitative research. Findings have been cross-referenced across semi-structured interviews, the service-technician survey, the observational study, and the complementary document and literature review. Statements regarding operational friction were verified against firsthand observations from the site walkthrough, while claims about recycling feasibility were cross-checked between internal interviews and external recyclers.

Confirmability concerns the extent to which the findings are shaped by the data rather than by the researchers' own preconceptions. As this thesis has been conducted in collaboration with Camfil, particular attention was given to remain impartial and to not be shaped by the case company's commercial interests. This has for example been done through biweekly discussions with the supervisor of the thesis. The examiner and the opponents have provided further external scrutiny through structured reviews at fixed meetings, where assumptions, framing, and conclusions were challenged. Feedback from these reviews has been incorporated continuously and has on several occasions led the authors to reconsider interpretations that had been influenced by proximity to the case company.

Generative AI tools have been used in a complementary role for literature searches, interview-guide brainstorming, language refinement, and the retrieval of interesting quotes from interview transcripts. AI introduces specific risks to research quality, primarily through inaccurate outputs, fabricated sources, and algorithmic bias (Agrawal et al., 2024). To prevent these risks from affecting the findings, AI has

been restricted to clearly delimited supporting tasks, and every AI-assisted output has been validated against primary material. Sources provided by AI were verified by confirming peer-review status and reading the cited passage in full before use. Quotes retrieved by the AI agent were verified against the original recordings and discarded if they could not be confirmed. The analytical interpretation and the conclusions remain the responsibility of the authors.

All respondents were informed of the purpose of the study, how the material would be used, that participation was voluntary, and that it was in collaboration with Camfil. Explicit consent was obtained for recording and transcription. Respondents' identities have been anonymized and are presented through role-based descriptions rather than names, which both protects their integrity and, as Adams (2015) notes, encourages more candid answers. Competitors were intentionally excluded from the interview study as there existed an ethical conundrum in extracting competitors competences for Camfil's benefit. Since the study has been conducted in collaboration with Camfil, certain internal information that has been shared with the authors is not suitable for publication. Internal documents containing commercially sensitive information have therefore been excluded from the appendices, and formulations in the results chapter have, where necessary, been adjusted to protect business-sensitive information without distorting the substantive content.

5. Results

This chapter presents the results from the interview study. It has been divided up into six sections of differing themes. The chapter begins be examining why incineration persists as the EoL pathway, followed by the influence logistics, density, geography and costs play. The chapter continues by presenting what customers gain from material recycling. 5.4 presents alternatives and prerequisites for the technical solution of material recycling, followed by a breakdown if ownership and responsibility. Finally, 5.6 presents what Camfil, and other market-leading manufacturers stand to gain from implementing a take-back system.

5.1 Filter Handling

The findings from the empirical data show that the current handling of used air filters in practice constitutes an integrated system driven by operational routines, logistical conditions, and behavioral constraints. Two sub-themes in this empirical data are identified: incineration as the norm, and operational friction. They are closely interconnected and mutually reinforcing and together, they provide an explanation for why the current way of waste material handling continues to look that way, despite increasing external sustainability demands. Table 4 contains especially telling statements with implied meaning for the current filter handling and operational friction.

5.1.1 Incineration as the norm

A central and recurring pattern is that incineration constitutes the default solution for EoL handling of old filters across almost all customer segments. This applies regardless of whether the filters are discarded by property companies, contractors, service technicians, or Camfil themselves. The system is deeply institutionalized: it is familiar, simple, and requires minimal additional effort. Customers consistently describe incineration as the sole disposal route, with no alternatives considered or offered. This norm is reinforced by the perception that the material mix is difficult to handle and generally the understanding of how the downstream waste process is managed is either lacking or seen as irrelevant for users.

Internally within Camfil, similar conditions apply. The company essentially lacks a structured reverse logistics system. They provide the opportunity for customers to personally leave used filters at their sales offices throughout Sweden and Norway; however, these eventually make their way to incineration. During the service technician survey, several respondents expressed satisfaction over having the ability to discard filters at the same place they collected new ones. The Norwegian subsidiary extended this service by developing some RL capability. They have established a structured service for collecting customers' used filters, including pick-up operations conducted with their own electric vehicles. According to the Norwegian sales director, this simplifies the handling of used filters for the customer and encourages further collection, a pattern also reflected in the Norwegian customer survey. Customer integration is strengthened and return volumes increased – which are more than double that of the Stockholm office. This service constitutes a positive revenue stream but generally, the collection of material is considered a cost for Camfil. Paying for the disposal of used filters has however been seen as a worthwhile cost as it solves many disposal issues for their customers.

Camfil's chief purchasing director sees a large opportunity in utilizing this collected material. Purely economically, the containers are expenses. However, with introducing a recycling system there is the potential of decreasing the amount that is incinerated as well as generating revenue by selling the HIPS to plastic suppliers who can reuse the material in their own processes. As incineration is expensive, lowering this while generating more revenue would be favorable for Camfil. Recycling the HIPS would also be beneficial from an environmental point of view. Camfil's sustainability coordinator explains that every kilogram of HIPS plastic that in incinerated releases 3.10 kg CO_2e into the atmosphere. With this product dominating the Swedish comfort air filter market a decrease of this emission would provide a noticeable effect as it is compounded by the large installed base that Camfil has.

5.1.2 Operational Friction

Everyday operational factors such as time, dust, distance, habits, and work environment are decisive in practice. These factors systematically lead actors to choose the path of least resistance. One of the most consistent findings in both the interviews and in the service technician survey is the reluctance to add extra steps for material separation, even exceedingly small ones. Several service technicians state outright that they would not separate filters because they lack the time, and for many of them even a few extra seconds constitute a barrier that becomes too much to ask of them voluntarily.

A positive insight emerged around Camfil's local waste compactors containers that they have in the sales offices in Stockholm, Gothenburg, Malmö, and Oslo, which service technicians describe as solving several problems simultaneously. The option to leave old filters in the container is valued since it resolves the otherwise open question of where else to dispose of them. Similar reasoning appears when service technicians explain why they transport used filters to Camfil. The alternative of using a municipal recycling center requires separating cardboard and other fractions and is perceived by many as troublesome, making the route to Camfil's containers comparatively attractive. The underlying motivation is disposal, not recycling and technicians go to Camfil because it is the easiest way to get rid of a problem, not because they see value in what happens to the material afterward. In several cases, service technicians express that customers expect the supplier or service partner to handle the dirty waste. This suggests that the handling of residual flows is not merely an internal routine but is perceived as a customer requirement embedded in the service offering. Interviews reinforce this picture by emphasizing how simplicity and logistical convenience shape customer behavior. Respondents highlight that customers value when the supplier manages waste handling, transport, and temporary storage, as this reduces complexity and influences their willingness to return used filters. The perception that the solution is easy and cost-efficient appears to lower the practical barriers to participation.

One interviewee further describes how service companies tend to organize their routines around the supplier's existing logistics system, particularly to avoid handling large volumes of dirty filters themselves. Most service technicians expressed how convenience and the established operational structures played a decisive role in the choice of disposal method, seemingly more than any formal environmental policies or articulated sustainability ambitions – as few seemed to know their own policies.

Similar sentiments were shared during the observational study where a service technician gave a guided tour of different HVAC systems. The reality of what operational frictions exist was visualized. Most HVAC systems were old, outdated, and hard to service. As the visited buildings were built before central ventilation existed, the HVAC systems were retroactively fit. This led to a large variation regarding the difficulty in servicing them. Most were tucked away in small areas far from any elevators or the buildings loading dock, with one required climbing a small, steep ladder to service it. When speaking to this service technician, the irritation, frustration, and general attitude regarding filter handling was made clear: they want to interact with dirty filters as little as possible.

When speaking to service technicians who visited the sales office, the general sentiment seemed to indicate that they would require some sort of compensation for participating in the separation of filters. Incentives seemed to primarily need to be personal and economic in nature, or to be mandated from within their own organizations as no voluntary sentiments were recorded. It does not seem unreasonable for higher-ups in these organizations to require some sort of involvement. The sustainability officer at a FM company said that a sacrifice in time or other increased involvement would be acceptable if the value generated from this participation was at least proportional to the temporal or economic investment. FM companies have long desired increased circular solutions as they are under pressure from tenants, owners, regulatory bodies, and other stakeholders to improve their own environmental performance. It is thus understood that some sacrifice and collaboration is required – at least initially – to implement circularity and help each other succeed. There might be some friction internally, but if upper management does not see the added work as disproportional or dangerous for their employees, there are few reasons not to participate.

Table 4: Selection of descriptive statements made by respondents and what these quotes imply.

Theme	Respondent	Quote	Implication
Incineration as the norm	Sales Director Norway	"At our location it is free for customers to throw away filters, other solutions require them to pay for the disposal…"	When incineration is free and co-located, it becomes the standard. Circular alternatives must match low marginal cost and convenience to be competitive.
	Service Technician in Survey 1. Service Technicians	"If it costs 700 SEK to throw it away at the landfill, it's hard to justify not coming here [to Camfil's container]."	Economic friction reinforces incineration at the supplier. An appreciated service is provided for free.
	Respondents in Survey 2. Municipally Owned Property Companies	"All filters are thrown in combustibles." "This is probably because they consist of several different materials, are dirty, and therefore difficult to recycle."	Reasons for incineration being the norm.
	Sustainability Officer – FM	"Absolutely much better for us to discuss this [material recycling], instead of burning them."	Incineration as the only EoL pathway is not true anymore as it solves customers challenges.
Operational friction	Service technicians in Survey 1.	"I would never separate them, I don't have time." "There's not a chance if it takes a few extra minutes." "I wouldn't take the filters out of the cardboard regardless of whether I know what happens to them sustainability-wise." "Very annoying and gross to throw them away at the municipal recycling center, you have to separate cardboard… Then it became very attractive to come here [to Camfil's container]." ***Question***: Where is your pain threshold timewise? ***Answer***: 2 seconds	Voluntary sorting at the technician level is unrealistic. System design must eliminate behavioral requirements rather than try to change behaviors.
	Sales Director – Norway	"Being on the right side of the city matters" – Customers' sentiments	Customers express operational difficulty to travel longer distances.

	Sales – Education & Experience Manager	"They have said that we will never separate them ourselves."	Manual sorting at the technician or customer level is unrealistic. The system can not only be behavior-driven and voluntary.
	Sales Manager – North	"When a customer arrives tired and grumpy… they see a container and throw in all waste."	Open containers lead to contamination and requires some technical barriers or pre-sorting before collection.
Customer expectations	Sales Director – Sweden	"[Customers expect that] the supplier handles the dirty waste"	Waste management is perceived as part of the offering, not as the customer's responsibility. This makes producer-led take-back legitimate.
	Key Account Manager – Central Agreements	"Customers change filters and leave the old and new ones at the same time."	Confirms that customer expectations are about practicality and ease of operation

5.2 Logistics, Density, Geography and Costs as Deciding Factors.

The second identified theme is the influence that logistics, density, geography and costs have on the feasibility of implementing a take-back system. Questions arise regarding how plastic frames are to be transported from the customer to Camfil's supplier's production in southern Sweden, where the recovered material can be fed back into the manufacture of new frames. Across interviews, respondents frame this question primarily through a cost lens, where transportation distance, time, handling effort, and the physical properties of the material itself determine whether a collection flow is perceived as viable or not. What matters is not only where filters can be collected at reasonable cost, but also where the processing step can be placed to minimize the total transport burden between customer, collection point, and production site.

The transportation of used goods has two segments that together determine the economics of the closed loop. The first runs from the customer to a collection point and the second goes from said collection point to the production site in southern Sweden. Since filters are bulky and largely consist of empty space, the distance a whole filter can be moved cost-effectively is limited and the two segments interact directly with how and where the material is processed. Two different alternatives exists for this transport. Filters can either be transported directly from the customer all the way south in their original form, placing the full transport cost of low-density products on the take-back system, or they can pass through an intermediate node where the plastic is separated and volumetrically concentrated, before being shipped onward. In the latter case, what leaves the node is then a compact, processed material rather than whole filters, and this transportation problem is effectively split into a short, low-density first leg and a longer, higher-density second leg. As long distances with low density make the transport economics increasingly difficult, increasing the density of the valuable material is necessary. This is exemplified by both the senior technical engineer and the VP of Logistics & Sourcing stating "*We do not ship air*".

As explained in section 5.1, the company already operates a number of sales offices where customers can pick up new filters and drop off old ones. This means that integrating collection into existing logistics does not add a separate flow and remains cost-neutral in practice for customers and Camfil. In

Oslo, approximately thirty percent of customers collect their filters at the sales office, and most discard their used filters here. As the Norwegian sales director puts it: ”*At our location it is free for customers to throw away filters, other solutions require them to pay for the disposal… It is often the same service technician who during the morning collected a pallet of fresh filters that later in the afternoon returns with the old ones and throws them away in our container*”. The example captures the underlying mechanism: when disposal is free and co-located with acquisition, the marginal cost for the customer is effectively zero, and the flow sustains itself.

Distance and urban geography emerge as a first cost dimension. A salesperson responsible for Northern Sweden highlights the poor collection opportunities created by the region's vast distances, in contrast to the conditions found in larger cities. They used to have a sales office with a waste container in the region but decided to close it down due to insufficient visits from customers. There were not enough customers driving to the location to justify the operational costs. The region is too large and has too few customers to efficiently have localized operations, according to this sales representative.

Similarly within cities, the same logic plays out at a smaller scale: customers on the far side of a larger city are less motivated to transport used goods to the designated drop-off location, and being on “*the appropriate side of the city*” is cited explicitly by service technicians as a determining factor for whether filters are returned at all. Service technicians in both Sweden and Norway express that the physical act of dropping off used filters at the case company is not perceived as an inconvenience, largely because the return is folded into trips that are taking place anyway. Friction arises once distances increase. To solves this, the Norwegian subsidiary offers a pick-up service where customers can book a time and date for collection. This results in customers paying for the EoL handling of filters economically instead of with their time. Taken together, this service and the ability to personally return filters improve collection rates as the return flow is integrated into existing routes, rather than requiring a separate trip.

A further cost dimension appears when volumes grow beyond what technicians can reasonably manage themselves. One customer in Norway, Appendix 3, describes how their choice of disposal method shifted as the volume changed. For small numbers of filters, it was not a cost-effective use of an employee's time to transport them across town and when volumes grew too large, it became more practical to outsource the handling and disposal entirely. The responses from municipally owned property company survey, Appendix 2, support this pattern, with “*logistical reasons*” and “*bulky*” dominating the reasons given for current disposal choices. Customers treat collection as a cost rather than a value-creating activity, and switch between self-handling, drop-off, or outsourced disposal depending on which combination minimizes their own effort.

Density, both in terms of how many customers are in an area and how many filters are at a single site, is therefore treated by respondents as a key determinant of feasibility for the first segment of the transport chain. As noted earlier in this section, around one third of the products sold in Norway are collected by customers at the sales office in Oslo, and similar collection and sales patterns are described for the other sales offices. Quantifying the urban share precisely is difficult since sales data is available at regional rather than city level, and collection in the major cities is likely to be considerably higher than the regional figures alone suggest This limitation reinforces the pattern. Collection potential is concentrated where volumes and geography line up, and the advantage of a large city is visible in the data even though it cannot be measured exactly.

5.3 Customer Value, Sustainability and Willingness to Pay

The empirical material indicates that customer value, sustainability, and willingness to pay cannot be treated as separate dimensions but should be understood as interconnected parts of the same value-creation process. To improve readability, however, this section will attempt to keep them separate.

5.3.1 Customer Value

The most detailed way of how a circular filter offering translates into customer value comes from the clear shift in how the property owner evaluates its filter suppliers. Moving from an exclusive focus on energy efficiency and indoor air quality toward a broader set of expectations that include production emissions, transport, and EoL treatment. For a supplier, this shift is significant. Circular offerings are

no longer evaluated as add-ons but as a prerequisite for remaining qualified in future procurements. The expectation that suppliers take responsibility for their own products at EoL, retrieving them and feeding them back into the loop rather than leaving disposal to the customer was expressed in interviews. The underlying ambition voiced on the demand side is that material flows should form a closed circle, with the supplier positioned as the natural actor to close it.

