In partial fulfillment of
Master Innovation Management
Master Industrial Design

UNLOCKING THE LOOP

A case study on embedding circular business model innovation in the product development process for medical consumables

Master Thesis

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PHILIPS

Preface

Designers are told to empathize. Engineers are told to optimize. Innovation managers are told to strategize. Somewhere in between, I found myself trying a bit of everything. My academic journey has taken me from industrial engineering to design, from Eindhoven to New Zealand, and eventually into the field of circular innovation in the healthcare industry. This thesis in front of you is the embodiment of approximately 7,5 years of interdisciplinary studying. Years in which I learned that complex challenges rarely define themselves by the border of a single discipline. This final project has not only been a final learning activity, but became a demonstration of how valuable interdisciplinary work can be in solving these complex challenges in practice. Before you dive into the topic of circular business model innovation, I want to express a few words of gratitude

I would like to express my gratitude to my mentor, Duygu Keskin, who supported me during this graduation project and had to deal with my chaotic mind at times. Her willingness to brainstorm during frequent check-ins and review my work helped me to remain critical of my own work. This, without a doubt, contributed to the quality of my work. Additionally, I want to thank Vikrant Sihag for being my second supervisor and for his help throughout the project. Next, I want to thank Jacopo Parma for his support and joyful, stress-reducing spirit. May the results of this study benefit your work later on. Lastly, I want to thank Maral Mahdad for taking the time to be my third assessor.

Additionally, I want to thank everyone from the Innovation Management team, the Hospital Patient Monitoring business unit, and the Group Sustainability Office at Philips. Spending my days at the office was not only relevant to the project, but resulted in meeting wonderful people and enjoying the first steps of corporate life. Everyone was extremely eager to help, and everyone's motivation to make a change for better healthcare was truly inspiring. I want to give special thanks to Margot Honkoop and Stephanie Resnick for guiding me throughout the project and Philips. Our meetings were a highlight of my week, and your kindness, knowledge, and support have been essential to the completion of my thesis. I additionally want to express my gratitude towards Steve Groen, who was willing to meet at the dawn of the day, adopted me in the world of product management, and every now and then reminded me of rule #1.

Last but not least, I would like to thank my friends and family. To my friends, thank you for an unforgettable student time and a book full of memories. To my family, for being my support and motivators to keep going in rough times. In special thanks to my boyfriend, for being my free therapist and always there for a hug. I am sorry for keeping you up at night during my late-night sessions.

Iris Borst
Eindhoven, March 3rd 2026

Executive Summary

This master's thesis was conducted at Philips in light of their ESCH-R consortium partnership. Therefore, this thesis focuses on improving the circular performance of medical consumables from a medtech OEM perspective. Medtech OEMs find themselves at the baseline of enabling circular performance for this product, due to their design, materials, and production choices. In this transition to circularity, they face an economic challenge (Macneill et al., 2020). The existing linear system, the required investments to enable circular solutions(Uloma Stella Nwabekee et al., 2024), and the relatively low value of these products creates a financially unattractive situation. This challenge is especially present in established organizations (Pascucci et al., 2024), where new circular solutions compete with linear offerings that fit within existing infrastructure. The circular economy is addressed as the solution (Macneill et al., 2020), which requires OEMs to rethink how they capture, create, and deliver value. Therefore, this thesis will focus on how circular business model innovation (CBMI) can be supported at a medtech OEM producing medical consumables.

CBMI consists of an outcome and a process perspective (Foss & Saebi, 2017). The effectiveness of CBMI is dependent on its alignment with the context (Bocken & Brezet, 2019). Therefore, the outcome perspective summarizes the potentially suitable CBM patterns and types. At the same time, the process perspective focuses on the iterative approach within organizations for developing a new CBM. This thesis combines the process perspective with the concept of dynamic capabilities. This integration creates a perspective of how established organizations can overcome their organizational rigidity to develop circular solutions.

Methodology

This project deploys the design science research (DSR) approach by following the DSR cycle as defined by Keskin & Romme (2020). This approach emphasizes a strong collaboration between theoretical and empirical insights to answer the main research question: *How can manufacturing organizations be supported in circular business model innovation for medical consumables?* 3 Subquestions supported the main research question:

1. *How are the dynamic capabilities and micro-foundations for CBMI demonstrated in the process of Philips?*
2. *Which CBMs and their operational mechanisms are relevant for medical consumables?*
3. *How can an actionable tool activitate dynamic capabilities to support the exploration and development of CBMs?*

In line with the DSR cycle, the project phases followed the order of exploration, synthesis, creation, and evaluation. In the exploration stage, desk research and interviews with Philips stakeholders were conducted. This was supported by observation of a project undergoing the business modelling process. This created a thorough understanding of the contextual situation. During synthesis, the data was analyzed using the dynamic capabilities framework, which led to the design requirements. A CBM typology and a collaborative CBMI workshop were created to support Philips in developing new CBMs for their medical consumables. This highlighted both the outcome and the process perspective of CBMI. The CBM typology was evaluated with academic and industry experts. The development of the workshop was supported through frequent stakeholder feedback, an exploratory focus group, and a user test. This was performed during the evaluation phase.

Results

Product managers and a small, multi-disciplinary team define the business model in the early stages of product development. The analysis of this process using the dynamic capabilities framework of Santa-Maria et al. (2022) illustrated that Philips demonstrates strong sensing and reconfiguring capabilities but has a gap in seizing. Philips is thus strong at identifying opportunities and adapting its resources, but is less effective in translating those opportunities into business models. Philips missed adopting a lifecycle perspective, implementing sustainability ideation tools, generating value propositions with sustainable/social impact, designing and implementing (sustainable/circular) business models, and generating business model architectures that transform socio-technical systems.

To address knowledge gaps and awareness of CBMs, a CBM typology tailored to manufacturing organizations producing medical consumables was developed. Seven relevant CBM archetypes and fourteen CBM types were identified in relation to the product lifecycle narrative. The CBM archetypes consisted of: (1) Digitalization & Dematerialization, (2) Sufficiency-based models, (3) Circular Supplies, (4) Resource & Process Efficiency, (5) Access Provision, (6) Product Lifecycle Extension, and (7) Resource Recovery & Recycling. The CBM types consisted of: (1) Digitalization & Dematerialization, (2) Profit Sufficiency, (3) Industrial Symbiosis, (4) Sourcing Circular Supplies, (5) Production-on-demand, (6) Process Optimization, (7) Sharing Platform, (8)Performance/use-oriented, (9) Product-as-a-Service, (10) Premium Durability, (11)Modularity/Upgradeability, (12) Lifecycle Services, (13) Reprocessing, and (14) Recycling/recovering value from discarded products. Experts evaluated the typology to be comprehensive and applicable to the context of this study. The models of industrial symbiosis, production-on-demand, sharing platforms, reprocessing, and recycling were deemed challenging to implement in the given context due to operational and economic constraints. The models affecting the use phase and operationalizing the R-strategies as (R1) Rethink, (R3) Reuse, and (R4) Repair seemed to be most relevant for medical consumables.

Based on the identified capabilities gap and CBMs, a collaborative workshop titled ‘Unlocking the Loop’ was developed. This workshop with the prototype consists of three exercises. Each exercise represents one of the higher-order capabilities: (1) business model decision tree to explore different CBMs and their characteristics (sensing); (2) circular business model identity cards to learn about and refine the preliminary model (seizing); (3) the business model blueprint, which translates the business model into more operational details (reconfiguring). The missing capabilities are reflected in the exercises and activities, and the CBM typology provided the content. The workshop supports product managers and their support team in exploring and discussing potential CBM characteristics for their product concept, translating them, ideating on a suitable CBM configuration, and finally translating this into a concrete CBM plan. The workshop was evaluated through a user test on a real consumable innovation project. The participants evaluated the workshop to be supportive of CBM design and exploration. The support for exploration was attributed to the workshop's guiding structure, especially the decision tree exercise. This structure assisted the involved stakeholders in sharing perspectives and creating a shared understanding of opportunities and their implications. Stimulation of lifecycle thinking and the identification of partnerships were recognized and included in the discussion about the concept in the test. Participants with varying prior knowledge perceived the educational and skill-building effects differently. The participants with little background in circularity would perceive these effects.

Conclusion

All together, this project explored how introducing the dynamic capabilities perspective and developing an actionable tool can support CBMI. It contributes a validated CBM typology specific to the context of OEMs producing medical consumables. This typology distinguishes distinct patterns across the product lifecycle and can support practitioners in not only identifying suitable options but also in creating all-around circular

combinations. Additionally, it presents an actionable workshop that supports lifecycle thinking and a structured CBM exploration suitable for the early stages of business modelling and the product development process. Embedding this workshop as a process step can help Philips to gradually refine the business model to align with the context and thus to overcome the design-implementation gap (Baldassarre & Calabretta, 2023).

Further refinement of the workshop and its prototype, combined with cross-organizational collaboration, would support the identification and implementation of CBMs across the value chain. Hence, support the progress to a more circular healthcare industry.

Contents

Overview of Abbreviations

BM	Business Models
BMI	Business Model Innovation
CBM	Circular Business Model
CBMI	Circular Business Model Innovation
CE	Circular Economy
DC	Dynamic Capability
GSO	Group Sustainability Office
IEN	Innovation Engineering
HPM	Hospital Patient Monitoring
OEM	Original Equipment Manufacturer
MF	Micro-foundation
MPU	Multi-Patient Use
SPU	Single-Patient Use
VPC	Value Proposition Creation

AI Statement

During the creation of this Microsoft Co-Pilot, Philips Enterprise AI and Grammarly were used from April 2025 to March 2026. All three were used to improve the text of this thesis. No text generated by these AI was directly copied. They served the purpose of improving text structure, grammar, and spelling mistakes.

Overview of Figures

Overview of Tables

1. Introduction

The healthcare industry has been focused on improving care through technological innovation (Bell et al., 2023). In this ambition for better care, the industry neglected its substantial, detrimental environmental footprint (Benedettini, 2022; Hoveling et al., 2024). This waste and emission drives climate change, which is in turn responsible for increasing illness (Duffy et al., 2023). Thus, paradoxically, leading healthcare's consumption and production to negatively affect the health outcomes it seeks to improve (Hoveling et al., 2025).

Original Equipment Manufacturers (OEMs) play a pivotal role in positively influencing the transition to sustainable healthcare. Their choices in materials, product design, and production processes shape a product's lifecycle and implicitly influence customer behaviour (Macneill et al., 2020). OEMs are therefore regarded as stakeholders sharing responsibility with regulatory bodies and customers for improving the environmental performance of the healthcare industry. Hence, the circular transformation challenges OEMs to balance economic growth with environmental preservation (Lieder & Rashid, 2016).

Medical consumables are a clear example of this situation. These products are used in high volumes and are incinerated or landfilled at the end of their lifecycle (Huijben et al., 2025; Macneill et al., 2020). Consequently, these products contribute significantly to healthcare waste. To improve the circularity of these products, significant investments are needed to modify product design (Klose & Fröhling, 2025), production infrastructure, and logistics to facilitate circular solutions (Uloma Stella Nwabekee et al., 2024). However, the low unit price of consumables combined with the uncertain and slow return on investment from circularity could render the product economically unviable. Additionally, some circular solutions pose a risk of sales cannibalization, as OEMs' current business models incentivize high-volume consumption to maximize profit (Macneill et al., 2020). This especially counts for established organizations making this transition, as their established resources, capabilities, and mental models make staying linear seem like the economically right choice (Sousa-Zomer & Cauchick-Miguel, 2019). The circular solutions are perceived as a threat to their current profit-and-loss position.

Thus, for OEMs to transition towards circularity, they need to rethink and innovate how they capture, create, and deliver value. In other words, how to enable circular business model innovation (CBMI). Research highlights that CBMI is not a single design exercise, but an iterative process that requires design thinking and the reconfiguration of existing resources and capabilities (Baldassarre & Calabretta, 2023; C. Shalley et al., 2015). Dynamic capabilities (DC) can be framed as 'best practices' and, as such, provide direction in the activities and skills required to overcome the challenge (Khan et al., 2020; Scarpellini et al., 2020). While DC and CBMI are conceptually linked, only a few studies provide a framework listing the required practices for effective CBMI. Two of these studies are Khan et al. (2020) and Santa-Maria et al. (2022). While these studies provide a clear overview of the required CBMI practices, they lack insight into *how* organizations can integrate these practices into their existing processes. This creates an opportunity to explore how this integration can lead to an actionable design solution supporting OEMs in CBMI.

1.1 Empirical Context

This study is conducted within the context of the ESCH-R consortium. ESCH-R is an interdisciplinary project, between academia and industry, directed at accelerating the transition from a linear to a circular healthcare industry in the Netherlands (*ESCH-R*, n.d.-a). This consortium focuses specifically on medical consumables. Philips is an industry partner within the consortium and an OEM developing medical consumables, including SpO2 sensors and blood pressure cuffs.

Philips's business modelling process is part of early product development, which is internally referred to as the value proposition creation (VPC) process. Product managers, who oversee a specific product's

upstream activities, are the primary employees driving the VPC process. During the VPC activities, they are supported by a small multidisciplinary team. The VPC activities are guided by numerous mandatory templates that help the team define and refine a product concept from the perspectives of the customer, the offer, and the business. Based on interviews, it became evident that Philips is coping with the described economic challenge and a capability gap in CBM design and implementation. Therefore, Philips is a good case study for the presented theoretical context, which allows to explore how the process and challenges unfold in practice.

One of the templates used by Philips is the *business case*, designed to capture costs and revenues to assess financial feasibility and viability. Product managers and an internal business case expert emphasize that this financial evaluation is critical in the current process. It is one of the determinants in deciding on the project's progression or termination in the development process. Additionally, capturing the benefits of sustainable solutions in this financial evaluation is challenging. Product managers find that sustainable solutions often entail higher costs compared to their linear alternatives. Especially, as the circular solutions would require a change in the existing architecture, which would require investment and effort, creating a barrier.

"I would say we are also very cost-conscious. Whether sustainability comes at a cost or whether it is accessible, the reality is, if a particular material that is more sustainable comes at a higher cost, it is going to be possibly less attractive" ~ Product Manager in HPM. [PM_02]

"We cannot bring ideas to life easily enough and fast enough. […] Some of these circularity models, it is a no-brainer. We should do it. It can be done profitably, but it needs an architecture that does not exist. I could also just sell them a new one. So which one do you think will happen?" [PM_01]

"*This costs money, to put it bluntly. It costs a lot of money, and if you cannot prove it is actually profitable, it is stopped anyway"* ~ Business Case Expert [EX_02]

This financial evaluation seems to hinder the exploration of alternative CBM configurations. Product managers primarily build on the existing model and adapt it in minor ways. Thereby, the time they spend radically rethinking the plan underlying their business model is limited. The mandatory VPC templates contain only limited sustainability sections, making an almost insignificant contribution to the effective inclusion of sustainability considerations in the value proposition. Underlying both lies unawareness and inexperience on how circularity and business model design affect the organization, and thus how operations need to be adjusted to accommodate the CBM.

"In my experience, we almost went straight to it. No, it is a good point. I think we had ideas that we packed in, but more or less went straight away to the model that we know." ~ Product Manager in HPM [PM_03]

"It is something we have a little section for that we can fill out, but does it contribute to the overall value of the VPC? Not really. Okay, yes. We can say we have accounted for it, but what happens after that? Nothing." ~ Product Manager in HPM [PM_04]

"What I see and what I discuss a lot with colleagues is that we as a company underestimate how many aspects a business model affects." ~ VPC Expert [EX_01]

Altogether, this underscores the need for a process that helps explore new CBMs and how they affect and change the organizational infrastructure and processes. This requires a close examination of current practices and their contribution to CBMI.

1.2 Research Questions

This thesis focuses on how OEMs that produce medical consumables can be supported in enabling circular business model innovation with Philips as a case study. Therefore, this project focuses on the following research question:

How can manufacturing organizations be supported in circular business model innovation for medical consumables?

From this perspective, CBMI guides both "what" to design and "how", i.e., new CBM configurations, through an iterative and dynamic approach. For CBMI to be effective, the contextual influence on CBMs (Bocken & Brezet, 2019; Wells, 2016) and the effective CBMI capabilities for the iterative approach (Mezger, 2014) need to be taken into account. To answer the main research question, the following subquestions will be answered throughout this thesis:

1. How are the dynamic capabilities and micro-foundations for CBMI demonstrated in the process of Philips?

Philips's process is examined through the dynamic capabilities framework of Santa-Maria et al. (2022), using interviews, observations, and organizational documents. This empirical perspective is required, because micro-foundations are context-dependent and cannot be deduced from theory alone. By grounding the analysis in empirical data from Philips's practices and processes, the thesis ensures that the proposed solution is both theoretically informed and practically feasible.

2. Which CBMs and their operational mechanisms are relevant for medical consumables?

This sub-question outlines suitable CBMs for medical consumables and their operational mechanisms. The operational mechanisms include the retention loops involved, the R-strategies deployed, and the product lifecycle phase affected. Literature increasingly describes CBM patterns, both in general and in specific sectors. Notable examples are the work of Guzzo et al. (2020) and Pieroni et al. (2020). Nevertheless, no comprehensive overview of CBMs seems to exist specifically for OEMs producing medical consumables. Simultaneously, these frameworks do not clearly link R-strategies to business model patterns and do not reduce conceptual uncertainties among the operational mechanisms. To address these gaps, a literature review of systematic reviews on CBM patterns is conducted and supported by academic and industry expert validation interviews.

3. How can an actionable tool activate dynamic capabilities to support the exploration and development of CBMs?

This third subquestion will combine the insights of the previous subquestion to develop a design solution to support CBM exploration for medical consumables. Accordingly, this question will be addressed by designing and evaluating a solution.

Overall, the first and second sub-questions provide insights into what a solution should include to support the CBMI process effectively. The third sub-question translates these insights into an actionable solution that supports the transition of the existing system to a more circular-oriented system. These relationships are summarized in Figure 1.

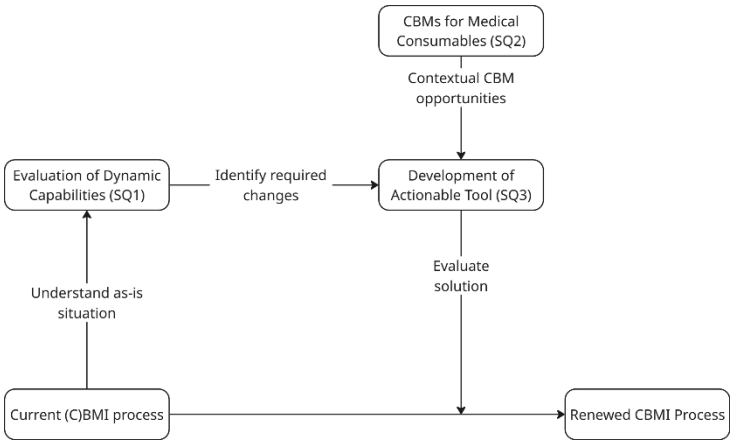


Figure 1 Relationships between the subquestions

1.3 Thesis Outline

With the scope of this thesis defined, Chapter 2 presents the relevant background. This background will focus on the context of consumables, CBMI as a process, and the role of dynamic capabilities. Chapter 3 then elaborates on the applied methodology. Chapter 4 presents the results of the developed CBM typology and evaluation of Philips's process according to the dynamic capabilities framework. In Chapter 5, the developed solution and its evaluation with respect to the research question are discussed. Finally, Chapter 6 summarizes the answers to the research questions, presents the contributions, and discusses the research limitations and future recommendations. Chapter 7 lists the references, followed by the appendices.

2. Theoretical Background

This chapter elaborates on the previously established literature in the field of circular business model innovation (CBMI) and dynamic capabilities. It, therefore, lays the foundation for this thesis and identifies gaps this project could address. The theoretical background will be concluded with a conclusive summary.

2.1 Medical Consumables and OEMs ' Circularity Challenge

As the healthcare industry relies on a wide array of consumables and devices, from blood pressure cuffs to MRI scanners, it is important to clarify how the medical consumables in this thesis are defined. Although the term "medical consumables" is frequently used, there is no ISO-standardized definition.

A working definition can be deduced from definitions of consumables, non-specific to the healthcare industry, and medical devices. Consumables in general refer to products with a short lifespan that, due to the way they are 'consumed', are difficult to recycle or reuse (Willskytt, 2021). This thesis focuses on electronic consumables, such as blood pressure cuffs and pulse oximeters. Therefore, they can also be classified as small medical devices. Medical devices are instruments that serve a diagnostic purpose and are powered by a source other than the human body, and contain electronics (Guzzo et al., 2020; Hoveling et al., 2024). The two previously mentioned examples of pulse oximetry and blood pressure cuffs, respectively, measure a patient's oxygen saturation level in their blood and blood pressure (Duffy et al., 2023; Sanchez et al., 2019). They are both extensions to a patient's bedside monitor and thus serve a supplementary role. These consumables are available in single-patient-use (SPU) and multi-patient-use (MPU) formats. The SPUs resemble the consumable categorization, as low costs, limited use, and a short lifespan characterize them (N. Bocken & Konietzko, 2022; Willskytt, 2021). In contrast, the MPU consumables are designed for reuse and thus to have a longer lifespan. These devices, especially the SPU alternative, are consumed by hospitals in high-volume and generally have a lower financial value (Macneill et al., 2020). Therefore, the thesis adopts the following working definition: medical consumables are small measurement devices that serve a supplementary role to another device, have a relatively low financial value, and are consumed in high volumes.

The healthcare industry has a growing dependence on SPU alternatives (Macneill et al., 2020). This leads to an increase in the already high consumption. Additionally, both alternatives of these medical consumables have mixed material composition, as they consist of, amongst others, plastics, electronics, and elastomers (Guzzo et al., 2020). This leads to both SPU and MPU alternatives being incinerated or landfilled at their end-of-life (Guzzo et al., 2020; Huijben et al., 2025). Consequently, they contribute significantly to waste generation in the healthcare system. As pressure increases to reduce waste in healthcare, medtech OEMs are under similar pressure to differentiate with a more sustainable product offering.

OEMs are challenged in this transition. They operate in a system where production and consumption are designed towards an efficient linear norm. Considering these medical consumables, production processes are designed to maximize throughput, and the existing business model incentivizes high-volume consumption (Macneill et al., 2020). Changing the product, production, and operational processes to incorporate more sustainable practices requires significant investments, which, in combination with the low financial value of these medical consumables, could create a financially unviable situation (Klose & Fröhling, 2025; Uloma Stella Nwabekee et al., 2024). Additionally, more sustainable consumption would entail a reduction of the consumed volume, which conflicts with current business models and risks cannibalization of new sales. The circular economy (CE) is gaining traction as a solution to improve the environmental performance of the healthcare industry, while rethinking how organizations can capture, create, and deliver value within environmental boundaries (Macneill et al., 2020). The subsequent section will elaborate on the circular principles and how the circular economy can be operationalized.

2.2 Circularity Principles and Operationalization

The economic challenge for healthcare OEMs is embedded in the concept of the circular economy and in the principles that form its operationalization. For industry stakeholders, understanding how these circular principles and characteristics translate into practical strategies is crucial for implementing circular business models.

The concept of the circular economy has evolved, resulting in numerous definitions. In general, these definitions embed the idea of an economic system designed to eliminate waste by using renewable materials and keeping materials and products in use at their highest value as long as possible (Ellen MacArthur Foundation, 2025; Huijben et al., 2025). Other definitions underscore different circular characteristics, such as its systemic nature (Brown et al., 2021; Das et al., 2023), the role of business models in creating environmental prosperity and social equity (Kirchherr et al., 2018; Reike et al., 2018), or the maximum use of a product's lifecycle (Centobelli et al., 2020). Altogether, these definitions illustrate how circularity is shaped by the flow of resources, optimal use, maximization of the product's lifecycle, and how this value is captured, created, and delivered through business models. Accordingly, the role of these principles in operationalizing circularity is elaborated. These principles provide a foundation for understanding how the circular economy can be applied to medical consumables.

First, it is examined how resource flows can be shaped to achieve circularity. The mechanisms that describe how resources flow in the system are often referred to as retention loops (N. Bocken et al., 2016). They are commonly categorized as *narrowing, slowing*, and c*losing*. *Narrowing* involves using fewer products, materials, and resources throughout a product's lifecycle. *Slowing* relates to extending the period during which a product, material, or component remains in use. *Closing* emphasizes the reintroduction of waste materials into the economic cycle. This list is later nuanced by Geissdoerfer et al. (2018) with the inclusion of *intensifying* and *dematerializing*. *Intensifying* emphasizes a more intensive use phase. *Dematerialization* involves the digitalization and virtualization of physical assets with software solutions. This introduction of the latter two loops creates a more comprehensive overview and offers opportunities to capture value and reduce material usage in a technology-intensive industry, such as healthcare. Figure 2 compares the loops with the traditional linear resource flow.

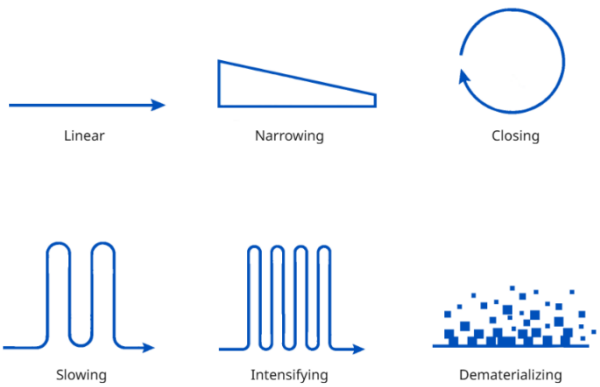


Figure 2 Visualization of the Retention Loops building on Konietzko et al. (2020)

The retention loops remain relatively abstract regarding how organizations can operationalize them. The R-hierarchy framework translates the value retention loops into actionable strategies (Reike et al., 2018). Consequently, these R-strategies elaborate on how the retention loops can be operationalized. Despite this conceptual connection, it remains unclear whether specific retention loops imply specific R-strategies in

their operationalization. This gap may be explained by the substantial variation in the number of R-strategies and ambiguity in their definitions (Reike et al., 2018), which makes it difficult to integrate and define these connections. This indicates a literature gap, which will be addressed by combining the retention loops and R-strategies in the analysis of circular opportunities. To date, the 10R framework offers one of the most comprehensive overviews (Ciano et al., 2025) and will, as such, be referred to when applying the R-strategies. Table 1 lists the 10 strategies and their definitions. Additionally, this 10R framework introduces a hierarchy that categorizes strategies by their environmental yield (Potting et al., 2017). In this case, R0 yields the highest environmental yield, whereas R9 yields the lowest. Hence, this framework not only presents concrete strategies but also guides how to prioritize them within operational activities.

Table 1 10R-strategies and their definitions (Ciano et al., 2025)

R-strategy	Definition
R0 Refuse	Rendering a product redundant by either abandoning its function or replacing it with a radically different product offering the same function. Additionally, refuse can be extended to encompass the rejection of certain materials or production processes, aiming to foster a more circular economy.
R1 Rethink	Re-elaboration and reconceptualization of ideas, dynamics, processes, concepts, uses, and post-uses related to a product to make it use-intensive.
R2 Reduce	Using fewer natural resources results in reduced energy, raw materials, and waste inputs. This concept can also be extended to reducing the overall number of products, such as decreasing car ownership, thereby promoting reuse.
R3 Reuse	Utilizing a product still in good condition for a second or subsequent time, either by another user or owner. In this process, the product continues to serve its original function effectively. A reused product retains both its function and identity intact.
R4 Repair	Repair involves restoring the original function of a defective product and making a broken product operational again by fixing or replacing failed parts. Corrective maintenance is often considered synonymous with repair.
R5 Refurbish	Refurbishing involves restoring an old product and updating it to meet modern standards. It aims to upgrade or modernize the product's functionality. Unlike remanufacturing, refurbishing usually does not entail disassembly; instead, it focuses on replacing parts. Refurbished products are generally improved and restored to meet specific quality standards.
R6 Remanufacture	Incorporating parts of discarded products into a new product with the same function. The process ensures that the remanufactured product attains the quality equivalent to a brand-new one, even when utilizing components retrieved or reclaimed from other products.
R7 Repurpose	Utilizing discarded products or their components to create a new product with a different function. It also refers to reusing a product for an alternative purpose, termed open-loop reuse.
R8 Recycle	Extracting secondary materials from discarded products. Secondary materials may undergo upcycling, a transformation that converts them into materials of higher quality, or in the opposite direction, i.e., downcycling, which occurs in most cases. While upcycling is intuitively the preferable solution due to its higher value, it is not always a feasible solution.
R9 Recover	Incineration of materials with energy recovery. In a broader context, it refers to waste that is not recycled but used as a source of energy or valuable biochemical compounds. Recovery encompasses various conversion processes, primarily focused on organic waste.

Secondly, the lifecycle of a product can be seen as a sequence of phases from product creation to its end-of-life (Islam & Iyer-Raniga, 2023; Montesinos et al., 2024). There are minor differences between the stages considered in the lifecycle. One of the main differences is whether the design phase is included or excluded. This thesis will exclude the design phase, as it focuses on the product's operational lifecycle and its resource flow. Consequently, the lifecycle stages considered are material extraction, material processing, production, distribution, use, and end-of-life. The framework of the value hill connects these lifecycle phases with R-strategies (Achterberg et al., 2016; Huijben et al., 2025). This visualizes which part of the product lifecycle can be affected by the specific R-strategies. Figure 3 visualizes this. On the left side are the lifecycle activities, where each step adds value to the product and increases on the value hill.

During the use phase, the product is at its peak value. The right side of the value hill indicates that the further down the R-strategies, the greater the value lost.

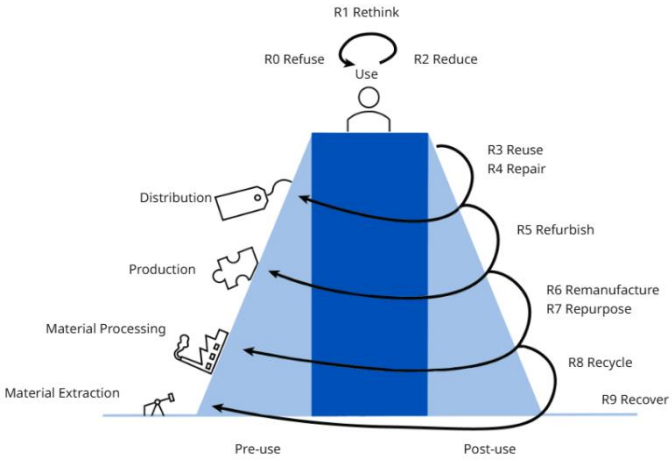


Figure 3 Visualization of the Value Hill and R-strategies (adapted from Achterberg et al. (2016) and Huijben et al. (2025))

Overall, the retention loops, R-strategies, and the lifecycle perspective outline how product and resource value can be retained. CBMs, in their turn, translate and operationalize these mechanisms into the economic system. Hence, CBMs can be defined as the financial and structural framework that defines how organizations create, deliver, and capture by focusing on resource efficiency and extending the product lifecycle (Frishammar & Parida, 2019; Pascucci et al., 2024; Teece, 2010). Circular Business Model Innovation (CBMI) entails the conceptualization and implementation of new CBMs (Geissdoerfer et al., 2023). Research about CBMI can be divided into CBMI as an outcome or CBMI as an activity-based process (Foss & Saebi, 2017). In the following two sections, these two perspectives will be discussed.

2.3 Circular Business Model Innovation as Outcome

CBMI, as outcome, entails new configurations of a business model. Adapting BMs to new configurations is considered essential to sustain competitive advantage (Osterwalder & Pigneur, 2010; Teece, 2010). From that perspective, CBMI not only enables a circular transition but also serves as a strategic activity that improves an organization's market position (Pascucci et al., 2024). Prior research developed taxonomies and typologies to identify the possible CBM outcomes. These types of classifications enable the identification of patterns and relationships and support comparisons and generalizations (Lambert, 2015). Typologies and taxonomies are, therefore, a useful representation of CBMs and their characteristics. A taxonomy is an empirically defined categorization encompassing a wide range of characteristics. Typologies, on the other hand, are simpler and generally deduced from prior research. Typologies hence categorize the possible forms of CBM outcomes, whereas taxonomies observe which CBM forms are present in practice. CBM typologies and taxonomies often classify CBM options into archetypes and types. Archetypes cluster a generic set of underlying mechanisms that group CBM types together (Bocken et al., 2014). CBM types represent a more distinct and specific configuration of the CBM archetype. The operational mechanisms are considered the CBMs applied retention loop, R-strategies, and the affected lifecycle phase.

Examples of these taxonomies and typologies are the research of Lüdeke-Freund et al. (2019), and Pieroni et al. (2020). These typologies range in archetype numbers differs. Lüdeke-Freund et al. (2019) identify 6 main patterns, and Pieroni et al. (2020) identify 20 archetypes. As such, Pieroni et al. (2020) seems to take a more granular perspective towards identifying distinct patterns. This highlights the importance of classifying when a cluster of similar mechanisms is perceived a pattern. Additionally, these typologies and

taxonomies have in common that they are not industry-specific. General categorizations contradict the context-specific nature of circularity (Bocken & Brezet, 2019). This addresses the need for a typology specified in terms of the context it is meant for (Pieroni et al., 2020). There seems to be only a handful of articles that synthesize CBM types and patterns specific to the context of healthcare and manufacturing organizations. Holly & Schild (2025), despite not being a typology or taxonomy, create an overview of CBMs specific to the manufacturing industry. They present 6 CBM clusters: circular inputs and design; product life extension; recycling, recovery, and reverse logistics; resource efficiency and optimization; service-oriented models; and sharing and collaboration. These clusters, however, are not described in terms of their characteristics and operational mechanisms. This list thus provides manufacturers with an overview of which CBM patterns are relevant to their role, but does not provide insights into how these clusters can be implemented.