This expectation is directly coupled with the customer's own competitive positioning. Value from a circular offering moves along the chain and does not stay with the direct customer alone. A property owner who can document circular filter handling becomes a more credible sustainability actor toward its tenants, who increasingly request emission data from their facilities. A facility manager can point to verifying EoL data in their own reporting. Customers therefore need this data as much as they need the service itself, and a circular filter offering gives them both. A circular filter service gives verified and improved environmental data that they can carry into their own sustainability reporting.

The clearest concrete illustration of how value is generated along the chain, rather than captured only at the transaction point, emerges from the relationship with the supplier that produces Camfil's plastic filter frames. In a closed loop, the plastic recovered from spent filters can be returned to the supplier as recycled material input. This gives the supplier the security of knowing that its largest customer is operationally integrated with its own material flow, which in turn translates into somewhat lower prices, and it provides the supplier with communicative advantages that it can carry into its relationships with other customers. The value created by the closed loop therefore does not stay with the supplier alone.

Another type of customer reinforces the same pattern. The sustainability coordinator at a public procurement organization describes how circularity is moving from a peripheral nice-to-have into a concrete point of differentiation in evaluations. Reuse and a closed loop have historically been difficult to realize, and members have largely accepted the status quo, but once a concrete circular offering is signaled in the market, interest rises sharply and expectations shift accordingly.

5.3.2 Sustainability

The interviews reveal how sustainability is shifting from an isolated set of optimization activities toward a system-level, life-cycle perspective. Respondents describe increasingly ambitious long-term sustainability goals that customers are working to reach, with climate neutrality set as a long-term commitment on the horizon. FM companies work with these sustainability goals; both as a commitment towards their own customers, and as a differentiation strategy against their competitors. This puts pressure on their suppliers and incentivizes them to also commit to climate neutrality. Historically, filter-related emissions have been marginal in relation to district heating and purchased electricity and have therefore received limited attention. This is changing. The logic voiced on the demand side is that climate neutrality cannot be reached by one actor alone. Suppliers are expected to assist in the journey, and filter handling is then explicitly pulled into scope. For suppliers, this means that product-level climate performance is increasingly treated as a condition of continued relevance rather than only a differentiating feature.

From interviews with the internal sales organization a shift in what customers accept as sustainability evidence was described. Customers are moving away from spend-based estimates, where emissions are calculated from purchase costs, toward product-specific and activity-based data. They want real volumes, real transport figures, and real product characteristics rather than average approximations. In practice, this often shows that actual emissions are lower than the generic estimates suggested, which in turn strengthens the incentive to demand better data from suppliers. This shift has direct implications for how prior sustainability investments now get leveraged into sales.

Internal respondents describe Camfil as an actor with a relatively high degree of sustainability maturity, with substantial investments in LCAs, Environmental Product Declarations (EPDs), and an optimization of energy efficiency during the use phase. People in the sales organization confirm the commercial value of this groundwork. As end customers increasingly demand documentation and traceability, prior EPD and LCA investments function as assets in the customer dialogue. These investments acquire a new meaning in the current environment. They were originally motivated by the

logic that the use phase dominates the total carbon footprint and that efforts should therefore be concentrated there. Customers confirm that this logic still holds but argue that it is no longer sufficient on its own, and that remaining life-cycle phases now need to be addressed as well, as sustainability requirements tighten. In this context, closing the material loop is less a new initiative and more the next logical step in a trajectory that has already begun. At the same time, the interviews make clear that sustainability claims must be anchored in concrete, tangible activity if they are to remain persuasive.

Internal respondents describe circular services as an operationalization of sustainability ambitions that are already in place, rather than as an independent initiative. The take-back offering is described as a concrete, measurable reference point that both lowers the risk of sustainability communication being perceived as greenwashing and gives the sales organization a tangible tool that aligns with the kind of value customers are now asking for.

5.3.3 Willingness to Pay

Interviews show three explicit conditions that must hold for a sustainability-linked price increase: (i) the offering must generate a measurable environmental benefit, (ii) the added cost must be perceived as reasonable in relation to that benefit, and (iii) the added operational friction must remain within acceptable limits for the customer.

The first two conditions are visualized by a quote from the FM company sustainability officer regarding how sustainable purchasing decisions are made: "*Suppose there is a regular air filter that costs 100 SEK and a recycled filter, collected from the property owner, that costs 110 SEK, with a 22 percent lower carbon footprint – then we would buy the recycled one*". Both the sustainability coordinator in public purchasing and the sustainability officer at the FM company expressed a willingness to pay provided that (i) and (ii) were satisfied. They described how this becomes an attractive deal for both them and suppliers as they get environmentally improved EoL handling and suppliers receive longer contracts with lock-in effects. Internally, several different salespeople pointed out this increased customer retention as the most important factor. By being the largest on the market, the risk of losing customers is greater than the ability to increase market share.

The third condition was received direct from interview with customers. When asking questions to the FM Sustainability Officer regarding service technicians and workflow, see Appendix H, the respondent described that the EoL handling route can be managed and changed as long as the operational friction created for the route remain within acceptable limits, and (i) and (ii) hold.

Respondents, both internal and external, describe how procurement and sustainability functions inside the same buying organization tend to evaluate an identical offering very differently. Procurement is typically oriented towards price reduction and treats a premium as a cost to be defended against, while the sustainability function is more prepared to accept a higher price where the offering demonstrably supports climate targets and reporting obligations. The price level that can actually be realized therefore depends less on the offer itself and more on which of these internal voices carries the most weight in each procurement.

Regarding willingness to pay for recycled material, Camfil's Group Purchasing Director suggested keeping the pricing structure similar to the current negotiation arrangement with the supplier producing the plastic filter frames. Managing relationships in the value chain is dependent on fair prices and the Group Purchasing Director described that the relationship is kept thanks to fair negotiations. Prices are set for a defined period, and any imbalance between the agreed level and how the flow developed is compensated for in the following period. Adjusting price reciprocally keeps negotiations fair and sustains a willingness to pay overtime. If both parties continue to derive fair, tangible value from the arrangement, a willingness to pay and participate exists on both sides. The negotiations center on how the value is allocated between the actors and takes on the character of co-creation rather than single firm focus.

5.4 Technical Solutions and Process Innovation

A central empirical pattern concerns the development of technical systems for handling and processing used filter frames. The Senior Development Engineer expressed how the supplier that produces Camfil's plastic filter frames has the ability to create new filters from the collected material. This technical prerequisite then frames the current technical solutions around separations and collection. Respondents consistently describe the current stage as pre-commercial, marked by prototyping and unresolved questions regarding automation, safety, logistics and cost efficiency. Three different systems emerge: (i) mobile processing technologies that break down the product at customer's locations, (ii) stationary node-based systems at existing organizational hubs, and (iii) outsourcing this activity.

5.4.1 Mobile Mill Model

A mobile milling solution places machinery on a truck that travels to customer sites, additionally providing a direct service towards customers by processing material on location. This machinery could take many different forms. It could be a shredding machine that breaks down the products into smaller fractions, or a compaction solution. What is important regardless of machinery choice is that it enables a greater number of filters to be collected and handled. A case from a Finnish competitor that a sales representative brought up illustrates the radical volume reduction enabled by on-site compaction, where their vehicle could handle a surprising number of filters before being full – many times more than if the packages had been intact. The model requires almost no behavioral change from service technicians, as intact filters could be loaded directly without unpacking or sorting, aligning with technicians' strong preference to avoid additional handling. This type of solution can take many different forms. Collection has been discussed internally, and two main ways have been advocated. For large customers, with many filters in the same location, there could be enough material to motivate them to bring milling machinery to the customer, process it over a few hours, and then leave with all the material. This requires a team of operators who handle and sort the different fractions to extract the material and environmental value from the filters. Several trucks will be required since the amount of filter media, plastic frame and cardboard boxes will be substantial. This solution has primarily been discussed to handle the large customers such as data centers.

The other way is aimed to cover a greater amount of customers, but who each has fewer amounts of filters per location. A vehicle with either a shredding or compaction function will travel between customers, collecting the filters before heading to the next customer. Synchronizing the specialized truck with varied technician schedules can however make reliable route planning and pickup difficult. As this type of route-planning and optimization logistics are not core competencies for Camfil, this could present major challenges. Operational considerations such as personnel, safety, training, and insurance also complicate day-to-day use. Structurally, milled material must still be transported to specialized subcontractors, often located far from collection sites, meaning the mobile mill reduces some logistical steps but cannot eliminate dependence on extended outbound transport.

Camfil Norway has some experience with this second type of collection solution. They lack a mobile mill but offer the service of collecting customers' old filters with their electric truck. They offer different options in different price ranges depending on how urgent the removal of waste is and how large the volume is. The most basic service has an unspecified pick-up time during the chosen day and the most expensive has a specific time for collection. This service is currently unavailable in Sweden.

5.4.2 Stationary Node Model

A node model places shredding and separating machinery at fixed locations and decreases the logistical complexity. By utilizing Camfil's sales offices, where many technicians currently discard used filters, operational friction can be negated by keeping customers' routines unchanged. Fixed installations enable in-house control of operations. Once filters are deposited, the equipment compresses the large volume each package contains, creating denser material flows and reducing onward transport inefficiency. A technical engineer at Camfil explains that this makes the model particularly compatible with steady, predictable drop-off patterns. The model's main constraints are geographic and volumetric. It requires sufficient, consistent throughput to justify investment, and service technicians choose

disposal points based on convenience and distance. Additionally, operational security must be ensured – both for humans and machines. Clear directives were given by internal actors. If external parties such as the service technicians operate the machines, human health cannot be compromised upon. Allowing untrained external actors to operate a machine that potentially could be dangerous raises serious liability concerns and will not be accepted by customers.

The technical engineer also states that the machinery requires some type of insurance or failsafe to for its health. Camfil has different types of filters, and both plastic and metal frames are used. Competitors' products also end up in Camfil's waste compaction containers. The safety of the machine and purity of HIPS plastic must thus also be considered. As the technical engineer explains, this can presumably be done the easiest through a type of QR-code that only allows the correct type of frame through or be managed in-house. The volume probably requires dedicated personnel to handle these duties – introducing additional labor and training costs. Storage will presumably be required in this case. If customers leave the filters and their boxes intact this will quickly turn into a volumetric disaster. During the field visit to the sales office this was visualized. The waste compaction container was full from the day before. This meant that all customers had to leave their old filters next to the container, quickly building up to a substantial amount. All the filters in the image below in Figure 5 come from a single customer. If customer handling of the filters is out of the question, storage concerns will need to be addressed.



Figure 5: Image of used air filters that did not fit in the waste compaction container. All filters pictured arrived from a singular customer. (Photograph taken by the authors).

5.4.3 Outsourcing

A third choice of waste handling is to outsource the activity. Discussions were held with two different recycling companies regarding their knowledge and abilities to handle these mechanically bonded products. Both expressed skepticism towards the feasibility for them to handle this operation. Neither one had ever done this type of recycling, where the different materials still were bonded. They lacked availability of the necessary equipment that could break down the filters into smaller, more pure fractions. This equipment was used for more high-value materials, and the scale of the operation did not make commercial sense. The larger of the recycling companies, one of the largest in Sweden, explained how they operate at a scale where several thousand tons of plastic waste gets sorted and

processes annually and not hundreds of tons as will be required in Camfil's case. Their recovered plastic is later sold on a separate open market, ultimately not allowing Camfil to operate in a closed-loop supply chain – which has been an internal target. Since they operate at such a comparatively massive scale, the recycling company lacks the ability to keep the HIPS frame separated from other types of plastics. This complicates the future sorting – leading to decreased plastic purity and consequently resulting in a lower wholesale price.

Neither actor believed that the technical aspect of recycling the HIPS plastic from the filters would be a major issue, rather that it is the cost-effectiveness of the separation that is the limiting factor. Setting up a production line for just these filters is out of the question as it would be extremely expensive and the smaller company did not even have the required machinery. Regardless, they believed that a substantial amount of manual labor would be needed. Here they saw an opportunity to collaborate with a staffing agency that focuses on monotone, repetitive, and simple tasks. As long as the working environment is kept clean enough, this could prove to be an economically viable option. This structural and technical uncertainty was seen in their price estimates. Both organizations struggled as it was highly dependent on the complexity of the solution, but agreed it would be at least a few million SEK. When asked why they were apprehensive and skeptical of the recycling feasibility, the marketing manager explicitly stated that *"If it is not separated, it won't be recycled"*. In this case, the separating cost is seen as to large for material recycling to be a viable option, leaving incineration as more desirable.

A product manager at Camfil's American subsidiary shared their experiences with outsourcing the material recycling of comfort air filters. They partnered with an external actor to recycle the frames and incinerate the filter media in order to eliminate landfill as the disposal method. Without mentioning the specifics, the cost of handling of these American filters is far greater than that of the inhouse solution being developed in Sweden. This partnership is relatively new and has higher operational costs than should be expected in the long run. The American product manager explained how the situation in the US is completely different to that of Sweden's. Here, the only real alternative is to outsource the separation. This mainly comes from the fact that the distances between customers and production sites are huge.

5.4.4 Cost Uncertainty and Automation

The cost of processing machinery is both uncertain and highly dependent on degree of automation. One engineer emphasized the need for a machine that "*just swallows and grinds everything*", since manual handling of bulky filter bags is undesired. Achieving an autonomous operating system with little human input dramatically increases engineering complexity and capital expenditure as vision systems or robotic feeders may be required to handle all frame dimensions. Consequently, the economic assessment cannot be meaningfully separated from the technical solution and degree of automation.

Another contention regarding automation is how the filters arrive and are handled. As pictured in Figure 5, filters primarily return to the sales offices in Camfil boxes. When service technicians install new air filters, they place the old ones in the packaging that the new ones arrived in. This is a practical solution as these old filters are dusty and should be enclosed during transportation. The question then arises during waste handling whether the separation and sorting machines should treat the entire boxes that the filters arrive in or if manual extraction of filters is required. The results culminate in different demands on automation and ultimately the costs. Further complexity occurs when returned Camfil boxes do not contain Camfil filters. One salesperson explained that if the customer switched supplier, they still use the packaging that the new filters arrived in. This might complicate automation efforts as filters that seem to be one type are in fact a completely different kind. This could compromise the integrity of the machinery or the purity of HIPS and should be avoided.

Taken together, the costs of procuring the machinery and setting up a disassembly line is challenging to estimate. Either the process will require many people to manually separate and sort the material – making operational expenses high, or the high degree of automation will result in major purchasing prices. Waste treatment is not a core competency, and several internal respondents express a hesitancy if this will be accepted from upper management.

5.5 Roles, Responsibility and Ownership

The interviews reveal a recurring uncertainty regarding the handling of used air filters after deinstallation. Responsibility passes between customers, Camfil, and waste management companies, creating practical challenges and legal questions regarding transport, storage, and the handover phases between actors.

Internally, the organization believed that starting to provide a service of a producer-led take-back system could disrupt existing roles and business models, since service companies and waste contractors currently handle a substantial portion of the waste flow as part of their commercial offering. The view was that, for many service companies, managing their customers' used filters constitutes an integral part of the service they provide. Since Camfil supplies these companies with filters, a system in which Camfil also retrieves and manages the waste was perceived as a risk of removing an important service component from them, effectively stealing a part of their business. They did not wish to encroach on their customers' businesses and cannibalize part of their service offering. Through conversations with service technicians and other customers, however, a clearer picture emerged. The EoL handling is not something the service companies want to own, but rather something they want Camfil to help them with in delivering toward their own customers. The only cannibalizing service activity expressed was the actual installation and replacement of the filter itself, something Camfil has little interest in providing. The site walkthrough with a service technician made this particularly explicit. Filter handling is not the sole activity of a facility-management company, and removing parts of it is perceived as a simplification rather than an encroachment. Drawing the boundary at the waste handling instead of at the service itself therefore keeps the supplier's role distinct from the service companies' role and relieves them of a task they do not value.