Guzzo et al. (2020) is an example in which the CBMs are specifically identified for an industry and described with greater operational detail, while additionally not being classified as a typology or taxonomy. Their categorization identifies 9 CBMs for the medical device industry and describes them based on their value capture, creation, and delivery characteristics. The 9 CBM types include: full-care-equipment-as-a-service; in-hospital lifecycle care services; support for hospital-based reprocessing; mobile solutions; platform for device circulation; refurbished system; full-provision of reprocessed devices; end-of-life equipment; and continued collection of disposables. These models, however, are not defined in light of the circular principles of the retention loops, R-strategies, and the affected lifecycle phase. Furthermore, they assign model suitability based on a combination of product value and criticality. This provides practitioners with a guide in identifying a suitable model for their context. However, they introduce multiple different devices matched with specific CBM. This can make it complicated to obtain an overview of all potential suitable CBMs for a specific product group. Comparing the overview of Guzzo et al. (2020) with Holly & Schild (2025), distinct differences are present in the identified CBMs. For example, the overview of Guzzo et al. (2020) does not include the patterns of circular Inputs and design, product life extension, and resource efficiency and optimization. This underscores the need to define a typology of CBM archetypes and types, along with their operational mechanisms, specific to OEMs producing medical consumables. Thus, taking the product, industry, and role in the value chain into account when assessing the applicability of the CBM types.

2.4 Circular Business Model Innovation as Process

This section elaborates on the second perspective of CBMI. The previous section emphasizes the CBM options. However, it does not provide an understanding of how organizations arrive at these CBM conceptualizations or how they adapt them to their existing context. For this research, the perspective of CBMI as a process complements the CBMI as an outcome. This perspective is essential for established organizations. Their existing strategy, structure, processes, and practices create an organizational rigidity that complicates the successful implementation of new CBM configurations (Pascucci et al., 2024; Sousa-Zomer et al., 2018). This is also referred to as the *'incumbent curse'* (Chandy & Tellis, 2000). Baldassarre & Calabretta (2023) frame this from a process perspective, highlighting the design-implementation gap. This is where established organizations in their CBM design process are unable to determine the appropriate configuration between the desired model and their current context.

Therefore, scholars have examined CBMI as an activity-based iterative process (Foss & Saebi, 2017). Two of these examples are the 4-I framework by Frankenberger et al. (2013) and the framework by C. Shalley et al. (2015). The 4-I framework defines an overall process flow: initiation (understanding the system), ideation (generating new ideas), integration (internal alignment of the business model), and implementation (making investments). The framework of C. Shalley et al. (2015) describes a similar process flow: observe, synthesize, generate, refine, and implement. Both frameworks describe CBMI as a staged iterative process, where organizations progressively refine their BM. Earlier in this chapter, the conceptualizations of CBMs

were attributed to retention loops, R-strategies, and the product lifecycle, which together outline the mechanisms by which value can be maintained, extended, or recovered. The introduction of these circularity principles becomes an essential criterion for identifying opportunities and for configuring resources, and thus distinguishing elements between CBMI and BMI.

However, while these frameworks clarify the stages of a CBMI process, they provide limited insights into the specific practices and required capabilities for executing it effectively. Mezger (2014) addresses this gap by introducing the concept of dynamic capabilities (DC) as a foundation to BMI. This combination identifies the stages alongside the required capabilities to create a suitable CBM configuration for implementation. This provides insight into how established OEMs can overcome their organizational rigidity to embed new CBM configurations. Therefore, this thesis adopts an integrated perspective of CBMI and DC. The next section introduces the background of dynamic capabilities and their implications for CBMI research.

2.5 Dynamic Capabilities for Circular Business Model Innovation

Literature underscores the role of dynamic capabilities in the adoption of circular practices and overcoming the sustainability challenge (Bocken & Geradts, 2020; Khan et al., 2020; Scarpellini et al., 2020) This creates flexibility that enables organizations to handle uncertainties while creating organizational commitment to overcome organizational rigidity (Gusmerotti et al., 2019). To elaborate on this perspective, it is important to clarify how dynamic capabilities are conceptualized within CBMI.

Dynamic Capabilities (DCs) build on the Resource-Based View (RBV). The RBV emphasizes how a unique configuration of existing organizational resources and capabilities is a source of competitive advantage (Chari et al., 2022; Teece, 2018). In contrast, DCs underscore that organizational adaptability creates value from new opportunities in emerging in dynamic environments. It supports organizations in remaining adaptable and maintaining their value. A DC is comprised of higher-order capabilities and Micro-Foundations (MFs). Higher-order capabilities are connected clusters of entrepreneurial activities and organizational learning (Mezger, 2014; Teece, 2018). These higher-order capabilities in the perspective of CBMI comprise sensing opportunities, seizing them, and reconfiguring organizational resources and practices. An organization's strength in these capabilities determines how quickly and effectively its resources and business models align with customer needs. MFs specify these capabilities into specific skills and routines and can be defined as ‘best practices’.

There are a handful of articles that describe the DCs and corresponding MFs for CBMI specifically. Khan et al. (2020) and Santa-Maria et al. (2022) are two examples of these articles. One of the main differences between the two frameworks is their unit of analysis. Khan et al. (2020) identifies the MFs for start-ups and recently established organizations, where Santa-Maria et al. (2022) focuses the required MFs for established organizations. This differentiation is important, as start-ups do not face the organizational rigidity that established organizations do in transitioning to circularity. As this thesis focuses on an established organization. Therefore, the framework established by Santa-Maria et al. (2022) will play a more prominent role in this thesis. They present two frameworks: one derived from empirical cases with successfully implemented CBMs and a more comprehensive framework. This comprehensive framework complements the empirical framework with findings from other literature. To evaluate the empirical situation in this case study, the empirical framework serves as the foundation for analysis. This thesis will reflect on the emergent findings, considering the comprehensive framework in the discussion. The higher-order capabilities and MFs of the empirical framework will be discussed below. The structure of this explanation was informed by (Pascucci et al., 2024).

Sensing - Sensing refers to the awareness and understanding of circularity implications and reframing these as potential business opportunities (Bocken & Geradts, 2020; Khan et al., 2020; Santa-Maria et al.,

2022). It requires organizations to collaborate, gain new perspectives, and explore innovative solutions (Bocken & Geradts, 2020; Pascucci et al., 2024). To do so, organizations should develop external sensitivity to leverage opportunities arising from changes in customer and stakeholder needs or exogenous technological developments (Santa-Maria et al., 2022). A holistic and lifecycle perspective is, in turn, required to translate these innovation opportunities into circular opportunities. This allows the organizations to identify opportunities from a cradle-to-grave perspective and connections to the wider environments (Santa-Maria et al., 2022). Organizations should complement these perspectives by gaining new knowledge and implementing established sustainability frameworks, such as the Sustainable Development Goals (SDGs). This new knowledge assists in turn with the creation of new or the improvement of existing offerings. Sustainability frameworks guide and manage the sustainable impacts. The sensing capability thus embodies practices for deriving changes from the external environment while activating internal knowledge and frameworks to translate them into circular opportunities.

Seizing - Seizing within CBMI refers to the translation of the identified opportunities into the mobilization of resources and value capture into a CBM (Teece, 2018). To reap value and benefit from the identified opportunities, the organization should develop initiatives, structures, and procedures (Kaur, 2023) , such as fostering a sustainability-innovative culture, establishing clear sustainability strategies and goals, and providing employee education (Santa-Maria et al., 2022). These procedures and structures allow the organization to integrate social and environmental factors as a focus point in their propositions to develop circular business models and solutions. Due to the systemic nature of circular solutions, an additional MF underscores collaboration among internal and external stakeholders and customers early in the process (Santa-Maria et al., 2022).

Reconfiguring – Reconfiguration, also referred to as transformation, includes adaptation of organizational routines, resources, and capabilities (Teece, 2018) and the implementation of new CBMs (Bocken & Geradts, 2020). The implementation of new CBMs requires an organization to prioritize projects that align with its (in)tangible assets. When a gap remains in this alignment, the organization should focus on acquiring resources and capabilities that enhance value (Santa-Maria et al., 2022). Upholding this flexible behaviour in implementation becomes key to quickly adapting and reducing uncertainties and risks. Furthermore, it is critical to ensure factual, transparent external communication to build trust and engagement among stakeholders in the system. This is especially relevant for established organizations to prevent the perception of greenwashing or misleading suggested impacts (Santa-Maria et al., 2022). Ecosystem orchestration skills are required to identify, manage, and coordinate strategic partners to operationalize the new model. Internal leadership is a critical success factor for innovation as they provide the resources needed or guidance to implement the required organizational change.

The above-described MFs and practices, which together present the empirical framework of Santa-Maria et al. (2022), are summarized in Table 2.

Table 2 Dynamic Capabilities, Micro-foundations, and practices as identified by Santa-Maria et al. (2022)

Dynamic Capability	Micro-foundation	Practice, routines or skills
Sensing	External Sensitivity	• Understanding the needs of customers and key stakeholders • Being open to external support • Leverage developments of exogenous science and technology
	Knowledge Creation	• Undertaking R&D activities
	Adopting a Holistic Perspective	• **Adopting a lifecycle perspective** • Adopting a systemic perspective
	Use of Sustainability Instruments	• **Implementing environmental management tools** • Guidance from sustainability frameworks
Seizing	Delineating sustainable solutions and business models	• **Ideating and developing value propositions with environmental and/or social impact** • Designing and implementing the (sustainable/circular) business model • Generating business model architectures that can transform socio-technical systems
	Stakeholder engagement & collaboration	• **Engaging strategic partners in collaboration and co-creation** • Engaging customers early in the innovation process • Engaging an interdisciplinary team to participate in the innovation process
	Supporting sustainability & innovation culture	• Articulating a clear and ambitious sustainability vision • **Developing a sustainability strategy and culture**

		• Developing and supporting an innovation and continuous improvement culture • Educating workers in sustainability and empowering them to propose innovations
Reconfiguring	Co-specialization of assets	• Prioritizing projects that fit existing organizational capabilities and resources
	Organizational flexibility	• Implementing experiments/pilots to validate, learn, and adapt quickly • Build decentralized innovation teams and allow flexible organizational structures
	Trust-building communication	• Having a fact-based, consistent, and transparent external communication
	Ecosystem Orchestration	• **Skills to integrate stakeholders and coordinate partners in the business ecosystem**
	Leadership & Change Management	• Commitment and support from top management (key role of leadership) • Proficiency at organizational change management • Implementing specific sustainable and circular KPI's

(Practices in **bold** are the practices required for successful CBMI as defined by Santa-Maria et al. (2022)

Their framework encompasses a combination of practices common to BMI and those specific to CBMI. This implies that, in order to advance CBMI, the more 'general' BMI practices need to be in place. Their framework identifies 6 critical practices for successful CBMI: (1) adopting a lifecycle perspective, (2) implementing environmental management tools, (3) ideating and developing value propositions with environmental and/or social impact, (4) developing a sustainability strategy and culture, (5) engaging strategic partners in collaboration and co-creation, and (6) integrating stakeholders and coordinating partners in the business ecosystem. As such, Santa-Maria et al. (2022) suggest these practices should receive priority in organizations engaging in CBMI. Additionally, they emphasized the following practices to achieve short and medium-term loops: engage more with customer early in the process; understand the needs of key stakeholders; performing experiments; and promoting an innovation culture. The practices for focusing on longer-term loops: engaging in strategic partnerships; effective coordination of business ecosystem; open for external support; fact-based information.

Santa-Maria et al. (2022) prioritizes these practices from the perspective of creating effective CBMI. These six practices are still a combination that could be equally relevant for BMI outside the circularity context. This thesis, therefore, classifies these practices as critical CBMI practices and assumes that CBMI-specific practices are those that introduce sustainability/circularity elements. An example is implementing *sustainable and circular* KPI's.

These frameworks are a good basis for evaluation existing processes and identifying areas for improvement and (Klitsie et al., 2018). However, they remain relatively abstract in how organizations can improve on the missing capabilities. This creates an opportunity to explore how the dynamic capabilities can be applied in an actionable manner and directly influence CBMI through for example a tool.

2.6 Conclusion

This Chapter illustrated how OEMs face economic challenges in improving the sustainability of medical consumables. Transitioning to the circular economy would overcome this challenge. Despite the existing literature on CBM archetypes, CBM types, and operational mechanisms, there is a gap for a contextualized typology tailored to OEMs producing medical consumables. Simultaneously, defining new CBM opportunities is an iterative process that requires organizations to adjust and adapt their capabilities. The integration of the dynamic capabilities into the CBMI concept, therefore, creates a foundational perspective of the process and the required capabilities to create new CBMs. There is an opportunity to explore how DC can be applied in an actionable manner in the context of CBMI. The next Chapter will introduce the methodology that is used to address the defined challenge and gaps.

3. Methodology

This chapter discusses the applied methodology to answer the main research question. The general approach of this project is discussed. Followed by the specific applied techniques and their implications for data reliability and validity.

3.1 Research Approach

The goal of this thesis is to investigate how medtech OEMs can be supported in CBMI for medical consumables. This goal requires generating both contextual knowledge and a design solution, and as such, a Design Science Research (DSR) approach is combined with a single case study at Philips. Contextual knowledge is a prerequisite to identifying meaningful intervention opportunities, due to the context-specific nature of CBMI (Bocken & Brezet, 2019). This combination approach allows for identifying what should be designed by (1) synthesizing and classifying CBMs, and how by (2) evaluating the CBMI process with a dynamic capabilities perspective, and (3) designing and evaluating a design solution that operationalizes the missing micro-foundations. Capturing these insights into a solution design equips OEMs with actionable, practical, and repeatable means to perform CBMI.

The applied DSR approach in this study follows the DSR cycle by Keskin & Romme (2020), which describes an iterative, simultaneous approach to analyzing theoretical and empirical data. This approach allows solving complex field problems by sensemaking through prior established theoretical knowledge. Therefore, this cycle bridges theory and practice. This is deemed suitable for CBM challenges as they are complex challenges. Here, theory can create conceptual clarity, and practice is required to make it applicable to a context. The DSR cycle follows four stages. The process is initiated with exploration. Here, the scope and the boundaries of the field problem are defined through developing a thorough understanding of the problem context. The synthesis stage involves sensemaking of underlying factors influencing the problem and the establishment of design requirements through abductive analysis of the collected data. These design requirements and insights are applied during the creation phase to develop a solution to achieve the desired outcome. In the final stage, evaluation, this solution is assessed for its pragmatic and theoretical value.

The empirical data collection and analysis were based on a single case study with Philips. This leads to rich contextual insights, which are deemed valuable for research where the contextual conditions are an important determinant in the research process (Hunziker & Blankenagel, 2021). As is described, this is the case with circularity. This project, therefore, chooses depth over breadth. The case study focuses on the business modelling process of the HPM business unit within Philips. The use of multiple qualitative data sources supported triangulation in this study and enriched the data analysis by providing different perspectives (Yin, 2018). The following data sources were used based on their availability and applicability: interviews, organizational documents, and direct observations.

To strengthen the findings of this single-case study, the study applied abductive reasoning logic. The collected data was thus analyzed using a prior established theoretical framework, while remaining open to emerging context-specific patterns (Dubois & Gadde, 2013). Integrating theoretical data in this abductive analysis strengthens the external validity of the insights of a single case study (Yin, 2018). The literature provides additional grounding and explains empirical patterns through established theoretical mechanisms.

The described stages of the DSR cycle (Keskin & Romme, 2020) serve as a guide for gradually developing an understanding of the real-world business modelling process and for designing a CBMI-supportive solution. Figure 4 presents the research process. Exploration began by getting acquainted with Philips's processes and defining the business modelling process. Observing the process through desk research, on-

site visits, and project observations provided situated, real-time insights that were integrated with experiential and contextual insights from interviews. This integration created methodological triangulation and an encompassing understanding of the empirical situation. The application of visual mapping techniques (Langley, 1999) supported the externalization and structuring of the problem context and framed the experienced challenges in the BMI process.

The synthesis phase aimed to identify patterns in the challenges and process dynamics experienced, as well as in the circular performance of the business modelling process. Additional interviews were held and the project observations continued. The collection of established theoretical patterns on CBMI challenges assisted in the interpretation and synthesis of the empirically gathered process data of Philips. Later, this data is evaluated against the empirical framework of Santa-Maria et al. (2022) as described in Section 2.5. This phase concluded with a set of design requirements. The goal of the creation phase was to translate the design requirements into a design solution that supports CBMI within Philips. The design process was supported by literature and feedback from Philips representatives to ensure effectiveness and alignment with the context of med-tech OEMs producing medical consumables. This led to the creation of a collaborative workshop with corresponding digital templates (prototype) as the design solution. The evaluation phase iteratively supported the creation stages. Intermediate feedback from Philips supported refinement of the design solution. During this feedback, the concept was discussed, and Philips shared its perspective on the design's fit within the organization. More elaborate testing, including a concept test and a user test, evaluated how well the designed solution met the set goals and requirements, and provided feedback for further development (Venable et al., 2016).

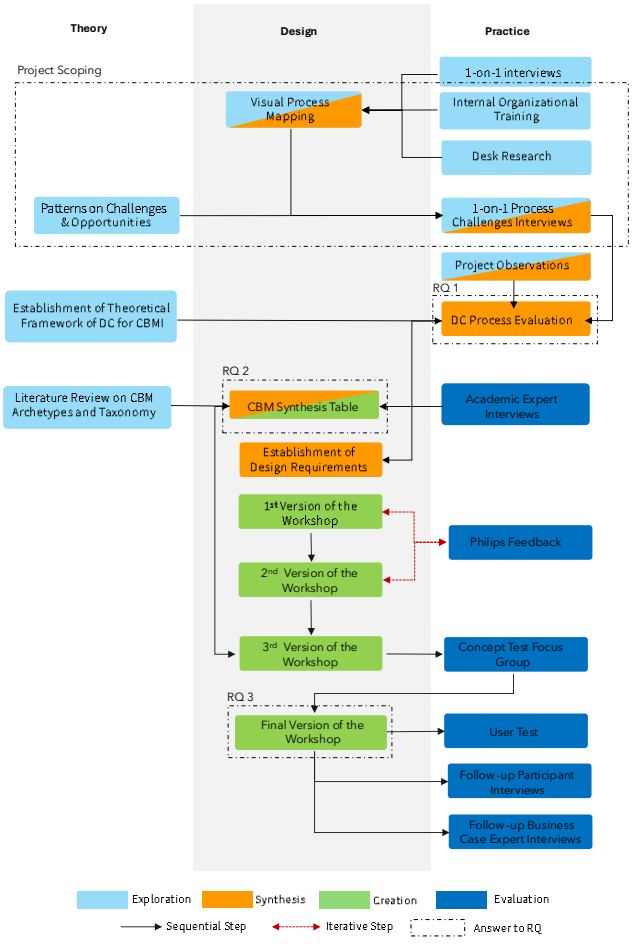


Figure 4 Process Flow of the Research Activities

3.2 Empirical Setting

This study is conducted within the ESCH-R consortium. ESCH-R refers to 'Evidence-based Strategies to create Circular Hospitals: Applying the 10-Rs framework to healthcare' (*ESCH-R*, n.d.-a). This consortium is an interdisciplinary project between academia and industry aimed at accelerating the transition from a linear to a circular healthcare system. The industry partners consist of organizations that collectively represent stakeholders across the product value chain, including medtech OEMs. ESCH-R focuses specifically on medical consumables. Consequently, ESCH-R brings together the relevant stakeholders and knowledge to explore how the economic challenge of circularizing medical consumables can be overcome through practical interventions.

The case study was conducted at Philips, an industry partner within ESCH-R. This case study enables an in-depth exploration of the defined challenge in practice and evaluation of the developed intervention in a real-world context. Philips, as an established medtech OEM, demonstrates routines, practices, and experienced challenges that characterize established OEMs undertaking the circular transition. Therefore, Philips is a clear representative case for established medtech OEMs. The unit of analysis is the business modelling process within the Hospital Patient Monitoring (HPM) business unit. This business unit is responsible for medical consumables, such as pulse oximetry sensors and blood pressure cuffs, and therefore aligns with the product group this thesis focuses on.

The case study resulted in close collaboration with Philips and being on-site at the offices on the High-tech Campus, 3 to 4 days a week. This granted access to internal documents, enabled connecting with potential interviewees, facilitated interesting interactions with employees, and allowed real-time observation of CBM(I) practices (Yin, 2018). As such, it created an information-rich real-world environment for the case study, which supported the depth of the findings. Additionally, considering the DSR approach, Philips was a practical environment for developing and evaluating the solution design within a real business modelling process.

3.3 Data Collection

This section presents how the data in this study was collected. CBMI is defined by organizational norms, the interpretation and capabilities of employees, and collaboration between stakeholders (Antikainen et al., 2017; Geissdoerfer et al., 2023), making it a complex social process. Therefore, this study needs to understand the contextual dynamics, the underlying tacit knowledge, and *how* these enable CBMI. This is best captured through qualitative data (Yin, 2018). This qualitative data is collected through interviews, observations, organizational documents, and later user testing. Each technique is discussed in more detail below.

Interviewing – Interviewing produces rich, detailed data drawn from the accumulated knowledge and experience of the interviewees (Castillo-Montoya, 2016; Yin, 2018). Interviews are thus able to capture the tacit and experience-based knowledge and contextual dynamics underlying CBMI. Therefore, it serves as the primary source of data collection. However, because it relies on personal perceptions, this technique is prone to bias (Yin, 2018). This study aimed to mitigate this bias by creating clear, reliable interview protocols and by including interviewees with diverse relevant backgrounds. The interview scripts are created following the example of Castillo-Montoya (2016). Castillo-Montoya presents a framework for systematically aligning the interview protocol with the review questions. Following this example ensures that the collected data fits the research questions. In total, this study included 21 semi-structured interviews, of which 12 were conducted during the exploration and synthesis phase and 9 during the evaluation phase. The creation and evaluation phases overlapped. The initial evaluation episodes supported refinement of the workshop and the prototype, which was used during the final evaluation. Furthermore, during the creation phase, informal conversations were held with supervisors and product

managers from Philips to tailor the concept of the workshop. Table 3 provides an overview of the interviewees and their corresponding IDs. These IDs are used throughout the thesis to identify illustrative quotes.

Table 3 Overview of the Interviewees

Exploration & Synthesis		**Evaluation**	
Interviewee ID	**Job Role**	**Interviewee ID**	**Job Role**
PM_01	HPM Product Manager	AC_01	CBM Academic Expert
PM_02	HPM Product Manager	AC_02	CBM Academic Expert
PM_03	HPM Product Manager	AC_03	CBM Academic Expert
PM_04	HPM Product Manager	AC_04	CBM Academic Expert
EX_01	Value Proposition Creation Expert from Innovation Management team	AC_05	CBM Academic Expert
EX_02	Business Case Expert from Innovation Management team	PC_01	CBM Industry Expert
EX_03	Circularity and Sustainability Expert from Group Sustainability Office	US_01	User test participant Product Manager
EX_04	Sustainability Consultant from Innovation Management team	US_02	User Test participant Product Manager
EX_05	Portfolio Management & Governance consultant from Innovation Management team	EX_02	Business Case Expert from Innovation Management team

The exploration and synthesis interview scripts were developed to answer the initially framed sub-section: *What is the current status of the business modelling process within Philips?* Therefore, the topics presented in Table 4 focus on the 'as-is' practices, experienced challenged, and foreseen opportunities to improve CBMI. However, through the reframing of the theoretical framework (as will be described in Section 3.4), this data is later used to answer the subquestion: *how are the dynamic capabilities and micro-foundations for CBMI demonstrated in the process of Philips?*

Table 4 Overview of the Topics covered in the Interview Scripts

	Topic	**Script 1**	**Script 2**	**Script 3**
1	The current organization of the new product development process	X		
2	The current organization of the business model development process	X		
3	The relationship between the product development and business model development processes.	X	X	
4	Current business model of medical consumables		X	
5	The product lifecycle of medical consumables		X	
6	Existing circular business model support/thinking in the processes	X	X	X
7	Experienced challenges in circular business model development		X	X
8	Future circular ambitions within the modelling processes			X
9	Foreseen opportunities that can support circular business model development.		X	

(x = indicates the presence of this topic in the questions of the interview scripts; script 1 = Philips process introduction; script 2 = product managers; script 3 = experts)

Interviewees were identified using availability and criterion sampling and selected based on their job descriptions and roles in the business modelling process. The selected interviewees consisted of three types:

1. **Product Managers** are responsible for the upstream activities of a specific medical consumable, e.g., SpO2 or ECG leads. They are the main responsible employees and drivers in the business

modelling process for these products and, due to their influential role, provide a critical, in-depth perspective on the current process. All interviewed product managers were part of the HPM business unit and thus operating with consumables.

2. **Innovation Consulting Experts (Value Proposition, Business Case, Portfolio Management)** support business units and their teams in developing new products at different levels. Employees with expertise directly involved in the business modelling process (value proposition, business case, portfolio management) have broader experience of the process than product managers. As they experience the process across different business units and projects. This broader experience provides a more generalizable perspective on the process at Philips and potential lessons from other successful projects. These employees were part of the Innovation Management team, which provides strategic support to business units seeking support, among other things, with the product development process.

3. **Sustainability and Circularity Employees** focus on improving and supporting the sustainability and circularity activities within Philips. They provide the perspective of the current circularity initiatives and inclusion within Philips's processes. One interviewee stemmed from Group Sustainability Office, which is the central team responsible for the organizational sustainability strategy, roadmap, KPIs, and keeping track of the targets and progress in these goals.

As Table 4 illustrates, the interview scripts were tailored towards the introduction of Philips's process, product managers, and the Innovation Consulting and Sustainability employees. The full three scripts are presented in Appendix A.

During the evaluation phase, two additional interview rounds were performed. The first round supported the answer to the subquestion: *Which CBMs and their operational mechanisms are relevant to medical consumables?* Through these interviews, the developed typology was validated, and its applicability in the context of medical consumables and healthcare was examined. The interviewees consisted of academic experts with prior research in the field of CBMs. As such, the interviewees would be able to evaluate the typology's completeness and accuracy. These academic interviewees were identified through their published work and selected based on their availability. Due to the limited research on CBMs in healthcare, not all interviewees had experience with the healthcare industry. Therefore, an industry expert was included. This industry expert was a sustainability and circular economy manager from Group Sustainability Office and a business partner for the HPM business unit. All interviewees received the same typology prior to the interviews and were interviewed following the same script. Table 5 presents the topics included in the interview script. The interview script is presented in Appendix A.

Table 5 Topics Addressed in the Table Validations Interviews

	Topic
1	Completeness of the typology
2	Accuracy of the typology
3	Applicability of the archetypes and CBM types to the context

The second round supported the evaluation of the designed workshop and thus answered the subquestion: *How can an actionable tool activate dynamic capabilities to support the exploration and development of CBMs?* This last set of interviews was targeted to deepen the understanding of the participants' experience of the workshop and to refine the assessment of the workshop's fit within Philips's processes. The interviewees consisted of two user test participants and the previously interviewed business case expert. Because the interviewees addressed the strong connection between the business case and the business modelling activities, the business case expert was selected to evaluate the fit with these existing practices. The interviewees were selected based on their availability. The interview scripts were tailored to the

interviewee type. Table 6 presents the topics included and their representation in the interview scripts. These interviews were conducted one month after the user test. This time break was created for a temporal distance to explore how the workshop affected the progression of the discussed concept and their understanding of CBMI.

Table 6 Overview of the Topics Covered in the Evaluation Interviews

	Topic	Script 1	Script 2
1	The outcomes and added value of the workshop	X	
2	Relevance and feasibility of the included CBMs	X	X
3	Support in CBM development	X	X
4	Educational effect on CBM topics	X	
5	Influence on strategic thinking in product development	X	
6	The organizational fit of the workshop with Philips's processes.	X	X
7	Future use and recommended adjustments to the workshop.	X	X

(x = indicates the presence of this topic in the questions of the interview scripts; script 1 = user test participant; script 2 = business case expert)

All interviews lasted approximately 1 hour and were recorded. Based on the interviewees' preferences, the interviews were held either online via Microsoft Teams or in person at the office in Eindhoven. The recordings were transcribed using Microsoft Teams and Word, and the transcripts were manually checked for accuracy.

Observations - The interviews were supported by direct observations of two product managers, who collaborated on a project at the current stage of value proposition creation. These observations provide an opportunity to support the interviews with real-time findings and to observe the actual process and behaviour (Busetto et al., 2020). The observations were made over a 5-month period. These observations consisted of weekly check-ins with the two HPM product managers and meetings with the support team on refining the product concept. The product managers used these check-ins to discuss project progress, decide on next steps, and refine and detail the project. An example of their activities was by evaluating different scenarios in the business case template. The support team included product managers, design directors, a senior scientist, and a research product manager. Field notes for planned observations were collected using the template in Appendix B. Ad hoc field notes were collected manually. The notes focused on describing the product concept, the activities performed, the considerations, and the team's collaboration. The template concluded with a summary of the key points. During the user test, notes were taken on participants' behaviour interacting with the workshop material and activities, and their main discussion topics.

Organizational Documents – Internal documents were retrieved to contextualize the business modelling activities and processed within Philips. These documents included internal presentations, VPC and business case templates, guides and training materials, process frameworks, and business model-related materials, such as intranet pages providing background information. They were provided by employees or accessed through internal platforms. The documents were reviewed and analyzed based on their content, and supported the triangulation of the interview data (Yin, 2018). They were reviewed based on the content they provided, their purpose, and their relationship to the process. By validating the practical use of these documents in the interviews and visually mapping these tools and processes onto the visual map, gaps and emphasis in the process could be identified. This visual map is presented in Appendix C, and this process will be elaborated in Section 3.4.

Workshop Evaluation - the developed workshop is evaluated formatively and summative. As Figure 4 shows, there is some overlap between the creation and evaluation phases. Therefore, the first evaluations also led to direct improvements and refinements in the workshop. The workshop has low social and technical risk and uncertainty, as the prototype is simple and draws on identified skills and thus has a

limited risk of not aligning with the user. Therefore, a 'quick and simple DSR evaluation strategy' was applied, as suggested by Venable et al. (2016). As such, the evaluation consisted of a few formative evaluations and one main evaluation episode including a summative evaluation. The formative evaluations consisted of feedback sessions on early workshop ideas and designs, clarity of the questions and text in the developed workshop material (the Miro board), and exercises. This was concluded by a bigger formative evaluation through an exploratory focus group. The final summative test was performed through a naturalistic user test (Venable et al., 2016).

A more elaborate evaluation instance in this process was an exploratory focus group (Tremblay et al., 2010). This exploratory focus group enabled the identification of areas for improvement in the design of the workshop and its prototype. It additionally provided exploratory insight into whether the workshop held the potential to support CBM design. Therefore, this focus group was performed halfway the creation phase to inform the final creation steps. The focus group was performed with four participants, listed in Table 7. The focus group lasted 1.5 hours, in which the participants performed the exercises of the workshop and engaged in a group discussion afterwards. The main goal was to gain inspiration for improvements and to determine whether the design was heading in the desired direction. As such, the participants should be sufficiently diverse to generate creative ideas (Tremblay et al., 2010), while remaining sufficiently representative of the eventual target group to ensure that the improvements align with them. Therefore, the participants were selected based on their background and availability: a product manager for experience in the business modelling process, sustainability employees for their experience with existing circularity support tools andc alignment with sustainability goals and practices in the organization, and an operations employee for the inclusion of a more interdisciplinary perspective (similar to the core team). The session concluded with a group discussion of their experiences with the exercises regarding usability, clarity, fit within Philips, and support for CBM exploration.

Table 7 Overview of the Testing Participants

Focus Test		**User Test**	
CT_01	Concept Test Participant Product Manager	US_01	Product Manager HPM
CT_02	Concept Test Participant Innovation Engineering circularity and sustainability consultant	US_02	Product Manager HPM
CT_03	Concept Test Participant Innovation Engineering sustainability business analyst	US_03	Product Manager HPM
CT_04	Concept test Participant Innovation Engineering Operations Consultant	US_04	Strategic Initiatives Lead

A concluding naturalistic user test (Venable et al., 2016) was conducted to evaluate whether the workshop achieved the expected and desired outcomes. A naturalistic test involves evaluating the design solution in a real environment, without control over potential confounding variables (Venable et al., 2016). Accordingly, the test was conducted with a recently established project team that was in the process of defining the business model for a new consumable offering. This real-world context setting improves the knowledge outcome and the evaluation of the workshop's effectiveness in practice (Venable et al., 2016). Four participants were selected for the test based on their participation in the support team of the project and availability. The user test lasted 3 hours and was concluded with a survey. Despite the small number of participants, this survey remains a useful method for generating exploratory insights and refining recommendations (Anderson & Lightfoot, 2022). The survey consisted of 15 items and focused on usability, clarity, perceived support in CBM exploration and development, and suggested areas of improvement of the workshop and its exercises. The survey is presented in Appendix D. The focus group was followed by 3 additional in-depth interviews to deepen insights into the workshop's effects and experiences and to validate its fit within Philips. This led to further recommendations.