In conversation with a large industrial recycler – that was repeatedly suggested throughout multiple interviews as the natural actor to solve this kind of problem – the picture emerged that they are unlikely to take on this role. The volumes involved are too small for a large recycler's operating model, and developing a dedicated, company-specific solution is not something they would pursue without being paid substantially for it. This sentiment was reinforced by the interview with the other recycling company. Additionally, for them to agree to be responsible for the recycling step, ownership of the material would go to the recycler and with it, the direct economic material value. The responsibility for recycling the filters therefore appear to fall on the supplier itself, not by choice but because no external actor is both willing and economically positioned to carry it. This is reinforced by the American product manager. As stated in subsection 5.4.3, they have outsourced the recycling of their filters. In their contract's current configuration, Camfil USA have lost ownership of the extractable value. This partnership is purely compliance-based, where it exists to answer for data center's zero-waste policies and be a devise to win these procurement negotiations over other competitors.

The buyer can also play an active role in deciding how EoL should be managed. One FM firm describes how they can prescribe how EoL handling should be done directly in its service agreements with the contractors and technicians it works with. The FM firm sets the routine, the contractor follows it, and the filters are directed back to the supplier by contract rather than by voluntary coordination. This gives the FM firm a real influence over how the EoL flow is shaped, alongside the supplier's ability to design the take-back offering. The responsibility for recycling may land with the supplier, but the route the material takes there depends just as much on what the FM firm requires as on what the supplier can offer.

Regarding responsibility, consideration should be made towards regulatory demands. Many different kinds of permits are required when waste is involved. According to both the large recycler and a legal advisor at a supervisory authority this process can become expensive. The cost comes from an increased complexity when more actors get involved and has a compounding effect. It gets particularly complicated when cross-national transportation is introduced or if the waste is considered hazardous. Both these actors spoke in general about required permits since it is dependent on several factors. What is important is that legally, companies may claim the role of ownership but it requires permits can become complex.

5.6 Positioning, Competition and First to Market

The empirical material indicates that circularity is not interpreted primarily as an environmental initiative, but as a strategic instrument for defending and extending Camfil's market position in an industry where the scope for purely technical differentiation is gradually narrowing. Several respondents, both internal and external, framed a functioning circular filter system as a vehicle through which a supplier can differentiate itself, engage with a broadening sustainability conversation, and protect existing sources of revenue that are exposed to competitive and communicative pressures. The following subsections examine how this plays out and especially telling statements with implications regarding positioning, competition and first to market are presented in Table 5.

5.6.1 Circularity as a Differentiator

A recurring interpretation across the sales organization is that the HVAC filter market is moving toward increasing commodification, even though technical performance, total cost of ownership and particle-efficiency classifications remain important differentiators. Respondents describe circular services as an emerging complement to these established competitive dimensions and as one of the mechanisms through which a distinctive position can be strengthened as the technical differentiation opportunities decreases. Camfil's market director states that where two suppliers can credibly offer comparable filtration performance and life-cycle cost, the services surrounding the product become an increasingly decisive competitive factor. This is particularly true for those services that relieve the customer of operational burdens and negative environmental impacts. Several other internal respondents also express this broader industry shift, where the services surrounding the filter carry increasingly more weight in the customer's evaluation. A take-back and recycling offering can be expected to function as both a practical and a symbolic marker of environmental leadership alongside the technical arguments that Camfil has traditionally led with.

This is reinforced by claims surrounding how competitors are already actively communicating sustainability narratives as a differentiation strategy. Both a respondent working with key accounts and central agreements as well as the marketing director describe how at least one competitor is pursuing the position of "*the most environmentally friendly alternative*" in the market through consistent communication on social media and through a visible collection service carried out with its own vehicles. Whether the competitor's overall environmental performance supports that claim is a separate question, and one that the interview material does not resolve. According to internal respondents, the effect of this positioning is not only lost share in individual procurements but a gradual redefinition of what the market expects a credible filter supplier to offer. The salience of this threat is amplified by the fact that customers themselves echo the narrative. A customer survey respondent referenced the same competitor's collection service approvingly, without prompting, indicating that the communicative work done by competitors is being internalized on the demand side. Procurement organizations confirm this trajectory. A sustainability coordinator at a public procurement organization describes a strong and increasing focus among member organizations on circularity and climate impact, combined with growing frustration that air filters are still routinely sent to incineration, and emphasizes that suppliers offering innovation linked to circular flows are perceived as more future-oriented and therefore more attractive in framework-agreement contexts.

Against this, the ability to offer collection and material recycling is treated by respondents less as an add-on service and more as a concrete competitive tool in procurement, particularly within municipalities and regions where sustainability requirements are intensifying. One sales representative with insight into larger procurement processes argues that taking care of customers' used filters can be developed into a genuine competitive advantage. The person continues by stating that this advantage exists even if the general, standalone business case for the take-back system fails. He evaluated the offering as an integrated component of the broader commercial package, where its value is realized through won or kept contracts rather than through the direct economics of the closed loop.

5.6.2 Increased Sustainability Arguments

A second rationale runs through the material and is articulated most clearly by the marketing function. The marketing director describes how customers and competitors are increasingly discussing filter materials and the waste generated by used filters, and how the environmental burden associated with spent filters has become a more visible part of the sustainability conversation in the industry. A central observation is that Camfil has for years directed customer attention toward the use phase rather than the material composition of the product. This emphasis reflects a deliberate and well-founded strategic choice, anchored in the observation that energy consumption during operation represents by a large margin the dominant contribution to the product's total CO_2 footprint. From an LCA point of view this prioritization remains fully defensible, and none of the respondents question this underlying logic. What the empirical material does suggest, however, is that the communicative landscape has broadened. Parts of the conversation have migrated toward the material and EoL dimensions of the product, and engaging with that dimension is increasingly expected of a credible supplier. A closed material loop is in this reading not a retreat from the use-phase argument but a complement to it, allowing Camfil to remain present in a conversation that now spans more phases of the product's life cycle than its historical communication has addressed.

Competitors are described as challenging Camfil's material choices in their own communication, arguing that their own frames are environmentally superior on the grounds that they can be recycled, and, in some instances, that they are in fact recycled. Camfil's marketing director frames a closed loop as the most direct response available. By collecting and materially recycling its plastic frames, Camfil converts the plastic frame from a rhetorical liability into a demonstrable circular asset. This re-establishes the conditions under which Camfil can credibly occupy the role it has long cultivated as what respondents, namely the Swedish marketing director and the education & experience manager, internally refer to as "*the big green dragon*". This dragon metaphor recurs across several interviews and captures a strategic image the organization is unwilling to cede – that of the consistent, visible, and largely unchallenged default choice for customers who wish to act sustainably. Retaining that image is described as dependent on consistent communication backed by tangible activity, and a take-back service is interpreted as precisely the kind of concrete activity that stabilizes the narrative against competition.

5.6.3 First-Mover Advantage

The value attributed to being first on the market to recycle filters can be framed as crucial rather than optional. Internal respondents interpret early market entry as a form of long-term brand protection, with the ambition of occupying the role of the clearly leading green actor. Many in the sales organization do not see the primary value with being first to market with the increased marginal sales volumes it generates in the short term, but that the position once taken, is expected to be difficult to displace. Customers tend to associate sustainability with whichever actor first succeeds in operationalizing a circular offering at scale. This logic is paired with a desire, voiced by several internal respondents, to demonstrate that Camfil genuinely cares and acts innovatively, rather than merely being compliance-based and following regulation once it becomes binding. An early move is thus interpreted both as a commercial maneuver and as a signaling act that reinforces the company's claim to environmental leadership.

Coupled to the first-mover argument is a clear articulation of customer lock-in as a structural benefit of a combined collection and recycling service. Respondents describe how a take-back offering, once integrated with the customer's operational routines, increases switching costs and creates a form of integration that competitors would find difficult to replicate on short notice. The logic is both operational and relational. Operationally, customers have reorganized their service and waste routines around the supplier's logistics, and relationally, a shared circular flow generates a form of data exchange and procedural interdependence that is not easily reproduced by a transactional competitor. This is directly reflected in the observation from one sales respondent that it becomes materially easier to sell new filters when the supplier also collects the old ones. The closed loop strengthens the customer relationship, which in turn makes the customer more inclined to keep buying new filters from the same supplier.

Respondents consistently argue that a closed loop does not need to stand on its own as an economically self-sustaining business, provided that its costs remain within reasonable bounds. Internal respondents, both from sales and the product & sustainability coordinator expressed that value is being captured winning procurements where circularity has become a qualifying criterion. The value also comes from increased sales with existing customers even where circularity is less of a decrementing criterion. These customers are kept because the take-back system provides a service that relieves them of an operational pain point.

Differentiating from competitors in an increasingly commoditized market and sustaining the communicative image as the default environmental choice is expressed as the biggest value Camil gains directly. The take-back system functions as a strategic investment whose returns are realized primarily through the protection and expansion of the forward-sales business, and through the preservation of market position rather than through the direct profitability of the closed loop itself.

5.6.4 Internal Mobilization

Beyond the external market logic, interviews also highlight an internal dimension concerning how a credible circular offering is expected to affect Camfil's own organization. Two respondents within the sales function describe a new, innovative service of this kind as something capable of "*igniting the team*", mobilizing the sales organization around a concrete offering that carries both commercial and communicative weight. The same respondents articulate the opposite possibility with equal force. The prospect of a competitor arriving at a functioning solution first is described in terms such as "*embarrassing*", language that signals how closely the organization's self-image is tied to the green dragon narrative and how much of its internal coherence depends on that narrative remaining credible. A circular offering is thus interpreted not only as an external market instrument but as an internal alignment device, one that reconnects the organization's day-to-day sales activity with the environmental identity it has cultivated over time.

Table 5: Selection of descriptive statements made by respondents and what these quotes imply.

Theme	Respondent	Quote	Implication
Competition	Marketing Director – Sweden	[Competitor] markets itself as "most environmentally friendly"	Circularity is already a communicative battlefield, regardless of actual performance.
	Marketing Director Sweden	"If you have something concrete, it sticks."	A concrete circular solution strengthens the brand more than abstract sustainability communication.
	Municipally owned property companies in Survey 2.	"There are already other filter manufacturers offering collection and recycling of old filters." "Yes, possible framework agreements for comfort air filters can be affected as requirements for recycling must be included in these."	Customers are noticing competitor's sustainability communication and changes in procurement processes are coming.

	Sales – Education & Experience Manager	"I think it's a super important service and we talk every day about how the market is becoming more and more alike. Competitors are starting to catch up with us on certain things. We need to differentiate ourselves. This is typical of such a thing, I think."	Commoditization in the market and how competition is increasing.
	Key Account Manager – Original Equipment Manufacturer	"That we take care of customers' used filters… that is absolutely a competitive advantage."	Increased integrating with customers operations is valuable.
First mover	Several sales respondents	Someone else succeeding first is described as "devastating"	The value lies in position-locking, not in short-term profitability.
	Sales – Education & Experience Manager	"The one who comes first in the industry will have one hell of an advantage." "Above all, the marketing aspect of being able to say we are first with this. We take care of this [material recycling]. I think it's super great for us – we are the big green dragon. We must be the first ones with this. It would be embarrassing otherwise."	The value lies in strategic positioning, not initial profitability. A competitor beating the case company to material recycling would be devastating and it underscores how critical the first-mover position is perceived internally.
	Marketing Director Sweden	"It would be embarrassing if there are companies that overtake us."	First-mover position is perceived as strategically critical, not optional. Reinforced that it comes from several different internal respondents.
Customer lock-in	Sales – Project & Service	"It becomes easier to sell new filters when we collect the old ones"	The closed loop strengthens forward sales. Circularity is a strategic investment.
	Sustainability Coordinator – Public Purchasing	"Once a concrete circular offering exists, expectations shift quickly"	Circularity functions as a qualifying requirement, not a premium feature. First in the market sets the new standard.

6. Analysis and Discussion

This chapter consists of an analysis of the empirical results and a discussion that ties the gathered results in with the theoretical framework. It has been divided into three sections, where each section is centered around a research question.

6.1 Barriers for Circular Economy Implementation

The first research question seeks to identify the barriers that currently sustain incineration as the default EoL pathway for bonded, short-lifecycle products. The findings from this study confirm several of the well-documented barriers in CE literature while simultaneously challenging others, suggesting that the landscape in which firms operate is evolving in ways that warrant a more nuanced reading of the existing theoretical framework.

6.1.1 Technological barriers

Conventional design practices constitute barriers, where firms have historically deprioritized designing for reuse, remanufacturing, and recyclability in favor of practices with faster financial return (Masi et al., 2018). In parallel, current design practices still tend to address environmental problems incrementally rather than at the source (Wautelet, 2018), however insights from costumer interviews in this study suggest that customer demands are now beginning to catch up with these limitations, pushing firms toward more substantive change rather than the small, incremental environmental improvements that have historically dominated. Design choices at early development stages carry long-lasting consequences for circularity potential and constitute a significant barrier for CE implementation, as upwards to 70 percent of a products environmental impact is decided in the design phase (Grafström & Aasma, 2021; Kong et al., 2022). For the case company, these early design decisions have functioned as both a barrier and an enabler. The product has been designed to have an efficient use-phase and not damage HVAC systems. The senior technical engineer explained that this unintentionally has led to the difficulty in separating the different materials for material recycling. As for the enabling design, the earlier strategic choice to use recycled and recyclable plastics increases current CE implementations feasibility. This means the material substrate required for circularity is already in place. In this sense, Grafström and Aasma's (2021) observation about long-lasting consequences holds, but the direction of those consequences is determined by the strategic foresight embedded in earlier design decisions. The previous decision around the material choice of HIPS plastic gives the product good properties for recycling (zu Castell-Rüdenhausen, 2025). This has created a pathway forward rather than locking the company into a linear trajectory.

While the material substrate may be in place, the infrastructure required to act on it is not. The lack of adequate infrastructure for waste management is consistently highlighted in the CE literature. Grafström and Aasma (2021) argue that recyclables are often not separately collected, which complicates downstream sorting, while Milios et al. (2018) demonstrate that the capability to handle bundled collected waste in the Nordic countries is insufficient. During the interview with the marketing manager for plastic recycling, as well as with the waste management consultant and operations manager, described in 5.5, similar infrastructural gaps were confirmed. The infrastructural shortfall is particularly pronounced for bonded, short-lifecycle products. The interviews described how the existing waste management system is not equipped to process such streams, where multiple materials are joined in a single unit and cannot be recovered without dedicated separation. The lack of infrastructure to handle these products was further explained by the fact that it is not economically attractive to build the recycling capacity required to effectively process them. The infrastructure that does exist is geared toward higher-volume, single-material streams, leaving bonded short-lifecycle products without a viable material recycling pathway.

6.1.2 Institutional barriers

The underdevelopment of recycling infrastructure described above is not incidental but a product of the institutional environment in which it has evolved. At the institutional level, the findings reinforce the argument that path-dependent regulatory frameworks designed for linear economic models have yet to

adapt to circular principles (de Jesus & Mendonça, 2018). The broader policy environment reinforces political institutions and a short-term focus on waste management rather than waste prevention have anchored governance in linearity (EEA, 2024).

Sweden's longstanding reliance on incineration as a primary disposal route is grounded in its national energy policy, where both electricity and district heating is generated from a waste flow of material (Energimyndigheten, 2025). This premise stems from a dated idea that the energy is recovered from something that otherwise has no use or value. Over several decades, Sweden has built one of the world's most extensive waste-to-energy systems, in which municipal solid waste serves as a primary fuel input for district heating networks. By 2022, waste incineration generated heat that supplied approximately 25 percent of all district heating in Sweden (Nordic Council of Ministers, 2024). This deep integration between waste incineration and energy infrastructure has created a lock-in that extends well beyond physical assets, where the financial logic of the system itself reinforces continued reliance on incineration. Actors operating within the incineration network benefit from a dual revenue stream where they receive gate fees for accepting waste while simultaneously generating revenue from the heat and electricity produced (Panepinto & Zanetti, 2018). This should arguably lead to added friction between waste handlers and manufacturing companies that wish to increase material recycling, as waste handlers continue to be incentivized to incinerate. The infrastructure described in 6.1.1 is thus the downstream consequence of an institutional environment that has long treated waste as a fuel rather than a material.

Interviews with customers in the study suggest that environmental impact is gradually being expanded into corporate decision-making. At the same time the scope of environmental assessments is evolving for EoL handling to reach solutions higher up in the waste hierarchy. This evolving scope means a corresponding expansion of infrastructure is required to respond to the demand. This barrier is ultimately economic in nature, but heavily influenced by institutional factors and regulatory decisions. The case study indicates that setting up separation and recycling lines capable of handling company-specific product streams is prohibitively expensive relative to the volumes processed. Separation and material recycling of such streams are too costly at those volumes for the function to be commercially viable under current market conditions. This requires changes in waste policy, a change that promotes material recycling over energy extraction. Alternatively, removal of the favorable policy framework that currently promotes incineration could be chosen to decrease the institutional barriers for material recycling.

6.1.3 Market barriers

The empirical findings of this study regarding market barriers are limited, which constrains the scope of the discussion around this topic. The empirical findings in this study, however, identified a similar barrier as previous research and revolves around the fair allocation in pricing environmental impact. Negative externalities are not internalized into the price, making recycled alternatives appear less economically attractive (Kirchherr et al., 2018). Environmental impact is often paid for on a societal level, even when it is known what company is responsible for the emission. This study expands on Kirchherr et al. (2018), by arguing that the same logic regarding virgin and recycled materials also applies to EoL handling externalities. As long as the negative externalities of incinerating recyclable material remain unpriced for the producer, the underlying structural problem will remain. In line with Kirchherr et al. (2018), this points to a market failure that is unlikely to self-correct, and regulatory intervention, such as introducing extended producer responsibility, therefore seems necessary. The true environmental cost is not reflected in the purchasing price and must be compensated for through deliberate and informed consumer or procurement decisions. The customer interviews with the sustainability coordinator and the sustainability officer indicate a shift on the market, where these negative externalities are beginning to get priced into their purchases. As seen in subsection 5.3.1, the sustainability evaluation in procurement now starts to include EoL handling and waste reduction as criteria. This shift towards sustainable purchasing can provide a competitive advantage for suppliers who invest in EoL handling and work on internalizing their negative externalities.

6.1.4 Social barriers

Social and cultural barriers can often be identified as primary blockers of CE implementation. Kirchherr et al. (2018) argue that the lack of consumer interest and hesitant company culture constitute the most pressing barriers for CE. Grafström and Aasma (2021) similarly cluster social barriers to CE adoption around three dimensions: resistant organizational culture, low consumer awareness, and weak supply-chain cooperation.

The findings of this study suggest that these barriers are not as pressing as the literature implies, at least for Camfil. Sustainability is embedded in the organization as a core value and is viewed as an integral part of the business rather than an afterthought. Customer interest in circular solutions is notably strong, suggesting that demand-side barriers often cited in the literature may be weakening in this segment. Additionally, there is also substantial co-creation with the upstream supplier of plastic frames. This co-creation provides the prerequisites consistent with Kanda et al. (2021), who argue that the implementation of CE requires firms to create value within an ecosystem of new and existing partners, a dynamic clearly present in the case. The fact that the major behavioral and social barriers emphasized in the literature do not manifest in the case company may represent either an exception or, more interestingly, an indication that the market is evolving. Older theoretical formulations that position these barriers as decisive may no longer capture the dynamics of firms operating in maturing CE contexts in the same way.

A similar observation applies to consumer awareness. According to Rizos et al. (2015) and Wycherley (1999), many customers lack environmental awareness of their purchases, which leaves sustainability as a low priority in their companies decision-making. This claim does not align with the empirical data collected in this study. The customers and end-users engaged with during the research demonstrate a clearly increasing awareness of circularity, and CE considerations are becoming more prominent rather than peripheral in their purchasing decisions. This suggests a notable shift relative to the time periods both Wycherley (1999) and Rizos et al. (2015) conducted their research, likely to reflect broader developments in sustainability communication, regulation, and procurement practices over the last decade.

Customers and service companies treat waste handling as the supplier's responsibility and organize their routines around Camfil's logistics to avoid directly handling dirty filters themselves. In the absence of regulation, transitioning to a take-back system will not occur until the market signals a willingness to pay or participate. No actor has the incentive or willingness to take ownership of EoL handling, so improving it falls on the supplier by default. For behavioral change to take hold, the circular alternative must be proportionate in effort, visibly valuable to the participating organization, and either mandated or compensated at the individual level. Voluntary motivation alone is insufficient. Even marginal increases in handling effort are enough to deter participation in separation, as seen in 5.1.2. The service technician's overriding objective is to minimize contact with dirty filters, and any added sorting task runs directly counter to that. The resistance is based in physical, economical, and temporal realities, which means interventions relying on voluntary behavioral change at the operational level are unlikely to succeed. This dynamic explains the popularity of Camfil's compactor containers. Although Camfil also route their material to incineration, technicians prefer them over municipal recycling centers precisely because they eliminate the need for fraction separation and solve a disposal problem. The very simplicity that makes the current system work against circularity is what makes it work for the technician, and any alternative must match or beat that level of convenience to displace it. Otherwise, the behavioral barrier remains too high, and the current EoL pathway will persist.

6.2 Commercially Viable Take-back Systems

The second research question aims to determine the considerations that should be make when designing a take-back system of bonded short-lifecycle products in order for it to be compelling for a market-leading manufacturer to develop. The empirical findings align with RL literature and the context this recycling system operates within enables and promotes the in-house handling of comfort air filters.

The issue producers of low-density products face in RL is how these products can go from point A to point B in the most resource-efficient way possible. Solving that question enables a cost-effective return system that economically could stand on its own. In Camfil's case it revolves around shipping only HIPS to southern Sweden. This would remove a large portion of the product's volume and increase the shipped material's value. As the filter media currently lacks the potential to be materially recycled and must be incinerated, it should be removed from the take-back system of plastic early in the process. Increasing the density of shipped material allows more value to be extracted and captured, which is necessary for making the business case of a take-bask system compelling.

6.2.1 Outsourcing

Before a make-or-buy decision can be made, an analysis must be conducted of what can be done with the product after its EoL and which actors are capable of performing those operations. Only once these two questions have been answered can a well-founded decision be taken. RL frames this decision primarily as a question of competence and control (Meade & Sarkis, 2002). Outsourcing the take-back system to a specialist recycler transfers operational complexity but it also transfers ownership, data, and economic value (Agrawal et al., 2015). Empirical data from 5.4.3 and 5.5 explore and suggest that outsourcing, is not the pathway that enables a commercially viable material recycling system in Sweden for this product. It primarily stems from an unwillingness or inability from external actors to manage these flows effectively, leading to a sub-optimal EoL handling of HIPS frames.

The conversations with the two Swedish recycling companies reveal this apprehension. The larger actor handles thousands of tons of plastic annually whereas Camfil only requires the processing of hundreds of tons. Setting up a dedicated processing line is not commercially attractive for them. They would require a major capital investment from the producer which ultimately would come from their customers. These recycling companies additionally operate as wholesalers on an aftermarket for plastics. Since there would not be a dedicated line for the HIPS frames it would be mixed with other plastics. This reduces purity and value, as well as eliminating any possibility for Camfil to operate in a closed-loop supply chain with its frame supplier, something that is actively being pursued.

Outsourcing also removes the communicative assets that a functioning take-back system can generate. Camfil's plastic frames are already produced from post-consumer HIPS. This is something that is great for their filters in an EPD context. Much positive environmental performance is gained from using post-consumer HIPS, but it hides the fact that this product in its current configuration has a linear flow. In the context of R-Strategies, this current operation – with post-consumer HIPS frames – could arguably fall within being a slowing strategy, where material stays in circulation for a longer time before ultimately getting incinerated (Bocken et al., 2016). Short-lifecycle products lead to much waste generation as products are frequently being replaced and EoL handling has a large potential to improve environmental performance. This indicates that a Closing strategy is more optimal for producers of bonded, short-lifecycle products as these strategies emphasize the EoL phase and the material recovery (Bocken et al., 2016).

The closed-loop supply chain that the case company could operate within can easily be communicated to customers. It is more difficult to build up and tell a cohesive story of recycling the plastic frame into some other product than it is telling the story that the same plastic is used to produce the same product. Questions customers may have about downcycling are eliminated as the end-product is identical. This becomes a communicative advantage towards competitors who may try to discredit plastic frames based on their environmental performance. Much of this discredit currently comes from the incineration of the HIPS. Instead of having to defend their choice, the closed loop of HIPS can become a selling argument. The effect is ultimately two-fold; it is easier to sell new products if you can communicate the closed-loop supply chain, and you can compare the plastic's environmental performance to that of competitors.

Insights can be gathered from the American subsidiary who have outsourced their EoL handling of filter frames to an external partner. This arrangement functions as a compliance tool rather than a commercial one. It stems from a reactive position of answering data center customers' zero-waste policies and Camfil gains little to none of the economic value the recovered material generates. Ownership of the

HIPS plastic passes to the recycler, and with it the value embedded in that material stream. The arrangement is also significantly more expensive per unit than the in-house model being developed in Sweden. This chosen pathway is not necessarily wrong. Despite losing out on the economic value of the material flow, environmental performance in EoL handling significantly improves and it also allows for the continuation of contracts with current customers. As these contracts are greater than the material value recovered from the HIPS plastic, an argument can be made that this is the right choice. It is often cheaper and faster to outsource development and handling to an expert that it is to develop it inhouse – as long as it is not a core competency or critical for the company (Meade & Sarkis, 2002; Agrawal et al., 2015). This should apply to all companies who lack the capabilities to operate in a closed-loop supply-chain, as the American subsidiary does not currently have the ability to cost-effectively remanufacture their products.

6.2.2 Internal Take-back System

The argument for designing an internal take-back system stems from more than simply stating that outsourcing might not be the best alternative. The results point to a configuration where the take-back system is not a standalone operation but rather an extension of existing local presence and network – utilizing the built-in customer through-put and the material flow that generates.

As seen in subsection 5.1.2, Camfil already operates sales offices in four Swedish and Norwegian locations with substantial customer throughput. The same service technician who collects a pallet of new filters in the morning often returns with the old ones in the afternoon to discard them in the container – an insight shared by both the Norwegian sales director and a sales representative working in Project & Service. This disposal logic is already ingrained within many customers as the natural way of filter handling. The added marginal cost of routing used filters through the same point for them is thus effectively zero, and the collection flow sustains itself without additional logistics. This aligns with the importance of consolidation in RL. Uhrenholt et al. (2022) explain that less product consolidation result in higher costs for the return of materials as the transport is less efficient. Both Fleischmann et al. (1997) and Kant-Hvass and Pedersen (2019) also show that fixed costs must be distributed across sufficient return volumes to reach break-even. A sales office acts as a natural consolidation node. It accumulates volume from many customers, converting a dispersed and low-density material flow into a concentrated one.

The processing step is what makes this viable beyond simple collection. Used air filters are bulky and largely consist of empty space. Transporting them as whole units over long distances places the full cost of low-density products on Camfil. If the plastic frame is separated from the filter media and compacted at the node, the material that travels onward is dense, clean, and high in value relative to its volume, resulting in more efficient transport. It makes little economic sense in transporting whole filters down to the plastic supplier, only to discard half of the material and most of the product's volume.

Additional benefits and reasons for internal control of the closed loop, exist in the supplier relationship. Both organizations see great value in extending their collaboration in this field. Market-leading manufacturers of bonded, short-lifecycle products such as Camfil gain, among others, economic value from increased sales and decreased supplier costs, and as earlier stated in this chapter, communicative advantages. They can also expect the pricing terms to reflect the value of the stable, high-quality material stream the internal control allows for. Supply chain disruptions, from the likes of Covid-19 and the recent blockade of the Strait of Hurmuz introduce uncertainty in the pricing and supply of materials. With an unstable geopolitical reality with fluctuating material prices, this becomes increasingly important to control. By being ones own supplier, a manufacturing company can increase their supply security. In return, the supplier also receives increased supply security of material but they also gain communicative advantages in their other customer relationships. By showing to other customers that they are willing to engage in closed loop supply chains and further integrate operations to decrease the negative environmental impact that their business generates, the supplier can greatly increase their reputation and image. In this case, this mutually beneficial arrangement is only possible when Camfil controls the material from the point of collection. Outsourcing the separation step dissolves the potential closed loop arrangement and eliminates what could be a relational and communicative asset.

6.2.3 Volume and Density Constraints

The node model described is not universally viable. First and foremost, a company must have localized activities on a market for it to be attractive. In this case study, the company has an established network of locations where customers already visit, and this then requires a near-zero added marginal cost for both parties. If a company lacks this infrastructure, the business case becomes less compelling to pursue. This also applies to the case company as they have a varying degree of local presence throughout Sweden. The results from this study, primarily presented in section 5.2, make it clear that geography and density of products are decisive factors, and the system only works well where both are favorable. This is partially the reason the case company do not have any sales offices outside of the three largest Swedish cities. The sales representative for Northern Sweden explained that they used to have a sales office in northern Sweden but decided to close it down as it lacked sufficient throughput to justify its existence. They also had a waste compacting container, however this was barely used and subsequently also closed.

Zhang et al. (2013) found that expanding a RL network increases profit up to a point, beyond which excessive collection infrastructure becomes uneconomical. That non-linear relationship is visible in this case. The question is not whether more nodes are always better, but whether each node commands sufficient and consistent throughput to justify the investment in machinery, personnel, and storage. A stationary separation node requires a predictable and sufficient minimum volume to function economically. Where that volume is absent, the fixed costs dominate and the investment is difficult to justify.

The density constraint manifests most clearly in northern Sweden. The sales representative responsible for that region explicitly identified the vast distances between customers as a structural obstacle, as seen in section 5.2. The added marginal cost of transporting used filters to another city for recycling is likely too great for most customers. Its environmental motivation might also be mitigated or even cancelled out by the long, low-density transport. There is already often enough operational friction to transport used products to the other side of a city, as noted in the service technician survey in subsection 5.1.2. If this framing applies within a city, it applies with even greater force across the geography of Norrland.

The implication is that the system will not function equally across all geographies from the outset. When rolling out separation machinery, the focus should be placed on the locations with the greatest current collection rate and the greatest potential. Applied to the case, Camfil has the greatest collection rate in Oslo, Norway and Stockholm, Sweden is the largest Nordic city. Prioritization should be given to these markets and before committing machinery and personnel to additional locations these should be evaluated. Evaluation criteria can include processing rates and operational economics. Starting where the collection is easiest comes from applying the BECE framework's recommendation to stage circular transitions across time horizons, moving from low-risk interventions within existing systems toward more ambitious network extensions as capabilities and volumes mature (Mendoza et al., 2017).

6.2.4 Additional Service Offerings

The node model is a logistics infrastructure. Once it exists, it supports services that would not be viable without it. Two categories of additional services are directly indicated by the results.

The first is a structured pick-up service for customers who either cannot or will not bring filters to the sales office themselves. The Norwegian subsidiary already operates this. Customers book a time and date and Camfil collects the filters with its own electric vehicle. The return volumes at the Oslo office are more than double those at the Stockholm office, with the pick-up service being a contributing factor. Customers pay for this service, effectively converting the container handling from a cost into a revenue stream for Camfil. The service also deepens the customer relationship in a way that the passive drop-off model does not. Technicians no longer need to plan a trip to the sales office, and the problem of filter disposal is solved by a scheduled, reliable collection. Importantly, despite this service requiring new logistical capabilities in route-planning and transportational optimization, it does not require any additional stationary infrastructure, only vehicles, as the collected filters are routed directly to the nearest node for processing. The pick-up service is therefore an extension of the node model, not a

parallel system. The usefulness of a pick-up service is not limited to Camfil. Other manufacturing companies that wish to extend their collection area gain the same benefits. This is a simple service to add to an organization and BECE principles can be applied here. As capabilities improve, complexity can be added (Mendoza et al., 2017).