3.4 Data Analysis

This subsection elaborates on the data collection by presenting how the data is analyzed and further applied in the process.

Visual Mapping – The collected data on processes within Philips, the involved stakeholders, and the sustainability guidance were mapped visually. This supports a shared understanding of the process and interdependent system elements, and the identification of intervention areas (Langley, 1999; Nielsen et al., 2024). It allows for a gap analysis. This was deemed necessary given the complexity and scale of Philips's processes. A visual map was created through interviews, organizational documents, and the performance of business modelling associated training, as such, triangulated data. The visual map was evaluated and adjusted three times through interviews with two product managers, who are the primary stakeholders in the business modelling process. The final visual map is presented in Appendix C.

Interview Coding – The exploration and synthesis interviews were coded following the abductive systematic logic of Dubois & Gadde (2013). Abductive coding is a combination of codes derived from literature and emerging codes. This combination is critical to support the external validity of a single case study (Yin, 2018). As mentioned previously, the interviews were initially analysed based on established barriers and opportunities, which highlighted a potential gap in capabilities. This informed the redirection to the dynamic capabilities perspective. Consequently, the empirical framework of Santa-Maria et al. (2022) was used to re-evaluate the transcripts. This confirmed the presence or absent of the defined practices and uncovered new influential practices from Philips's process. The final codes are presented in Figure 5. The practices visualized in bold are the emerging codes added. The evaluation was supported by observations, organizational documents, and additional validations. This validation was performed with a product manager and a sustainability employee to clarify remaining uncertainties in the evaluation. This supported an accurate representation of the practices after the redirection of the theoretical framework.

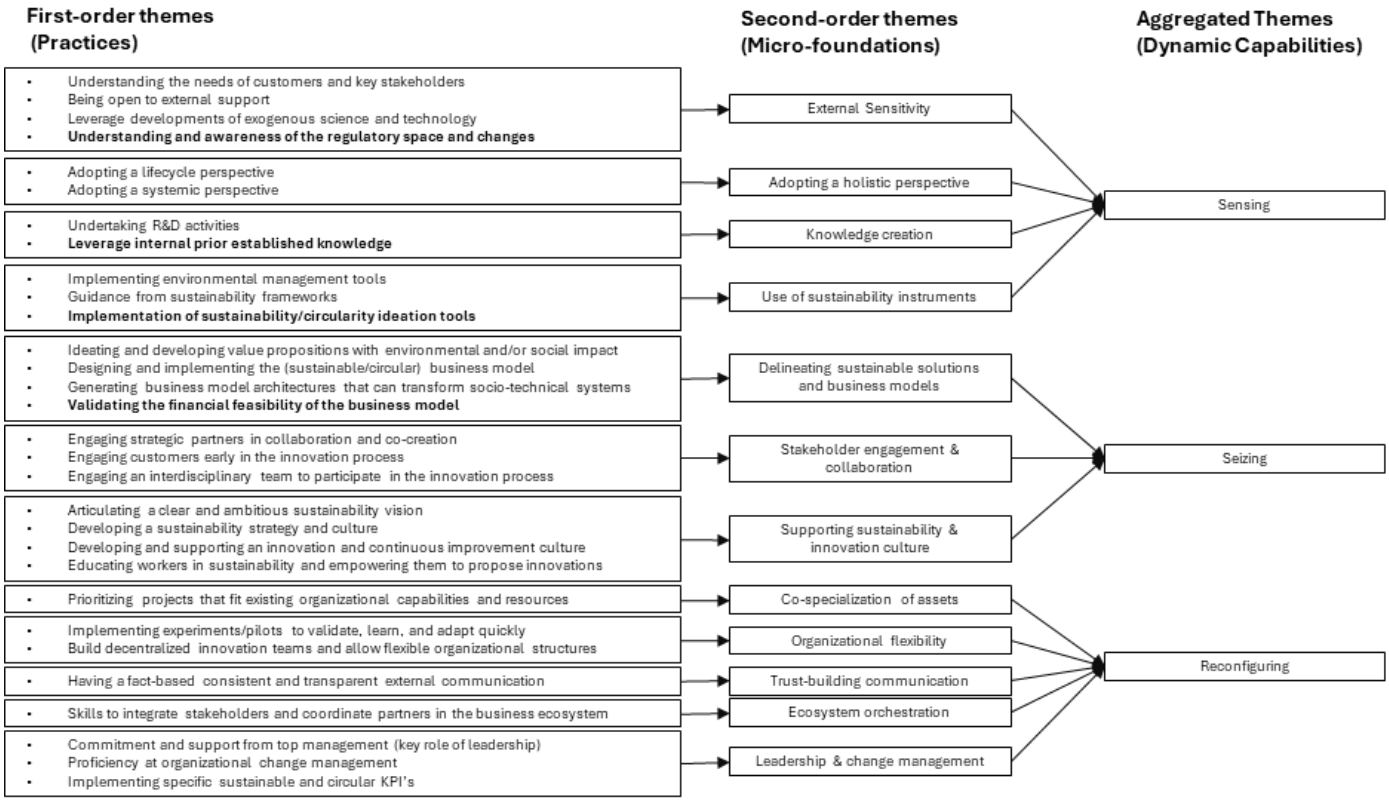


Figure 5 Coding Scheme Dynamic Capabilities (adapted from Santa-Maria et al. (2022))

The expert interviews were analysed in light of the evaluation criteria for the table. The evaluation themes are presented in Table 8. This led to an overview of the perceptions and suggested changes on the overall typology and the specific CBM archetypes and types.

Table 8 Overview of Evaluation Themes for Expert Interviews

	Evaluation Themes
1.	The made typology – *Perceptions on the included models, categorization*
2.	The labelling – *Perceptions on the assigned retention loops, R-strategies, and lifecycle phases*
3.	Completeness – *addressing missing models or archetypes*
4.	Accuracy- *correct descriptions*
5.	Applicability of the models and archetypes to the context.

Additionally, the qualitative answers of the survey and the transcripts follow-up interviews were analysed according to the criteria presented in Table 9. Functional criteria were mainly assessed through the survey.

Table 9 Overview of Evaluation Themes User Test interviews

	Evaluation Themes
1.	Added value of the workshop
2.	Relevancy of the included CBMs
3.	Support on circular opportunities identification
4.	Influence on capability development
5.	Fit within the organization
6.	Influence on the understanding of CBM design and implementation
7.	Recommendations for the workshop

The coding process during the exploration and synthesis phases was performed manually with support of NVivo. Due to a switch in licenses, the later interviews were coded using MaxQDA. All coding was performed twice to ensure analytical rigor.

Literature Review – An initial exploration of the literature on CBMs revealed that there exist about 8 systematic reviews of CBMs. To develop the CBM typology for medical consumables, these existing systematic reviews were synthesized into an initial typology. Appendix E presents a comprehensive list of the articles used and their contribution to the typology. The archetypes, models, and definitions reported across these articles were collected in Microsoft Excel. Here, the archetypes and models were categorized using colour coding and comparison criteria. The goal of this synthesis was to distill conceptually distinct patterns of CBMs. The comparison criteria are presented in Table 10.

Table 10 Evaluation Criteria of the CBM Archetypes and Types

	Criteria
1	The archetype or model should be mentioned at least twice.
2	An archetype or model cannot be one of the R-strategies or retention loops.
3	Archetypes and models should be relevant to the context of a medical technology OEM.
4	The archetypes and models should be conceptually distinct.

After the synthesis of the archetypes and CBM types, the typology was elaborated with their applied operationalization mechanisms: value creation, delivery, and capture, retention loop, R-strategies, and lifecycle phases. Additional literature was used to identify these relationships. These are presented in Appendix E as well. Due to the lack of articles specific to the context of medical consumables and OEMs, the applicability was primarily derived from the judgment of the experts.

4. Results

This Chapter addresses the first and second sub-question. Section 4.1 evaluates Philips' business modelling process according to the framework of Santa-Maria et al. (2022) and thus assesses the presence of dynamic capabilities. Section 4.2 presents the potential CBMs and their characteristics for medical consumables.

4.1 Dynamic Capabilities within Philips

This section presents the evaluation of the business modelling process with respect to dynamic capabilities (DC). The micro-foundations (MF) are the practices, routines, and knowledge that ideally occur within a CBMI process. As addressed previously, these are derived from the empirical framework of Santa-Maria et al. (2022). This analysis provides a strategic evaluation of process improvements. Appendix F presents the comprehensive table of all capabilities and practices with corresponding evidence.

4.1.1 Overview of the Dynamic Capabilities Assessment

This subsection presents how the higher-order DC are represented in the business modelling process and operational practices. This overall assessment identifies CBMI strengths and gaps in the product development process and provides the foundation for a more detailed examination of the MFs in terms of associated practices. Through interviews, observations, and organizational documents, a comprehensive overview of the practice was developed. Appendix F presents an elaborate table presenting the complete evaluation along with the additional evidence, quotes, and the sources from which the evidence was derived

Figure 6 presents how the higher-order DCs are represented in the steps of the product development process. This figure presents a simplified version of the business modelling process described in the introduction and presented in Appendix C. The three colours indicate how the different capabilities are represented in the process. This shows that the value proposition templates align with the different capabilities. Some templates contain elements of multiple capabilities. This is indicated by the small overlap in the colours. The process is depicted in a relatively linear manner. In practice, this process is iterative, and product managers take different approaches to completing it. Consequently, some MFs across different DCs and associated practices occur simultaneously rather than in the presented sequence of sensing, seizing, and reconfiguring.

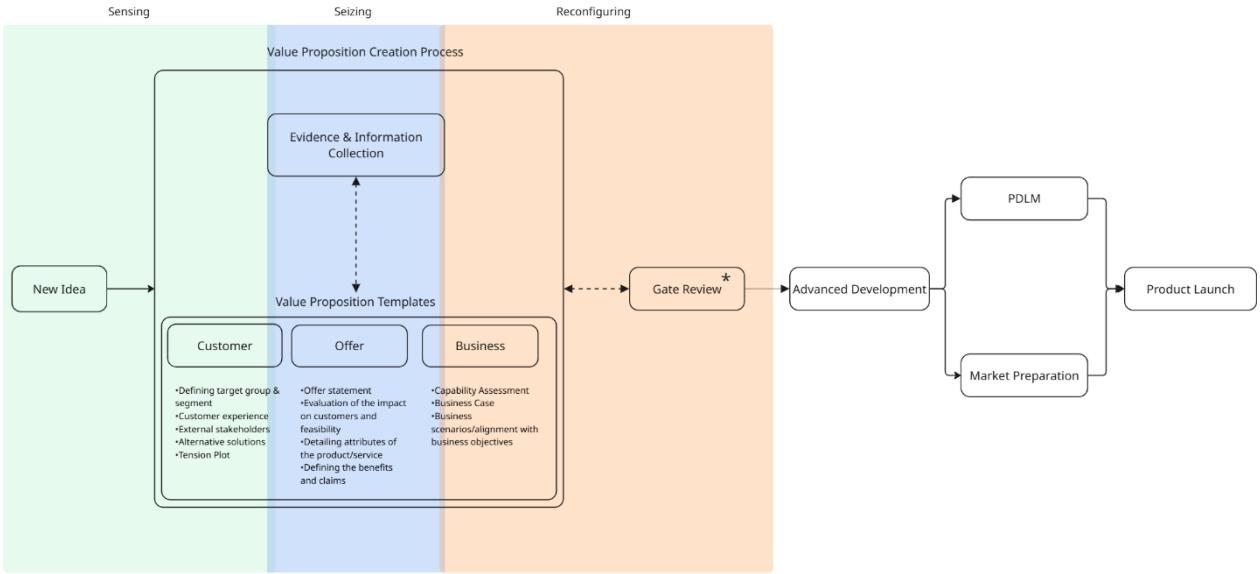


Figure 6 Representation of the Dynamic Capabilities in Philips

Additionally, MFs associated with strategy, culture, and change management might not be connected to a specific practice in the process, but to a more overarching activity or presence in the organization. Table 11 presents the MFs representation. This representation shows that *adopting a holistic perspective* and *leadership and change management* are underdeveloped (~), and *delineating sustainable solutions and business models* is absent (x).

Table 11 Overall Assessment of the Dynamic Capabilities

Capability	Micro-foundation	Presence
Sensing	External sensitivity	✓
	Adopting a holistic perspective	~
	Knowledge creation	✓
	Use of sustainability-oriented instruments	~
Seizing	Delineating sustainable solutions and business models	x
	Stakeholder engagement & collaboration	✓
	Supporting a sustainability & innovation culture	✓
Reconfiguring	Co-specialization of assets	✓
	Organizational flexibility	✓
	Trust-building communication	✓
	Ecosystem orchestration	✓
	Leadership and change management	~

(Presence: ✓ = present, ~ = partially present, x = absent; DC and MF are derived from Santa-Maria et al. (2022))

This table indicates that Philips has the majority of the MFs in place and is the strongest in reconfiguring. The sensing capability is not much weaker. However, there is a lack in the representation of seizing MFs. Philips is thus relatively good at identifying opportunities and, once they are seized, at reconfiguring and adapting existing processes and capabilities to implement the product and models. The gap in seizing creates a bottleneck in translating (circular) opportunities into business models. This is reflected in the interviewees addressing how ideas are cancelled prematurely or exchanged for ideas that hold the prospect for shorter-term benefits. Opportunities are thus identified, but they fail to reach implementation.

"We cannot bring ideas to life easily enough and fast enough. […] Some of these circularity models, it is a no-brainer. We should do it. It can be done profitably, but it needs an architecture that does not exist. I could also just sell them a new one. So which one do you think will happen?" [PM_01] [1]

"*Well, I think there are ideas, but they are cancelled too soon.*"[EX_02][2]

The next subsections discuss MFs in more detail, elaborating on how their first-order practices are represented. The subsections will follow the order of sensing, seizing, and reconfiguring. This provides a more granular perspective on how the practices are demonstrated in the process.

4.1.2 Sensing

This subsection examines the sensing capability. The underlying practices of the MFs are analyzed through the associated practices. Sensing occurs in the earliest stages of the process. Therefore, this subsection presents how opportunities are identified, knowledge is generated to shape these opportunities, and tools are applied to guide effective impact. Table 12 presents the MFs with their corresponding first-order practices of the sensing capability. Below, these practices will be described. The practices added in bold emerged from the case and are added to the empirical Santa-Maria et al. (2022).

Table 12 Representation of the Sensing MFs and Practices

Micro-foundation	Practice	Presence
External Sensitivity	Understanding the needs of customers and key stakeholders	✓
	Being open for external expert support	✓
	Leverage the development of exogenous science and technology	✓
	Understanding and awareness of the regulatory space and changes	✓
Adopting a holistic perspective	Adopting a lifecycle perspective	X
	Adopting a systemic perspective	✓
Knowledge creation	Undertaking R&D activities	✓
	Leverage internal prior established knowledge	✓
Use of sustainability-oriented instruments	Guidance from sustainability frameworks (e.g., SDGs, FSSD, C2C, Doughnut, and Biomimicry)	✓
	Implementing environmental management tools (e.g., LCA, ISO14000, and Sustainability Reporting)	✓
	Implementing Sustainability Ideation Tools	~/x

(Presence: ✓ = present, ~ = partially present, x = absent; MF and practices are derived from Santa-Maria et al. (2022))

The MFs of *external sensitivity* and *knowledge creation* are connected in the process of Philips. This combination of MFs is required to complete the mandatory value proposition templates. These mandatory templates include a customer, an offer, and a business category. As shown in Figure 6, the customer and offer templates both address identifying the customer, external stakeholders, their needs, the current market environment, and alternative solutions. Completing these templates helps product managers identify new opportunities and develop the product concept in line with the needs of stakeholders and differentiate it from competitors. These templates contain activities, such as identifying stakeholder profiles and the customer journey. These contribute to developing an understanding of the customer and stakeholders. Additionally, one product manager stressed the need to be in contact with the customer to understand their perspective to apply this in developing meaningful solutions.

"So I have gone to customer sites and talked to bedside nurses. I have talked to nurse managers, I have talked to procurement officers" [PM_01][3]

Additionally, at the time of this study, the HPM business unit is involved in two consortia, DICE and ESCH-R. Both focus on improving the sustainability of medical products, such as medical consumables. Another example is the consortium Sustronics. This consortium was initiated by Philips to collaboratively explore and innovate on PCBAs (Printed Circuit Board Assemblies) to enhance their sustainable performance. Ultimately, this project aims to identify a PCBA innovation that improves the sustainability of their electronic products using a PCBA. These collaborations underscore Philips's pursuit of external collaboration to support innovation in new technologies and how they leverage these developments. Additionally, research in the early stages is performed to explore existing alternative solutions. This could inspire product managers to explore the role of different technologies for their products.

The practice *awareness of the regulatory space and changes* was added to the framework. The interviews and observations highlighted the regulatory influence on the feasibility of potential solutions, for example, through prohibitions on certain materials. Philips was said to place strong emphasis on compliance with this regulatory environment. This makes the organization well aware of the regulatory field and thus creates opportunities that align with regulations. However, this focus on compliance was at times also a limiting factor. Focusing on what was not allowed would create a barrier to creating new opportunities.

"We are very sensitive, as I said, as a company that standardizes everything, we really want to obey and implement those rules" [EX_02][4]

"I think that is a mindset shift that we need to work towards. There are always ways to work around it or find ways [...]. They say we cannot do this because of regulations, and then they stop."[EX_03][4]

The *adoption of a systemic perspective* is one of the MFs that is not embedded in a specific single practice. This perspective is embedded in Philips' strategic activities and impact assessments. For example, Philips calculates the impact of its products and services on the number of lives improved. Thus also focuses on the social impact of products. Additionally, Philips has Group Sustainability Office (GSO), the central sustainability department. They are, amongst others, responsible for establishing the strategic roadmap and sustainability goals, and take a more holistic perspective when deciding on the right and effective impact. They focus on the environmental and social impact of care and thus have to take a more systemic perspective.

The *adoption of the lifecycle perspective* seems absent, or, as one of the product managers remarked, *"Zero. We do not involve it a lot." [PM_03][5]*. The product managers are primarily devoted to the traditional sales moment with their customers and are less acquainted with taking a cradle-to-grave perspective and responsibility. The experts attributed this to the novelty of circularity and the defined targets, which stimulate employees to focus on the sales and less on what happens at the end of its life. This lifecycle thinking and how it informs opportunities and organizational practices does not become internalized into the process.

"*Customer lifetime value is there, but a large part of the business just doesn't get it or doesn't have it in their minds. You can't really blame them for that. They're always directed to sell as much as possible. So if that's your task, who cares what a customer does with it later? I just have to meet my targets tomorrow, but neither really internalizes it."* [EX_01][6]

In addition to this gathering of external information, Philips draws on internal knowledge and its creation to further develop the product concept and to complete and verify the content in the templates. Product managers continuously seek contact with different teams and functions to iterate and refine on what is possible in terms of product and concept, and to define what the product proposition would require to be operationalized. This involves working with R&D and engineers to support more technical explorations of possibilities, for example, with prototyping. Other teams, such as research or marketing, are consulted, for example, to assess existing patents or to explore how choices would resonate with the customers. The product manager functions as a sort of orchestrator in the process of connecting with the right employees and collecting the necessary information and knowledge. They aim to learn from existing knowledge inside the organization. Hence, the process is iterative and combines diverse information sources and synthesis activities, such as these templates, to explore and formulate a suitable, innovative proposition. This demonstrates the practice of *undertaking R&D activities* and of l*everaging internal (prior established) knowledge*.

"*That is why we have the research team helping us do the templates. We have got an engineer who is helping us create prototypes or give advice on what is possible or not."* [PM_02][7]

"There is a huge amount of additional people we can include as part of the discussion who have their expert opinions that we need, because I am not the expert. As my role, I need to bring people together and pull on those experts" [PM_02][8]

"It was taking all the learnings collected from different sources, the competition, voice of customer, some R&D learning here and there, and then making sure to put that towards the template and making that fit a VPC process" [PM_03][9]

Guidance from sustainability frameworks and *implementing environmental management tools* are both present. In the later stages of the product development process, tools support the identification of more

sustainable product design choices. Examples are EcoDesign Criteria, Recyclability and Disassembly Assessment tools, or Life Cycle Assessments (LCAs). Additionally, Philips uses sustainability frameworks such as Sustainability Development Goals (SDG), Science-based Target Initiative (SBTI), and ESG Impact Ambitions to guide their sustainability goals, which are translated to the process and products. These frameworks play a more strategic role in defining the suitable opportunities for environmental impact.

Despite the presence of these sustainability-oriented instruments, there is a lack of tools contributing directly to the VPC process. The interviewees addressed the need for tools and methodologies stimulating a more circular practice within the VPC, and thus, tools supporting the creation of more sustainable propositions. The current templates do not meet this need, as they only include a small section on sustainability and do not support ideation towards sustainability. Only the circularity expert from Group Sustainability Office addressed the presence of additional generic templates for developing a more circular proposition. Other employees addressed that there were no existing circularity or sustainability tools. As such, these are not used in the process of the HPM business unit. Furthermore, the product managers currently have to complete about 15 templates, which is considered too many. New circularity static circular templates might not fulfill this need for a circularity tool. Therefore, the practice *implementing sustainability ideation tools* is added to the practice list.

"We need a new tool. We need something that models for consumables. We need something that models for circularity" [PM_01][10]

"Yes, I have an idea why that is. That is part of the reason why we are doing that exercise, the tooling is missing." [EX_01][11]

"I think it is really illustrative of that there is just way too many templates and these templates don't have a clear purpose or deliverable." [PM_01][12]

4.1.3 Seizing

This subsection discusses the MFs and practices in the light of seizing, outlining how Philips translates the opportunities emerging from sensing into viable business models. Each practice presented in Table 13 is discussed. The practice in bold represents the added emergent practice.

Table 13 Representation of the Seizing MFs and Practices

Micro-foundation	Practice	Presence
Delineating sustainable solutions and business models	Ideating and developing value propositions with environmental and/or social impact	~/x
	Designing and implementing the (sustainable/circular) business model	~/x
	Generating business model architectures that can transform socio-technical systems	~/x
	Validating the financial feasibility of the business model	✓
Stakeholder engagement & collaboration	Engaging strategic partners in collaboration and co-creation	~/✓
	Engaging customers early in the innovation process	✓
	Engaging an interdisciplinary team to participate in the innovation process	✓
Supporting sustainability & innovation culture	Articulating a clear and ambitious sustainability vision	✓
	Developing a sustainability strategy and culture	✓
	Developing and supporting an innovation and continuous improvement culture	✓
	Educating workers in sustainability and empowering them to propose innovations	~/✓

(Presence: ✓ = present, ~ = partially present, x = absent; MF and practices are derived from Santa-Maria et al. (2022))

The MF *delineating sustainable solutions and business models* consists of three original practices and one added practice. The three original practices all seem to be absent. Primarily, because sustainability is not a focus point in the current value proposition process. The mandatory templates contain little to no elements that support product managers in defining sustainability propositions. Sustainability is overshadowed in the mandatory templates in this process by the customer and financial perspective. Consequently, sustainability within the value proposition becomes a byproduct, reflected in the design requirements. This is essentially not undesirable, if it were not the case that the sustainability requirements are often dropped later in the process. This is discussed in the practice *validating the financial feasibility of the business model* below. Currently, an emphasized focus of sustainability in the value proposition is driven by the product manager's personal motivation or a specific customer request. The latter makes sustainability a key selling point to drive customer value and thus becomes a customer requirement. In these cases, this may result in a more sustainability-oriented proposition, but these are not the standard. Altogether, this makes the practice *ideating and developing value propositions with environmental and/or social impact* predominantly absent.

"*Nothing is being asked about sustainability at this moment. So there is currently no obligation to think about it, and therefore, it is not always done centrally in that process.*"[EX_01][13]

"*The primary driver is to provide value to the customer, […]. The secondary value is how do I drive revenue? Customer comes first, and then the good byproduct is sustainability"* [PM_01][14]

"*[…] this is something that has to be in the heart and mind of the product manager from the get-go, and it's something you have to keep there the whole time. It's not something that you have one special week where you think about sustainability. It's an everyday, all the time thing. It's a mindset".* [PM_01][14]

"*I would say if sustainability would not have jumped so high on a requirement from a voice of customer, we would not have looked for the right internal stakeholders to pursue an avenue of having what can we have in terms of sustainability, circularity, and things like that."* [PM_03][15]

The practice of *designing and implementing (sustainable/circular) business models* is mostly absent. This is demonstrated in the tendency of product managers to adjust existing business models incrementally. Performing a financial evaluation in a business case is the main activity in designing the business model. As such, business modelling was primarily performed by adjusting the values in the business case instead of rethinking the model behind it and how it affects the organization. For consumables, Philips currently focuses on cost-down innovations. Sustainable solutions were perceived to have a higher associated cost compared to projects that are more in line with the existing architecture. This results in a trade-off between cost and sustainability, where costs often win. This strong financial focus thus limits the exploration of circular business models and their implementation, as these are likely to be too costly. Additionally, this financial focus, in combination with the focus on being compliant, makes them more risk-averse to challenge existing social-technical systems through their business model architecture.

"On my experience, we almost went straight to it. No, it's a good point. I think we had ideas that we packed in, but we more or less went straight away to the model that we know." [PM_03][16]

"I would say we are also very cost-conscious, whether sustainability comes at a cost or whether it's accessible. The reality is, if a particular material that is more sustainable comes at a higher cost, it's going to be possibly less attractive." [PM_02][17]

"*There they were mainly faced with a price tag, so if you literally compare it with I can put in a new replaced part or the effort to get the product back, take the part out, test the part, and then put that part back in again. The new part wins in terms of price"*[EX_04][18]

"This costs money. To put it bluntly, it costs a lot of money, and if you cannot prove it's actually profitable, it is stopped anyway"[EX_02][19]

This financial evaluation is also added to the list of practices. This financial evaluation seems to be a core principle in their business modelling. Additionally, a business case helps assess the overall feasibility of the business models prior to implement, thereby reducing risks. This contributes to exploring how the business model can be best implemented while remaining economically viable. Regarding the economic challenge of consumables, modelling different financial scenarios helps determine whether the model becomes unviable.

The MF *stakeholder engagement & collaboration* consists of three practices. The first practice, *engaging strategic partners in collaboration and co-creation,* is partially represented. The previously presented example, Sustronics, illustrates co-creation with strategic partners. Within the HPM business unit, there is an additional example of strategic collaboration with Stryker. Stryker reprocesses single-patient use (SPU) consumables and resells them. This collaboration provides Philips the opportunity to market its SPU consumables with a reprocessing claim, which could win over customers. However, one of the experts addressed that these collaborative partnerships are not yet common within Philips. The expert highlights an example in which Philips has the ability to set up a collaborative repair component business but does not do so. This highlights that collaboration within the process is emerging, but not a standard practice.

"*So to achieve this reprocessing claim on disposables, we had to partner with Stryker. […] It is something we verbally say to our customers. If we know that they are looking: 'oh this is much cheaper. Why don't I just go with non-Philips?' Well we have this reprocessing initiative and we can connect you to our representatives at Stryker, for example. There is economic value in sustainability ultimately"*[PM_04] [20]

"We are still really far from, well we can start it at any point, we know how to do it, the willingness to hire such a party or to establish such a relationship with the party to actually set up an entire component business" [EX_02][21]

The second practice, *engaging customers early in the innovation process*, is present and often combined with the practice *understanding customer needs*. Product Managers get in touch with customers throughout the process, for example, by interviewing. This helps them gain insights into customers' preferences and perspectives on their new concepts and their needs. It becomes a practice to validate and refine the product concept. As is exemplified by the following quote of a product manager describing the next step in VPC project: "*It will still continue, because whilst we are doing some market interviews over the next couple of weeks, we then need to do direct customer interviews"* [PM_02][22].

As previously noted, the product managers are supported by a small team of employees with diverse backgrounds. Therefore, the third practice of *engaging in an interdisciplinary team to participate in the innovation process* is evaluated as present. This is illustrated by Quote [23], which additionally emphasizes how product managers actively seek support with different teams alongside their core teams.

"*I would say it is helpful to have a core team, so that would obviously for this project be myself, the other product managers. We also have the product manager in the research team, […] Then I would say it's always beneficial to have someone from clinical as well and I think someone from technical."* [PM_02][23]

The practices of *articulating a clear and ambitious sustainability vision* and *developing a sustainability strategy and culture* are taken on by GSO. They establish Philips's sustainability strategy and corresponding goals. This strategy is communicated and translated into specific goals and KPIs across the different business units. The business units, in turn, based on these goals and strategy, determine their strategic roadmap and opportunities for improvement in their product portfolio. These business units are supported by a business partner from GSO to drive this sustainability vision, strategy, and corresponding KPI's.

Additionally, Philips points out *'Eco-Heroes'* to motivate sustainable choices. This term is awarded to products that meet all EcoDesign and Circular-Ready requirements and outperform the relevant benchmark. They are promoted as sustainability champions within the organizations. Altogether, this aims to promote the sustainability vision and to translate it into a sustainability strategy and culture.

There is a strong emphasis at Philips on innovation and delivering new propositions. Business units and product managers are driven to innovate and maintain their product portfolios through strategic roadmaps. The gaps between the current portfolio and the strategic roadmap can be an indicator for a potential innovation. The value proposition process and templates support the refinement of this opportunity to make it differentiated from existing alternatives and fit with the market, customer, and strategy. There are additionally various initiatives outside of the VPC process, such as 'Innovation for Breakfast' or the 'Innovation Impact Week'. Here, information about new innovations is shared and promoted within the organization. Furthermore, there are teams such as the innovation management team that support business units and product managers in this value proposition and product development process. During the interviews, it was additionally addressed how this drive for innovation was a key motivator for employees to assist in the small core team of product managers. Altogether, this highlights how innovation is promoted within Philips and ingrained in its organizational culture.

"So a business strategy is often translated into the intended portfolio, which is then translated into the innovation roadmap. Gaps arise there, on that innovation roadmap, then you have to do a VPC, because we need to develop a new product,[...]"[EX_01][24]

"I would say, the reason why they get involved is because they want to see the success of the company that they are working for and they believe in the core value of what we are trying to do as a company and everyone is enthusiastic about driving innovation" [PM_02][25]

Philips creates opportunities for employees to develop and gain knowledge on different topics. They provide multiple digital platforms through which employees can easily access digital training. Examples of these platforms are Cornerstone, TEDs, and LinkedIn Learning Hub. One of these training opportunities is the 3-hour course "The Ellen MacArthur Foundation's Circular Economy Foundation". The opportunities for training focused on sustainability seem to be emerging. The circularity program manager addressed the creation of a new sustainability training specifically for product managers: *"what we've been doing now, started last year, it's another team within group sustainability and started to do sustainability claims trainings with product managers in different business units"* [EX_03][26]. However, during the interviews, it became evident that these educational opportunities do not seem to reduce the knowledge gap on circularity. Interviewees reported a level of inexperience and lack of awareness regarding circularity and how it can be realized in practice. The circular education thus does not reach the employees effectively. Building on the previous practice, employees are empowered to propose innovations. Therefore, the practice of *educating workers in sustainability and empowering them to propose innovations* is not fully present.

4.1.4 Reconfiguring

This subsection focuses on the reconfiguring capability and thus on how Philips adapts and restructures its assets and processes to implement the newly defined CBMs. This presented elaboration clarifies the extent to which this reconfiguring capability is embedded in the current process and practices. Table 14 presents the evaluation of these practices, which is followed by an analysis of the individual practices. No additional practices were added.

Table 14 Representation of the Reconfiguring MFs and Practices

Micro-foundation	Practice	Presence
Co-specialization of assets	Prioritizing strategic fit of resources and capabilities	✓
Organizational flexibility	Implementing experiments/pilots to validate, learn, and adapt quickly	✓
	Build decentralized (sustainability-oriented) innovation teams and allow flexible organizational structures	✓
Trust-building communication	Having a fact-based, consistent, and transparent external communication	✓
Ecosystem orchestration	Skills to integrate stakeholders and coordinate partners in the business ecosystem	✓
Leadership and change management	Commitment and support from top management	~/✓
	Proficiency at organizational change management	~
	Implementing specific sustainable and circular KPIs	✓

(Presence: ✓ = present, ~ = partially present, x = absent; MF and practices are derived from Santa-Maria et al. (2022))

The value proposition process contains multiple gate reviews. During these gate reviews, the value propositions and the results of the business case are evaluated regarding the fit with the organizational strategy, goals, product portfolio, and perceived benefits in comparison with other projects. Therefore, the practice *prioritizing projects that fit existing organizational capabilities and resources* is present. This prioritization could involve sustainable projects not progressing in development process, when other projects are deemed more strategically relevant.

> "*There is, moreover, another problem on the horizon, which is the question of strategic priority, so all the answers may be correct, but even then, the business can decide that it is not a priority and that they should spend the money on something else"*[EX_01][27]

When defining the value proposition, product managers articulate their initial assumptions about the proposition and the business model. The previously described connection with users and prototyping of R&D are examples of activities aimed at validating these assumptions. These activities additionally serve the purpose of exploring the concept's feasibility. The business case is additionally an example of how different model scenarios can be modeled to validate the financial viability. Furthermore, one of the product managers addressed that they performed a pilot/experiment with a new model to explore if this would match with customer needs. These examples reflect the presence of *implementing experiments/pilots to validate, learn, and adapt quickly*.