The second type of service addresses customers whose filter volumes are too large, and whose locations are too inconvenient for either drop-off or standard pick-up to be cost-effective. Data centers are a example of this type of customer. A large data center operates continuously and runs a high density of comfort air filters. Several data center operators have strict no-waste policies and apply increasing pressure on their suppliers to handle this. The volume at a single site can be large enough to justify sending a mobile processing unit directly to the customer. The mobile mill model, as described in subsection 5.4.1, places shredding or compaction machinery on a vehicle that travels to the customer, processes the material on site, and departs with a compact, high-density output. Examples of its effectiveness is a sales representative's description of a Finnish competitor. The volume reduction enabled by on-site compaction allowed for many times more filters being handled and collected per trip than if the filters were transported intact. For data centers, this approach removes the customers' challenges regarding handling, storing, and transporting such a large amount of dirty filters. The service aligns with what customers have expressed, namely a supplier who manages the waste generated, and they are willing to pay for it.

Large commercial buildings like shopping centers, hospitals and hotel complexes represent a second application for the mobile solution. These buildings combine high filter density with operational constraints that make drop-off impractical. Large volumes arrive simultaneously at scheduled maintenance intervals, the buildings are often located in dense urban areas without convenient routes to a sales office, and the FM companies operating them are under increasing pressure to document circular outcomes for tenants and property owners. Many of these customers already have their own containers on-site since enough waste is produced in the buildings to justify the cost of handling. It is less efficient – environmentally, economically and temporally – to transport hundreds of filters to another location, just for them to still end up being incinerated. The results show that customers increasingly value traceability and documentation over the entire product life cycle. If these companies can get a certificate that states the reduction in CO_2e, they will be eager participants – a sentiment shared by the interviewed Sustainability Officer at the FM company. Similarly, the Sustainability Coordinator at a public procurement organization describes how circularity is shifting from a peripheral nice-to-have to a concrete evaluation criterion in framework agreements. If the supplier can demonstrate a concrete, verifiable activity that decreases customer emissions, customers will partake.

The mobile model is not a true complement to the node model. They build on two fundamentally different principles but are not mutually exclusive. Whereas one utilizes existing infrastructure, the other brings the infrastructure to the customer. The mobile model captures a customer segment that the node model realistically cannot serve. Its economics depend on a sufficient filter volume per customer visit to justify the operational cost of dispatching a vehicle and processing crew. Below a certain volumetric threshold, the operational cost of the mobile service becomes exorbitantly expensive per kilogram of recovered material, compared to the node model, and the customer should be directed to the drop-off or pick-up option instead. The two models therefore serve different volume tiers and together extend the commercial reach of the take-back system across a wider range of customers. Despite these models not being mutually exclusive, an investment in one should not affect the development of the other.

Additionally, and irrespective of either a pick-up service or mobile milling solution, is the possibility of adding additional designated drop-off locations. Service technicians in both Sweden and Norway state that being on the appropriate side of the city is a determining factor in whether they return used filters at all. It could therefore be argued that offering more locations within a city would vastly improve collection rates. These might not have enough throughput to justify dedicated machinery but could provide additional collection. A drop-off location or storage system that gets serviced once full could prove to be valuable for both producers and customers. This can then either be handled as a pick-up

service, where the filters get transported to the node for separation, or with the mobile mill, and densified directly.

6.3 Competitive Advantages from Closing the Loop

The third research question asks what competitive advantages are created for a market-leading manufacturer by closing the material loop of bonded, short-lifecycle products. The empirical findings from 5.6 show that circularity functions less as an environmental initiative and more as a strategic instrument. The closed loop creates value through differentiation, customer relationships, and communicative positioning. The following discussion develops this through five arguments: how a take-back offering reshapes competitive dynamics in a commoditizing market, how value is created relationally across the supply chain, how a closed loop generates communicative assets, how market leadership creates structural advantages, and finally, the risk and cost of not acting.

6.3.1 Differentiator in Increased Commoditization

The starting point for the analysis is the description from the empirical material of a HVAC filter market which is increasingly commoditizing. Technical performance, particle-efficiency classifications, and total cost of ownership remain relevant criteria, but distances between competitors are decreasing. Several internal respondents express, see subsection 5.6.1, how services increasingly become more important as a differentiating factor as products become more similar. This aligns with Geissdoerfer et al. (2018), that when product-level differentiation narrows, the value proposition must shift toward services and relationships. This case adds to this by identifying the new value proposition aimed at service technicians. Rather than customer support or installation services, in this case they receive an EoL handling service. As noted in technician interviews in subsection 5.1.2, this has historically not been seen as a value-creating phase of the product lifecycle but rather a problem that needs to be solved.

This service-oriented reframing has a direct implication for how the take-back offering should be evaluated. The CBM literature tends to evaluate circular investments as isolated cost-benefit decisions, where the primary concern is whether the upfront capital expenditure can be justified by direct financial returns (Jaeger & Upadhyay, 2020; Sousa-Zomer et al., 2018). Several respondents in the empirical material explicitly challenge this framing. They argue that the take-back system does not need to be independently profitable, provided its costs remain within reasonable bounds, because its commercial returns are realized elsewhere. Commercial returns are rather found in won procurements, in retained contracts, and in the communicative position the organization defends in the market. That means that it is the forward-sales business that realizes the captured value, even though this value is created by another part of the organization. Tabares et al. (2023) warn against this error of evaluating a circular offering on the wrong financial dimension. For manufacturing companies, this would mean evaluating the commercial success of the take-back system exclusively on the material value of the economic generation of the collected material and not on the above stated reasons. This differentiating factor that primarily exists in relation to sustainability expresses itself financially very differently.

6.3.2 Relational and Institutional Value Creation

The value creation dynamics documented in subsections 5.3.1 and 5.3.2 are difficult to capture within a single firm. What the findings show instead is an ecosystem in which the circular offering produces different value for multiple actors in the supply chain. A property owner who can document circular filter handling becomes a more credible sustainability actor toward its tenants. A FM company who can point to verified EoL data becomes a stronger performer in sustainability reporting. Camfil, as the originator of the data and the service, becomes a more indispensable partner to both. This structure reflects the ecosystem collaboration logic described by Kanda et al. (2021) and Viglia et al. (2023). Circularity functions as a reporting and credentialing input that propagates downstream. Co-created value is contingent on each actor perceiving that sufficient benefit is to be gained from participation. This filter offering would succeed not because it offers a financial incentive to each actor but because it solves a communication and compliance problem that is becoming progressively more pressing for all involved.

The results in subsection 5.3.3 identify three conditions for a sustainability-linked price premium: (i) a measurable environmental benefit, (ii) a reasonable cost-to-benefit ratio, and (iii) an acceptable increase in operational friction. These conditions place willingness to pay at the organizational level. The sustainability function's ability to influence procurement determines whether a higher price is accepted. The finding that procurement and sustainability functions within the same buying organization evaluate an identical offering very differently reveals that value is internally contested, and that the outcome depends on who drives the purchasing decision. This matters because customers are already paying for waste disposal today. The future question is not whether they will pay, but whether a circular offering can be positioned as a better use of a cost they already accept.

The relationship with Camfil's plastic frame supplier illustrates the risk of imbalanced negotiating power that Benoliel and Salama (2010) describe in co-creation arrangements. As described in subsection 5.3.3, this risk is actively managed through a pricing arrangement treated as a fair exchange, where future adjustments depend on whether one party received favorable terms in previous negotiations. Camfil's Group Purchasing Director stated that this helps ensure neither party feels repeatedly disadvantaged. The arrangement works because both parties continuously extract sufficient value from the collaboration. The future value the supplier gains from a closed loop becomes material security, lower inbound cost, and advantages in other customer relationships. This is created together with Camfil rather than at its expense and reflects a broader condition for sustained co-creation. Each party must perceive the collaboration as worthwhile to remain genuinely engaged (Viglia et al., 2023). The same negotiation logic explained could guide how future pricing of collected filter materials can be structured, using mutual adjustment as a mechanism to manage conflicts before they undermine the collaboration.

6.3.3 Communicative Assets

The theoretical framework distinguishes between narrowing, slowing, and closing the loop. As noted in section 6.2, slowing is a less suitable R-Strategy for a bonded, short-lifecycle product like a comfort air filter than a closing the loop strategy. The empirical material adds a communicative dimension to this theoretical premise. Choosing a closing strategy is not only a technical and economic decision but also a competitive and narrative one.

Camfil's plastic frame is made from HIPS, a thermoplastic that retains comparable mechanical performance across recycling cycles provided contamination is controlled (Perrin et al., 2016). Despite the fact that their frames are already produced with post-consumer HIPS, discussions with Camfil's senior technical engineer and product & sustainability coordinator brought forth that the mechanical recycling of their own frames would require less energy than the production of virgin plastic, or even other post-consumer HIPS. Closing the loop would then result in improved environmental performance. This holds several different values, as examined in the rest of section 6.3, and one type is communicative. By returning the regranulated material to the same supplier for remanufacture of new HIPS frames, the material loop for frames is closed. The same material re-enters the same function at lower energy cost. Unlike open-market material sales, a closed-loop supply chain produces a narrative that is clear, simple and verifiable. The plastic frame becomes a new filter frame, and the destination and quality of the recovered material are unambiguous. This removes the risk of the arrangement being perceived as downcycling. As Forrest and Mack (2005) note, closed-loop polystyrene recycling requires a pure, separated stream, which is exactly what the internally controlled collection models are designed to produce.

Competitors are actively contesting Camfil's sustainability narrative by challenging the material choice of the plastic frame. The marketing director frames a closed loop as the most direct available response. By closing the loop on HIPS, Camfil converts a rhetorical liability into a demonstrable circular asset. The material choice is defended not through a counter-claim about the material's properties, but through the physical reality of the loop. The frame becomes not only recyclable but is recycled, and turned back into the same product. This is significant because it illustrates a mechanism through which a circular system generates communicative value that is not simply proportional to the environmental benefit. The benefit of mechanical HIPS recycling, while real, is not the primary commercial value being created. The primary value is rather the communicative position the loop enables as the "*green dragon*" claim

becomes verifiable rather than asserted. As seen in the interview with the sustainability officer at the FM company, see subsection 5.3.3, customers actively premier more environmentally friendly options in their decision-making, with a willingness to pay for it as well.

6.3.4 Structural Advantages

Structural advantages that a market-leading manufacturer can have are some of the most impactful reasons to establish a take-back system. Camfil holds the largest market share in the Swedish HVAC filter market, meaning it also has the largest potential collection volume. Capital investment in machinery is required for processing used products regardless of configuration, se section 5.4. The economic viability is directly coupled to its throughput volume. The payback time is directly influenced by how many filters pass through the system. A competitor attempting to replicate the same offering faces the identical fixed-cost investment in processing equipment but a materially smaller throughput base, which extends its payback horizon, compresses its operating margin, and makes internal investment approval correspondingly harder to achieve. This is not a temporary advantage that can be lessened by a competitor who matches the service offering. It is a scale-based barrier to entry that is structurally enforced by the fact that the largest installed base provides the greatest implementation potential. Tukker (2004) argues that risks in product-service transitions are not always negative as they can generate revenue opportunities if managed properly. The risk Camfil accepts by investing in recycling infrastructure is precisely the kind that becomes an advantage as the market develops. The firm absorbing that risk early and at scale makes the same investment prohibitively difficult to justify for later entrants.

The BECE framework's emphasis on building capabilities ahead of regulatory requirements is directly relevant here. The structural advantage described above is maximized if Camfil establishes the system before the regulatory environment requires it. Once take-back or recycling obligations become binding, the investment is no longer a strategic choice but a compliance cost. The empirical material describes this as a plausible trajectory in the medium term, given the direction of public procurement requirements. A firm that has already absorbed the investment, worked through the operational learning curve, and established the collection volumes to justify the infrastructure is then positioned to meet the regulatory threshold at a fraction of the marginal cost facing a late entrant. The first mover can communicate their position as market leading and also establishes a cost structure that competitors must reproduce from a lower-volume, higher-cost starting point. This proactive position might influence the development of suitable systems in general. It then allows firms to shape their own transition instead of having too adapt to a less optimal, externally imposed solution (Mendoza et al., 2017).

6.3.5 Cost of Inaction

The discussion so far has examined the value that a circular take-back offering creates. The final point concerns the risk of not creating it. The CBM literature tends to frame the investment decision as a cost-benefit calculation in which the main risks are the upfront capital expenditure and the uncertainty of customer adoption. These articles do not highlight the long-term risk of not acting or investing in new solutions. Unruh, (2000) argues, in contrast, that inaction itself carries substantial long-term risk. Incumbent industrial systems become locked in through path-dependent processes that inhibit the later adoption of more sustainable alternatives, even when these hold clear environmental and economic advantages (Unruh, 2000). For a market-leading manufacturer, the greatest value lies in maintaining its market position and failing to act puts this position at risk. Waiting too long can lead to lost relevance in a market that is moving toward circular solutions. The risk of inaction is therefore greater than the risk of early investment, as brand position and customer trust are difficult to rebuild once lost. Assuming the continuation of incinerating waste as the default EoL handling method itself is a risk, with potentially devastating consequences.

Several internal respondents in sales and market describe the risk of inaction in direct terms. Language such as "*embarrassing*" and "*devastating*" is used to describe the scenario of a competitor being first to develop a take-back system. This helps illustrate that the organization's self-image and the identity of being the "*green dragon*" is not only being used in marketing, but as a source of internal coherence. Should a competitor credibly occupy the circular leadership position first, the consequence is not limited

to lost procurements. It would redefine what the market expects from a responsible filter supplier, leaving the incumbent actor in a weakened position. In this case it would mean that Camfil would need to be reactive and get forced into a defensive position. This reactiveness would go against the upside of being proactive, as described in subsection 6.3.4 and by Heyes et al. (2018). The ability to influence and implement a take-back system that would work optimally for them would decrease.

Tukker (2004) argues that risk in circular transitions can present revenue opportunities when managed strategically. The risks related to action and inaction are not evenly balanced. The risk of investing in a take-back system with capital expenditure, operational complexity, uncertain margin of the closed loop, is constricted – it has an upper limit. The risk of not investing, or of investing too late, is potentially unbounded as it could include the loss of an identity that took decades to build and cannot be purchased back once ceded. This asymmetry is what several internal respondents are articulating when they use terms such as "*embarrassing*". A respondent in the survey to municipally owned property companies, see 5.6.1, referenced a competitor's collection service approvingly and unprompted, indicating that the competitor's communicational effort is already being internalized on the demand side. This is the mechanism through which communicative positions in sustainability become self-reinforcing. Early and visible action shifts the reference point against which all subsequent actors are evaluated. Given that a competitor is actively pursuing the sustainability leadership role, this risk of not acting has a compounding effect. Falling behind in the sustainability conversation makes it increasingly expensive and difficult to displace a competitor from that position.