> *"We have tried subscription model. It does not necessarily work. It is really customers buy what they need, when they need it, they have their own inventory management, ways of working"* [PM_05][28]

The practice *build decentralized innovation teams* and *allow flexible organizational structures* is reflected in Philips's organizational structure and the creation of cross-functional teams. Philips operates under a matrix structure in which business units are responsible for specific product categories. For example, the HPM business unit focuses on the monitor and associated medical consumables. These business units can be interpreted as decentralized teams, as they hold a degree of autonomy over how processes are performed, their product portfolio, and their strategic roadmap, within the goals set by higher management. This autonomy is highlighted by the sustainability expert, who notes that business units independently determine how they complete the value proposition process and templates: "*Managing those VPC(value proposition creation) templates has therefore also gone to the businesses. So there is no longer a single VPC way of working. Each business can decide for itself how to implement it, so perhaps there was a business or someone from design who once said that we include the planet as a stakeholder, but that doesn't mean that it immediately spreads as a way of working.*" [EX_04][29] Additionally, once a project and

product mature, they are assigned a cross-functional team to support the product through its lifecycle. This highlights how the structure is adapted to projects.

"We also do a lot of work in what we call MLD projects, which are updates to existing projects, and the existing products have to have a cross-functional team to support them through their lifecycle. And for an MLD project we will often tap the CFT for insights." [PM_01][30]

The later stages of the product development process include multiple mandatory reports that verify compliance with the EcoDesign criteria and request proof about (sustainability) claims. Compliance with the EcoDesign criteria is assessed through the *ESG case*. Claims can entail, for example, a product claiming to use less energy compared to its predecessor. Evidence towards these claims needs to be presented in documents such as the *Ecopassport* and the *Energy Consumption Template*. These templates follow established CSRD and COCIR methods, which are industry-standardized methods for reporting on sustainability. Furthermore, Philips publicly elaborates on their calculation methods of, for example, their LCA assessments and estimated lives improved. The combination of evidence and transparency in methodology supports fact-based communication.

Philips's skills in integrating stakeholders and coordinating partners within the business ecosystem are reflected in their collaborations and in how they organize their upstream activities. Philips collaborates with different partners to complement their capabilities. One example is the previously mentioned collaboration with Stryker, where Stryker holds the reprocessing capabilities that Philips does not have. Additionally, Philips does not have a vertically integrated supply chain. This means that Philips is dependent on multiple suppliers, distributors, and stakeholders and must coordinate them to create and deliver its products. This combination demonstrates that Philips has the skills to integrate and coordinate stakeholders and partners.

The product development process contains many different gate reviews with many different stakeholders. Convincing these stakeholders and gaining their support is crucial for progressing in the process. Higher management is part of these stakeholders, but does not necessarily include top management, such as the CEO. Whether a project receives support from higher management depends on their vision and the benefits of the evaluated project relative to other new projects. Product managers expressed the necessity and difficulty of convincing all stakeholders and gaining their support during the process. So even if a project receives support from an internal stakeholder, this does not guarantee others will as well. Therefore, this practice is partially represented.

Philips's *proficiency at organizational change management* is partially represented. Interviewees addressed how employees sometimes remain focused on the traditional practices. This limited change was attributed to the existing DNA in Philips and a misalignment in the targets. These targets then fail to incentivize the employees to think differently. Additionally, a barrier to change might be present due to the effort it requires to change or the unawareness of how to do it. Still, a growing awareness towards the need to change seems to be emerging. This indicates that efforts to promote sustainability and circularity are starting to take hold among employees. Therefore, this practice is deemed partially present.

"I think part of it may just be a fixed way of working and thinking? We've always done it this way. We've been doing it for so long. It works this way, and just changing that alone takes time, money, and process adjustments. Even if you simply wanted to try, a lot would need to be set up to actually do it and stay within the rules[…]"[EX_04][31]

"I think that people are increasingly open and understanding of the product lifecycle and that they have to take this into account. They find it too difficult to figure out how to do it, so it maybe happens infrequently or not at all."[EX][32]

The business units are guided in their innovation choices by KPI's derived from the central 2030 sustainability strategy. These KPI's provide guidance and an incentive in making more sustainable choices. Business units have to decide on options that improve sustainable and social performance to meet these KPI targets. The sustainability expert emphasizes this role of the KPI's: "*The project surrounding measuring and predicting sustainability KPIs stems heavily from the ESG agenda. I think it's all about the KPIs and do we, as Philips, deliver what we have promised to do. Of course, these KPIs are often linked to people's targets, so there's internal incentive to work on them and thus to be able to predict them"*[EX_04][33].

4.1.5 Conclusion

The analysis in this section reveals insights into the dynamic capabilities that Philips employs to identify opportunities, mobilize resources, design business models, and adapt its structure. This resulted in three general insights of Philips's CBMI process:

- The DC and MFs are generally well represented in the current business modelling process.
- Philips is strongest in reconfiguration and experiences a gap in seizing. This gap is mainly demonstrated in MF the delineation of business models and sustainable solutions. The current process lacks exploration of new configurations and is focused on financial evaluation. Tools are missing to support the product managers in this exploration
- The missing practices are mainly related to dealing with specific sustainability or circularity elements or change management.

To improve the CBMI process, the missing practices provide clear opportunities for improvement. From the missing/partially present practices, three are part of the priority list as defined by Santa-Maria et al. (2022): *adopting a lifecycle perspective; ideating and developing value proposition with environmental/social impact; engaging in strategic partnership collaboration and co-creation*. Hence, these should receive main attention in the design. Additionally, given the analysis's findings of a lack of business modelling and a knowledge gap, the design should develop a business model and present educational information on CBMs and their implementation. To ensure fit with the existing process and the emphasis on the business case, the design should support the translation of the idea into the business case template. Additionally, by ensuring the design fits within the existing practices and the process, it aims to lower the threshold to use the design and thus support incrementally to change in the existing process. A tool should support product managers in exploration circular propositions for consumables However, the tool should be more than a template, as the existing circularity templates did not reach adoption among the product managers and their team. Lastly, commitment of higher management was said to be dependent on the ability to convince these stakeholders, therefore, the tool should support developing a clear line of thought to be able to deliver a convincing story. However, as the commitment of higher management is also dependent on their personal perceptions, this aspect is seen as out of scope for the purpose of the design.

Product managers and their supporting teams are primarily responsible for the content and propositions created during this process. They are the target group for the design. Based on insights gained on their way of working, the requirements were established. These requirements were approved by Philips. Table 15 presents the design requirements and where they are derived from.

Table 15 Overview of the Design Requirements

Main Requirement	**Based on**
Support lifecycle thinking	DC analysis and literature
Stimulate ideation and development of sustainable value propositions	DC analysis
Emphasize the identification of strategic partnerships	DC analysis and literature
Support requirement	
The outcome of the design should be a (circular) business model	DC analysis and empirical context

The design should create an iterative design process towards business modelling	Literature (see Section 2.4)
Should fit as a step in the existing process and connect to the business case	DC analysis
Provide educational information on CBMs and their operationalization characteristics	DC analysis and empirical context
Should support structured and thorough exploration	DC analysis
Functional requirements	
Support collaboration among participants.	Empirical context
Should operate online	Empirical context
It should function as a tool	DC analysis

4.2 Circular Business Model for Medical Consumables

This section presents the developed CBM typology. The typology aims to identify the applicable CBM archetypes and types for OEMs producing medical consumables. Each subsection represents a section of the typology. Subsection 4.2.1 presents the CBM archetypes, types, and their definitions. Subsection 4.2.2 presents the value capture, creation, and delivery mechanisms. The associated retention loops, R-strategies, and affected lifecycle phase are discussed in subsection 4.2.3. This section is concluded with subsection 4.2.4, which discusses the evaluation of these models considering the context.

4.2.1 Circular Business Model Archetypes and CBM Types

This subsection presents the circular business model (CBM) archetypes and corresponding CBM types for OEMs producing medical consumables. These archetypes reflect principal strategic pathways through which OEMs can embed circularity and organize different resource loops to narrow, close, slow, intensify, and dematerialize.

Table 16 presents an overview of the final set of archetypes, CBM types, along with their definitions, an example, and expert comments. Appendix G presents the typology developed prior to receiving interviewee feedback. Appendix H presents the final typology in one overview. The table serves as the foundation for the in-depth discussion that follows, in which the archetypes are examined with respect to their underlying mechanisms, operational implications, and expert input gathered during the evaluation phase.

Each archetype represents a main pattern in CBM mechanisms and solutions. The CBM type is a more detailed configuration that operationalizes these patterns. The types hence illustrate strategic pathways through which the broader pattern and the CBM goal can be implemented. The typology aims to support OEMs of medical consumables, who influence circularity throughout the product lifecycle, in identifying and operationalizing CBM opportunities. Therefore, the archetypes are organized according to their effects on the lifecycle stages, from material extraction to recovery. The archetypes are framed as distinct as possible to facilitate conceptual connections between CBM types and their operational mechanisms. The CBM archetypes and types, along with the feedback from the interviewees, are presented in Table 16. Each archetype is discussed below in relation to its inclusion in the typology. Overall the interviewees considered the typology to be thorough and complete.

"My first reaction is that it looks very comprehensive and systematic and I like the frames that you use." [AC_04][34]

"I thought it was very thorough."[PC_01][35]

Dematerialization & Digitalization are included as they highlight the opportunity to deliver product functionality without initiating a material flow. This archetype is first in order, as it does not require material extraction. Two interviewees debated its role as a standalone archetype and type. They perceived this archetype as a transversal and enabling category. As such, *Dematerialization & Digitalization* would support and facilitate the infrastructure required to implement the other archetypes. For example, Airbnb and Uber require a digital platform to enable the sharing of rooms and cars. This makes digitalization an enabler for the *Sharing Platform* archetype. Another interviewee suggested placing this archetype as a submodel under *Resource & Process Efficiency*, as dematerialization would reduce resource use. In contrast, two other interviewees advocated retaining it as a standalone archetype, emphasizing that empirical cases such as Spotify illustrate its distinct effect. These different perceptions illustrate how patterns can be understood and framed in multiple ways. However, given the typology's aim of presenting distinct archetypes, *Dematerialization & Digitalization* remained a standalone model.

Sufficiency Economy emphasizes the intentional reduction of consumption. This pattern prioritizes sufficiency in production and revenue over maximizing production to increase growth. *Sufficiency Economy* can therefore be understood as an intention not to use more resources than necessary; while its effect is most directly visible in reduced resource use, it extends across all lifecycle stages. Its type was rephrased from *Sufficiency Model* to *Profit Sufficiency*. The practice expert suggested this rephrasing, as for a manufacturing organization, the outcome of sufficiency would entail being satisfied with the profit earned and not reinvesting it to increase production and stimulate consumption.

Circular Supplies highlights the perspective of introducing renewable materials into the product and production process. The interviewees were initially presented with a typology that was not structured by lifecycle stages. Therefore, three interviewees addressed the integration of *Circular Supplies* with *Resource Recovery & Recycling*. They argued that the value chain would require both to result in a closed resource loop and require similar activities. However, merging the two patterns would imply that the upstream supply decision and the downstream recovery process operate as a unified mechanism, even though they have distinct roles in the product lifecycle. It would additionally overlook the possibility that organizations may introduce renewable materials without recycling the products themselves, or may enable recycling without directly integrating secondary materials into their production processes. This distinction is less clear with Industrial Symbiosis, as it depends on the organization towards providing the input, using the input, or both. As OEMs can take on these different roles, each with different operational implications, the two remained separate. Therefore, the typology's narrative was enhanced by reordering the archetypes by lifecycle phase to emphasize the difference between upstream and downstream orientation of the models.

Resource & Process Efficiency additionally targets the production process, striving to optimize the process to align closely with demand and reduce unnecessary resource use. Initially, *Sufficiency Economy* was a CBM type under this archetype. The interviewees, however, addressed that *Sufficiency Economy* did not match the objective of efficiency. Efficiency strives for an optimized process in which more, or an equal amount, is produced with fewer resources. Sufficiency, as described above, focuses on reduced consumption and operating on sufficiency rather than growth. This does not necessarily require an efficient process. Because of this different intention, *Sufficiency Economy* is listed separately.

The ***Access Provision*** archetype rethinks ownership as a prerequisite for product use. All corresponding CBM types highlight different perspectives on how (temporary) access to a product can be provided without requiring the customer to invest in ownership. The ***Product Lifecycle Extension*** *archetype,* compared with *Access Provision*, highlights the role of design and product modification in shaping the use phase of the product lifecycle. The CBM types underscore that product design, the ability to modify a product after production, the maintenance and replacement of product components, and support for an extended product life reduce the need to purchase a replacement. Neither archetypes nor models received significant feedback from interviewees. A potential reason is that these patterns are well-established and

represented in the CBM literature. This makes them two archetypes they would expect to find in a typology. This is additionally supported by the fact that both archetypes were present in seven of the eight articles.

Resource recovery & Recycling entails the recovery and reuse of materials so that they can be used again in the same or a different production process. Occurring in the final phase of the product lifecycle, this archetype extends the life of resources by preventing them from being wasted.

Table 16 Overview of CBM Archetypes, CBM types, and their Definitions

CBM Archetype	CBM type	Definition	Example	Expert Feedback and changes made
Digitalization & Dematerialization	Digitalization & Dematerialization	The development of a digital/non-physical solution as a concept or as a substitute for a physical product, thereby creating a dematerialized resource loop.	Digitalizing physical supplement materials -e.g. *eIFU* (electronic instructions for use) (Vasudevan, 2025)	Adjustments: placed at the beginning of this typology, as the typology was reorganized in order based on the affected lifecycle phase. As this model involves no resource flow, it was placed in front. *"I also had this problem in my categorization, and it could fit in the circular economy in collaboration, and then it was also needed for other things. So, then I used it as* ***a transversal category that feeds into all categories****"* [AC_02] *"More as indeed the* ***context or environmental factor****. We see all sorts of trends going on. Digitalization could be one and see other technological changes. We also see maybe different environmental, legal,* ***all these sorts of contexts that might have an effect somewhere as an enabler.****"* [AC_03] *"When I was doing this type of classification,* ***I tended to keep dematerialization by itself****. For instance, I think Spotify is more dematerialization, because you had a CD and you do not have them anymore."* [AC_04]
Sufficiency Economy	Profit Sufficiency	Active promotion of reduced consumption and pursuit of sufficiency rather than excess profit. It narrows the flow of resources by discouraging overconsumption. It also aligns with intensification strategies by encouraging the maximum use of existing products.	No current example in healthcare was identified. Don't buy this jacket campaign -e.g. Patagonia (Patagonia, 2011)	Adjustments: Moved from *Resource & Process efficiency* to its own archetype. Reframed to profit sufficiency to align it closer to how this would affect the OEM. *"Sufficiency to me is a* ***philosophy*** *and an alternative to traditional capitalism"* [AC_05] *"The goal of the sufficiency economy, as I have read it,* ***is not really to be more efficient****, […], but run businesses not really to accumulate huge amounts of money, but to satisfy the needs of different stakeholders, and I think satisfying those needs doesn't always require high efficiency"*[AC_01] *"A sufficiency-based business model, which I prefer over the economy, would reduce the resource use in theory. It assumes that the firm agrees that the outcome of a sufficiency-based business model will be* ***profit sufficiency*** *and not exponential growth. So then when instead of that rebound effect, when you've optimized your manufacturing processes, instead of reinvesting those savings into making more, you say, we are sufficiency-based.* ***We have made enough profit this year****."* [PC_01]
Circular Supplies	Industrial Symbiosis	The output of one process becomes the input to another, thereby closing the loop and preventing resources from being wasted. A special form of symbiosis is organic feedstock, which focuses on bio-based materials.	Collecting non-contaminated plastic waste to transform it to oil suitable for their plastic production - e.g. Saabic Zuyderland collaboration (Sabic, 2025)	Adjustments: rephrased the definition to focus on cycling in general instead of cycling longer. *"I am not sure if it is really about circulating resources longer, but I agree with most of the definition. […] I think it is more like a closing thing. So it is not that you want resources to cycle longer****, but you want them to just cycle****"* [AC_01]
	Sourcing Circular Supplies	Sourcing recovered materials and renewable energy in the product and the production process, which contributes to the circulation of resources by closing the loop.	Introduction of polymers derived from renewable sources in a medical consumable -e.g. LoFric Elle Wellspect Healthcare (Plastics Today, 2023)	Adjustments: reorganized the order of the archetypes according to the lifecycle phase to highlight the distinction with recycling the archetypes. *"What I see is exactly that narrative. If you had that narrative as we have inputs, we have those steps. If you keep it in that way, then it makes sense here, because you had input and then now you are talking about another ways and that is totally understandable. But the way you are having it right now,* ***because it doesn't have the logic then don't see why you don't put them together.*** *So maybe rethink about the narrative and categorize it based on let's say, steps."* [AC_02]
Resource & Process efficiency	Production-on-demand	The production process is only initiated when demand is quantified and confirmed. This narrows the resource flow and minimizes waste from overstock and unwanted products	Start assembling a device when an order is placed -prosthetics or customized devices	Adjustments: name changed from 'produce on demand' to 'production-demand' Interviewees mostly agreed
	Process Optimization	The focus is on process optimization, cleaner production, and energy-efficient use. This reduces the use of (virgin) sources, waste production, and emissions, and thus narrows the resource flow required to produce the product.	General organizational practice	Adjustments: name change from 'resource efficiency' to 'process optimization' Interviewees mostly agreed
Access Provision	Sharing Platform	A facilitation of C2C or B2B product/equipment sharing that otherwise tends to be underutilized. This intensifies their usage. Sharing can be facilitated through a digital platform.	The facilitation of a B2B sharing marketplace to share equipment, knowledge, facilities, and excessive stock.	Adjustment: added the 'digital platform' to the definition *"This* ***sharing platform can go a lot with digitalization****. This is one thing I wanted to tell you, the platforms and digital platforms, they are going together. You cannot have a platform nowadays without having a digital platform" [AC_02]*

(Sections stressed in **bold** highlight emphasize the key points)

			-e.g. Floow2Healthcare A digital platform orchestrating the sharing of equipment and excess capacity -e.g. Cohealo (Cohealo, n.d.)	
	Performance/ Use-oriented	Customers do not pay for ownership of the products, but for their performance or use cycles, with guaranteed uptime to drive increased utilization, which intensifies the loops.	Offering equipment for lease with pay-per-use -e.g. MRI and CT equipment (Resonandina, n.d.)	Interviewees mostly agreed
	Product-as-a-Service	The provision of temporary access to a product or piece of equipment, including company equipment, in an idle state. This intensifies product usage.	A monthly subscription or one time for renting of medical equipment for a set time – Defibtech defribrilator renting (Defibtech, n.d.)	Interviewees mostly agreed
Product Lifecycle Extension	Premium Durability	The products are designed for robustness and longevity to endure more use cycles. This slows the resource loop as the product is used longer, and so are its materials.	Sell products with superior design leading to longer-lasting products -e.g. Layer (Ertz & Patrick, 2020)	Interviewees mostly agreed
	Modularity/upgradability	The product allows customization or enhancement of its parts, ensuring market value throughout the product lifecycle. This extends the functional life of the product (parts) and thus slows the resource loop.	Upgrade services that expand the functionalities existing equipment to become up-to-date again -Philips upgrade services (smart path) (Philips, n.d.-d)	Interviewees mostly agreed
	Lifecycle Services	A service that assists the customers in maintenance and repair, aimed at extending the product's functional life and thereby slowing the resource loop.	Care programs and services to maintain the performance of equipment – Philips Remote Services (Philips, n.d.-c)	Interviewees mostly agreed
	Reprocessing	The products are designed for repair, disassembly, or refurbishment, and are supplemented with repair parts. This slows the resource loop through component recovery.	Reprocessing and remanufacturing of used medical devices, which are resold again -Van Guard Medical remanufacturing (VanGuard Medical Remanufacturing, n.d.)	Interviewees mostly agreed "[…] it's not a **globally standardized term**. Meaning it has not been harmonized. It is used as an umbrella term, but that is not how we use the term at Philips" [PC_01]
Resource Recovery & Recycling	(Upcycle/downcycle) recycling/ recovering value from discarded products	The materials of a product are recovered and prepared for recycling. These materials then become input for new production, thereby closing the resource loop.	The collection of electronic materials to retain their resources and materials and sell them for new production -e.g. Mirec (Mirec, n.d.)	Adjustments: The narrative made it confusing to distill the difference between recycling and sourcing circular supplies. Therefore, the order of the archetypes was adjusted according to the lifecycle phases. *See row circular supplies*

(Sections stressed in **bold** highlight emphasize the key points)

4.2.2 Value Creation, Capture, and Delivery

This subsection examines how the identified circular business model (CBM) types generate, capture, and deliver value in the context of low-value medical consumables. While Section 4.2.1 outlined the conceptual distinctions between the archetypes and their underlying model types, the focus here shifts to the practical implications of these models, specifically, how each CBM type creates functional, economic, and environmental value; how this value is captured by medtech OEMs; and through which channels or mechanisms it is delivered to customers and other stakeholders. By combining expert insights with the characteristics of each CBM type, this section highlights the diverse pathways through which circular and economic value can be realized simultaneously. Table 17 provides an overview of how the CBM types differ in their value-creation, value-capture, and value-delivery mechanisms, clarifying the practical implications of each model.

Dematerialization & Digitalization, and its CBM type, create value by eliminating the need for physical products and associated logistical activities. This could enable faster delivery to customers as no physical resources have to be moved. Value is often captured through recurring income from subscriptions. Interviewees, however, raise concerns about the actual circular effect of this archetype and type. This type includes digital solutions, such as software. However, digital solutions still require energy and some form of hardware to operate. An increase in digital solutions could potentially lead to an increase in resource and energy usage. The resource flows and usage shift toward the required hardware, and thus, overall resource use might not decrease. This effect implies that organizations should evaluate on a broader level than a single product, whether this leads to an overall environmental benefit.

Profit Sufficiency creates value by fostering more conscious consumption and, in turn, production. It aims to create a balance between stakeholder needs and the environment. This improves the organizational brand image, as it demonstrates that the organization is not only prioritizing its own benefit.

The CBM types in ***Circular Supplies*** create value by introducing renewable resources into the process, as such reducing the depletion of non-renewable sources while maintaining product performance. Value is not only captured through sales, but also in an improved brand image.

The ***Resource & Process Efficiency*** archetype creates clear environmental value by reducing resource use. Each CBM type reflects a top-down or bottom-up approach to achieve efficiency. A top-down approach aims to achieve efficiency through strategic planning. The bottom-up approach focuses on individual processes at an operational level. *Production-on-demand* deploys a top-down approach by aligning the product systems with verified demand, reducing the need for unnecessary stock keeping. *Process Optimization*, on the other hand, takes a bottom-up approach by enhancing efficiency independent of demand certainty. This model seems to primarily create value for the organization. Despite the reduction of resource usage, which creates a clear cost and environmental benefit, interviewees addressed a rebound effect created by these generated savings. This rebound effect entails using the generated cost and material savings to increase output, which in turn is sold to increase profit. Thus, instead of reducing product and material consumption, it stimulates consumption and achieves the opposite from the desired effect. This perception highlights the importance of an organization's intention when operationalizing these CBM types

The CBM types in ***Access Provision*** reduce individual ownership and thus do not involve a single sales moment. It captures value each time a user requests access to this equipment, creating a recurring value capture over a single product. The recurring revenue stream is captured in a charge per time or per-use cycle. It prevents equipment from remaining underutilized. Additionally, in this archetypes value can be captured through improve customer relationships.

In ***Product Lifecycle Extension***, CBM types create value by enhancing product performance or extending the functional performance of the owned product. Therefore, value is captured through the (re-)sale of the original product or spare parts. Increasing the quality and reliability of the products allows OEMs to capture value through premium pricing, as it deliver superior performance. Whereas sales of spare parts or repair services generate recurring revenues. *Lifecycle services*, despite not involving the sales of a physical product and value being captured through e.g. subscription, are still included in this archetype. They support the value creation of extending the functional lifetime of products and equipment, similar to the other included CBM types. The CBM types additionally improve the organization's brand image, as a longer lifetime is often associated with higher-quality products.

Resource Recovery & Recycling creates value in extending the resource life. If the organization can use the recovered/recycled materials itself, this reduces material costs. Otherwise, the recycled materials can be sold, which results in an additional revenue stream.

Two interviewees addressed additional perspectives and patterns in the typology. The first interviewee addressed a general pattern in the value capture mechanisms. The second interviewee suggested an additional classification according to upstream and downstream orientation.

"Like most of the time, the value capture for organizations is these kinds of things: reputation, reduction of costs, and then risks" [AC_02][36]

"It is like in Marina's paper. She also organizes into upstream and downstream in the value chain" [AC_04][37]

Combining these perspectives reveals patterns in the value capture between up- and downstream-oriented CBM types. Upstream archetypes, including *Resource & Process Efficiency* and *Circular Supplies*, primarily capture value through cost savings, reduced resource consumption, and revenue from recovered byproducts. Downstream archetypes, such as *Dematerialization & Digitalization, Access Provision, Product lifecycle extension,* and *Resource Recovery & Recycling*, capture value mainly through increased or recurring sales, enhanced brand image, and improved customer relationships. The *Sufficiency Economy* does not easily fit into this categorization because of its holistic orientation that spans the entire lifecycle.

Table 17 Overview of Value Capture, Creation, and Delivery of CBM Types

CBM Archetypes	CBM types	Value Creation	Value Capture	Value Delivery	Expert Feedback and changes made
Digitalization & Dematerialization	Digitalization & Dematerialization	Value is created through reduced material use and logistic activities	Value is captured through the sales of licenses or subscriptions.	Value is delivered through a digital platform system or service.	*"The question there that I've heard in some debates is, is it really dematerialization or I mean you remove the physical products, but **you are using other materials to build the service**"*[AC_01]
Sufficiency Economy	Profit Sufficiency	Value is created in more conscious consumption and the establishment of partnerships	Cost and resource savings in production, customer loyalty, and improved brand image.	Value is delivered through a shift in marketing, sales, and quality goods.	Mostly agreed by the interviewees.
Circular Supplies	Industrial Symbiosis	Value is created through a process in which residual outputs become inputs, thereby combining to reduce waste and the use of non-renewable materials.	Value is captured through cost savings, through the use of the byproduct itself, or through a new income stream when selling the byproduct to other organizations.	Value is delivered through partnerships and sharing networks.	These aspects not covered in every interview, but interviewees mostly agreed.
	Sourcing Circular Supplies	Value is created through innovation in product and process by introducing renewable materials, thereby reducing the use of non-renewable materials.	Value is captured through cost savings on supplies, (*premium) pricing/product sales*, and improved brand image.	Value is delivered through products with circular quality.	*"In some of these circular supply strategies, they say like, we have made our PET bottles with recycled material, you do not pay more for that. In general, **I would not call it premium pricing**" [AC_01]*
Resource & Process Efficiency	Production-on-demand	Value is created by aligning production with verified demand, offering reliable and flexible supply while reducing unnecessary resource use.	Value is captured through operational cost savings by avoiding overstocking and the production of unwanted products that would otherwise be wasted.	Value is delivered through demand-drive production processes and systems.	These aspects not covered in every interview, but most interviewees agreed.
	Process Optimization	Value is created through an optimized production process, reducing resource and energy consumption. Potentially generating cheaper products and shorter waiting times.	Value is captured through reduced costs, compliance with emissions and waste regulations, and environmental benefits, achieved by minimizing the footprint.	Value can be delivered through partnerships, value network configurations, product redesign, and reducing supply chain emissions.	*"So, the more efficient a firm's production processes are, which is always the goal, the more savings that are realized, like lower energy costs. Then **those savings are reinvested into increasing the output**, increasing the production to increase profit"* [PC_01]
Access Provision	Sharing Platform	Value is created by enabling access to underutilized equipment, offering users greater flexibility and reliable availability while reducing the need for individual ownership	Value is captured through a transactional agreement when assets are shared or lent, or through an improved brand image.	Value is delivered through sharing platforms and places that provide access to equipment.	**"**Underutilized capacity. I guess so. […]. It could be you just have **an excess**. Use-based, I guess so, but I'm not sure if this will clearly explain to the reader what it means. Is it a delivery or capture?[…] Maybe the value created for customers is access to something cheaper." [AC_01]
	Performance/ Use-oriented	Value is created by providing (temporary) access without the need for individual ownership, ensuring reliable uptime, and enabling users to only pay what they actually consume.	Value is captured through a pay-per-use agreement or performance-based charging, which results in a continuous revenue stream.	Value is delivered through product performance or agreement on result.	These aspects not covered in every interview, but interviewees mostly agreed.

(Sections stressed in **bold** highlight emphasize the key points)

	Product-as-a-Service	Value is created by enabling (temporary) access to equipment, offering flexibility and performance reliability while reducing the need for individual ownership.	Value is captured through a subscription that yields a continuous, recurring revenue stream or reduces costs associated with machine idle time.	Value is delivered through service offering and access to product.	These aspects not covered in every interview, but interviewees mostly agreed.
Product lifecycle Extension	Premium Durability	Value is created by the production of products with extended functional performance, offering users durable and reliable, qualitative products, and so reducing the cost and frequency of replacement.	Value is captured in profit through sales with premium pricing and improved brand identity.	Value is delivered by products claiming long-lasting lifetime and thus superior quality.	Adjustments: stressed the difference between Product lifecycle extension by addressing the value creation to the customer Interviewees mostly agreed
	Modularity/ upgradability	Value is created through customization, offering users a product tailored to their needs, and through extended product value by enabling upgrades to functionality upon request, reducing the frequency and costs of replacement.	Value is captured in profit in recurring sales on upgrades or new modular parts, a premium price for customized goods, and improved customer relationships.	Value is delivered through upgrading systems.	Adjustments: stressed the difference between Product lifecycle extension by addressing the value creation to the customer Interviewees mostly agreed
	Lifecycle Services	Value is created through ensured product uptime, stable performance, and reliability, offering the user peace of mind in their equipment maintenance.	Value is captured through continuous revenues from subscription fees or agreements and improved customer relationships.	Value is delivered through repair and maintenance services.	Adjustments: stressed the difference between Product lifecycle extension by addressing the value creation to the customer Interviewees mostly agreed "*I think lifecycle services, the value proposition is* ***peace of mind*** *[AC_04]*
	Reprocessing	Value is created through the extended product lifecycle or its parts, offering products with a reduced price or a low-cost opportunity to maintain the functional performance of their existing products, reducing the cost and frequency of equipment replacement.	Value is captured in profit from (re-)sales of spare parts or of refurbished/manufactured products, and in improved brand image.	Value is delivered through the collection of used products/components and their re-offering.	Adjustments: stressed the difference between Product lifecycle extension by addressing the value creation to the customer Interviewees mostly agreed
Resource Recovery & Recycling	(Upcycle/downcycle) recycling/ recovering value from discarded products	Value is created by extending the life of existing resources and providing users with the availability of a renewable material, thereby reducing virgin materials usage.	Value is captured in an additional revenue stream by selling recycled material or reducing costs and raw material acquisition, when using the material itself.	Value is delivered through the collection of used products through a collection system.	These aspects not covered in every interview, but interviewees mostly agreed.

(Sections stressed in **bold** highlight emphasize the key points)

4.2.3 Retention Loops, R-strategies, and Lifecycle Phases

This subsection examines how the identified circular business model (CBM) types contribute to retaining value across the product lifecycle phases. The models vary in the extent to which they apply the circular principles introduced in Section 2.2. These connections reveal distinct patterns in retention loops and R strategies, as well as the specific lifecycle stages at which each model operates. Understanding these relationships clarifies not only how value is preserved, slowed, or restored, but also how the models can be operationalized in practice. By mapping CBM types to these circular principles, this section highlights the mechanisms through which material, functional, and economic value are maintained. Table 18 presents an overview of these linkages and presents the mechanisms of the CBM types through which material, functional, and economic value are maintained.

The typology illustrated that the archetypes are aligned with distinct retention loops. Consequently, the retention loop functions as a primary differentiating factor among CBM archetypes. These retention loops additionally align with the lifecycle phases. Closing affects material extraction, material processing, and recovery. Narrowing affects production. Slowing, intensifying, and dematerializing affect the use and distribution phases.

The connected R-strategies refine how retention loops, and thus CBM types, are operationalized. The typology allows for conceptualizing clear distinctions between the loops and the strategies. Narrowing aligns with Reduce (R2). Closing aligns with Recycling (R8) and dematerialization with Refuse (R0) and Rethink (R1). There is overlap between the strategies used to slow and intensify, which may be attributable to their shared definitions. As presented in Section 2.3, Slowing is part of the initially defined loops and solely focuses on extending the product's lifecycle. Intensifying is added to provide a more nuanced perspective and increase frequency of use, without aiming for an extended lifespan. Aligned with this difference, intensifying includes the strategy Rethink (R1), whereas slowing includes Refurbish (R5), Remanufacture (R6), and Repurpose (R7).

The overview does not include the strategy Recover (R9), as no business models were identified with this strategy. This is additionally supported by the following academic expert: *"So, of course, there is also R9, but I do not think that really would be a business model. R9 would be recover energy from incineration. I don't think that should be a separate business model or anything"* [AC_05][38]. This interviewee addressed the value of R9 as too low to create a viable business model.

Table 18 Overview of CBM Archetypes and Types Operational Mechanisms

CBM Archetype	CBM Type	Retention Loop	R-strategy	Lifecycle Phase	Expert Feedback and adjustment
Digitalization & Dematerialization	Digitalization & Dematerialization	Dematerializing	Refuse (R0) Rethink (R1)	Use (Design)	Not elaborately discussed in the interviews, but interviewees mostly agreed
Sufficiency Economy	Profit Sufficiency	Intensifying, Narrowing	Refuse (R0) Rethink (R1)	Material Extraction Production	Not elaborately discussed in the interviews, but interviewees mostly agreed
Circular Supplies	Industrial Symbiosis	Closing	Recycle (R8)	Material Extraction Material Processing Production	Not elaborately discussed in the interviews, but interviewees mostly agreed
	Sourcing Circular Supplies	Closing	Recycle (R8)	Material Extraction Material Processing	Adjustments: interviewees advised to highlight the **dominant mechanisms** of the CBM types to make them more conceptually distinct. Therefore, narrowing was removed from the retention loops
Resource & Process Efficiency	Production-on-demand	Narrowing	Reduce (R2)	Production	Not elaborately discussed in the interviews, but interviewees mostly agreed
	Process Optimization	Narrowing	Reduce (R2)	Production	Not elaborately discussed in the interviews, but interviewees mostly agreed
Access Provision	Sharing Platform	Intensifying	Rethink (R1) Reuse (R3)	Use (Distribution)	Not elaborately discussed in the interviews, but interviewees mostly agreed
	Performance/ Use-oriented	Intensifying	Rethink (R1) Reuse (R3) Repair (R4) (R4 are entitled to uptime guarantee)	Use (Distribution)	Not elaborately discussed in the interviews, but interviewees mostly agreed
	Product-as-a-Service	Intensifying	Rethink (R1) Reuse (R3) Repair (R4) (R4 are entitled to uptime guarantee)	Use (Distribution)	Not elaborately discussed in the interviews, but interviewees mostly agreed
Product lifecycle Extension	Premium Durability	Slowing	Reuse (R3)	Use	Not elaborately discussed in the interviews, but interviewees mostly agreed
	Modularity/ upgradability	Slowing	Reuse (R3) Repair (R4) Remanufacture (R5)	Use	Adjustments: Interviewees advised took out R5 and R6 to make the difference between the models more clear and conceptually different
	Lifecycle Services	Slowing	Reuse (R3) Repair (R4)	Use	Adjustments: Interviewees advised took out R5 and R6 to make the difference between the models more clear and conceptually different
	Reprocessing	Slowing	Reuse (R3) Repair (R4) Refurbish (R5) Remanufacture (R6) Repurpose (R7)	Use	Interviewees mostly agreed
Resource Recovery & Recycling	(Upcycle/downcycle) recycling/ recovering value from discarded products	Closing	Recycle (R8)	Recover	Interviewees mostly agreed

(Sections stressed in **bold** highlight emphasize the key points)

4.2.4 Applicability to Medical Consumables

This last subsection examines whether the identified circular business model (CBM) types can be applied to the products discussed in this thesis. In contrast to the previous section, which describes the CBM types and their characteristics, this section focuses on the applicability of CBM types across different product modalities and in the context of medical consumables. By combining the assessment of the interviewed experts with the CBM types, characteristics, and product modalities, an evaluation of their applicability for these products is explored. Experts were presented with two contrasting product modalities. Based on the described sustainability challenge in Section 2.1, the contrast was based on volume and financial value. The supported insights into how these product characteristics influenced the applicability of the models. Table 19 summarizes the assessment. Only the models that are evaluated as less preferable or challenging are discussed. Across the interviewee responses, no model was unanimously deemed unsuitable.

The first notable distinction between low-value and high-value is the set of models evaluated as less preferable or more challenging. For low-value medical consumables 5 models were evaluated as challenging or less preferable, compared with 3 for higher-value devices. One interviewee even emphasized this relationship between value and applicability: *"I think it makes almost all of them easier to implement."*[AC_04][39]. One potential explanation is that the higher value of the machine generates more economic incentive to retrieve valuable materials and generates more economic flexibility to earn back investments required for the implementation.

For both product modalities, *Industrial Symbiosis* is seen as challenging. This CBM type requires a specific alignment between input and output across organizations. Additionally, partners are often required to be geographically proximate. Interviewees addressed that this is often not the case, thereby complicating the sharing of process byproducts with others.

Production-on-demand is the first CBM type with a different evaluation across the two product modalities. For low-value consumables, this model was deemed less preferable because healthcare demand is unpredictable, making it difficult to align production effectively with demand. Additionally, one interviewee addressed that not having the product on display could negatively impact patient care in case of emergencies. However, this negative impact depends on the product's criticality in healthcare delivery. This implementation challenge, arising from demand unpredictability and potential negative effects on workflow, makes this CBM type less preferable. For the higher value, lower volume devices, the applicability of this CBM type was not questioned. This may be due to the lower volume, which potentially makes demand easier to predict. Additionally, with higher value products, it was assumed that they come with a certain complexity that would increase the waiting time, and so justifies the waiting time associated with *Production-on-demand*.

For both product modalities, the *Sharing Platform* was deemed relevant but challenging to implement. This was attributed to the complexities of moving and coordinating products across different customers. For example, moving heavy equipment, such as an MRI, or making it financially viable for lower-value products. The industry expert addressed limited incentives for an OEM to mediate between customers to share underutilized equipment. However, in combination with an additional model that allows to scale revenue, this would increase the incentives and attractiveness for OEMs.

This economic challenge is why *Reprocessing Models* and *Recycling/Recovering value from discarded products* are considered challenging for the low-value high-volume modality. The CBM types are seen as relevant, especially due to the high volume associated with these products. This could, namely, result in the retrieval of a significant amount of materials. However, in order to clean, repair, or recycle these products, they need to be suitable for reprocessing and recycling. To do so, additional efforts and costs are made, which could exceed the value of the product. This would make these activities financially

unattractive. The higher value product has more economic flexibility to still make these efforts financially viable. However, as these higher-value devices often have low volumes, material recovery is only marginal and therefore can be financially uninteresting. Additionally, an interviewee addressed this model as undesirable, as it would take away the complexity, which is costly to achieve and gives the product its value.

Table 19 Assessment of the Applicability of the CBM Types

CBM	**Applicability to low-value high-volume**	**Applicability to high-value low-volume**	**Expert Feedback**
Dematerialization & digitalization	Yes	Yes	Interviewees agreed
Profit Sufficiency	Yes	Yes	"*Sufficiency is **always possible**. I guess you don't need sufficiency in terms of health care. It's an interesting discussion"*[AC_04]
Industrial Symbiosis	Yes, challenging	Yes, challenging	"*The only model I have seen working for a long time is the Kalundborg model in Denmark. That's the main case study everybody knows about in the 70s. I mean, I think that could be super interesting in a healthcare setting. Especially, where you have healthcare systems. Many hospitals in one healthcare system, but **they are not physically located next to each other**"*[PC_01]
Sourcing Circular Supplies	Yes	Yes	Interviewees agreed
Production-on-demand	Less preferable	Yes	For low-value: *"I don't know if that is practically possible, because demand has to be quantified and confirmed. […]. You don't know when people come in and how many. That needs to be done on the spot, **so it's quite unpredictable.** That makes it difficult."* [AC_03] *"For emergencies and these kind of things, and it's not those should be manufactured by demand. **They should be there because it's an emergency.** We cannot wait until the demand rises and then we produce"* [AC_02]
Process Optimization	Yes	Yes	"*I think resource efficiency **in general should apply** across the board"* [PC_01]
Sharing platform	Yes, challenging	Yes, challenging	"*I would also say, a sharing economy or a sharing platform for health tech is perhaps not exactly applicable."*[PC_01] *"Sharing. I can imagine that that also might be a little bit more **complex and help get settled**"*[AC_03]
Performance/use-oriented	Yes	Yes	Interviewees agreed
As-a-service	Yes	Yes	Interviewees agreed
Premium durability	Yes	Yes	Interviewees agreed
Modularity/ upgradeability	Yes	Yes	Interviewees agreed
Lifecycle Services	Yes	Yes	Interviewees agreed
Reprocessing Models	Yes, challenging	Yes	Low-value: "*The difficult thing is not so from a circularity or sustainability perspective, it could be from an **economic perspective**. The costs to recover, clean, repair etc., then often exceed the product's market value*."[AC_03]
(Upcycle/downcycle) recycling/ recovering value from discarded products	Yes, challenging	Less preferable	High-value: "*The numbers in low volume. Upcycling here is like **very marginally meaningful**. […] it's not systemic change."*[AC_02

(Sections stressed in **bold** highlight emphasize the key points)

4.2.3 Conclusion

This Section presented the developed CBM typology. The typology illustrates how CBM archetypes and type are conceptually differentiated through their underlying value creation, capture, and delivery, retention loops, R-strategies, and affected lifecycle phase. The overall findings classify all CBM archetypes and types as relevant. This typology, therefore, is a comprehensive foundation for the content required in the design solution.

5. Designing and Testing the Solution

Drawing on the identification of suitable CBMs and the analysis of missing capabilities, a design solution is developed to support the exploration and development of new CBM configurations. The developed design is evaluated on its support for CBMI. Consequently, this chapter will first introduce the design solution and will subsequently present the evaluation of the focus group and user test. Only the final design solution will be discussed elaborately; adjustments after the evaluation and feedback moments were included in the design process, but only briefly touched upon.

5.1 Final Design

To support product managers and their team members in exploring new CBM configurations, the workshop *Unlocking the Loop* was developed. This workshop comprises three exercises that support participants in sensing opportunities, turning them into a business model, and reconfiguring them into a detailed business model outline. Figure 7 presents the workshop workflow. Participants, prior to the workshop, must define a general product concept they would like to explore during the session. The first activity begins with a collective description of the concept to ensure participants have a shared understanding of what is being discussed. The participants perform three sequential activities that transforms the general product concept into a detailed business model plan: (1) the business model decision tree, where the participants explore the application of the different CBMs and decide on a preliminary CBM; (2) circular business model identity card, which educates the participants on the details of their chosen model and triggers them to define operational details and explore new combinations; (3) the business model blueprint, where participants define the required activities, resources, partnerships, costs and revenues to operate the model.

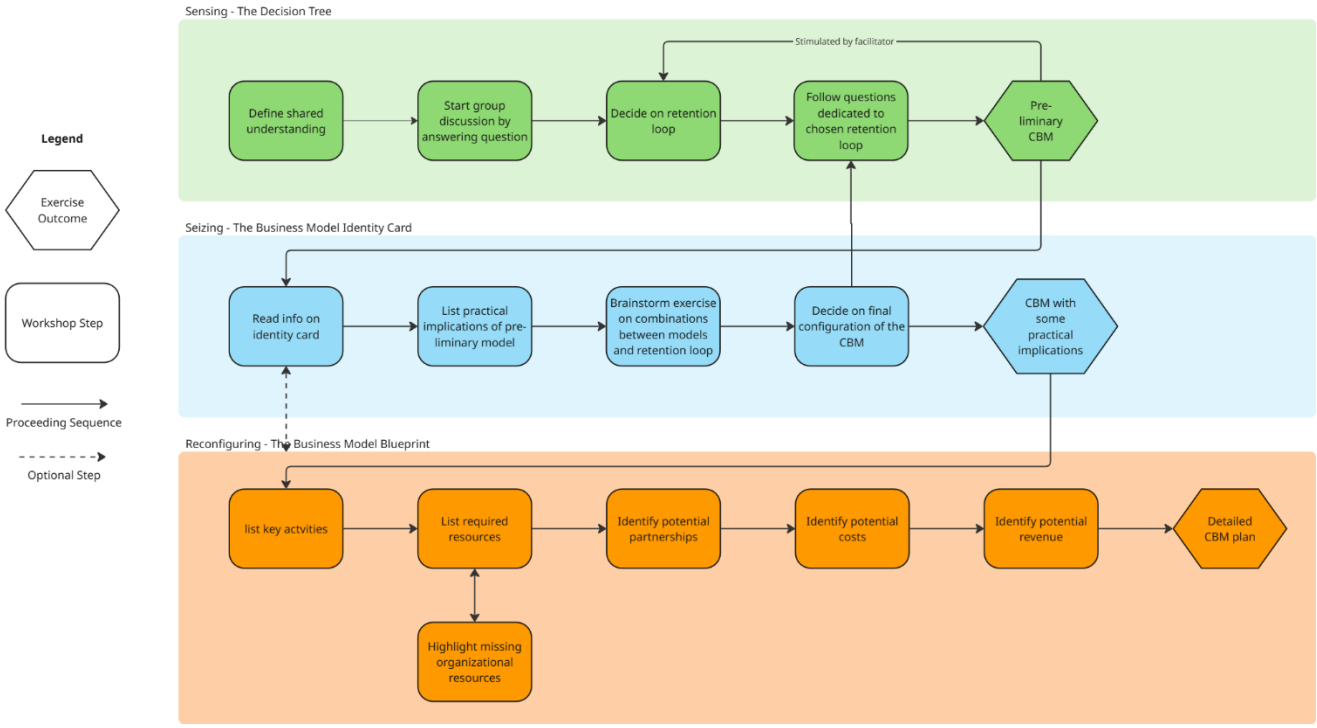


Figure 7 Representation of the Workshop Flow

An independent facilitator guides the workshop. This facilitator provides additional information on the exercises, keeps track of time, and encourages participants to explore other options if the group becomes fixated on one alternative. During the activities, participants can consult previous exercises or information. This creates iterative cycles between different workshop steps and activities. The workshop is

accompanied by a digital whiteboard and collaboration platform called Miro. In this platform, explanations and templates for the exercises are presented. This makes the workshop suitable for online, hybrid, and offline collaboration settings.

5.2 Design Logic and Components of the Workshop

This section discusses the three workshop exercises in more detail. This elaboration includes a more thorough explanation of the steps performed in the exercise and as presented in Figure 7. Additionally, it provides background on the design choices and how they support the goal of supporting CBMI and, hence, CBM exploration and design. Key in CBMI is design thinking, and thus, a level of creativity (Shalley et al., 2015). Therefore, the activities are stimulating divergent thinking. The exercises will be discussed according to their sequence in the workshop.

5.2.1 The Business Model Decision Tree

The first exercise, the Business Model Decision Tree, supports sensing capabilities. Consequently, this exercise aims to raise awareness and guide participants in exploring the applicability of CBM opportunities to their overall product concept and context. This decision tree consists of questions and their corresponding answers. Appendix I illustrates how this exercise is presented in Miro. Participants must discuss these questions and reach a consensus on the answer, considering their concept. The answers are discrete options. Each option leads to the next question. The questions and answers are based on the developed CBM typology. The choices made in these questions, thus, determine a characteristic of CBM. Thereby, at each question, narrowing the applicable options and guiding towards a preliminary CBM that should match the context of the considered. The participants are encouraged to explore multiple paths in this decision tree.

Apart from the choices leading to a preliminary model, there is value in the discussion surrounding the reach of consensus. The formulation of the questions is inspired by Dan Lockton's Design with Intent method (Lockton, 2013). Therefore, the questions are intentionally framed as "How can you...?" or "Can you...?". These sentence structures suggest that a solution is feasible. Consequently, prompting participants to focus on implementing a business model characteristic rather than merely assessing its applicability to the situation. Figure 8 presents an overview of the included questions and how they are connected to each other. The discrete answers to these questions are presented on flipcards. The back of these flipcards contains additional information about what the answer means or potential contextual implications. The use of these flipcards also provides a trail of the discussed questions and answers, and thus a level of transparency into the chosen path. Examples of a combination of a question and a flipcard, along with their different configurations, are presented in Figures 9, 10, and 12. Reaching the preliminary model leads to a button that automatically directs to the business model identity cards. This button is visuals in Figure 11.

An important element in the decision tree is the question identifying the applicable retention loop. As Section 4.2.3 shows, these loops seem to be conceptually connected to the different lifecycle phases. Deciding on the applicable retention loop, thus, involves deciding on the lifecycle phase that will be targeted. To stimulate lifecycle thinking and the exploration of different characteristics, the facilitator should promote exploring the line of an additional retention loop after reaching the first preliminary model.

Overall, this exercise provides a structured approach to guide the brainstorm and group discussion to explore the different facets and characteristics of a circular business model and how they can be applied to their product concept. As such it contributes to the development of sustainable value propositions. The provided additional information on the back of the answer cards supports overcoming the knowledge gap.

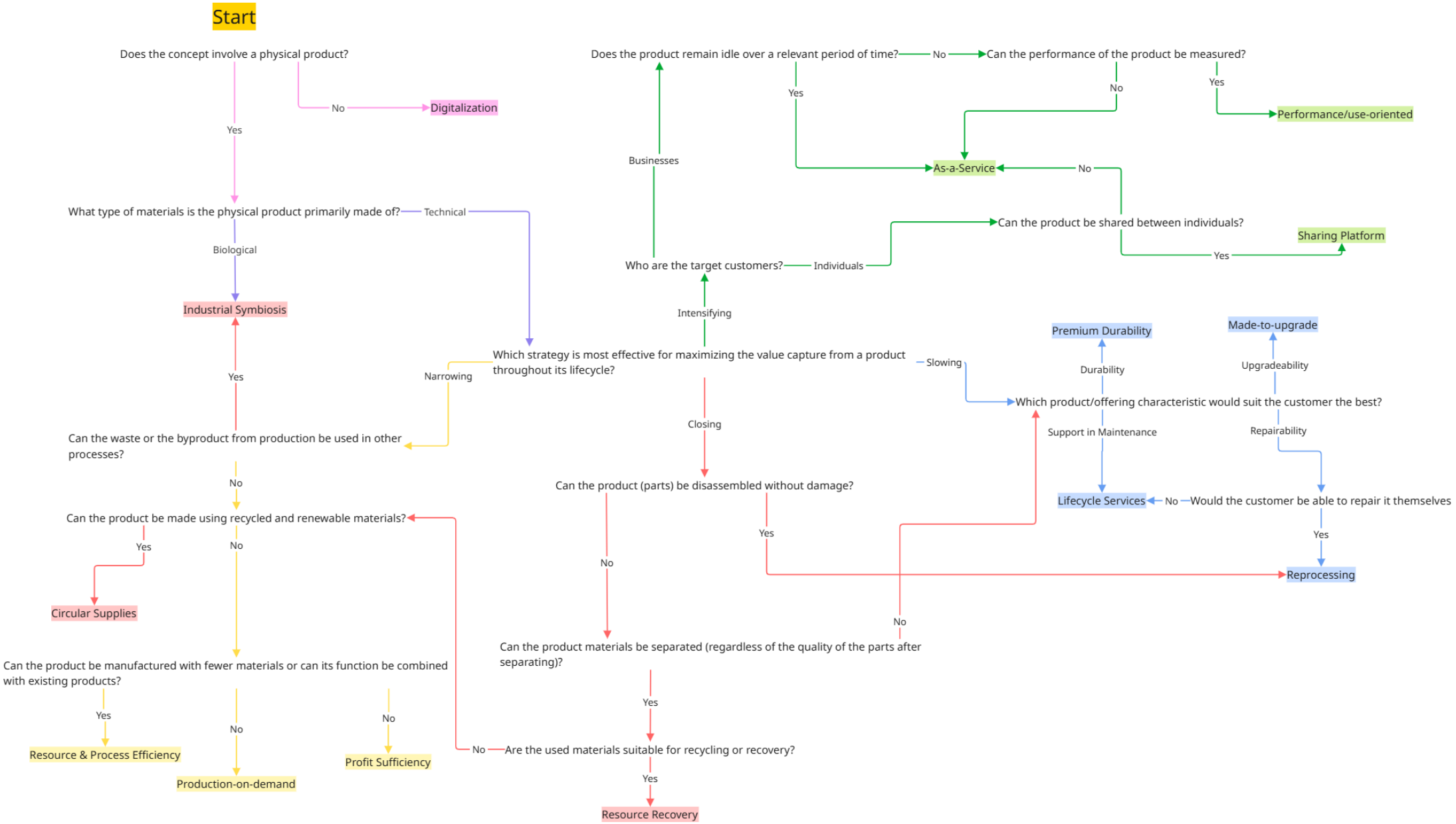


Figure 8 Overview of Decision Tree Question and Answers

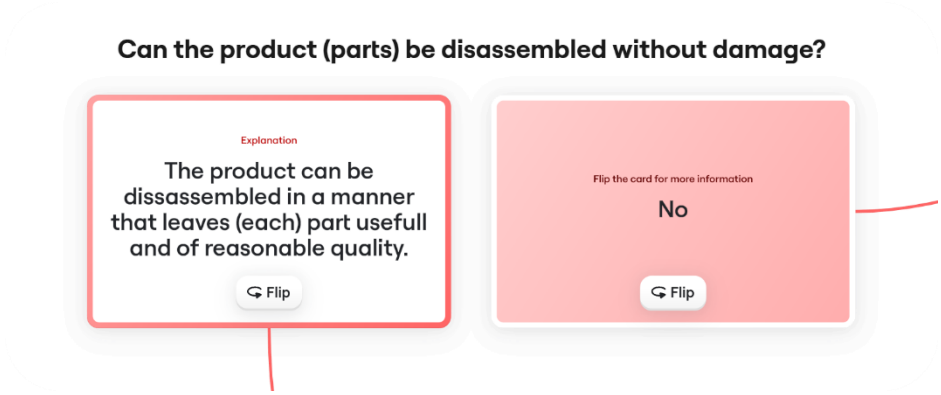


Figure 9 Decision Tree Question with Answer Cards Half Open Half Closed

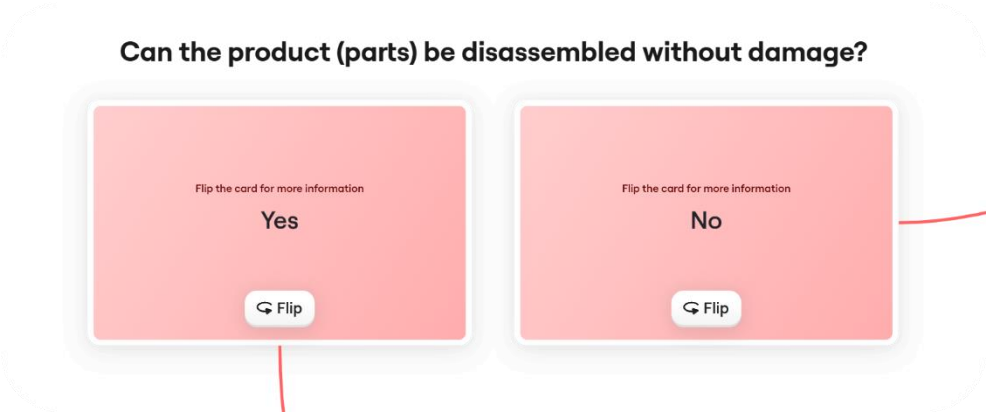


Figure 10 Decision Tree Question with Answer Cards Close

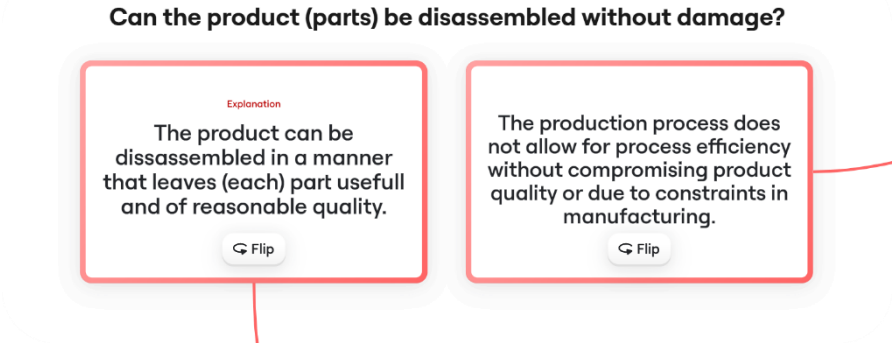


Figure 12 Decision Tree Question with Answer Cards Open

Figure 11 Pre-liminary Business Model

5.2.2 The Circular Business Model Identity Cards

The decision tree exercise leads to the Circular Business Model Identity Cards. As such, the value proposition and preliminary CBM will be further explored and converged in the eventual CBM choice. These identity cards, therefore, align with seizing capabilities. Each model from the developed CBM typology is included and thus has an identity card. These cards contain a passive element that presents the information and operational mechanisms of the business model, and an active element that engages participants in activities to detail the model and explore new potential configurations. Appendix J presents the identity cards of all 14 included CBMs.

The format of cards is specifically chosen as their tangible/illustrative characteristic is seen as an effective tool to bring information into group discussions (Hsieh et al., 2023; Lucero et al., 2016). The cards first present the information about the CBM. This supports the participants to first learn more about the outcome before brainstorming on its practical implications and ideating on its configurations. The information is derived from the developed CBM typology and thus includes: the model's definition, value capture, creation, and delivery mechanisms; the affected product lifecycle; and the operationalized R-strategies. Additionally, emphasis is placed on the lifecycle aspect and the R-strategies. The lifecycle emphasis is created by visualizing the lifecycle and the loop the CBM creates. The emphasis on the R-strategies is created by presenting them more visually prominent. Figure 13 presents an empty template of this first section of the identity card.

Following this information, the participants complete three sub-exercises to refine the operational details of the business model. All exercises include an example and explanation to support participants. These complement the facilitator's explanation. The first sub-exercise prompts the participants to brainstorm about required operational steps, changes in knowledge, skills, and equipment, product characteristics, and potential collaboration opportunities. These topics aim to outline the implications of implementation and prompt participants to identify strategic partnerships.

The second sub-exercise challenges the participants to explore new configurations of the established value proposition by applying the creativity strategy *Combination and Adjustment*. This is a cognitive process that supports creative thinking by merging two or more concepts into new ones, and this modification could result in innovative and unexpected ideas (Sun et al., 2019). During the first round of this sub-exercise, participants must apply this strategy to create combinations between their developed proposition and a different retention loop. Consequently, stimulating CBM combinations targeting multiple phases in the lifecycle to create a more all-around circular product. In subsequent rounds, participants build on the ideas developed by other participants. The identity cards conclude with a summary statement of their chosen CBM and its assumed practical implications, which is presented as the last subexercise and a convergent statement. The second part of the identity card is presented in Figure 14.

Retention Loop Circular Business Model Identity Card

Title of the CBM Type

Value Creation
Description value creation mechanism

Value Delivery
Description value creation mechanism

Value Capture
Description value creation mechanism

About the Cards

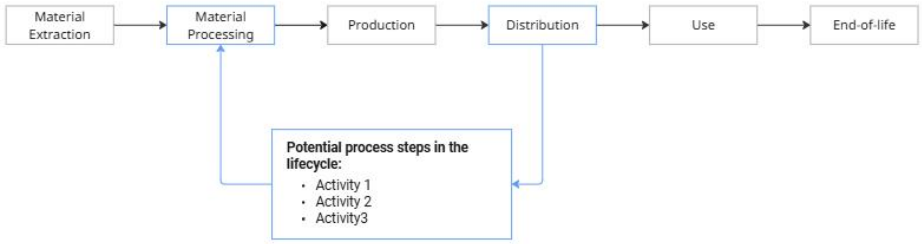
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

A description of the CBM type as derived from from the CBM typology.

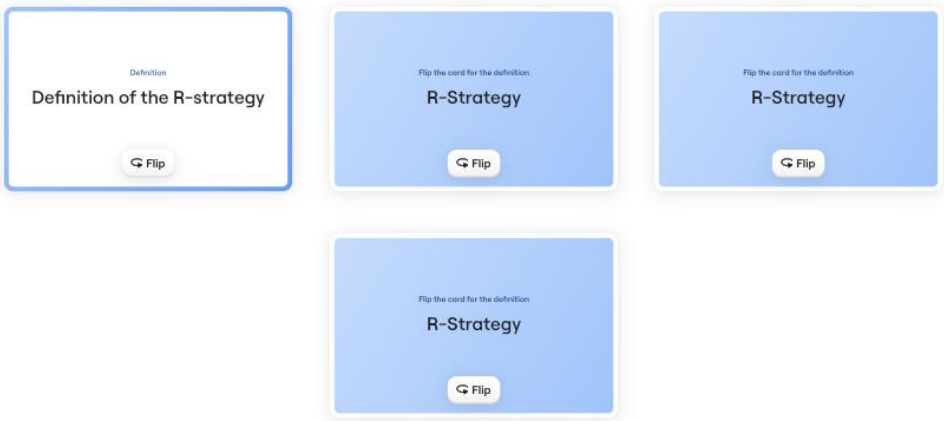
Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

The cards describe strategies that are essential in implementing and designing your model. Each strategy might have a different outcome on each product. Each R-strategy is supported by their definition [2].

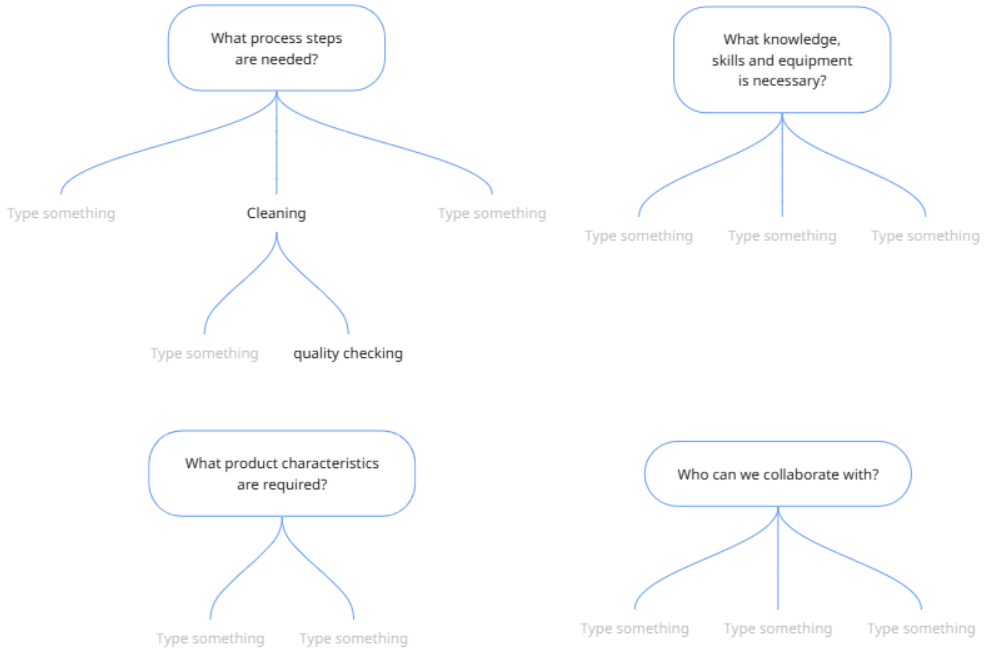


References:
[1]Hoveling, T., Ijzenbrandt, J., Hinrichs-Krapels, S., Ritzen, L., Bramer, W. M., Van Raaij, E., Faludi, J., Bakker, C., & Diehl, J. (2025). Mapping circular economy product and material flows in healthcare: A visual taxonomy. *Journal Of Cleaner Production*, *538*, 147258. https://doi.org/10.1016/j.jclepro.2025.147258
[2] Ciano, M. P., Peron, M., Panza, L., & Pozzi, R. (2025). Industry 4.0 technologies in support of circular Economy: A 10R-based integration framework. *Computers & Industrial Engineering*, *201*, 110867. https://doi.org/10.1016/j.cie.2025.110867

Figure 13 Information Overview of the Identity Card

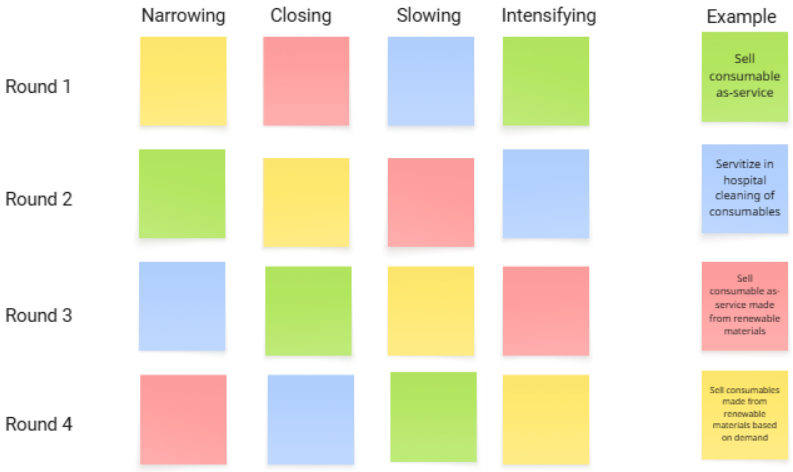
Can you make it happen?

Now that you have explored the nuances and implementation possibilities of the model, it is time to document your ideas. Use the mind maps below to write down your thoughts, using the questions provided.



Expand the model

Deeper insights may spark new ideas. Therefore, below you will find a creative exercises that allow you to broaden the set of opportunities. Each participant is assigned a post-it color. In the first round, each participant has to make a combination between the model of the identity card and the strategy, the post-it color is assigned to using the cards web. Afterwards, we move one row down, where each participant follows its post-it color and expands on the ideas of the participants before. In the end every participant has iterated on every idea that is developed in the first round.



Choose a path

With the expanded number of ideas, it is now time to reflect on which concept you will use in the upcoming steps. Select one model and place it in the designated frame. Additionally, make a list of the practical considerations, you want to incorporate.