When implementing CE, the BECE framework provides a useful lens for analysis. Future implications regarding Eco-design revolves around the long-term strategic vision of a product. Here, modular design that enables disassembly should be prioritized. Disassembly allows for reuse which is a much more resource-efficient alternative than recycling as it sits higher up in the waste hierarchy, see Figure 2. This would then not require any advanced machinery to separate the bonded material. It can thus seem unnecessary to invest substantial time and capital in finding mechanical solutions to this separation process if future handling ends up making it redundant. Building up a RL system might be unnecessary if future EoL handling eliminates recycling and instead reuses the material without additional processing. This could create a sort of structural contradiction where current technologies lock the system into material recycling but long-term customer goals point towards modular reuse. Adopting the pathway of material recycling may foreclose or delay the other. It could harm supplier relationships if they are less required in the future and many of the capabilities acquired and internally developed will not be of much use. This is in many ways a question of effectiveness and efficiency, between doing the right things and doing the things right. Is it worth it for companies to invest and build up these capabilities if it is only required in the short- or medium-term? The authors believe it primarily depends on how challenging it is to redesign the product and how urgent customer demands are. If it can be done relatively cheaply or easily, without affecting the functionality of the product negatively, a redesign should be prioritized. From the company case description it is presented that a redesign becomes to expensive. It would either be so expensive that this RL cost is negligible, or the development time would be so long that the investment would already have paid itself off. This eliminates the structural contradiction and means that it is a worthwhile investment to develop a functioning RL system.

Regarding backcasting in the BECE framework, firms should base their present-day investments on a perceived circular future. This helps avoid locking them into sub-optimal linear trajectories that become increasingly difficult and expensive to exit over time (Heyes et al., 2018; Mendoza et al., 2017). Applied to the present case, if the long-term future state is one in which filter take-back is either expected by the market or required by regulation, then the present-day question is not whether to invest but when, and on whose terms. A firm that invests early shapes the infrastructure, the supplier relationships, the customer routines, and potentially the regulatory parameters. A firm that invests late inherits all those constraints from actors who moved first.

7. Conclusion

What barriers for circular economy currently sustain incineration as the default end-of-life pathway for bonded, short-lifecycle products?

Incineration is sustained by several different barriers that all together make recycling a less attractive alternative. One of the largest barriers for circular economy are the early design choices made that influence where the product's future emissions will occur. Not all products are designed to be disassembled for material recycling. This fact is compounded by a Swedish waste management infrastructure that is not designed for handling bonded products. Current infrastructure focuses on high-volume, single-material streams. Even if a product *could* be recycled, inadequate material recycling infrastructure prevents it, sustaining incineration as the EoL pathway for bonded, short-lifecycle products. Additionally, the volumes of this case product are too small for dedicated recycling lines for recycling firms to perceive them as economically viable.

Swedish energy policy and waste management systems currently favor incineration over material recycling – especially for bonded, short-lifecycle products. Incineration is deeply integrated into energy production and district heating, with financial incentives maintaining this arrangement. Recycling companies receive gate fees for accepting waste, and revenue streams from selling the energy production – creating a system lock-in. In this case, corporate culture and customer purchasing awareness are not major barriers. Instead, the convenience and simplicity of incineration remain barriers. Operational frictions in handling used products persist as the largest social barriers – and is quite possibly the largest overall barrier for the adoption of alternative EoL pathways.

What considerations should be made when designing a take-back system of bonded short-lifecycle products to make it compelling for a market-leading manufacturer to develop?

A central consideration in deciding between building an internal take-back system or outsourcing it is answering the questions of what you can do with the recycled material and what you want to receive from the recycling activity. In this specific case, an internal take-back system should be developed. Camfil can exist in a closed-loop supply-chain, which ensures control over data and the material flow, the economic value of the recycled material, and the communicative advantages with the closed loop. It is easily communicated to customers and questions regarding potential downcycling are eliminated. Most of these advantages are lost when this activity is outsourced.

Nodes, where the material value is increased, should be used. The different components of the product are separated and only the useful materials get shipped for remanufacturing. If possible, a company should utilize existing infrastructure and local presence – such as sales offices – as nodes, as these trips carry a near-zero increased marginal cost for the customer and act as a natural consolidation point. However, this model does not work universally. Geography, product density and customer density are critical factors to consider. Implementation should start where conditions are most favorable and volumes the greatest. As RL capabilities increase, increases to the complexity of the system should be make. More locations can be added are additional, or complementary services, can be introduced. These could consist of pick-up services or mobile solutions that separate the materials at larger customer locations.

What competitive advantages are created for a market-leading manufacturer by closing the material loop of bonded, short-lifecycle products?

Closing the material loop for bonded, short-lifecycle products creates multiple, reinforcing competitive advantages for a market-leading manufacturer. As the market increasingly commoditizes, EoL management emerges as a new opportunity for differentiation. A take-back system, therefore, does not need to be profitable in isolation. The take-back system´s value is realized indirectly through increased forward sales, won tenders, and strengthened customer retention, not necessarily in the material value. By closing the material loop, other actors within the value chain benefit from the increased sustainability and wish to participate in collaboration. The case company stands to gain from others perceiving a value in this collaboration. It improves relationships, increases switching barriers for customers, and helps

secure material flows for their own production, all of which is beneficial for the manufacturer. The increased sustainability value also creates a willingness to pay from customers as long as it fulfills three conditions: (i) measurable environmental impact, (ii) reasonable cost-benefit ratio, and (iii) low added operational friction.

By enabling verifiable recycling through a closed loop, the manufacturer can neutralize criticism and strengthen its sustainability proposition. For a firm with a large market share, a closed loop creates a structural scale advantage that smaller competitors struggle to replicate. The large installed base provides the market-leading manufacturer with the greatest return potential, resulting in shorter payback times and giving the company a competitive advantage. First mover advantages also apply. It can help solidify a company's position as a leading actor for sustainability. By moving first and investing in closing the material loop, a company influences supplier relationships, customers routines, and potentially even regulatory frameworks. Early adoption and development of suitable systems ahead of future regulatory requirements allows firms to shape their own transition instead of having too adapt to externally imposed solutions that are less optimal.

For a market-leading manufacturer, the greatest value lies in maintaining its market position and failing to act puts this position at risk. Waiting too long can lead to lost relevance in a market that is moving toward circular solutions. The risk that arises from inaction is therefore greater than the risk from early investments, as brand position and customer trust are difficult to rebuild once lost.

7.1 Contributions

The main contributions of this thesis are societal and managerial. It highlights why incineration persists as the default EoL route. Waste-to-energy infrastructure is convenient, established, and available to all industries, which creates strong lock-in effects that hinder the development of circular alternatives. By showing how these lock-ins can be broken, the thesis demonstrates a way to move from linear to circular material flows for products that are often deemed to not have the ability to do so. Managerially, many organizations regard sustainability and recycling primarily as a cost. This thesis shows that material recovery can be economically sound, through the material value itself but above all through the added values it creates, with a direct positive financial effect on the company. Notably, the business case holds for a product not designed for recycling, meaning firms can pursue recovery without waiting for redesigned products.

7.2 Recommendations for the case company

- Implement the node model now to achieve more efficient transport and retain control over the material. Integrate the routine into customers' waste management so that active participation becomes easy.

- Start where conditions are most favorable and then scale gradually to increase collection. Add complexity as the system matures, either by adding more services at each existing node or by adding more nodes.

- Develop the collection process in parallel with a product redesign. The routines and customer behavior established now remain valuable even when recycling shifts to reuse.

8. Future Research

This thesis has examined aspects surrounding the technical and physical separation of the bonded comfort air filters. There is an inhouse solution for the separation of plastic frames, however it is still in development and requires much manual labor. For the context of an automated node-based solution, this is not optimal. Future research should thus examine how the separation process may be automated and made more efficient.

This thesis has focused on the plastic frame. As no methods currently exist for material recycling of the glass fiber media, the product as a whole cannot yet be fully recycled. With customer demands moving towards full recyclability, further research into improved EoL handling of the filter bags is needed.

Another aspects that future studies could dive deeper into is how pronounced the willingness to pay actually is from customers. This study managed to directly interview two customers, both of which were positive towards this initiative. These do not however represent the entire market accurately as many companies are cost-driven in their purchasing. It would be interesting to find the limit to how much of a price increase, if any, would be accepted.

This thesis identified several values that the market-leader would gain from introducing a take-back system. Quantifying these has not occurred and would be very interesting from a business case development point of view. By having these values quantified, companies could expedite the implementation of a take-back system by applying these values to their own system and the business case could be developed quicker.

Additional research could examine whether the economic value of a take-back system is exclusive to market-leading manufacturers or whether smaller actors can also benefit. There are several structural advantages that the incumbent actor has and investigating whether these are critical factors or not for the feasibility of running a profitable recycling system could be investigated.

Finally, in the long run, redesigning the product for material separation would enable a move up the waste hierarchy, from recycling to reuse. Such a redesign involves potential trade-offs between the use phase and the EoL phase. For air filters, where the use phase dominates the environmental footprint, even a small increase in pressure drop or leakage from a separable design could offset the gains from reuse. Examining whether and how these two phases correlate would therefore be a valuable direction for future research.

References

Abdallah, T., Diabat, A., & Simchi-Levi, D. (2012). Sustainable supply chain design: A closed-loop formulation and sensitivity analysis. *Production Planning & Control*, *23*(2–3), 120–133. https://doi.org/10.1080/09537287.2011.591622

Acampora, A., Cova, M., & Capolini, F. (2026). Over twenty years of Environmental Product Declarations (EPDs): From communication tools to sustainability decision-support systems. *The International Journal of Life Cycle Assessment*, *31*(13). Springer Nature Journals (edssjs.1F99992E). https://doi.org/10.1007/s11367-026-02612-5

Adams, W. C. (2015). Conducting Semi-Structured Interviews. In *Handbook of Practical Program Evaluation* (pp. 492–505). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119171386.ch19

Agrawal, S., Singh, R. K., & Murtaza, Q. (2015). A literature review and perspectives in reverse logistics. *Resources, Conservation and Recycling*, *97*, 76–92. https://doi.org/10.1016/j.resconrec.2015.02.009

Agrawal, V., Bhardwaj, S., Pathak, N., Dixit, J., Agarwal, S., & Momin, M. (2024). *Augmenting Research: The Role of Artificial Intelligence in Recognizing Topics and Ideas* (pp. 23–32). https://doi.org/10.4018/979-8-3693-1798-3.ch003

Agyemang, M., Kusi-Sarpong, S., Khan, S. A., Mani, V., Rehman, S. T., & Kusi-Sarpong, H. (2019). Drivers and barriers to circular economy implementation: An explorative study in Pakistan's automobile industry. *Management Decision*, *57*(4), 971–994. https://doi.org/10.1108/MD-11-2018-1178

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, *84*(3), 488–500. https://doi.org/10.2307/1879431

Åkesson, L. (2014). Towards Sustainable Waste Management. *TOWARDS SUSTAINABLE WASTE MANAGEMENT / IVL-Report C69*, *C69*. http://www.ivl.se/download/18.1acdfdc8146d949da6d659d/1419236358373/C69+TOSUWAMA+report+.pdf

Alvehus, J. (2023). *Skriva uppsats med kvalitativ metod: En handbok* (Vol. 3). Liber.

Ashby, M. F. (2021). End of first life: A problem or a resource? In *Materials and the Environment* (pp. 65–85). https://doi.org/https://doi.org/10.1016/B978-0-12-821521-0.00004-9

Badampudi, D., Wohlin, C., & Petersen, K. (2015). Experiences from using snowballing and database searches in systematic literature studies. *Proceedings of the 19th International Conference on Evaluation and Assessment in Software Engineering, EASE '15*, 1–10. https://doi.org/10.1145/2745802.2745818

Bakker, C., Wang, F., Huisman, J., & den Hollander, M. (2014). Products that go round: Exploring product life extension through design. *Journal of Cleaner Production*, *69*, 10–16. https://doi.org/10.1016/j.jclepro.2014.01.028

Baumann, H., & Tillman, A.-M. (2004). *The hitch hiker's guide to LCA : an orientation in life cycle assessment methodology and application / Henrikke Baumann & Anne-Marie Tillman.* Studentlitteratur. LiUB Library Catalogue (lub.oai.folio.org.liuaf.91315da1.20dc.44c8.a6c7.d7824588cd7f). https://research.ebsco.com/linkprocessor/plink?id=00234ff3-b472-3bfe-8fc2-faa297163472

Bell, E., Bryman, A., & Harley, B. (2019). *Business Research Methods* (5th ed.). Oxford University Press.

Benitez-Fuentes, P. (2016). *Coordination and return uncertainties in closed loop supply chains* (p. 195). https://doi.org/10.1109/ICCCC.2016.7496759

Benoliel, D., & Salama, B. (2010). Towards an Intellectual Property Bargaining Theory: The Post-WTO Era. *University of Pennsylvania Journal of International Law*, *32*(1), 265.

Bhattacharjee, S., & Cruz, J. (2015). Economic sustainability of closed loop supply chains: A holistic model for decision and policy analysis. *Decision Support Systems*, *77*, 67–86. https://doi.org/10.1016/j.dss.2015.05.011

Biglan, A. (2009). The Role of Advocacy Organizations in Reducing Negative Externalities. *Journal of Organizational Behavior Management*, *29*(3–4), 215–230. https://doi.org/10.1080/01608060903092086

Blomberg, J., & Söderholm, P. (2009). The economics of secondary aluminium supply: An econometric analysis based on European data. *Resources, Conservation and Recycling*, *53*(8), 455–463. https://doi.org/10.1016/j.resconrec.2009.03.001

Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, *65*, 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039

Borrego, M., Douglas, E., & Amelink, C. (2009). Quantitative, Qualitative, and Mixed Research Methods in Engineering Education. *Journal of Engineering Education*, *98*(1), 53–66. (36587532). https://doi.org/10.1002/j.2168-9830.2009.tb01005.x

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Boyer, R., Mellquist, A. C., Williander, M., Nyström, T., Linder, M., Algurén, P., Vanacore, E., Hunka, A., Rex, E., & Whalen, K. (2021). *Three-dimensional product circularity*. *25*, 824–833. https://doi.org/10.1111/jiec.13109

Brändström, J., & Eriksson, O. (2022). How circular is a value chain? Proposing a Material Efficiency Metric to evaluate business models. *Journal of Cleaner Production*, *342*, 130973. https://doi.org/10.1016/j.jclepro.2022.130973

Camfil. (n.d.). *We are Camfil*. Camfil. Retrieved May 11, 2026, from https://www.camfil.com/en-us/about-us/we-are-camfil

Camfil. (2025, March 19). HVAC Engineers Resource for Low-Pressure Drop Air Filters. *Air Filters for Clean Air*. https://cleanair.camfil.us/2025/03/19/hvac-engineers-resource-for-low-pressure-drop-air-filters/

Castiglione, C., Alfieri, A., & Pastore, E. (2025). Circular economy at scheduling level: Influencing factors and impacts on system performance. *International Journal of Production Research*, *0*(0), 1–22. https://doi.org/10.1080/00207543.2025.2562970

Circle Economy Foundation. (2024). *CGR 2024*. https://circularity-gap.world/2024

Das, T. K., & Teng, B.-S. (2001). Trust, Control, and Risk in Strategic Alliances: An Integrated Framework. *Organization Studies*, *22*(2), 251–283. https://doi.org/10.1177/0170840601222004

de Jesus, A., & Mendonça, S. (2018). Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics*, *145*, 75–89. https://doi.org/10.1016/j.ecolecon.2017.08.001

Dev, N. K., Shankar, R., & Swami, S. (2020). Diffusion of green products in industry 4.0: Reverse logistics issues during design of inventory and production planning system. *International Journal of Production Economics*, *223*, 107519. https://doi.org/10.1016/j.ijpe.2019.107519

EEA. (2024, December 3). *Sweden 2024 circular economy country profile*. https://www.eea.europa.eu/en/topics/in-depth/circular-economy/country-profiles-on-circular-economy/circular-economy-country-profiles-2024/sweden_-2024-ce-country-profile_final.pdf/@@download/file

EEA. (2026, February 19). *Assessing the climate mitigation potential of the circular economy*. https://www.eea.europa.eu/en/analysis/publications/assessing-the-climate-mitigation-potential-of-circular-economy

Ellen MacArthur Foundation. (2013, January 1). *Towards the circular economy Vol. 1: An economic and business rationale for an accelerated transition*. https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an

Ellen MacArthur Foundation. (2015, December 1). *Towards a circular economy: Business rationale for an accelerated transition*. https://www.ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an-accelerated-transition

Energimyndigheten. (2025). *From Waste to Wealth—Sweden's comprehensive approach to Energy Recovery*. Energimyndigheten. https://www.energimyndigheten.se/en/news/2025/from-waste-to-wealth---swedens-comprehensive-approach-to-energy-recovery/

Esposito, M., Tse, T., & Soufani, K. (2018). Introducing a Circular Economy: New Thinking with New Managerial and Policy Implications. *California Management Review*, *60*(3), 5–19. https://doi.org/10.1177/0008125618764691

European Parliament. (2018). *L_2018150EN.01010001.xml*. https://eur-lex.europa.eu/eli/dir/2018/850/oj/eng

Fact.MR. (2025). *HVAC Industrial Filtration Market | Global Market Analysis Report—2035*. Fact.MR. Fact.MR. https://www.factmr.com/report/hvac-industrial-filtration-market

Fleischmann, M., Bloemhof-Ruwaard, J. M., Dekker, R., van der Laan, E., van Nunen, J. A. E. E., & Van Wassenhove, L. N. (1997). Quantitative models for reverse logistics: A review. *European Journal of Operational Research*, *103*(1), 1–17. https://doi.org/10.1016/S0377-2217(97)00230-0

Forrest, M., & Mack, T. (2005). Closed-loop control system for recycling plastic products. *Global Plast. Environ. Conf. Creating Sustain. Environ.*, 123–140.

Frishammar, J., Parida, V., Panda, D., & Kaipainen, J. (2025). On the Right Path to Circularity or Running Around in Circles? A Fresh Perspective on Circular Business Model Barriers. *Business Strategy and the Environment*, *34*(4), 4958–4979. https://doi.org/10.1002/bse.4225

Geissdoerfer, M., Morioka, S. N., de Carvalho, M. M., & Evans, S. (2018). Business models and supply chains for the circular economy. *Journal of Cleaner Production*, *190*, 712–721. https://doi.org/10.1016/j.jclepro.2018.04.159

Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Goertz, G., & Mahoney, J. (2012). *A tale of two cultures: Qualitative and quantitative research in the social sciences* (3rd ed.). Princeton University Press.

Grafström, J., & Aasma, S. (2021). Breaking circular economy barriers. *Journal of Cleaner Production*, *292*, 126002. https://doi.org/10.1016/j.jclepro.2021.126002

Gu, F., Guo, J., Zhang, W., Summers, P. A., & Hall, P. (2017). From waste plastics to industrial raw materials: A life cycle assessment of mechanical plastic recycling practice based on a real-

world case study. *Science of The Total Environment*, *601–602*, 1192–1207. https://doi.org/10.1016/j.scitotenv.2017.05.278

Gyulasaryan, M. R., Matevosyan, A. V., Grigoryan, A. Z., & Matevosyan, M. H. (2025). CASH-FLOW-BASED SOLVENCY ASSESSMENT IN TECHNOLOGY SERVICE COMPANIES WITH SAAS REVENUE MODELS: A CASE STUDY OF SERVICENOW. *Proceedings on Engineering Sciences*, *7*(3), 1713–1720. https://doi.org/10.24874/PES07.03.029

Heyes, G., Sharmina, M., Mendoza, J. M. F., Gallego-Schmid, A., & Azapagic, A. (2018). Developing and implementing circular economy business models in service-oriented technology companies. *Journal of Cleaner Production*, *177*, 621–632. https://doi.org/10.1016/j.jclepro.2017.12.168

Horbach, J., & Rammer, C. (2020). Circular economy innovations, growth and employment at the firm level: Empirical evidence from Germany. *Journal of Industrial Ecology*, *24*(3), 615–625. https://doi.org/10.1111/jiec.12977

Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: Cases from the manufacturing industry. *Journal of Enterprise Information Management*, *33*(4), 729–745. https://doi.org/10.1108/JEIM-02-2019-0047

Jiang, Y., Leng, B., & Xi, J. (2024). Assessing the social cost of municipal solid waste management in Beijing: A systematic life cycle analysis. *Waste Management*, *173*, 62–74. https://doi.org/10.1016/j.wasman.2023.11.004

Kallio, H., Pietilä, A.-M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: Developing a framework for a qualitative semi-structured interview guide. *ResearchGate*. https://doi.org/10.1111/jan.13031

Kanda, W., Geissdoerfer, M., & Hjelm, O. (2021). From circular business models to circular business ecosystems. *Business Strategy and the Environment*, *30*(6), 2814–2829. https://doi.org/10.1002/bse.2895

Kant-Hvass, K., & Pedersen, E. R. G. (2019). Toward circular economy of fashion: Experiences from a brand's product take-back initiative. *Journal of Fashion Marketing and Management*, *23*(3), 345–365. https://doi.org/10.1108/JFMM-04-2018-0059

Kinnunen, P. H.-M., & Kaksonen, A. H. (2019). Towards circular economy in mining: Opportunities and bottlenecks for tailings valorization. *Journal of Cleaner Production*, *228*, 153–160. https://doi.org/10.1016/j.jclepro.2019.04.171

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecological Economics*, *150*, 264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028

Kong, L., Wang, L., Li, F., & Guo, J. (2022). Toward product green design of modeling, assessment, optimization, and tools: A comprehensive review. *International Journal of Advanced Manufacturing Technology*, *122*(5/6), 2217–2234. https://doi.org/10.1007/s00170-022-10021-9

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. New Age International Ltd. http://ebookcentral.proquest.com/lib/linkoping-ebooks/detail.action?docID=431524

Krueger, J. (1999). *International Trade and the Basel Convention*. Earthscan.

Kumar, S., & Sethi, S. P. (2009). Dynamic pricing and advertising for web content providers. *European Journal of Operational Research*, *197*(3), 924–944. https://doi.org/10.1016/j.ejor.2007.12.038

Kwon, S., Park, B., & Oh, B. (2025). Impact of High-Efficiency Filter Pressure Drop on the Energy Performance of Residential Energy Recovery Ventilators. *Energies*, *18*(16), 4326. https://doi.org/10.3390/en18164326

Li, C., Wang, H., Zeng, X., Li, X., Jin, R., Chi, Y., Liu, Q., Bai, L., Li, Z., & Tham, K. W. (2025). Strategies for enhancing performance sustainability of air filters: Challenges and future directions. *Separation and Purification Technology*, *376*, 133912. https://doi.org/10.1016/j.seppur.2025.133912

Lin, C.-H., Chen, Y., Chang, K.-I., & Chi, P.-Y. (2025). The evaluation of economic impact of the Basel Convention on the trade of waste electrical and electronic equipment. *Journal of Asian Economics*, *100*, 101996. https://doi.org/10.1016/j.asieco.2025.101996

Lüdeke-Freund, F., Gold, S., & Bocken, N. M. P. (2019). *A Review and Typology of Circular Economy Business Model Patterns*. *23*(1), 36–61. (vdc.100103111301.0x000001). https://research.ebsco.com/linkprocessor/plink?id=131a9c5e-bdb1-339e-934d-11623ec41e28

Mandić, A. (2025). *Optimizing the Research Process: The Role of AI Tools in Scientific Literature Searches* (p. 1163). https://doi.org/10.1109/MIPRO65660.2025.11131993

Mangla, S. K., Luthra, S., Mishra, N., Singh, A., Rana, N. P., Dora, M., & Dwivedi, Y. (2018). Barriers to effective circular supply chain management in a developing country context. *Production Planning & Control*, *29*(6), 551–569. https://doi.org/10.1080/09537287.2018.1449265

Marrucci, L., Daddi, T., & Iraldo, F. (2025). Boosting circular economy solutions in the construction sector using a life cycle assessment. *Journal of Industrial Ecology*, *29*(2), 473–485. https://doi.org/10.1111/jiec.13614

Masi, D., Kumar, V., Garza-Reyes, J. A., & Godsell, J. (2018). Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. *Production Planning & Control*, *29*(6), 539–550. https://doi.org/10.1080/09537287.2018.1449246

Meade, L., & Sarkis, J. (2002). A conceptual model for selecting and evaluating third-party reverse logistics providers. *Supply Chain Management: An International Journal*, *7*(5), 283–295. https://doi.org/10.1108/13598540210447728

Mendoza, J. M. F., Sharmina, M., Gallego-Schmid, A., Heyes, G., & Azapagic, A. (2017). Integrating Backcasting and Eco-Design for the Circular Economy: The BECE Framework. *Journal of Industrial Ecology*, *21*(3), 526–544. https://doi.org/10.1111/jiec.12590

Milios, L., Holm Christensen, L., McKinnon, D., Christensen, C., Rasch, M. K., & Hallstrøm Eriksen, M. (2018). Plastic recycling in the Nordics: A value chain market analysis. *Waste Management*, *76*, 180–189. https://doi.org/10.1016/j.wasman.2018.03.034

Mitchell, V.-W. (1995). Organizational Risk Perception and Reduction: A Literature Review. *British Journal of Management*, *6*(2), 115–133. https://doi.org/10.1111/j.1467-8551.1995.tb00089.x

Naturvårdsverket. (2025, September 24). *Cirkulär ekonomi*. Naturvårdsverket. https://www.naturvardsverket.se/amnesomraden/cirkular-ekonomi

Nordic Council of Ministers. (2024). *Waste incineration in the Nordic countries*. https://pub.norden.org/temanord2024-524/1-current-status-of-the-waste-incineration-sector-in-the-nordics.html

Owen, G. (2014). Qualitative Methods in Higher Education Policy Analysis: Using Interviews and Document Analysis. *The Qualitative Report*, *19*(26), 1–19. https://doi.org/10.46743/2160-3715/2014.1211

Panepinto, D., & Zanetti, M. C. (2018). Municipal solid waste incineration plant: A multi-step approach to the evaluation of an energy-recovery configuration. *Waste Management*, *73*, 332–341. https://doi.org/10.1016/j.wasman.2017.07.036

Parida, V., & Frishammar, J. (2023). *Circular business models: Where does Swedish industry stand?* Enreprenörskapsforum.

Pauwels, K., & Weiss, A. (2008). Moving from Free to Fee: How Online Firms Market to Change Their Business Model Successfully. *Journal of Marketing*, *72*(3), 14–31. https://doi.org/10.1509/JMKG.72.3.014

Payne, A., Frow, P., & Eggert, A. (2017). The customer value proposition: Evolution, development, and application in marketing. *Journal of the Academy of Marketing Science*, *45*(4), 467–489. https://doi.org/10.1007/s11747-017-0523-z

Peeters, J. R., Vanegas, P., Tange, L., Van Houwelingen, J., & Duflou, J. R. (2014). Closed loop recycling of plastics containing Flame Retardants. *Resources, Conservation and Recycling*, *84*, 35–43. https://doi.org/10.1016/j.resconrec.2013.12.006

Perrin, D., Mantaux, O., Ienny, P., Léger, R., Dumon, M., & López-Cuesta, J. M. (2016). Influence of impurities on the performances of HIPS recycled from Waste Electric and Electronic Equipment (WEEE). *Waste Management*, *56*, 438–445. https://doi.org/10.1016/j.wasman.2016.07.014

Pires, A., & Martinho, G. (2019). Waste hierarchy index for circular economy in waste management. *Waste Management*, *95*, 298–305. https://doi.org/10.1016/j.wasman.2019.06.014

Potting, J., Hekkert, M. P., Worrell, E., & Hanemaaijer, A. (2017). *Circular Economy: Measuring Innovation in the Product Chain*. PBL Publishers.

Prieto-Sandoval, V., Jaca, C., & Ormazabal, M. (2018). Towards a consensus on the circular economy. *Journal of Cleaner Production*, *179*, 605–615. https://doi.org/10.1016/j.jclepro.2017.12.224

Rahnama Mobarakeh, M., & Kienberger, T. (2022). Climate neutrality strategies for energy-intensive industries: An Austrian case study. *Cleaner Engineering and Technology*, *10*, 100545. https://doi.org/10.1016/j.clet.2022.100545

Rani, J., Guru, R., & Santhanam, S. (2025). *Case Studies on the Use of AI in Literary Research and Academic Studies* (pp. 1–36). https://doi.org/10.4018/979-8-3373-6330-1.ch001

Ranta, V., Aarikka-Stenroos, L., & Väisänen, J.-M. (2021). Digital technologies catalyzing business model innovation for circular economy—Multiple case study. *Resources, Conservation and Recycling*, *164*, 105155. https://doi.org/10.1016/j.resconrec.2020.105155

Richardson, J. (2005). The Business Model: An Integrative Framework for Strategy Execution. *Strategic Change*, *17*, 133–144. https://doi.org/10.1002/jsc.821

Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M., & Ioannou, A. (2015). *The Circular Economy: Barriers and Opportunities for SMEs* (SSRN Scholarly Paper No. 2664489). Social Science Research Network. https://papers.ssrn.com/abstract=2664489

Shehab, E., Meiirbekov, A., Amantayeva, A., & Tokbolat, S. (2023). Cost Modelling for Recycling Fiber-Reinforced Composites: State-of-the-Art and Future Research. *Polymers*, *15*(1). https://doi.org/10.3390/polym15010150

Singh, P., & Giacosa, E. (2018). Cognitive biases of consumers as barriers in transition towards circular economy. *Management Decision*, *57*(4), 921–936. https://doi.org/10.1108/MD-08-2018-0951

Singh, R., Khan, S., & Centobelli, P. (2022). Investigating the Interplay between Social Performance and Organisational Factors Supporting Circular Economy Practices. *Sustainability*, *14*(24), 16781. https://doi.org/10.3390/su142416781

Sousa-Zomer, T. T., Magalhães, L., Zancul, E., & Cauchick-Miguel, P. A. (2018). Exploring the challenges for circular business implementation in manufacturing companies: An empirical investigation of a pay-per-use service provider. *Resources, Conservation and Recycling, Sustainable Resource Management and the Circular Economy*, *135*, 3–13. https://doi.org/10.1016/j.resconrec.2017.10.033

Stahel, W. (2016). Circular economy. *Nature*, *531*, 435–438. https://doi.org/10.1038/531435a

Tabares, S., Parida, V., & Visnjic, I. (2023). Revenue models for digital services in the railway industry: A framework for choosing the right revenue model. *Journal of Business Research*, *165*, 114041. https://doi.org/10.1016/j.jbusres.2023.114041

Technavio. (2025). *HVAC Air Filter Market Growth Analysis—Size and Forecast 2025-2029*. Technavio. https://www.technavio.com/report/hvac-air-filter-market-industry-analysis

Templier, M., & Pare, G. (2015). A Framework for Guiding and Evaluating Literature Reviews. *Communications of the Association for Information Systems*, *37*, 112–137. https://doi.org/10.17705/1CAIS.03706

Thomason, J., Jenkins, P., & Yang, L. (2016). Glass fibre strength-A review with relation to composite recycling. *Fibers*, *4*(2). https://doi.org/10.3390/fib4020018

Todeschini, B. V., Cortimiglia, M. N., Callegaro-de-Menezes, D., & Ghezzi, A. (2017). Innovative and sustainable business models in the fashion industry: Entrepreneurial drivers, opportunities, and challenges. *Business Horizons, THE GENERATIVE POTENTIAL OF EMERGING TECHNOLOGY*, *60*(6), 759–770. https://doi.org/10.1016/j.bushor.2017.07.003

Tukker, A. (2004). Eight types of product–service system: Eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment*, *13*(4), 246–260. https://doi.org/10.1002/bse.414

Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., & Valkokari, P. (2019). Unlocking circular business: A framework of barriers and drivers. *Journal of Cleaner Production*, *212*, 90–98. https://doi.org/10.1016/j.jclepro.2018.11.202

Uhrenholt, J. N., Kristensen, J. H., Rincón, M. C., Jensen, S. F., & Waehrens, B. V. (2022). Circular economy: Factors affecting the financial performance of product take-back systems. *Journal of Cleaner Production*, *335*, 130319. https://doi.org/10.1016/j.jclepro.2021.130319