Chosen model

Place/write a post-it with the model

List here the chosen assumtions

- List assumptions here
- List assumption here
- List assumption here

Figure 14 Subexercises of the Business Model Identity Card

5.2.3 The Business Model Blueprint

The Business Model Blueprint is the last exercise and aims to transform the defined CBM into a detailed overview of its implementation. It aims to support the exploration of how the model can be operationalized and create an initial overview of how organizational resources and processes need to be adjusted. Therefore, supporting the reconfiguration capabilities.

This operational exploration is guided by the template presented in Figure 15. This template comprises the columns representing the different lifecycle phases, which aim to support cradle-to-cradle thinking. For each column, the participants are requested to define the key activities, resources, partnerships, required investments, costs, and revenues. The template, as such, reorganizes the different elements of the traditional business model canvas from Osterwalder & Pigneur (2010). These elements are organized vertically to indicate how they inform each other. For example, after identifying the required activities, participants can more easily determine which resources are needed to perform them and whether the organization has them in place. After identifying the strategic partnerships in each phase, the participants generate, based on this information, the required investments to implement the model and the costs of operating and maintaining it. Lastly, the revenue streams are identified. In this bottom-up logic, it systematically prompts participants to think through the product lifecycle, formulate strategic partnerships, and identify the organizational and system-level changes required. This supports adjustments to organizational capabilities. Additionally, with this logic, it becomes a preparatory exercise for the business case evaluation.

Similar to the iterative nature of the value proposition process, the operational plan is similarly iterative and requires information gathering and exploration. Therefore, this template additionally serves the purpose as an overview to discuss with other relevant parties, such as operations, and to adjust according to the newly gathered information. Furthermore, the participants, when completing this template, might encounter an activity or resource or potential partner that requires more elaborate research. Participants can then consult the *Homework Boxes*. Here, the participants create an overview of the tasks that they need to follow up on after the workshop, and identify who they need to consult and will take on this task. This homework box is presented in Figure 16.

Figure 15 Business Model Blueprint

Figure 16 Homework Box

5.3 Evaluation of the Workshop

To evaluate the extent to which the solution design is perceived as useful and able to support CBMI, a focus group and user test were performed. This section will elaborate on how the design was evaluated during these instances. The emphasis in this section is placed on the final user test as the main purpose of the focus group was to identify opportunities for improvement in the design process and whether the design was heading in the right direction.

5.3.1 Focus Group

An exploratory focus group was performed to assess early in the design process whether the concept holds the potential to achieve the set goal and its fit with the target group. The focus group was performed with one of the earlier prototypes. In this subsection, the evaluation of this prototype and the content of the workshop are discussed.

The overall workshop was evaluated as a beneficial collaborative tool towards business modelling. The perceived benefits were attributed to the structure of the exercises. This structure guided participants' discussion, which helped develop a clear line of argument and raise awareness of the different CBM options. Consequently, the decision tree exercise was deemed the most valuable. The question actively supported the group discussion and challenged the participants to think about factors they otherwise might have overlooked.

"I liked it a lot. *I think the three steps were very clear. Clearly different steps. First one to broaden the mind a bit, and then converging again to the business models, and I like that it is really visual. That you follow a line based on the questions. The last part was really clear in guiding users to the next steps in the flowchart. Whereas in the last step, that was a bit more unclear to me, where to start and how to fill it in."* [CT_03][40]

"*[...] I think that the model, as we have gone through it now, is really helpful. Like I have a solution in mind, and you guide me through a discussion, which, because of the structure, also in a group, is much easier than when you have an open discussion. What I like, is that actually by doing so, you can bring in the challenge what people would not think about."* [CT_04][41]

Although the decision tree raised awareness of the different options, the identity cards did not prompt direct exploration of other CBMs. The prototype's identity cards had a simpler, less visual form, with only a question designed to encourage exploration. Despite the facilitator addressing the options for further exploration, the participants remained with the initial preliminary CBM. Therefore, this aspect did not result in the desired option of the participants exploring different CBMs. Participants addressed that the guiding structure of the decision tree might cause this effect. The questions, namely, steer the participants in a specific CBM direction. The combination of asking the participants to list the practical implications of the model and no direct push or need to explore the other models, made them fixate on answering the practical implications rather than exploring different opportunities. As such, the business model identity cards were redesigned with more visual cues and with additional subexercises.

"*I think answering the practical considerations tool all of my mind"*[CT_03][42]

"Now we have moved so much into this direction that I have locked out other alternatives. Because now I feel steered in a direction and I am fully focusing on that."[CT_04][43]

Furthermore, the business model blueprint was perceived as valuable, but requires clarification on the standpoint required when filling in the template.

The product manager reflected on the tool's usefulness in the current flow. This product manager addressed how the discussion-triggering nature of the workshop would be useful to distill from all different perspectives what the core customer benefit they are focusing on. As such, it would support the product

managers with their connection to other experts. Additionally, this participant addressed how the workshop could replace some of the existing materials. This is an indicator that the workshop aligns with the existing process of Philips.

"[...] they are coming from very different perspectives. So I think having this process helps us to kind of really address or realize what problem we are trying to address and making sure that we are resolving a pain point for the customer"[CT_01][44]

"We already have a lot of tools available, but possibly, yes, this could, this ideation phase could potentially replace what we already work with today."[CT_01][45]

Overall, this concept test indicates that the workshop has the potential to stimulate CBMI in Philips's processes. It underscores the need to make the practices more directly prominent through visualizations and direct exercises, for example, explicitly asking participants to list potential partnerships and make combinations between different CBM elements and new configurations. As such, the prototype is adjusted, and a more elaborate user test is conducted to evaluate the workshop more thoroughly with respect to its support for the missing practices, the goal of CBMI, and its fit with Philips's process.

5.3.2 User Test

This subsection presents the insights from the user test. This user test evaluated the effectiveness and applicability of the workshop in support of CBMI and the existing business modelling process of Philips. By integrating the insights from the test, survey, and interviews, this subsection identifies both strengths of the workshop as additional recommendations for improvement and integration into the existing business modelling process of Philips. Both Table 20 and Table 21Table 21 present the overall evaluation of the workshop and its materials. As this user test was conducted with a real business proposition, the concept will remain phrased as such.

Table 20 User Experience Evaluation Workshop

			Neutral			
Confusing			2	2		Clear
Inferior				1	3	Valuable
Obstructive			1	3		Supportive
Impractical				3	1	Practical
Complicated		2	1	1		Easy
Demotivating				2	2	Motivating
Inefficient			2	2		Efficient

(Numbers correspond with the number of participants who provided this answer)

Table 21 Workshop Evaluation

Statement	Totally disagree	Disagree	Neutral	Agree	Totally agree
I would like to use the workshop in future business modelling activities.				4	
The workshop will support me in exploring and developing more (circular) business models.			1	2	1
Using the workshop made circular business modeling more comprehensible.			1	3	
I have found the workshop to be beneficial to my needs.		1		3	
The workshop helped me break down circular business modeling into manageable steps.			2	1	1

(Numbers correspond with the number of participants who provided this answer)

From a user experience perspective, the workshop was evaluated as practical, valuable, and motivating, while being complex at times. This complexity was associated with exercises that required unfamiliar forms of ideation, such as the combination exercise of the identity cards. As one participant explained, "*The previous exercise of just kind of building off of the other person's ideas that was, once I grasped that, difficult but stimulating"* [US_04][45]. This reflection suggests that the workshop incorporated cognitively challenging tasks that, nonetheless, facilitated a more creative exploration.

CBMI support and exploration – participants consistently emphasized the workshop as a structured and supportive process for collaboratively exploring CBM opportunities. The structure was described as guiding participants through collective reasoning and consideration of these opportunities from diverse perspectives. One of the participants articulated this as follows: *"I like the process as a whole because it helps you think along and for everyone to be following that same line of thought, like it gives an opportunity for everyone to bring their own ideas and, that's a platform and space to do that and make sure that you're considering different perspectives. But also, the output there is a clearly defined action plan."*[US_01][45] This indicates that the workshop successfully fosters explorative divergent thinking behavior, which was an essential characteristic to sense new opportunities.

Moreover, a clear development process aligning the sensing, seizing, and reconfiguring was observable in the refinement of the concept across exercises. The participants initially proposed a general concept of improving the reusability of consumables to enhance product value and sales. Following the decision tree exercise, this concept was refined into the 'as-a-service' model proposition. During the identity card phase, this proposal was refined by incorporating potential third-party collaboration and preliminary considerations, such as material properties and standards. Finally, the blueprint exercise enabled the participants to articulate the required activities, partners, and resources, thus detailing the business model and the required changes, and follow-up 'homework' steps. Overall, this progression and refinement of the concept of how each exercise contributed to the formulation and detailing of the CBM. This capability, combined with increased awareness of new CBM opportunities, demonstrates the workshop's ability to scaffold CBMI.

Integration of lifecycle thinking and strategic partnership – lifecycle thinking as addressed was ingrained in the information and exercises of the workshop, and all three exercises contained different elements relating to a lifecycle perspective: the decision tree and the retention loops; the identity cards and the lifecycle visualization and combination exercise; and the blueprint with the lifecycle phase columns. This stimulated lifecycle reasoning. One example was observed when participants actively explored alternative retention-loop pathways, thereby creating opportunities in a different lifecycle phase. This willingness to explore is exemplified by the following comment made during the test: *"I don't want to dismiss what [US_04] said. Can we do a quick trip through yellow and then go down through blue?"* [US_03][45]. This illustrates how the decision tree motivated the participants to explore the different options. Additionally, the combination of identity cards yielded 15 distinct CBM configurations, the result of brainstorming on combinations between the as-a-service model and different retention loops.

Similar to lifecycle thinking, the identification of partnerships is embedded in the exercises for the identity card and the blueprint. The refinement of the concepts illustrated how this led to the inclusion of a third party, alongside the parties that were listed in the different lifecycle columns of the blueprint. Moreover, the business case expert confirmed the presence of this partnership emphasis, noting that "*but I see that the partnership trajectory runs like a common thread throughout the entire story, and you handle that well"*[EX_02][46].

Educational and skill-building effects – the workshop demonstrated educational value to some extent. Table 21 indicates that the workshop made CBMI more comprehensible and, for some, supported the translation to actionable steps. However, this educational effect seemed to differ between participants

depending on their prior experience and knowledge. A participant with limited prior experience in circularity emphasized this learning effect: *"I'm definitely coming away from this more informed than when I started"*[US_01][47]. A more experienced participant did not report this personal learning, but did recognize the workshop's value in strengthening the organization's capability: *"I personally am probably not more capable, because I spent a lot of time doing the work already. But is Philips more capable of doing it? The answer is yes."*[US_02][48] This is also assumed to explain why the person addressing the workshop did not find it beneficial to their needs, as this participant not only had significant prior knowledge and skills in circularity, but also a more fixed perspective on the concept's outcomes. This insight also indicates that the workshop should be used early in the process to prevent participants from becoming too attached to a specific CBM configuration they envision and to perform the exploration when opportunities are still fully open. This educational and skill-building effect of the inexperienced employee could positively contribute to a change of practices and thus to change management. However, a structural effect on change management in the organization cannot be deduced from this short evaluation period.

Alignment with the business case and internal process – the workshop was perceived as effective preparation for subsequent business case and process steps. Especially, the blueprint exercise allowed the participants to define clear follow-up tasks and validate the logic and input for completing the business case. As remarked by one of the participants, *"those homework items were definitely a strong output. We also had inputs to the business case. I don't know if there's a way to put it. Something like a sanity check on there of how to better validate the business case."* [US_02][49]. Detailing the plan and the elements required thus supported making a more fitting financial evaluation in the business case. This alignment with the business case was additionally confirmed with the business case expert, "*when you look at maintenance costs, I think it's fantastic that you've included that, because maintenance and R&D are too often lumped together. What you see is that as a company, we are actually only used to calculating investment."* [EX_02][50]. This expert additionally addresses how he perceives the workshop to draw attention to details that are in his experience overlooked in the business modelling process, "*there is tremendous strength in asking for attention to things that we currently pay too little attention to […]. That is what you address well here, and that makes me enthusiastic. You systematically handle that with the key activities and key partners through a business model and that canvas."*[EX_02][51]. Hence, these findings indicate that the workshop not only supports CBMI and the missing practices but also enhances the quality and comprehensiveness of the information fed into the established internal processes that would follow after the workshop.

A comparison can be made between the concept test and the user test with respect to group composition. The concept test included a diverse group of participants, while the user test included a subset of the real support team, which in this case predominantly consisted of product managers. This negatively impacted the blueprint exercise. Participants reported struggling to complete the business model blueprint, because they felt they lacked knowledge of operations or sales, i.e. these multidisciplinary backgrounds. This emphasizes the potential need to perform or validate the final exercise with additional stakeholders involved in the product lifecycle.

Moreover, the participants addressed three workshop enhancements to better align with the existing process and support effective implementation. First, aligning the exercises with the mandatory value proposition templates to enable smoother integration in the current process of Philips and so stimulating adoption by the product managers. This was not done in the initial workshop to avoid complicating the process and to keep the option open to use the workshop if the templates change or disappear. Second, support the prioritization of ideas to facilitate decision-making. This can be attributed to the timing of the workshop. As the concept was already previously explored in light of its possibilities, this could have generated a feeling of 'unnecessary' idea exploration. This therefore also indicates this workshop should be used early in the process. Additionally, different exercises could be added to introduce convergent

thinking. Last, but not least, the participants addressed the role of a workshop champion to promote and guide the workshop within the organization.

Stakeholder alignment and project continuation – The follow-up interviews highlighted an unanticipated effect of the workshop: it convinced different stakeholders in the process. This was part of the missing practice *commitment and support from top management*. The workshop did not perse create support from top management, but it did convince stakeholders determining on progression of the concept in the development process. This ensured its continuity in the processes. This convincing power was attributed to the structured flow and thoroughness of the exercises, which supported the communication of the concept rationale. As the participant remarked during the follow-up interview: *"it led to work that is making these things more real [...]. You have to convince person after person after person, and they have to go through this whole process of evaluating themselves, and is it worth doing? Should I spend money on this? And that's exactly what you did with the workshop."*[US_02][52]

Medical consumables - Lastly, the discussion enabled to identify key elements in the discussion of medical consumables. The concept was focused on consumables and highlighted potential for innovation. The different paths and corresponding retention loops triggered the exploration of the different topics, such as the use of different materials, for example, biocompatible materials. The outcomes of these brainstorms were often supplemented by discussing the implications of regulations and economic feasibility. Last, the participants took a more Philips-wide perspective when discussing the concept. The participants discussed whether new or existing projects could be an enabler of creating synergy between projects. During the workshop, the participants were drawn to the use-oriented CBM. Interviewees in the follow-up interviews additionally addressed models focusing on reuse, such as as-a-service, to be the most relevant. Especially, Quote 53 demonstrates the considerations taken into account when evaluating the match with a business model. This illustrates, for example, that the high price association of the consumables makes as-a-service an interesting business model as it prevents customers from having to invest in the consumables.

"For me, I see the most value at the top of the pyramid for my products. So, focusing on reuse and circularity is the most important" [US_02][53]

"I think we went with the right choice. It is as a service and durability, and making our products more robust is still the right strategy. There are two parts to being robust, because we actually need to improve the robustness and quality of our products. However, for disposables, we actually overspec. So it makes us more expensive. Therefore, obviously, people don't buy, or for certain products they reuse the disposables, or they use the disposables way longer than they should be used for, because our disposables are almost to the quality of a reusable." [US_01][53]

5.4 Conclusion

This Chapter presented the final design and its evaluation. The design took shape of a collaborative workshop guiding participants through the three dynamic capabilities. During the evaluation, the participants' experiences with the workshop, its contribution to exploring and designing CBM, and its fit within the organization were explored. The workshop was evaluated to be supportive. Some exercises were evaluated as complicated. The workshop represented the established design requirements. However, from this user test it cannot be concluded whether this leads to structural change in the behaviour in the long-term.

6. Discussion

This final chapter answers the research questions, corresponding subquestions, and discusses their results. Subsequently, the theoretical and practical contributions of this thesis are presented. This thesis will be concluded with a reflection on its limitations and opportunities for future research.

6.1 Research Conclusions

This thesis aims to explore how OEMs can create a positive impact on the environmental performance of the healthcare industry. Specifically, by exploring how they can operationalize circular business model innovation. Therefore, this thesis aims to answer the following research question: *How can manufacturing organizations be supported in circular business model innovation for medical consumables?* Answering this main question, is supported by three main questions. These will be discussed first, followed by a conclusion to the main question.

1. How are the dynamic capabilities and micro-foundations for CBMI demonstrated in the process of Philips?

This study examines the business modelling process of the Hospital Patient Monitoring (HPM) business unit of Philips. The practices in Philips and in the process are compared with the practices presented in the empirical framework of Santa-Maria et al. (2022). These practices represent the micro-foundations (MFs) required for the dynamic capabilities (DC) of sensing, seizing, and reconfiguring.

On the higher-order DC level, this analysis shows that Philips is the strongest in reconfiguration. Sensing is slightly less strong. A clear gap is present in seizing. This highlights that Philips is strong in identifying opportunities and adjusting resources during implementation, but struggles to translate the opportunities into business models that can be implemented. An uneven representation of the DC is a common pattern in organizations (Teece, 2018). However, as addressed by Baldassarre & Calabretta (2023), the process of designing and developing the business model is crucial for successful implementation. As such, this gap explains why Philips is struggling to deliver CBMs for their consumables.

A more granular perspective on how the DC and MFs are represented in the process is created by examining the specific practices in the process. The sensing practices are demonstrated in the early stages of the Value Proposition Creation (VPC) process through the activities and templates of the product managers. The product managers operate as an orchestrator in connecting with (internal & external) stakeholders, and collecting information. Activities such as customer interviews, collaborations in consortia, early prototyping demonstrate how product managers iteratively and systematically gather and interpret information to shape opportunities. Philips's seizing capabilities are primarily demonstrated in their business case activities, communication of the 2030 sustainability strategy, and impact ambitions, and engagement of customers and interdisciplinary teams. However, these practices are largely feasibility-driven and focus on the financial evaluation. Reconfiguration is demonstrated in the later stages of the process. It is demonstrated through gate reviews, the matrixed organizational structure, the emergence of cross-functional teams, and the keeping track of sustainability impact through specific KPI's. These illustrate how Philips identifies the required adaptations and aims to adjust accordingly. However, apart from the sustainability-specific KPIs and stakeholder coordination skills, these practices are not circularity-driven and thus their potential to drive CBMI is limited.

This evaluation additionally highlights which practices are missing and can be improved. The missing practices all seem to deal with specific sustainability or circularity orientations. The missing practices include:

(1) Adopting a lifecycle perspective

(2) Implementing sustainability ideation tools
(3) Ideating and developing value propositions with environmental and/or social impact
(4) Designing and implementing (circular/sustainable) business models
(5) Generating business model architectures that can transform socio-technical systems

The additional practices are underdeveloped:

(1) Engaging strategic partners in collaboration and co-creation
(2) Educating workers and empowering them to propose innovations
(3) Commitment and support from top management
(4) Proficiency at organizational change management

Additionally, the analysis added 4 practices to the list. The first entails *implementing sustainability ideation tool*, which was addressed as a key gap in developing circular business models. The other two added practices were *understanding and awareness of the regulatory space and changes* and *leverage internal prior established knowledge*. These were core activities of product managers in the VPC process. These two overlap respectively with *anticipating and responding to changes in regulation* and *employing accumulated experience, know-how, and intellectual property* as presented in the comprehensive framework of Santa-Maria et al. (2022). This comprehensive framework additionally presents the practices: (1) *Recognizing alternative models of competitors and across industries, (2) identification of social & environmental threats and opportunities, (3) embracing open innovation, (4) achieving incentive alignment, minimizing agency issues, and managing collective decision-making,* and *(5) organizational learning, knowledge transfer, know-how integration, and intellectual property management*. The first practice can be recognized in the mandatory value proposition templates. The second practice seems to be reflected in the strategic roadmap of the business unit, in combination with sustainability-specific KPIs. This drives them to find opportunities to improve their performance on the KPIs. The collected data does not allow for a conclusion on the practice of open innovation. The fourth seems to be absent and is experienced as a challenge. Experts identified linear targets as demotivating employees to adopt circularity. Product managers addressed the multitude of opinions from stakeholders to be challenging. These challenge the fourth practice. Considering the final practice, Philips does have a specific IP-research team. However, collaboration between the different business units was addressed as difficult, which could potentially negatively influence organizational learning. However, the collected data cannot present a conclusive evaluation on this practice. Lastly, Santa-Maria et al. (2022) identifies practices that target specifically short-term and long-term cycles. The evaluation of Philips's process shows they are equipped for both.

2. Which CBMs and their operational mechanisms are relevant for medical consumables?

This subquestion addresses CBMI from an outcome perspective and aimed to identify which CBMs and their operational mechanisms are relevant for OEMs producing medical consumables. Based on systematic reviews, a typology was developed that integrates CBM archetypes, CBM types, value creation, capture and delivery mechanisms, retention loops, R-strategies, and affected lifecycle phases. This typology, therefore, highlights both the CBM opportunities and the mechanisms required to operationalize them. This resulted in 7 CBM archetypes: dematerialization & digitalization; sufficiency economy; Circular Supplies; Resource & Process Efficiency; Access provision; Product lifecycle extension; Recycling & resource recovery. These archetypes represent 14 different CBM types (Table 19). An important remark on the applicability of these CBM archetypes and types is that regulations should allow these models to be implemented for them to be applicable. First, the overall applicability is discussed. This is followed by a more detailed discussion on the CBM types evaluated as convincingly relevant and associated patterns determining the CBM types' relevance.

The evaluation illustrated that all seven CBM archetypes and corresponding CBM types are relevant for medical consumables. However, for *industrial symbiosis, sharing platforms, reprocessing,* and

recycling/recovering value from discarded products were considered challenging in their implementation due to practical constraints. Geographical proximity and the potential imbalance between operational effort and economic return shape their feasibility.

Overall, the typology illustrates that the majority of the relevant CBMs are downstream-oriented and thus focused on offering customers a different type of proposition. This pattern is consistent with the findings of Pieroni et al. (2020). Furthermore, it illustrates that the most relevant CBMs are all intervening in the use phase (see Table 18). These entail *dematerialization & digitalization, profit sufficiency, sourcing circular supplies, process optimization, performance/use-oriented, as-a-service, premium durability, modularity/upgradeability, and lifecycle services*. These models emphasize rethinking how consumables are "consumed" by focusing on maintaining functional and economic value or removing the physical aspect. Therefore, it highlights the relevancy of slowing, intensifying, and dematerializing retention loops and the strategies of (R0) Refuse, (R1) Rethink, (R3) Reuse, (R4) Repair, and (R5) Remanufacture.

The influence of economic value was visible in the evaluation of the CBM types. High value was associated with fewer implementation challenges. This is potentially explained by the higher product value provide a stronger financial incentive for value retention (Kane et al., 2018) and more financial flexibility before the retention effort creates an unviable product. Additionally, this evaluation could also have been influenced by the availability of more (successful) CBM solutions for higher-value devices. Devices with higher value have received more priority towards circularity due to this financial incentive (Hoveling et al., 2024).

Altogether, all archetypes and types presented are relevant in the context of OEMs producing. CBM types affecting the use phase seem most practically relevant.

3. How can an actionable tool activate dynamic capabilities to support the exploration and design of CBMs?

This final subquestion illustrates how an actionable tool can overcome the gap in ideating and developing circular business models (CBMs) by operationalizing the dynamic capabilities (DC) and identifying missing micro-foundations (MFs). The design and evaluation led to the collaborative workshop *Unlocking the Loop*, where the missing practices are integrated as concrete, repeatable practices that fit within the early stages of the product development process.

The first exercise, the Business Model Decision Tree, activates the sensing capability by providing a structure guiding the participants in exploring the different opportunities. The decision tree stimulates lifecycle thinking and brings CBM options and considerations to attention that otherwise may have been forgotten. The content and questions in the decision tree are framed such that the participants are stimulated in terms of opportunities rather than constraints. This guiding structure, as such, supported the exploration of different opportunities and reduced the tendency to stay with the known existing linear business model.

The Circular Business Model Identity cards are the second exercise focusing on seizing capability. These cards provide an educational perspective by presenting information on the CBM and its operational mechanisms, and thus highlighting strategic pathways on how a model can be designed. Subexercises encourage the identification of strategic partners and key implications of the model on the context and product, and meaningful ideation of different CBM configurations. This translates the identified CBM opportunity to a CBM configuration further tailored to the context and product.

The third exercise entails the Business Model Blueprint, where participants have to specify the different business model elements, such as key activities, resources, and partnerships, along the lifecycle of the product. This makes the CBM explicit in terms of its operation and assists the participants in identifying

resources, partnerships, costs, and revenue structures. It helps them anticipate on the business case following in the process and so support the product managers in identifying a CBM that is financially viable.

Overall, the evaluation demonstrated that the workshop was found to be valuable, supportive, practical, and motivating. It supported the participants in exploring and refining the argumentation towards their choices in the business modelling process. Furthermore, the evaluation demonstrated that some interviewees were more informed about CBMs after the workshop. This aspect also highlighted the importance of employees being open to different opportunities to avoid becoming too fixated on a specific opportunity. All in all, the workshop assisted the participants to explore, refine, and detail CBM through an iterative and explorative process that would fit as an activity in the early stages of the product development process. Hence, the workshop becomes a solution to overcome the identified gap in business modelling.

All together, these subquestions emphasize how CBMI for OEMs producing medical consumables can be supported through a combination of conceptual specific CBMs, capability-based intervention, and process-embedded tool. As such, the developed workshop embodies CBMI support for OEMs producing consumables.

6.2 Theoretical and Practical Contributions

This study contributes, on both theoretical and practical levels, to improving the circular performance of OEMs producing medical consumables. It specifically contributes to CBMI literature on both process and outcome level.

This study expands on the integration between CBMI and DC. It provides a use case on how this integration contributes to the transition to a CBMI process and how it can be applied to develop actionable interventions. This study specifically validates the framework of Santa-Maria et al. (2022) through a case study. It provides empirical evidence for 5 of the 7 practices that were added from the literature in their comprehensive framework. Furthermore, this project identifies two new potential additional practices. This integration especially provided relevant insights for Philips. The close examination of how the practices are demonstrated provides clear insights into the current status of the process. Furthermore, this analysis provides Philips with a clear overview of practices that should be improved to improve CBMI in their processes.

This thesis contributes to the outcome perspective of CBMI through the developed typology. Often existing typologies, such as those presented by Lüdeke-Freund et al. (2019) and Pieroni et al. (2020), classify their CBM archetypes through their value capture, creation, and delivery mechanisms. While this is a common way to describe CBMs (Geissdoerfer et al., 2023), the typologies remain relatively high-level. They are additionally not developed regarding a specific context. Yet, this context is a critical determinant for successful CBM implementation (Bocken & Brezet, 2019). Altogether, creating a need for contextualized, more granular CBM typologies (Pieroni et al., 2020). This thesis thus expands on these contributions by creating this contextualized CBM typology, where CBM archetypes and CBM types are described according to their value creation, capture, and delivery, retention loops, R-strategies, and affected lifecycle phase. This typology is developed for OEMs producing medical consumables and therefore also extends to sector-specific contributions, such as Guzzo et al. (2020) in medical devices and Holly & Schild (2025) in manufacturing. The typology elaborates on these examples by integrating not only the role of industry, or role in the value chain, but the combination of a manufacturing organization producing medical consumables. Furthermore, the typology explicitly links the CBM archetypes and types to associated retention loops, R-strategies, and affected lifecycle phases, as these are presented in literature as key principles in CBM operationalization. This integration supports the conceptual clarity between these principles and their representation in CBM archetypes and types.

This typology offers a clear and practical overview of potential CBMs and their characteristics for implementation. For practitioners, this typology becomes a strategic framework presenting relevant CBM opportunities and their implementation characteristics. Additionally, this overview stimulates the creation of meaningful combinations between the different CBM patterns to create encompassing circular consumables.

The developed typology provides practitioners operating in the context of medical consumables a clear and actionable overview of the CBM options. By defining the CBM archetypes and types in their retention loop, deployed R-strategies, and affected lifecycle phases, the typology supports practitioners to not only understand what the CBM options are, but also how they are operationalized.

This study additionally contributes to the CBMI process perspective and literature on CBMI tools by designing and evaluating a collaborative workshop that integrates the dynamic capabilities perspective to support CBMI. Existing CBMI tools are often static and generally consist of checklists, guidelines, analytics templates, or process frameworks (Bocken et al., 2019). Additionally, these tools seem to either focus on CBM outcomes or on supporting the process. DC, at the same time, are often used in a comparative manner, such as how the framework of Santa-Maria et al (2022) is applied in this thesis and in the DC tool from Klitsie et al. (2018). Their tool supports practitioners in collecting relevant data to identify opportunities in their capabilities. However, this does not provide practitioners with a clear, actionable intervention that can improve their practices. By directly translating the missing capabilities into specific exercises, this thesis explores how the integration between DC and CBMI results in an actionable tool directly influencing the CBMI process and outcomes. This seems to be a novel integration in the field of CBMI tools.

For practitioners, the developed workshop offers a practical method and workshop supporting teams in exploring and designing CBMs in a structured and collaborative manner. It provides a clear process that a product manager can apply during the early stages of business modelling. Despite the fact that this workshop is the outcome of a single case study, it does not include Philips-specific elements. Therefore, any medtech OEM seeking support in exploring and developing CBMs could potentially benefit from embedding this workshop in their process.

6.3 Limitations and Future Research

This study entailed a single-case study primarily relying on qualitative data. Therefore, this study is subject to several limitations. The single case study generates results that are specific and embedded in the context of a singular example (Yin, 2018). Despite the introduction of multiple sources into this study, generalizing the results of this case study remains challenging. Additionally, the testing of the workshop is only attributed to a limited number test episodes and participants, due to availability. To more confidently assess the workshop's effectiveness for medtech OEMs in general, future research should evaluate the tool with different medtech OEMs, thus increasing the evaluation instances.

Furthermore, circularity is driven by systemic collaboration (Konietzko et al., 2020). This study focuses on the role of a single med-tech OEM in improving its circular healthcare performance. Despite drawing attention to the creation of partnerships, it does not include considerations of the needs of these stakeholders. Future work could therefore explore and iterate on the workshop from a value-chain collective perspective. This can be done by evaluating the workshop with multi-stakeholder participants.

Additionally, this study relies heavily on qualitative data. This allowed for in-depth insights into the process dynamics and uncovered the social complexities. However, the validation of the table and the tool relied on the perception and opinions of a few individuals and thus might be prone to bias (Yin, 2018).

Furthermore, this study was conducted over a relatively short period. Innovation within healthcare is time-intensive. Therefore, it was not possible to evaluate whether the workshop outcomes would lead to an implemented and successful CBM. Additionally, this short time span makes it difficult to perceive whether the workshop leads to a structural impact on the capabilities of the organizations. Introducing a more quantitative approach and evaluating the workshop and its outcomes over a longer period of time would allow to evaluate whether the workshop leads to successful results and structural improvement of skills and knowledge towards CBMI.

Furthermore, empirically derived models, such as those presented by Santa-Maria et al. (2022), often seem to be a combination of several patterns. These combinations are not represented in the current typology. Future work could expand on this typology by identifying patterns commonly observed in empirical cases.

Finally, as the workshop has an educational component and templates are static, its effectiveness could be prone to habituation. In the habituation effect, frequent exposure to the workshop helps users become acquainted with its content and learn what to expect (Colwill et al., 2023). Hence, the benefits of using the workshop are reduced as the thought-provoking elements become part of the standard thinking. Future design research could explore how the tool can be made dynamic, thereby evolving with the participants.

7. References

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Appendix A Interview Scripts

Interview Guide for Philips Process Introduction

Value Proposition Development Process

- How would you describe the value proposition development process
- How do you apply the process in your projects?
- What is your experience performing the value proposition development process? Does it support you in your work?
- How do you use the process guides and templates provided by Philips?

Involved stakeholders in Value Proposition Development

- Who are generally included in the process?
- What is their role in the process

Current Business Model Development

- How do you establish the business model for a new product?
- Where do you draw your inspiration from to design the business model?
- What is the role of the business model archetypes defined by Philips?

Interview Guide for Product Managers

Introduction

- Could you introduce your role and the product you are responsible for?

Details about Consumables:

- How does the product lifecycle and product journey of the consumable look?
- How would you define the current business model of the medical consumable?

Current Business Modelling Process:

- What is you experience with the current business modelling and value proposition design process?
- At what stage in the product development process does business model design typically come into play?
- Do you consider the business modelling process as an integral part or an independent activity?

Circularity within the Current Process:

- How do you currently involve circularity thinking and end-to-life ownership in the business modelling process?
- Could you name a specific example?
    - If yes, why did you include these elements and why at this specific stage?
    - If no, what is holding you back to develop business models more circular?
- How do you balance the technical feasibility and circularity of a product with the viability of the business model around it?

Opportunities for Circularity Support:

- Where do you foresee opportunities to support more circular thinking and end-to-life solutions in the development of products and related business models?
- Why these opportunities?

Interview Guide for Experts

Introduction:

- Can you introduce your role and your responsibilities?