UNEP. (2023). *Turning off the Tap: How the World can End Plastic Pollution and Create a Circular Economy*. United Nations Environment Programme. https://doi.org/10.59117/20.500.11822/42277

Unruh, G. C. (2000). Understanding carbon lock-in. *Energy Policy*, *28*(12), 817–830. https://doi.org/10.1016/S0301-4215(00)00070-7

Viglia, G., Pera, R., Dyussembayeva, S., Mifsud, M., & Hollebeek, L. D. (2023). Engagement and value cocreation within a multi-stakeholder service ecosystem. *Journal of Business Research*, *157*, 113584. https://doi.org/10.1016/j.jbusres.2022.113584

Vilaplana, F., Ribes-Greus, A., & Karlsson, S. (2006). Degradation of recycled high-impact polystyrene. Simulation by reprocessing and thermo-oxidation. *Polymer Degradation and Stability*, *91*(9), 2163–2170. https://doi.org/10.1016/j.polymdegradstab.2006.01.007

Waste hierarchy—EUR-Lex. (n.d.). Retrieved April 20, 2026, from https://eur-lex.europa.eu/EN/legal-content/glossary/waste-hierarchy.html

Wautelet, T. (2018). *The Concept of Circular Economy: Its Origins and its Evolution*. https://doi.org/10.13140/RG.2.2.17021.87523

Wycherley, I. (1999). Greening supply chains: The case of The Body Shop International. *Business Strategy and the Environment*, *8*(2), 120–127. https://doi.org/10.1002/(SICI)1099-0836(199903/04)8:2%3C120::AID-BSE188%3E3.0.CO;2-X

Yin, R. K. (2018). *Case study research and applications: Design and methods / Robert K. Yin.* (Sixth edition). SAGE. LiUB Library Catalogue (lub.oai.folio.org.liuaf.fa396a76.8b9b.495d.b897.60ca9d23fc7e). https://research.ebsco.com/linkprocessor/plink?id=80ad64b9-697e-3fa6-ac5a-ffc2eec4836d

Yit, J. E., Chew, B. T., & Yau, Y. H. (2020). A review of air filter test standards for particulate matter of general ventilation. *Building Services Engineering Research & Technology*, *41*(6), 758–771. https://doi.org/10.1177/0143624420915626

Zhang, X., Zhou, L., & Ieromonachou, P. (2013). The effect of uncertainty on economic performance of reverse logistic operation. *2013 International Conference on Advanced Logistics and Transport*, 110–114. https://doi.org/10.1109/ICAdLT.2013.6568444

zu Castell-Rüdenhausen, M. (2025). Material flow analysis and modelling of the feedstock potential for recycling polystyrene. *Circular Economy*, *4*(1). https://doi.org/10.1016/j.cec.2025.100127

Appendix

Each interview guide started with asking for permission to record the conversation as well as a description of their company and role within it. Appendix A-D are all for internal actors at the case company Camfil. Appendix E contains the questions asked to a legal advisor for transport of waste, Appendix F was for actors who worked with recycling of materials, Appendix G consisted of questions related to public purchasing and were asked to a sustainability coordinator. Appendix H were the questions for the sustainability officer at the FM company and Appendix I contains the questionnaires and surveys that were used in this thesis.

Appendix A: Sales

Role & responsibilities

1. Can you describe your role?
2. Which customers do you primarily work with?
    - Is it only this type of customers?

Customer types & structure

1. How do different customers differ from each other?
    - Do large customers have completely different conditions than smaller ones?
    - How does geographic spread and filter density differ?
        - FM: Do they all have similar setups, or does it vary a lot?

Products & volumes

1. What types of filters do your customers buy?
2. How large are the volumes of plastic frame filters?
3. How often do they purchase?
    - Are the purchases regular and predictable, or do they occur more sporadic?

Purchasing process & decision-making

1. What does the decision-making process look like at the customer – who decides what is purchased?

Buying arguments

1. Why do they buy from you?
2. Does goodwill and trust play a role in the purchasing process? How?
3. Is it mainly price and performance that determines the purchase, or do customers also make sustainability assessments?
4. Are there differences between new and existing customers in why they choose to buy from you?

Sales & delivery process

1. How does the sales process work?

2. What does the delivery look like in practice, and how do they differ?
    - Click & collect
    - Transport through 3PL
    - Own transport

Installation & replacement

1. How are the filters installed at the customers' sites?
2. How are replacements handled?
    - Are all filters replaced at the same time, or continuously over time?
        - Larger customers: Do they use intermediate storage and replace everything at once?

Handling of used filters / waste

1. How do your customers handle used filters?
2. Do they have their own containers on-site, or do they outsource it to waste management companies?
3. Have you heard anything about customers' attitudes or thoughts regarding the amount of waste generated?

Interest in future solutions

1. Are there customers who you think would be completely uninterested in such solutions?
2. Are there customers who you think would be interested?
    - Could we speak with them?

Click & Collect (whenever it is relevant)

1. Click & collect – do you know how it works in practice?
2. How much volume is generated?
    - What is the share of plastic frame filters?
3. What share of customers uses the container?
4. Is there room for an additional container?
5. What does this cost for Camfil?
6. Who is responsible for it?
7. Is it possible to get a picture?

Closing remarks

1. Is there any aspect or area that you think we missed asking about?
2. Do you have any other questions for us?

Appendix B: Logistics

1. Can you briefly describe your role and your responsibilities related to logistics
   - Does return flows, take-back systems, or waste management fall within your area of responsibility?
     - If yes: how involved are you in this?

2. Do you know about the collection of a large amount of used filters that recently took place?
   - Were you involved in this?
     - If yes: In what way or at which level? Was this a one-time setup, or was it based on existing logistics structures?
     - If no: Do you know who was involved?

3. If you were to introduce a take-back system today, which parts would you see as the most logistically challenging?

4. How would you describe your internal capabilities for handling reverse logistics?
   - Would this capability need to be built internally or purchased externally?
   - As a company, would you prefer to outsource this or build the capability in-house?

5. Which cost items do you think would be most significant in a take-back system?

6. Are there any additional people we should talk to? (internally or externally, 3PL)

7. What does the logistics chain generally look like for comfort filters? Who installs them?

8. How do you decide which partners to collaborate with?

Appendix C: Purchasing

Collaboration & negotiation

1. How do negotiations between [Company] and [supplier] typically work, and how often are agreements reviewed?
2. Which factors matter most to your company in these discussions (quality, delivery reliability, sustainability, long-term partnership)?

Material procurement

1. Does [Supplier] purchase recycled HIPS independently, or are you involved in specifications or supplier approvals?
2. Are there shared requirements or guidelines for material procurement?

Supply chain insight

1. How much visibility do you have in your suppliers' supply chains (origin, sustainability, risks)?
2. Do you review or approve your suppliers' subcontractors? If not, is this something you want to improve?

Pricing & supplier structure

1. What is the current price you pay for recycled HIPS, and what are the main cost drivers?
2. How are price adjustments handled? (index-based, annual reviews, or market-driven changes)
3. How many different suppliers in the same industry do you work?
4. Is the pricing model fixed unit price, or variable material price + fixed processing cost?

Appendix D: Marketing

Strategic value & positioning

1. How do you see this solution strengthening our brand?
   - PR, first-mover advantages?
2. If we succeed in establishing a functioning take-back system, how would that affect our market position?
3. How do you think this would influence our long-term legitimacy?

Customer value & added benefits

1. Which added values are the strongest to communicate to customers, and how?
2. Are there certain customer segments where this solution is particularly important
3. Can we charge customers for this?

Marketing opportunities

1. How could we package and communicate the solution?
2. What risks are there in communicating the solution too early (greenwashing, verifiability)?
   - Could transparency about being in a development phase build trust, or does it risk undermining credibility?

Environmental benefits & credibility

1. Which environmental benefits do you think are most relevant to highlight?
2. What is required for the communication to be perceived as credible? (data, third-party verification, etc.)
3. Are there risks that the benefits will be questioned?

Challenges & risks

1. What market-related risks or barriers do you see?
2. Is there a risk that the solution creates expectations that we cannot operationally deliver on?
3. What needs to be in place before we launch this broadly?

Appendix E: Legal Advisor

Own waste or someone else's

1. When we collect material from our customers, is this considered transportation of our own waste or transportation of waste on behalf of someone else?

Responsibility

1. In our setup, who do you see as primarily responsible: us as the manufacturer, our customer, the transporter (3PL), or the receiver?
    - In relation to signed contracts, is this something that needs to be formally regulated?

Waste transportation

1. Based on our volumes of this type of waste, is a permit required for national transport within Sweden?
    - Where should this be applied for?
2. What other factors than total volume and frequency of transport affect the legality of transport ing waste?
    - Must both volume and frequency be fully known?
3. If the waste arises in one municipality, does it have to be incinerated in that same municipality, or can it be transported together with other materials and then incinerated in another municipality?
4. If the material is collected from abroad for recycling, in what way does this impact on our case?
    - Norway is not part of the EU: would this require any additional international permutation or special authorization?

Partial recycling

1. If one part of the product goes to material recycling and the other parts to energy recovery, does that affect how you assess the permiting process?

Documentation

1. What documentation do we need to be able to provide to demonstrate that the flow is legal, both during inspections and in the permit application?

Moving forward

1. Should we apply for a formal preliminary ruling or submit a concrete application, and if so to whom?
2. How long does it usually take to obtain a permit?

Appendix F: Recycling

Incineration as the norm and what is required to change it

1. Why are composite materials such as air filters directed to incineration, and what are the key barriers preventing these materials from being recycled at the material level instead?
2. Is incineration primarily a consequence of lacking infrastructure and partners for collaboration, or is it due to insufficient economic viability?
3. Do you have experience in receiving and managing composite materials that require separation, for example plastics combined with fibers, and what is required for such processes to function effectively?

Separation of plastics and filter media

1. Do you have the capacity and capability to separate an incoming flow of HIPS plastic and glass fiber/synthetic fiber into pure fractions, or must companies deliver the material already separated?
2. What requirements do you place on incoming plastic materials in terms of purity levels, volume, and pre-treatment for them to be manageable and retain their value?
3. How does the degree of material separation affect the business case for recycling?
4. Do you have experience with situations where a customer has invested in shredders, compactors, or separation equipment at their own facilities prior to delivery to you? What advantages and disadvantages have you observed in such arrangements?

Investment, logistics, and collaboration

1. Do you work with long-term collaboration agreements with guaranteed volumes and material standards, and what do such arrangements typically look like?
2. Where in Sweden does your actual processing of collected HIPS plastic take place?
    - Is it carried out at multiple locations?

Your perspective and recommendations

1. What is your most important advice to an actor seeking to break the pattern of incineration and instead establish a functioning system for material recycling?
2. What role do you see that Stena Recycling could play in this context, and what conditions need to be in place to make this possible?
3. What do you consider to be easier: establishing a recycling flow internally or outsourcing this service?

Appendix G: Public Purchasing

Procurement Logic & Priorities

1. How does your procurement process for filters differ from a "standard public procurement (LOU)" process?
2. Which aspects play a role in your procurement process?
    - Are some factors weighted more heavily than others? Which ones matter the most?
    - The least? (Price Performance, Energy efficiency, Delivery reliability, Sustainability requirements)
3. How do you view innovation in procurement? Is it rewarded, or does it create risk?

Sustainability Requirements & Circularity

1. Do you currently include any requirements in your procurements related to:
    - Recycling?
    - Material choices?
    - Waste minimization?
    - Traceability?
2. Do your member companies have their own climate or ESG targets that influence procurement decisions?
3. Has circularity been a topic in previous procurements?
    - Will it be included in the future?
4. Are there legal or practical barriers to including take-back or collection requirements?

Handling of Used Filters

1. Do you have insight into how member companies handle used filters?
2. Is this something you follow up on?
3. Do you experience any ambiguity regarding responsibility within the value chain?
4. Do you see any risks (legal, environmental, or reputational) related to how this is currently handled?

Soft values & signaling

1. How important is it for you that your framework agreements signal sustainability and responsibility?
    - Why?
2. Who is willing to pay for informed and sustainable decisions?
3. Does a supplier's brand and credibility influence your choice?
4. How do you weigh risk minimization against cost?
5. Is it important for you to demonstrate that you are at the forefront?
6. Are there reputational risks if waste streams are not handled properly?

Incentives & barriers for a collection solution

1. Would it be possible to include take-back/collection as part of a framework agreement?
2. What would be required for this to be attractive?
    - Cost neutrality?
    - Administrative simplicity?
    - Central reporting?
3. Would some member companies be more interested than others?

4. Would this take-back/recycling be explicitly visible in the agreement, or how would members become aware of it?
5. How would it be communicated that this service is included in the framework agreement?
6. Is there a risk that it could be perceived as too complex?
    - Can this easily be mitigated in some way?

Future perspective

1. Do you think requirements for circularity in consumable products will increase?
2. How do you think public procurement practices will evolve?
3. Do you see member companies demanding more sustainable solutions, or is procurement still primarily price-driven?

Appendix H: Facility Managers

Recycling and collection

1. Do you see recycling and collection as must-have requirements in future filter supplier agreements, or are they more of a nice-to-have?
2. If Camfil offered to collect your used filters, would there be a willingness to pay for the collection of old filters? (Compare this with what you currently pay for waste management)
3. Is there a willingness to pay for recycling only (no collection)?

Competitive landscape and market dynamics

1. How do FM companies compete with each other, and is sustainability a major factor?
2. Do you think a recycling offering from Camfil would be a selling point for you when competing for customers, or is it something that is simply expected of you?

Sustainability requirements and reporting

1. Do you have your own sustainability targets linked to waste? (zero-waste goals, CO_2 reduction targets, recycling rates)
2. Do you need to report waste volumes or material recycling to your customers (the property owners)?
    - What sustainability requirements related to waste do your customers have today? Are these requirements increasing?

Service technicians and workflows

1. Could service technicians return old filters when they pick up new ones under contract?
    - At a Camfil office or depot?
2. Who in your organization owns the operational responsibility for waste management? (Site manager, procurement, sustainability manager, service technician)

Requirements and dealbreakers

1. What is the single most important requirement for you to sign an agreement for a filter recycling service?
2. Is there anything that would automatically be a dealbreaker?
   (Increased administration, sorting requirements, or additional cost)

Appendix I: Questionnaires

Three different questionnaires were made for different types of customers in this thesis. 1. was a verbal survey for service technicians who visited the sales office in Stockholm. 2. was a questionnaire for municipally owned property companies and finally, 3. was a short questionnaire posed to Norwegian HVAC contractors.

1. Service Technicians

1. Do you bring used filters back here, and if so, how often?
2. How many do you bring each time?
3. Why do you bring them / why not?
4. Do you return the filters on your own initiative, or is it based on directives from management?
5. If material recycling were to require a few extra minutes per assignment, would that affect how often you bring used filters back?
6. If you were compensated extra for removing filters from their packaging, would that motivate you to do so?
    - How much compensation would be required?
7. What is your time-related threshold (i.e., how much additional time are you willing to spend)?
8. Is there anything that would make it easier for you to always bring used filters back?
9. Does anything at the office need to change?
10. Do your customers place demands on you regarding cost and/or environmental performance?
11. How much influence do you have over how many or how often old filters are discarded within your organization?
12. Do your customers place demands?

2. Municipally Owned Property Companies

1. How are used filters disposed of today?
2. Who (customer, service partner, etc.) is responsible for disposal?
3. How does the process work in practice?
4. Are there variations between different customer segments?
5. Why is disposal handled this way today?
    - Is it due to routines, regulatory requirements, cost, logistics, or other factors?
6. What opportunities and barriers does [your company] see in collecting used filters back to the supplier?
7. What steps would simplify the process for housing companies?

3. Norwegian HVAC contractors

1. What would be a reasonable distance to transport used filters to a shared collection point?
2. Would an additional collection point in the Oslo area make a practical difference? If so, how?
3. Is there interest or willingness to pay for on-site collection if offered as a service?
4. How would a mobile solution (for example, on-site compaction across multiple stops) be perceived?