Sustainability or Circularity Initiatives in the Process:

- Can you describe the current circular/sustainability initiatives you are involved in?
- Where in the product lifecycle and the product development process would you place this initiative?
- How does this initiative support circular thinking in the process?
- What was the motivation to start this initiative?

Challenges and Opportunities for Circularity in the Process:

- What aspects do you think need to be overcome to create more circular business models?
- Where do you see the biggest potential for innovation in circular business models?

Interview Guide for Table Validation

Introduction:

- What were your initial thoughts on the table?

Completeness

- Is the overview of CEBM archetypes complete? If not, what is missing?
- Is the overview of CEBM types complete? If not, what is missing?
- Is there anything you miss in the table?

Accuracy:

- Are there any models or archetypes you would classify differently?
- Do you agree with the defined definitions and described value creation, capture, and delivery mechanisms?
- Would you change anything about the labelling of R-strategies, retention loops, or lifecycle phases?

Applicability:

- Which of the models would you deem applicable to the context of low-value, high-volume medical consumables/devices? Why?
- Which of the models would you deem applicable to the context of high-value low-volume medical consumables/devices? Why?

Interview Guide for Follow-up Participants

Outcomes and Added Value of the Workshop:

- What concrete outcomes emerged rom the workshop (e.g. ideas, insights, and next steps)?
- To what extent do you think these outcomes would have emerged without the workshop?

Relevancy and Feasibility of CBMs:

- Which CBMs explored during the workshop felt most relevant or feasible for you product and business context?
- What factor made these CBMs more relevant or feasible than other? (regulatory, cost, operational complexity, stakeholder acceptance)

Dynamic Capabilities:

- How did the tool support the identification of new circular opportunities?
- How did the tool support evaluation and selecting between different circular business models?
- Did the tool help you think differently about changes needed in existing processes, structures or partnerships? If so, how?

Learning Activities:

- How did the decision tree influence your understanding of possible circular strategies?
- How did the identity cards contribute to understanding the relationship between CBMs and their operational mechanisms?
- Did the tool increase your understanding of CBMs applicable to your specific product category? In what way?

Influence of Strategic Thinking:

- Which part of the workshop had the greatest influence on your strategic thinking and decision making?
- Why was this part particularly influential?

Capability Development:

- To what extent do you feel more capable of designing CBMs after participating in the workshop?
- Do you also feel more capable of implementing these models within Philips? Why or why not?

Organizational Fit and Future Use:

- How well does this workshop fit Philips' existing product development and business modeling processes?
- How likely is Philips is to reuse this tool in future innovation or sustainability initiatives?
- What changes would make it easier for Philips to adopt or reuse this tool?

Interview Guide for Expert Evaluation Workshop

CBM Design Support:

- Based on the explanation, what is your overall assessment of the workshop and tool?
- How do you think the workshop could support the development of CBMs within Philips?
- What types of CBMs do you think it supports particularly well?

Organizational Fit:

- What would be required to embed this tool into existing product and business innovation processes within Philips?
- Who would need to be involved for successful adoption?
- How well does the current design of the tool align with the requirements of Philips' business case development?
- Are there any organizational barriers that might limit the adoption of the tool?

Suggested Adjustments:

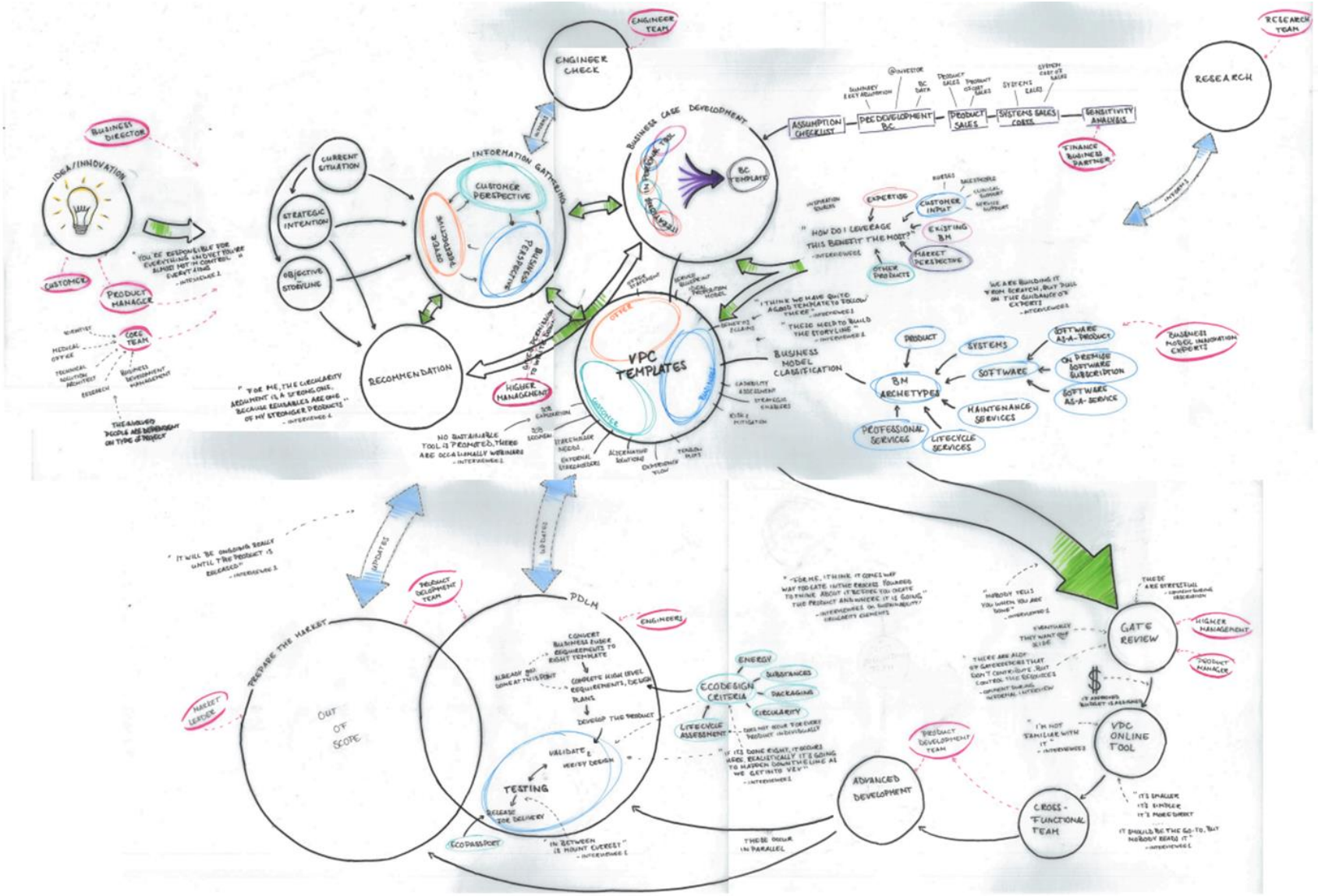
- What adjustments would improve its usefulness (or relevance) for building viable and circular business cases?
- What adjustments would make the workshop / tool easier to adopt and scale across different teams or product categories?

Appendix B Observation Notes Template

Meeting # _____dd/mm/yyyy
Meeting title:
Included role:
Meeting notes;

Reflection/Summary Findings:

Appendix C Visual Mapping



Appendix D User Test Survey

User experience survey - Unlocking the Loop

Thank you for participating in the Unlocking the loop workshop. I hope you have experienced the workshop as valuable and were able to explore (new) ideas for business models. In order to improve the workshop, this survey will ask you a few questions about your experiences during the workshop. In case you've only participated a part of the workshop, write this down in the first question.

* Required

1. Define your participation in the workshop *

- ◯ I only joined the first activity (the web of cards and identity cards)
- ◯ I only joined the second activity (the business model blueprint)
- ◯ I joined the full workshop

2. How was your overall experience in the workshop? *

3. How mentally demanding were the workshop activities? *

0	1	2	3	4	5	6	7	8	9	10

Very low — Very high

4. How successful were you in accomplishing what you were asked to do? *

0	1	2	3	4	5	6	7	8	9	10

Failure — Perfect

5. How did you experience the workshop? *

Confusing ◯ ◯ ◯ ◯ ◯ Clear

6. How did you experience the workshop? *

Inferior				Valuable
○	○	○	○	○

7. How did you experience the workshop? *

Obstructive				Supportive
○	○	○	○	○

8. How did you experience the workshop? *

Impractical				Practical
○	○	○	○	○

9. How did you experience the workshop? *

Complicated				Easy
○	○	○	○	○

10. How did you experience the workshop? *

Demotivating				Motivating
○	○	○	○	○

11. How did you experience the workshop? *

Inefficient				Efficient
○	○	○	○	○

12. To what extend do you agree with the following statements about the workshop? *

	Totally disagree	Disagree	Neutral	Agree	Totally agree
I would like to use the workshop in future business modeling activities	○	○	○	○	○
The workshop will support me in exploring and developing more (circular) business models	○	○	○	○	○
Using the workshop made circular business modeling more comprehensible .	○	○	○	○	○
I have found the workshop to be beneficial to my needs.	○	○	○	○	○
The workshop helped me breaking down circular business modeling into manageable steps	○	○	○	○	○

13. What would you suggest to change about the first activity (the web of cards and the business model identity cards)? *

14. What would you suggest to change about the second activity (the business model blueprint)? *

15. Are there any final remark about your experience in the workshop?

Appendix E Articles used for the Typology

Authors	Year	Title	Journal	Type	Contribution to Typology	Sources
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	Systematic literature review	Archetypes	(N. M. P. Bocken et al., 2014)
Colombo, B. Gaiardelly, P. Dotti, S. Boffelli, A.	2021	Business Models in Circular Economy: A Systematic Literature Review	IFIP Advances in Information and Communication Technology	Systematic literature review	CBM types Retention Loops Lifecycle	(Colombo et al., 2021)
Ertz, M. Leblanc-Proulx, S. Sarigöllü, E. Morin, V.	2019	Made to break? A taxonomy of business models on product lifetime extension	Journal of Cleaner Production	Systematic literature review	CBM types	(Ertz et al., 2019)
Holly, F. Schid, C.	2025	Concepts, Strategies and Business Models of the Circular Economy for the Manufacturing Industry: A Systematic Literature Review	Procedia CIRP	Systematic literature review	CBM archetypes and Types	(Holly & Schild, 2025)
Lüdeke-Freund, F. Gold, S. Bocken, N.M.P.	2019	A Review and Typology of Circular Economy Business Model Patterns	Journal of Industrial Ecology	Review	CBM archetypes and Types Value creation, capture, and delivery	(Lüdeke-Freund et al., 2019)
Moreno, M. De los Rios, C. Rowe, Z. Charnley, F.	2016	A conceptual framework design	Sustainability	Systematic literature review	CBM types Retention loop Value capture	(Moreno et al., 2016)
Pieroni, M.P.P., McAloone, T.C. Pigosso, D.C.A.	2020	From theory to practice: systematizing and testing business model archetypes for circular economy	Resources, Conservation and Recycling	Systematic literature review	CBM types Value capture, creation, and delivery	(Pieroni et al., 2020)
Rosa, P. Sassanelli, C. Terzi, S.	2019	Towards Circular Business Models: A Systematic literature review on classification frameworks and archetypes	Journal of Cleaner production	Systematic literature Review	CBM types	(Rosa et al., 2019)
Supporting articles						
Guzzo, D. Carvalho, M.M. Balkenende R. Mascarenhas, J.	2020	Circular Business models in the medical device industry: paths towards sustainable healthcare	Resources, Conservation and Recycling	Resources, Conservation and Recycling	CBM examples in healthcare	(Guzzo et al., 2020)
Hoveling, T. Ijzenbrandt, J. Hinrichs-Krapels, S. Ritzen, L. Bramer, W. M. Van Raaij, E. Faludi, J. Bakker, C. Diehl, J.C.	2026	Mapping Circular Economy Product and Material flows in Healthcare: a visual taxonomy	Journal of Cleaner Production	Systematic literature reviews	R-strategies Lifecycle (note: a prior to published version of the mapping was used)	(Hoveling et al., 2026)
Islam, M.T. Khan, M.I. Ali, A.	2025	Circular business models: A state-of-the-art systematic literature review and future opportunities	Sustainable futures	Systematic literature review	Lifecycle	(Islam et al., 2025)

Appendix F Dynamic Capabilities

DC	MF	Practice	Presence	Justification	Quotes	Source
Sensing	External sensitivity	Understanding the needs of customers and key stakeholders	✓	Product Managers connect with customers to identify their needs, and they try to estimate who the relevant stakeholders are in the proposition and what their needs are. The customer and stakeholder perspective is one of the categories of the mandatory VPC templates. Here they have to define the target group, how the customer journey is affected by the proposition, the involved external stakeholders. Additionally, product managers get in contact where possible with the customers or with the sales department to retrieve information about customer needs.	"So I have gone to customer sites and talked to bedside nurses. I've talked to nurse managers, I've talked to procurement officers." [PM_01] " So the exercises that I found most helpful, the tension plots are quite difficult to do and require you to understand what the place of your idea is in the larger market. I think that that's helpful for your context."[PM_01] "[...]. I think we did a bigger exercise with markets and everything on the voice of customer than the VPC per say." [PM_03]	Interviews Observations Organizational document
		Being open to external expert support	✓	Philips is part of multiple consortia and research initiatives to improve their sustainability performance and explore with partners from academics or value chain partners opportunities to do so. Some of these collaborations are: Ellen MacArthur Foundation(Ellen MacArthur Foundation, n.d.), DICE (DICE, n.d.), ESCH-R (ESCH-R, n.d.-b), CHARME (Sustainable Purchasing Leadership Council, n.d.). Sustronics is specifically started by Philips to collaborative innovate on, amongst others PCBAs to make them more sustainable and potentially improve the sustainability of electronic products (Sustronics, n.d.).	" We've had a lot of good education from our sustainability group's partnership with DICE. So we've been working with them quite a bit. They're helping trying to understand customer need and what's value to them in terms of sustainability practices and what they're expected to do. Not just in the United States, but globally, which has been interesting to learn about. I feel like over the last few years, we've been sought out, but also we've have chosen to invest in initiatives that help us design product that are best for the future overall." [PM_04]	Interviews Observations
		Leverage developments of exogenous science and technology	✓	The previous practice is combined with this practice. As Philips seems to collaborate in these initiatives to explore new innovations and they can contribute to Philips products. One clear example is Sustronics. As such Philips leverages the science and technology gained in these projects/consortia. Additionally, it is part of the VPC templates and the information gathering activities to explore alternative solutions. This search in alternatives makes them aware of different technologies	" So obviously there's a lot of work that happens in the didactic academic development space, where ideas for the product come from." [PM_01] " [...] there are of course many innovative things out there coming from competition. There are many interesting things that you can do and there are many amazing things within Philips. Also from an R&D perspective that are being developed every." [PM_03]	Interviews Observations
		Understanding and awareness of the regulatory space and changes	✓	Philips is really focused on compliance with all standards and regulations. To do so, product managers remain aware of the changes in the regulatory space. This is was also deemed important as the healthcare industry forms is highly regulated.	"It is also because we know there are a lot of generics out there that we compete with and they're swift movers and they're priced a lot lower than we are simply, because their overhead is much less expensive than Philips's. They also don't necessarily abide by all the most recent standards, and there are certainly gaps there where I can say that from a quality standpoint, Philips is truly number one [...]" [PM_04]	Interviews Observations

					"I would say it's inherent to my role. I'm not the only product manager who participates with the ISO IEC as a member […] I obviously represent the manufacturers aspect of it, which isn't always in line with academic or with regulatory considerations and between the three types of people on these committees, we come up with ideally the most serviceable way to regulate and have these products on the market." [PM_01]	
	Adopting a holistic perspective	Adopting a lifecycle perspective	X	The product managers and offerings seem primarily focused on the sales and do not seem to include main considerations of what happens at the end-of-life of these product. Product managers know the expected lifetime of their products, but do not design their products for the end-of-life. Philips does not seem to take the perspective of cradle-to-grave responsibility in their product yet.	"Zero. We do not involve a lot. That's unfortunate, yeah. Let's say that end-of-life, it's something we do not take care of or we do not have a process. We do not have a guidance towards the customers. It's very unfortunate, but we do not have anything on that." [PM_03] "Not. That one of the things that need to change in the VPC. Where it all started in the beginning. You put it in the box and move the box. […], but in the end, it doesn't matter what happens to it afterwards. […] So then you have to maintain that relationship, and you also have to develop it, and that way of thinking is currently not properly integrated into our company's entire methodology." [EX_01]	Interviews Observations
		Adopting a systemic perspective	✓	The department of Group Sustainability Office (GSO) brings this systemic perspective in the 2030 strategy of Philips and translates this to specific KPI and targets for the different business units. The strategy targets: reduce the impact on the environment, improve health and well-being. Additionally, they run projects like access to care to improve well-being on more remote areas worldwide. (Philips, n.d.-a)		Observations
	Knowledge creation	Undertaking R&D activities	✓	R&D activities are part of the VPC phase where these activities inform the technological offer, exploration of potentially associated costs, effect on the customer journey and experience. These insights are thus translated back into the VPC.	"It's really taking the template and diving in. So at least on my experience, it was taking all the learnings collected from different sources that that competition, voice of customers, some R&D learnings here and there and then making sure to put that towards the template and making that fit a VPC process." [PM_03] "we have got an engineer who is helping us create prototypes or give advice on what is possible or not" [PM_02]	Interviews
		Leverage internal prior established knowledge	✓	Product Managers during the VPC process reach out to many different internal stakeholders and departments to gain knowledge on how to refine their proposition, to explore the opportunities, and gain information on how to implementation would take shape.	" I mean that is also part of your role as a product manager. You're not meant to be the expert in anything. Big part of your world is bringing the right people together to get the most value from a product or project." [PM_02]	Interviews Observations

	Use of sustainability-oriented instruments	Implementing environmental management tools (LCA)	✓	Philips deploys LCA's, ESG Case (where the product needs to be accompanied by proof that it is designed according to EcoDesign criteria by for example using, Recycleability and Disassembly tools), and Ecopassports to evaluate the sustainability performance of the Philips's products and service. (Philips, n.d.-b, 2025a)	"They are currently making Lifecycle Analysis calculations" [EX_01]	Interviews Observations Organizational documents
		Guidance from sustainability frameworks	✓	Philips applies multiple frameworks in their goals setting. Some of these frameworks involves the SDG framework, SBTI (Science Based Target Initiative), ESG commitments. Interviews demonstrated that the goals setting according to the interviews are revised and refined. Philips additionally seeking to remain up to date with the frameworks they are applying. (Philips, 2025)	"So right now, I am working on more global frameworks, overarching frameworks.[EX_03]	Interviews Observations
		Implementing sustainability ideation templates	~/x	The current templates are not designed to support ideation towards circularity and sustainability. The intranet page does contain some generic circularity templates, but are not part of the mandatory templates nor seem to be known by the product managers. Interviewees addressed a lack of tooling.	"Yes, I have an idea why that is. That is part of the reason why we are doing that exercise, the tooling is missing."[EX_01] "We need a new tool. We need something that models for consumables. We need something that models for circularity" [PM_01]	Interviews Organizational documents
Seizing	Delineating sustainable solutions and business models	Ideating and developing value propositions with environmental and/or social impact	~/x	The current templates are guided towards the linear norm. They and their corresponding explanation material refer very little to sustainability as a key driver for the value proposition.	"Nothing is being asked about the sustainability at this moment, so no. There is currently no obligation to think about it, and therefore it is not always done centrally in that process" [EX_01] "It's something that we have a little section for that we can fill out, but does it contribute to the overall value of the VPC? Not really. Okay, yes we can say we've accounted for it, but what happens after that? Nothing." [PM_04]	Interviews Observation Organizational documents
		Designing and implementing the (sustainable/circular) business models	~/x	Product managers seem to have a tendency to stick with their existing business models. Revenue models are not radically explored. Intranet pages contain some standard archetypes and its actively promoted to stay within these. Business modelling seems to entail the practice of adjusting the business case and tweaking incrementally.	"On my experience, we almost went straight to it. No, it's a good point. I think we had ideas that we packed in, but we more or less went straight away to the model that we know." [PM_03] "I would say, the reality is they would try and put us into a bucket that already exists today. On paper, they want us to be innovative and think outside the box and maybe this sounds rather critical. We should have the freedom to be creative, but the reality is you will probably get pushed into an existing strategy or existing model"[PM_02]	Interviews Observations Organizational documents
		Generating business model architectures that	~	Philips is focused on being compliant with the existing regulations. However, Philips also holds the desire to set	" We are very afraid of overturning regulated behavior" [EX_02]	Interviews Observations

		can transform socio-technical systems		the mark in performing business that changes . Access-to-care and becoming the frontrunner in sustainability (Philips, 2025)		
		Validating the financial feasibility of the business model	✓	Philips extensively focuses on performing a financial evaluation of the business model and corresponding different scenarios.	"Price for us, it's a very big topic. So we know that we are very expensive today and the cuffs are becoming more and more cheaper and even with the suppliers or the scouting we did we do not see getting into so such low prices. So we need to understand, if we are actually gonna sell more, more expensive devices. So we did very early on to to understand that business case, but I know it's not from that AD work or a VPC process, it's not necessarily a mandatory part to have a business case from the very early stages." [PM_03]	Interviews Observations Organizational Documents
	Stakeholder engagement & collaboration	Engaging strategic partners in collaboration and co-creation	~/✓	The partnership practice is upcoming, such as collaborations as Sustronics. Here different stakeholders collaborate to innovate. This also happens on a more practical level in product offering, such as the Save Simply Program with Stryker (Stryker, n.d.) Another example is the MRI mobile systems truck which is a collaboration between Agito and Philips (Philips, 2024)	"So to achieve this reprocessing claim on disposables, we had to partner with Stryker.[…] It is something we verbally say to our customers, if we know that they are looking: 'oh this is much cheaper. Why don't I just go with non-Philips?' ' well, we have this reprocessing initiative and we can connect you to our representative at Stryker.' There is economic value in sustainability ultimately" [PM_04]	Interviews Organizational Documents
		Engaging customers early in the innovation process	✓	Product Managers seek contact with (potential) customers during the process to validate and gain insights in how the products fit best with the customer needs. This is done, for example, through interviewing.	"It will still continue, because whilst we are doing some market interviews over the next couple of weeks. We then would need to do direct customer interviews […]" [PM_02]	Interviews
		Engaging an interdisciplinary team to participate in the innovation process	✓	Product managers are supported by a small group of people with different backgrounds. Later once the project goes into the development stages, a cross-functional team is appointed to support the ongoing product support.	"I would say it's helpful to have a core team, so that would obviously for this project be myself, the other product managers. We also have the product manager in the research team, so [Employee B]. I'm not sure if you've met her. Then I would say it's always beneficial to have someone from clinical as well and I think someone technical." [PM_02]	Interviews Observations
	Supporting a sustainability & innovation culture	Articulating a clear and ambitious sustainability vision	✓	Group Sustainability is in charge of defining the sustainability vision and ambitions. These are translated into measurable target and KPIs. The performance on the ESG goals is additionally communicated on the dashboard on the intranet. Furthermore, this strategy is communicated through presentations and the business partners of the business units.	"Group Sustainability is working on the vision and targets for 2030, and that will need to be translated back into what the businesses need to do so that Philips can eventually say, we have indeed reduced this much CO2 and used this much less material, and so on." [EX_04]	Interviews Observations Organizational Documents
		Developing a sustainability strategy and culture	✓	Group Sustainability Office translates this vision into a strategy. Together with the Business Unit, these are reflected in a set of KPIs. Business units are stimulated to adjust their project to meet the KPIs.	We're currently working towards our 2030 targets. which also considers circular economy, of course, and I think if you have a long term target around that that also means that your whole innovation portfolio needs	Interviews Observations Organizational Documents

				There is an additionally sustainability consulting team that supports business units in their projects to improve their sustainability performance.	to deliver on those targets in the future. In that way there's a bit of an indirect link in terms of how that should also trigger VPC going forward or trigger innovations to start considering: OK, what does it mean right? Our new pipeline will need to let's say reduce our use of virgin materials going forward. What could be the key things that we take into consideration as part of the VPC for example.	
		Developing and supporting an innovation and continuous improvement culture	✓	Innovation is promoted within the organization and across the product managers. With the set goals a roadmap is created for the product portfolios of the business units. Furthermore, product managers are required to maintain up-to-date and innovate according to standards and trends within the ecosystem of the product. There is a drive among the employees to innovate.	"I would say, the reason why they get involved is because they want to see the success of the company that they are working for and they believe in the core values of what we are trying to do as a company and everyone is enthusiastic about driving innovation. I'm trying to look at it from the other perspective. From the other side, I think your motivation and desire to innovate is why they get involved, but not necessarily the recognition, apart from me giving the recognition for their support, it's not necessarily recognized on a bigger scale, I would say. It's important to foster a good environment, where thoughts and opinions are really taken on board and everyone's input is valued and to create and to foster that positive environment, because especially where we are at with this project now it's more goodwill, because this is not a funded project." [PM_02]	Interviews Observations
		Educating workers in sustainability and empowering them to propose innovations	~/✓	There are intranet pages with information about circularity and sustainability and tools, but these are not widely known within the organization. Each business unit has a business partner from GSO to drive the sustainability practices. Furthermore, Philips has a specific 3-hour training from the Ellen MacArthur foundation. This training is available to all departments/business units. More sustainability trainings are coming. Yet interviewees addressed that there is still a level of unawareness or a lack of knowledge surrounding circularity and its implementation.	"What we've been doing now, started last year, it's another team within group sustainability and started to do sustainability claims trainings with product managers in different businesses, where they have started to create awareness around the competitive landscape, what customers are asking to really try bringing these insights forward and actually having follow up sessions to think about what are sustainability claims that we could work and have a claims roadmap. I think this is also a very important aspect. If you think about the future claims that you want to make, how do you then work backwards in terms of what do we then need to do from the innovation perspective?"	Interviews Observations Organizational Documents
E(Philips, n.d.	Co-specialization of assets	Prioritizing projects that fit existing organizational capabilities and resources	✓	Along with the business case, higher management in the gate reviews evaluate whether the project aligns with the organizational capabilities and portfolio. Additionally, product managers addressed that linear solutions are also preferred as the infrastructure is already existing.	"There is, moreover, another problem on the horizon, which is the question of strategic priority, so all the answers may be correct, but even then, the business can decide that it is not a priority and that they should spend the money on something else."	Interviews Observations

	Organizational flexibility	Implementing experiments/pilots to validate, learn and adapt quickly	✓	The process includes a validation and verification step, where the product is evaluated. Furthermore, the business case operates as a model that supports the evaluation of different scenarios.	"We've tried subscription model, doesn't necessarily work. It's really customers buy what they need, when they need it, they have their own inventory management, ways of working." [PM_04] "These templates are actually calculation models. So it's not a static result; it's really a model, and you can ask it what-if questions." [EX_02]	Interviews Observations
		Build decentralized innovation teams and allow flexible organizational structures	✓	The cross-functional teams operate as a decentralized team. Additionally, the matrixed structure of Philips with their business units can be seen as a form of decentralized teams.	*"We also do a lot of work in what we call MLD projects, which are updates to existing projects, and the existing products have to have a cross-functional team to support them through their lifecycle. And for an MLD project we will often tap the CFT for insights."* [PM_01]	Interviews Observations Organizational Documents
	Trust-building communication	Having a fact-based consistent and transparent external communication	✓	Product managers during the PDLM are requested to complete the ESG case. This is a template, which collects the evidence of the environmental performance. This evidence is according the standards of CSRD and COCIR. Additionally, Philips communicates their methodologies for calculating their evaluations in for example their LCA (Philips, n.d.-b), and lives improved (Philips, 2025b). These outcomes and the aggregated results are presented in the annual report (Philips, 2025)	"Yes, we do that, so the CO2 footprint is, of course, extensively measured in the medical sector." [EX_02]	Interviews Organizational Documents
	Ecosystem orchestration	Skills to integrate stakeholders and coordinate partners in the business ecosystem	✓	Philips works with many suppliers and stakeholders to develop and deliver its products. Furthermore, the collaborations	"For a very profitable company like Masimo and Medtronic in this space, they're very vertically integrated. So it's one company that would own all the way up to purchasing the raw materials. They may even have their own electronics manufacturers. For us as Phillips, we are very spread out, so we would look for parts that are commonly available on the open market, so a certain type of raw plastic. We use fabrics. We use foams. Our, what I would call, Tier 3, Tier 4 Tier 5 suppliers, so our suppliers, suppliers, suppliers, supplier, they will get to a certain point and then pass it up the food chain." [PM_01]	Interviews Observation ?
	Leadership and change management	Commitment and support from top management	~/✓	Management is really stimulating new innovation, but the focus is not always on driving the project with the most sustainable projects. Interviewees addressed the need for management to steer more directly and with more emphasis on the importance of sustainability criteria. Management of different layers gets involved during the multiple gate reviews.	"No, I think it has to do with the fact that management doesn't ask for it and doesn't drive it. In the beginning, especially when you start with more sustainable products, they are probably a bit less profitable and somewhat more complicated. […] As long as management doesn't impose this themselves as a desire or requirement, yes, as a product manager you will always lose, and that's true for all innovations. […] And these also need to be directed either by the	Interviews Observation

					management, by the board, or by the supervisory board; otherwise, it won't work." [EX_05]	
		Proficiency at organizational change management	~	Philips tries to provide all the materials to support employees to adapt. Despite these efforts employees seem to stick with their existing way of operating. Additionally, Philips has some employees that work at the organization for quite some time. It could to be more difficult to change their way of working. Yet, more employees are becoming aware of the relevance of certain sustainability or circularity principles. They struggle how to implement it into there practices are not incentive enough. Hence, some change is happening, but not at the desired level yet.	"I think part of it may just be a fixed way of working and thinking? We've always done it this way. We've been doing it for so long. It works this way, and just changing that alone takes time, money, and process adjustments. Even if you simply wanted to try, a lot would need to be set up to actually do it and stay within the rules, and yes, is that a barrier? And I have the feeling that there first needs to be some sort of problem with the current situation [...] I have the feeling that there first needs to be a driver, a factor that suddenly challenges it, like, hey, that linear model we've been working with no longer works or doesn't work for this situation, do we have an alternative, oh wait, maybe a circular model is an option there. Otherwise, it's kind of too easy to stay in the model that works? That might be a thing." [EX_04]	Interviews Observations
		Implementing specific sustainable and circular KPI's	✓	Philips translates their ESG goals into KPIs and targets for circularity. In the strategy towards 2025 these included for example: 100% Ecodesigned NPIs, 25% from Circular renevue, 95% circular materials management, less than 0.5% waste to landfill as percentage of total regular waste. (Philips, 2025). There are additional KPIs for social and governance. Furthermore, are the targets specifically translated to the business units, but there seems to be ways to improve how these are implemented in the business units.	"The way we drive our KPI today, it's sometimes disconnected from how businesses might be operating in their daily work, so it needs to be where the decisions are being made, which are often financially driven. I think that is the biggest potential to stimulate sustainability and circularity." [EX_03]	Interviews Observations

Appendix G CBM Typology prior to Feedback

Archetype	Sub-model	Definition	Value creation	Value delivery	Value capture	Retention loop	Retention strategy	Product lifecycle stage	Suitability
Resource & process efficiency	Sufficiency economy	Active promotion of reduction and moderating consumption of the end-customer. It narrows the resource flow and depromotes over-consumption and promotes intensifying the usage of existing products.	Values is created through activities, partnerships that are focused on consuming less and using products longer	Value is delivered through a shift in sales and marketing and the delivery of high-quality goods.	Value is captured through savings in production, premium pricing, customer loyalty and improved brand image.	Intensifying Narrowing	Refuse (R0) Reduce (R2)	material extraction, use	Relevant for firms focusing on increasing the social and environmental aspects
	Produce-on-demand	The production process is only initiated when demand is quantified and confirmed, which narrows the resource flow and minimizes waste from overstock and unwanted products.	Value is created through a demand driven service and by reducing resource usage.	Value is delivered through demand driven production processes and systems.	Value is captured in operational savings and the avoidance of overstocking and unwanted products.	Narrowing	Reduce (R2)	Material processing, Production	Suitable for manufactung companies
	Resource efficiency	A focus on process optimization, cleaner production and energy efficiency. Hereby, reducing the use of (virgin) materials, waste production, emission and thus narrowing the resource flow.	Value is created through an optimized production process aimed at using fewer resources.	Value is delivered through partnerships, value network configurations and product systems reducing supply chain emissions.	Value is captured through costs savings and compliance, and provides and environmental benefit through minimised footprint.	Narrowing	Reduce (R2)	Production	Suitable for manufacturing and energy intensive industries.
Circular Supplies	Industrial symbioses	A solution where the residual output of one process becomes the input of another process and thereby closing the loop by circulating the resources longer in the cycle. A special form is symbioses is organic feedstock where there is a focus on bio-based materials.	Value is created through residual output synergy leading to a reductionin demand of raw materials.	Values is delivered through partnerships and sharing networks.	Value is captured by savings in supplies and by new revenue streams.	Closing	Recycle (R8)	Materials extraction, material processing, production	Suitable in situation of geographical proximity and where regulations allow.
	Sourcing of circular supply	Renewable energy and materials are introduced in the product and the production process, which circulates the resource loop by closing it.	Value is created through innovation in product and process by introducing renewable energy and materials.	Values is delivered through new partnerships based on renewable sourcing and delivering products with circular-quality.	Value is capture in savings in supplies, in premium pricing and improved brand image.	Narrowing, closing	Recycle (R8)	Materials extraction, material processing	Suitable when regulations allow and circular resource comply with the requirement qualities
Access model	Sharing platform/sharing economy	A facilitation of C2C or B2B sharing of undertilized goods or equipment, which intensifies product usage. Products remain in ownership of an individual, but sharing is facilitated through an integrator platform.	Value is created by using underutilized capacity and preventing unnecessary ownership.	Value is deliverd through sharing platforms and temporary acces to the product/equipment.	Value is captured in a transactional agreement when sharing or lending assets or in brand image	Intensifying	Rethink (R1), Reduce (R2) (R3) Reuse	Use	Especially suitable in mobility, accomodation or equipment.
	Performance-/ use-oriented	No change in ownership of the product, but providing a defined performance or use-cycles promoting the extending the number of use-cycles and thus intensifying the loop.	Values is created by through a use-based purveying.	Values is deliverd through performance or functional agreements, as for example pay-per-use agreements.	Value is captured in use/performanced based charging, resulting in a continuous revenue stream.	Intensifying	Rethink (R1) Reuse (R3) Repair (R4)	Use	Suitable when the performance outcome or the number of use-cycles can be measured.
	As-a-service/asset management	The provision of temporary acces to a product or equipment through a lease or subscription, which intensifies the usage of a single product.	Value is created by offering access without the ownership transfer and investment need.	Values is delivered through subscription systems.	Value is captured through a continuous and recurring revenue stream from subscriptions	Intensifying	Reuse (R3)	Use	Relevant for standardized products and situations. Customer-relationship is of important value.
Product life extension	Premium durability (quality)	The product is designed with the aim of life time extension and robustness to endure more use cycles. This slows the resource loops by extending the product life and increasing the number of lifecycle.	Value is created through the production of products with extended functional performance.	Value is delivered through high-quality goods.	Value is captured in premium pricing and improved brand identity.	Slowing	Reuse (R3)	Use (design)	Especially relevant for products that endure various number of use cycles.
	Upgrade/modularity	The product allows for customization, enhancement of product parts ensuring market value throughout the product lifecycle. Therefore, its extended the functional lifecycle performance in a slowing resource loop.	Value is created through durability and reliability of the product.	Value is delivered through upgrading systems	Values is captured through recurring sales on upgrades.	Slowing	Reuse (R3) Repair (R4) Refurbish (R5) Remanufacture (R6)	Use, distribution	Suitable for product design that allow for modularity and a dynamic environment.
	Lifecycle services	A service that provides maintenance, repair and refurbishment aimed at extending the products functional lifecycle and thereby slowing the resource loop.	Value is created through ensured performance and reliability.	Value is delivered through repair and maintenance services under service contracts or subscription	Value is captured through recurring revenues and improved customer relationships.	Slowing	Reuse (R3) Repair (R4) Refurbish (R5) Remanufacture (R6)	Use	Especially suitable for equipment and durable goods
	Reprocessing models	Products that are designed to be suitable for repair, disassembly or refurbishment and therefore allowing to slow the resource loop through component recovery.	Value is created by extending the lifecycle of parts therefore resource conservation.	Value is deliverd in spare parts, refurbished or remanufactured products	Value is capture through the (re-)sales of spare parts or refurbished/remanufactured products.	Slowing	Reuse (R3) Repair (R4) Refurbish (R5), Remanufacture (R6) Repurpose (R7)	Use	Suitable for products which design allows for repair and modularity.
Resource recovery & recycling	Upcycle recycling/ recovering value from discarded products	The materials of a product are recovered and prepared for recycling, therefore becoming input for a new production and closing the resource loop.	Value is created by extending the resource life and therefore preventing new resource mining.	Value is delivered through the collection of used/unwanted products through a collections system.	Value is captured in resource savings or in additional revenue streams from selling the recycled material.	Closing	Recycle (R8)	Recover	Suitable in situation where the material and regulations allow for recycling.
Digitialization & dematerialization		The development of a digital solution as a substitute for a physical product and thereby creating a dematerialized resource loop.	Value is created through the reduction of material usage and logistical activities.	Value is deliverd through digital platform, systems or services.	Value is captured through the sales of lincenses.	Dematerializing	Refuse (R0) Rethink (R1)	Use (design)	Suitable in situation where there is existing customer infrastructure to place the digital solution on.

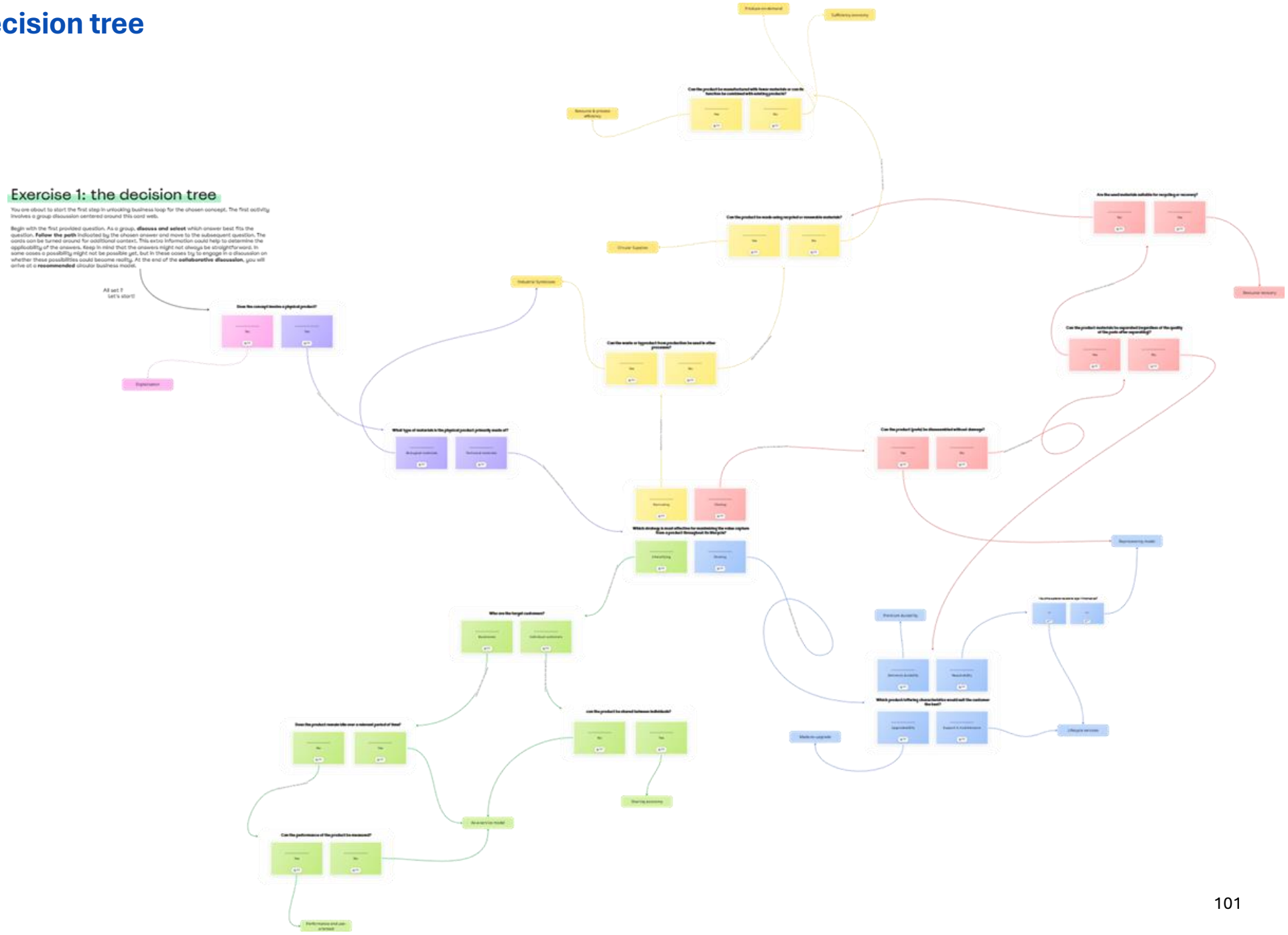
Appendix H Final CBM Typology

Archetype	Model	Definition	Value Creation	Value Capture	Value Delivery	Retention loop	R-strategy	Lifecycle	LV	HV
Dematerialization & Digitalization	Dematerialization & Digitalization	The development of a digital/non-physical solution as a concept or as a substitute for a physical product, thereby creating a dematerialized resource loop.	Value is created through reduced material use and logistic activities	Value is captured through the sales of licenses or subscriptions.	Value is delivered through a digital platform system or service.	Dematerializing	Refuse (R0), Rethink (R1)	Use (Design)	Yes	Yes
Sufficiency economy	Profit sufficiency	Active promotion of reduced consumption and pursuit of sufficiency rather than excess profit. It narrows the flow of resources by discouraging overconsumption. It also aligns with intensification strategies by encouraging the maximum use of existing products.	Value is created in more conscious consumption and the establishment of partnerships	Cost and resource savings in production, customer loyalty, and improved brand image.	Value is delivered through a shift in marketing, sales, and quality goods.	Intensifying, narrowing	Refuse (R0), Rethink (R1)	Material extraction, production	Yes	Yes
Circular Supplies	Industrial Symbiosis	The output of one process becomes the input to another, thereby closing the loop and preventing resources from being wasted. A special form of symbiosis is organic feedstock, which focuses on bio-based materials.	Value is created through a process in which residual outputs become inputs, thereby combine reducing waste and the use of non-renewable materials.	Value is captured through cost savings, through the use of the byproduct itself, or through a new income stream when selling the byproduct to other organizations.	Value is delivered through partnerships and sharing networks.	Closing	Recycle (R8)	Material extraction, material processing, production	Yes	Yes
	Sourcing of circular (renewable) supplies/ *closed loop supply chain*	Sourcing recovered materials and renewable energy in the product and the production process, which contributes to the circulation of resources by closing the loop.	Value is created through innovation in product and process by introducing renewable materials, thereby reducing the use of non-renewable materials.	Value is captured through cost savings on supplies, (*premium) pricing/product sales*, and improved brand image.	Value is delivered through products with circular quality.	Closing	Recycle (R8)	Material extraction, material processing	Yes	Yes
Resource & process efficiency	Production on demand	The production process is only initiated when demand is quantified and confirmed. This narrows the resource flow and minimizes waste from overstock and unwanted products	Value is created by aligning production with verified demand, offering reliable and flexible supply while reducing unnecessary resource use.	Value is captured through operational cost savings by avoiding overstocking and the production of unwanted products that would otherwise be wasted.	Value is delivered through demand-drive production processes and systems.	Narrowing	Reduce (R2)	Material processing, production	Maybe	Yes
	Process optimization	The focus is on process optimization, cleaner production, and energy-efficient use. This reduces the use of (virgin) sources, waste production, and emissions, and thus narrows the resource flow required to produce the product.	Value is created through an optimized production process, reducing resource and energy consumption. Potentially generating cheaper products and shorter waiting times.	Value is captured through reduced costs, compliance with emissions and waste regulations, and environmental benefits, achieved by minimizing the footprint.	Value can be delivered through partnerships, value network configurations, product redesign, and reducing supply chain emissions.	Narrowing	Reduce (R2)	Production	Yes	Yes
Access Provision	Sharing platform/ peer-to-peer sharing	A facilitation of C2C or B2B product/equipment sharing that otherwise tends to be underutilized. This intensifies their usage. Sharing can be facilitated through a digital platform.	Value is created by enabling access to underutilized equipment, offering users greater flexibility and reliable availability while reducing the need for individual ownership	Value is captured through a transactional agreement when assets are shared or lent, or through an improved brand image.	Value is delivered through sharing platforms and places that provide access to equipment.	Intensifying	Rethink (R1), Reuse (R3)	Use/distribution	Maybe	Yes
	Performance/use- oriented	Customers do not pay for ownership of the products, but for their performance or use cycles, with guaranteed uptime to drive increased utilization, which intensifies the loops.	Value is created by providing (temporary) access without the need for individual ownership, ensuring reliable uptime, and enabling users to only pay what they actually consume.	Value is captured through a pay-per-use agreement or performance-based charging, which results in a continuous revenue stream.	Value is delivered through service offerings, such as equipment on location.	Intensifying	Rethink (R1), Reuse (R3), Repair (R4) (R4 are entitled to the uptime guarantee)	Use	Yes	Yes
	As-a-service/asset management	The provision of temporary access to a product or piece of equipment, including company equipment, in an idle state. This intensifies product usage.	Value is created by enabling (temporary) access to equipment, offering flexibility and performance reliability while reducing the need for individual ownership.	Value is captured through a subscription that yields a continuous, recurring revenue stream or reduces costs associated with machine idle time.	Delivered through service offerings, such as equipment on location	Intensifying	Rethink (R1), Reuse (R3)	Use	Yes	Yes
Product lifecycle extension	Premium durability (quality)	The products are designed for robustness and longevity to endure more use cycles. This slows the resource loop as the product is used longer, and so are its materials.	Value is created by the production of products with extended functional performance, offering users durable and reliable, qualitative products, and so reducing the cost and frequency of replacement.	Value is captured in profit through sales with premium pricing and improved brand identity.	Value is delivered through sales channels.	Slowing	Reuse (R3)	Use	Yes	Yes
	Upgrade/modularity/customization	The product allows customization or enhancement of its parts, ensuring market value throughout the product lifecycle. This extends the functional life of the product (parts) and thus slows the resource loop.	Value is created through customization, offering users a product tailored to their needs, and through extended product value by enabling upgrades to functionality upon request, reducing the frequency and costs of replacement.	Value is captured in profit in recurring sales on upgrades or new modular parts, a premium price for customized goods, and improved customer relationships.	Value is delivered through upgrading systems.	slowing	Reuse (R3), Repair (R4) Remanufacture (R6)	Use	Yes	Yes
	Lifecycle services	A service that assists the customers in maintenance and repair, aimed at extending the product's functional life and thereby slowing the resource loop.	Value is created through ensured product uptime, stable performance, and reliability, offering the user peace of mind in their equipment maintenance.	Value is captured through continuous revenues from subscription fees or agreements and improved customer relationships.	Value is delivered through repair and maintenance services.	Slowing	Reuse (R3), Repair (R4)	Use	Yes	Yes

	Reprocessing models	The products are designed for repair, disassembly, or refurbishment, and are supplemented with repair parts. This slows the resource loop through component recovery.	Value is created through the extended product lifecycle or its parts, offering products with a reduced price or a low-cost opportunity to maintain the functional performance of their existing products, reducing the cost and frequency of equipment replacement.	Value is captured in profit from	Value is delivered through the collection of used products/components and their re-offering.	Slowing	Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), Repurpose (R7)	Use	Yes	Yes
Resource recovery & recycling	Upcycle recycling/recovering value from discarded products	The materials of a product are recovered and prepared for recycling. These materials then become input for new production, thereby closing the resource loop.	Value is created by extending the life of existing resources and providing users with the availability of a renewable material, thereby reducing virgin materials usage.	(re-)sales of spare parts or of refurbished/manufactured products, and in improved brand image.	Value is delivered through the collection of used products through a collection system.	Closing	Recycle (R8)	Recover	Yes	Maybe

Appendix I Business Model

Decision tree



Appendix J Business Model Identity Cards

Dematerializing Circular Business Model Identity Card

Digitalization & Dematerialization

Value Creation
Value is created through reduced material use and logistic activities

Value Delivery
Value is delivered through a digital platform system or service.

Value Capture
Value is captured through the sales of licenses or subscriptions.

About the Cards

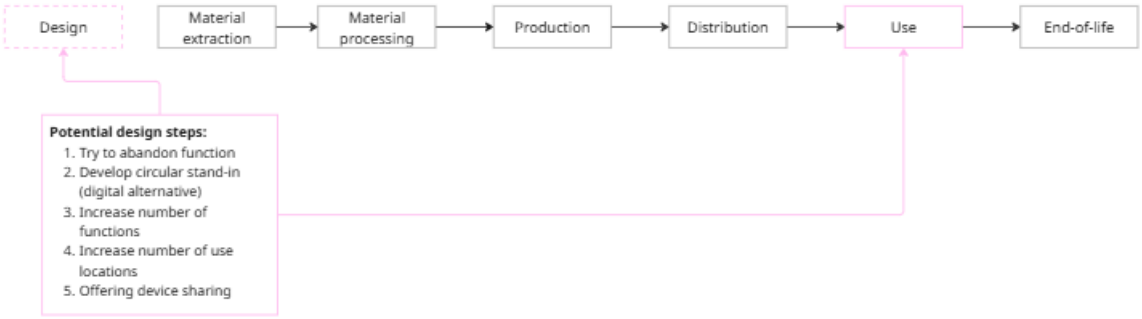
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The development of a digital/non-physical solution as a concept or as a substitute for a physical product, thereby creating a dematerialized resource loop.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

The cards describe strategies that are essential in implementing and designing your model. Each strategy might have a different outcome on each product. Each R-strategy is supported by their definition [2].

Slowing Circular Business Model Identity Card

Modularity & Upgradeability

Value Creation
Value is created through customization, offering users a product tailored to their needs, and through extended product value by enabling upgrades to functionality upon request, reducing the frequency and costs of replacement.

Value Delivery
Value is delivered through upgrading systems.

Value Capture
Value is captured in profit in recurring sales on upgrades or new modular parts, a premium price for customized goods, and improved customer relationships.

About the Cards

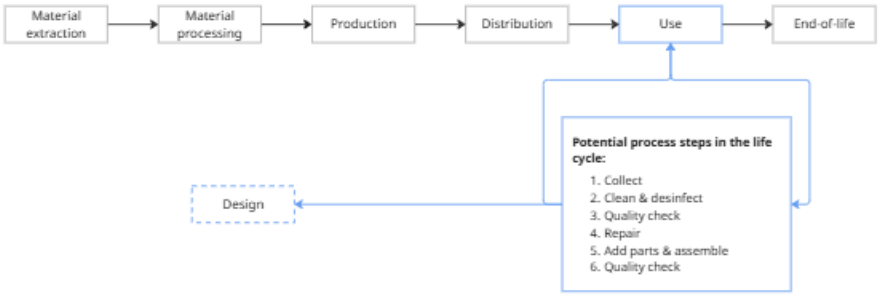
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The product allows customization or enhancement of its parts, ensuring market value throughout the product lifecycle. This extends the functional life of the product (parts) and thus slows the resource loop.

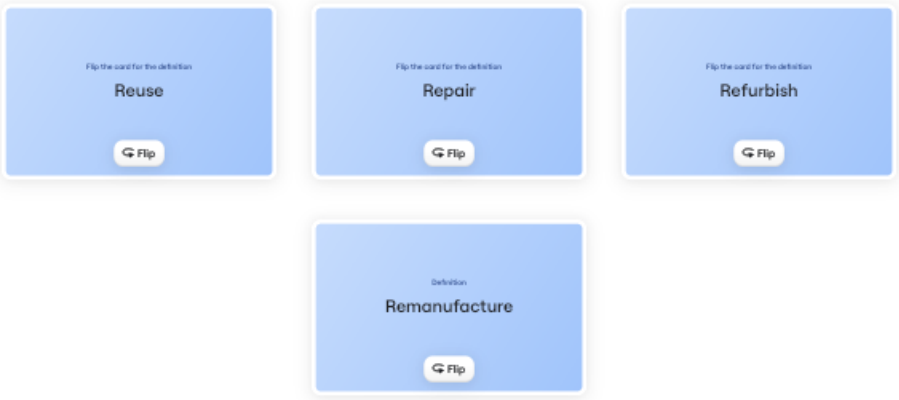
Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

The cards describe strategies that are essential in implementing and designing your model. Each strategy might have a different outcome on each product. Each R-strategy is supported by their definition [2].



Slowing Circular Business Model Identity Card

Premium durability

By Iris Borst

Value Creation
Value is created by the production of products with extended functional performance, offering users durable and reliable, qualitative products, and so reducing the cost and frequency of replacement.

Value Delivery
Value is delivered by products claiming long-lasting lifetime

Value Capture
Value is captured in profit through sales with premium pricing and improved brand identity.

About the Cards

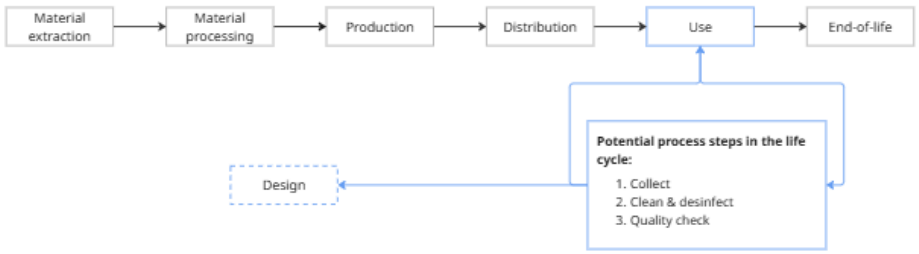
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The products are designed for robustness and longevity to endure more use cycles. This slows the resource loop as the product is used longer, and so are its materials.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

The cards describe strategies that are essential in implementing and designing your model. Each strategy might have a different outcome on each product. Each R-strategy is supported by their definition [2].

References

Slowing Circular Business Model Identity Card

Lifecycle services

Value Creation
Value is created through ensured product uptime, stable performance, and reliability, offering the user peace of mind in their equipment maintenance.

Value Delivery
Value is delivered through repair and maintenance services.

Value Capture
Value is captured through continuous revenues from subscription fees or agreements and improved customer relationships.

About the Cards

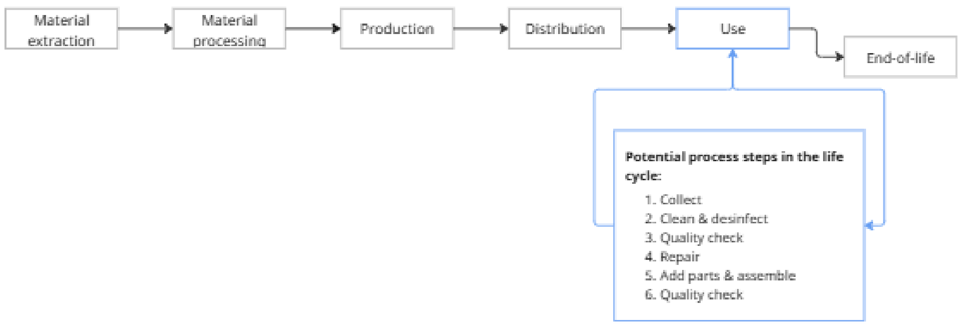
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

A service that assists the customers in maintenance and repair, aimed at extending the product's functional life and thereby slowing the resource loop.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

The cards describe strategies that are essential in implementing and designing your model. Each strategy might have a different outcome on each product. Each R-strategy is supported by their definition [2].

Flip the card for the definition
Reuse
Flip

Flip the card for the definition
Repair
Flip

Flip the card for the definition
Refurbish
Flip

Definition
Remanufacture
Flip

References

Slowing Circular Business Model Identity Card

Reprocessing

By Iris Borst

Value Creation
Value is created through the extended product lifecycle or its parts, offering products with a reduced price or a low-cost opportunity to maintain the functional performance of their existing products, reducing the cost and frequency of equipment replacement.

Value Delivery
Value is delivered through the collection of used products/ components and their re-offering.

Value Capture
Value is captured in profit from(re-)sales of spare parts or of refurbished/manufactured products, and in improved brand image.

About the Cards

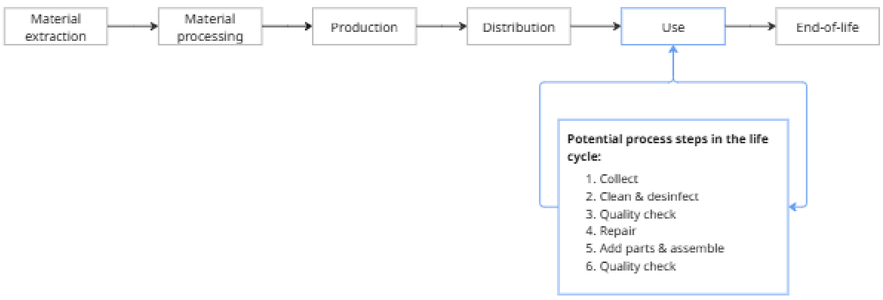
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The products are designed for repair, disassembly, or refurbishment, and are supplemented with repair parts. This slows the resource loop through component recovery.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

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Flip the card for the definition
Reuse
Flip

Flip the card for the definition
Repair
Flip

Flip the card for the definition
Refurbish
Flip

Flip the card for the definition
Remanufacture
Flip

Flip the card for the definition
Repurpose
Flip

References
[1] [illegible]
[2] [illegible]

Recycling Resource Recovery

By Iris Borst

Value Creation
Value is created by extending the life of existing resources and providing users with the availability of a renewable material, thereby reducing virgin materials usage.

Value Delivery
Value is delivered through the collection of used products through a collection system.

Value Capture
Value is captured in an additional revenue stream by selling recycled material or reducing costs and raw material acquisition, when using the material itself.

About the Cards

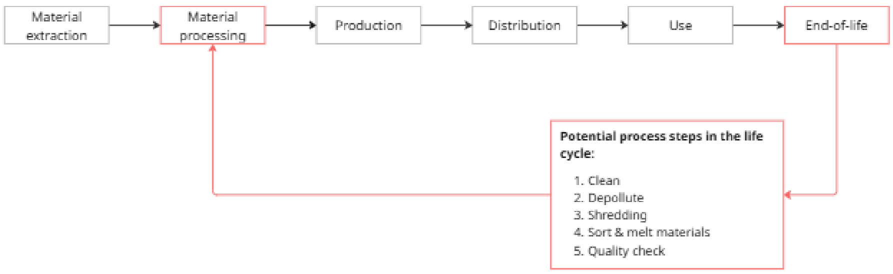
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The materials of a product are recovered and prepared for recycling. These materials then become input for new production, thereby closing the resource loop.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



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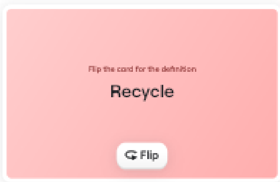

References
[1] [illegible]
[2] [illegible]

Circular supplies

By Iris Borst

Value Creation
Value is created through innovation in product and process by introducing renewable materials, thereby reducing the use of non-renewable materials.

Value Delivery
Value is delivered through products with circular quality.

Value Capture
Value is captured through cost savings on supplies, (*premium*) pricing/product sales, and improved brand image.

About the Cards

These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

Sourcing recovered materials and renewable energy in the product and the production process, which contributes to the circulation of resources by closing the loop.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].

Effective Strategies

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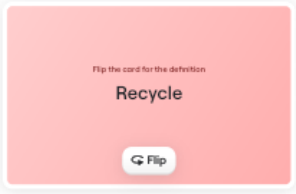


References

Industrial symbiosis

By Iris Borst

Value Creation
Value is created through a process in which residual outputs become inputs, thereby combine reducing waste and the use of non-renewable materials.

Value Delivery
Value is delivered through partnerships and sharing networks.

Value Capture
Value is captured through cost savings, through the use of the byproduct itself, or through a new income stream when selling the byproduct to other organizations.

About the Cards

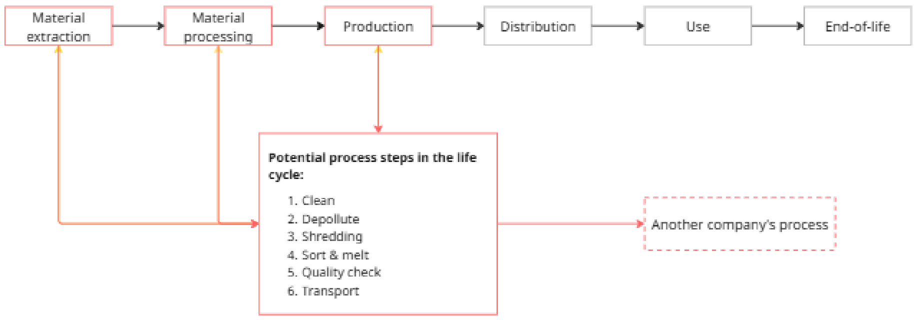
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The output of one process becomes the input to another, thereby closing the loop and preventing resources from being wasted. A special form of symbiosis is organic feedstock, which focuses on bio-based materials.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



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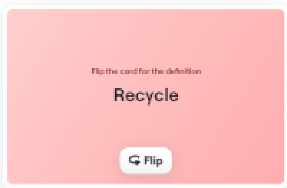


References:
[1] [illegible]
[2] [illegible]

Narrowing Circular Business Model Identity Card

Profit Sufficiency

By Ida Borat

Value Creation
Value is created in more conscious consumption and the establishment of partnerships

Value Delivery
Value is delivered through a shift in marketing, sales, and quality goods.

Value Capture
Cost and resource savings in production, customer loyalty, and improved brand image.

About the Cards

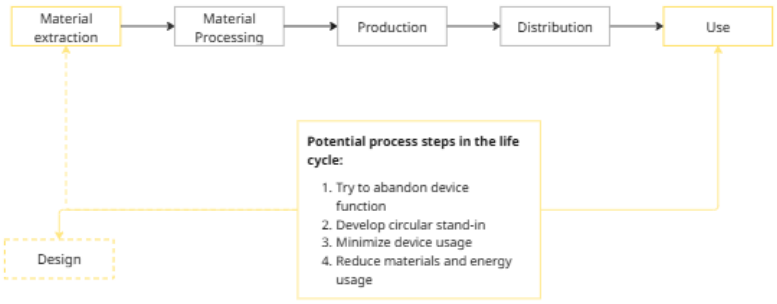
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

Active promotion of reduced consumption and pursuit of sufficiency rather than excess profit. It narrows the flow of resources by discouraging overconsumption. It also aligns with intensification strategies by encouraging the maximum use of existing products.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

The cards describe strategies that are essential in implementing and designing your model. Each strategy might have a different outcome on each product. Each R-strategy is supported by their definition [2].

References

Narrowing Circular Business Model Identity Card

Production-on-demand

Value Creation
Value is created by aligning production with verified demand, offering reliable and flexible supply while reducing unnecessary resource use.

Value Delivery
Value is delivered through demand-drive production processes and systems.

Value Capture
Value is captured through operational cost savings by avoiding overstocking and the production of unwanted products that would otherwise be wasted.

About the Cards

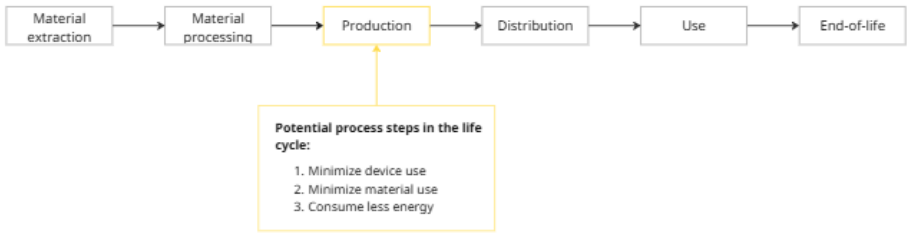
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The production process is only initiated when demand is quantified and confirmed. This narrows the resource flow and minimizes waste from overstock and unwanted products

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

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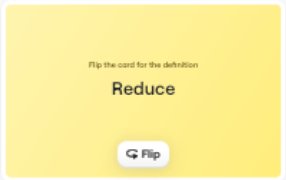


Narrowing Circular Business Model Identity Card

Process Optimization

By Iris Borst

Value Creation
Value is created through an optimized production process, reducing resource and energy consumption. Potentially generating cheaper products and shorter waiting times.

Value Delivery
Value can be delivered through partnerships, value network configurations, product redesign, and reducing supply chain emissions.

Value Capture
Value is captured through reduced costs, compliance with emissions and waste regulations, and environmental benefits, achieved by minimizing the footprint.

About the Cards

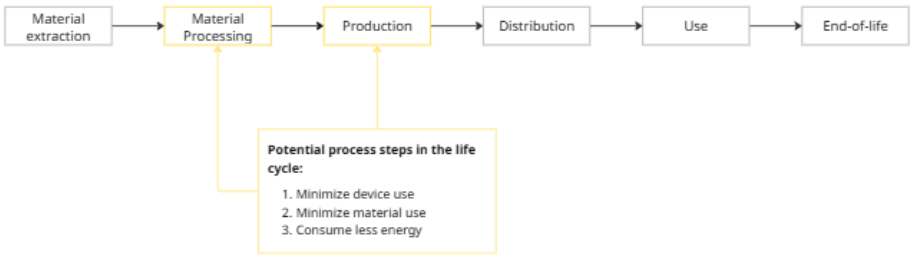
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The focus is on process optimization, cleaner production, and energy-efficient use. This reduces the use of (virgin) sources, waste production, and emissions, and thus narrows the resource flow required to produce the product.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



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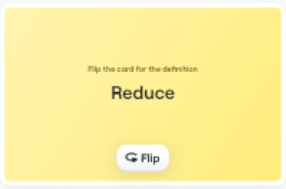


References

Intensifying Circular Business Model Identity Card

Sharing model

By Iris Borst

Value Creation
Value is created by enabling access to underutilized equipment, offering users greater flexibility and reliable availability while reducing the need for individual ownership

Value Delivery
Value is delivered through sharing platforms and places that provide access to equipment.

Value Capture
Value is captured through a transactional agreement when assets are shared or lent, or through an improved brand image.

About the Cards

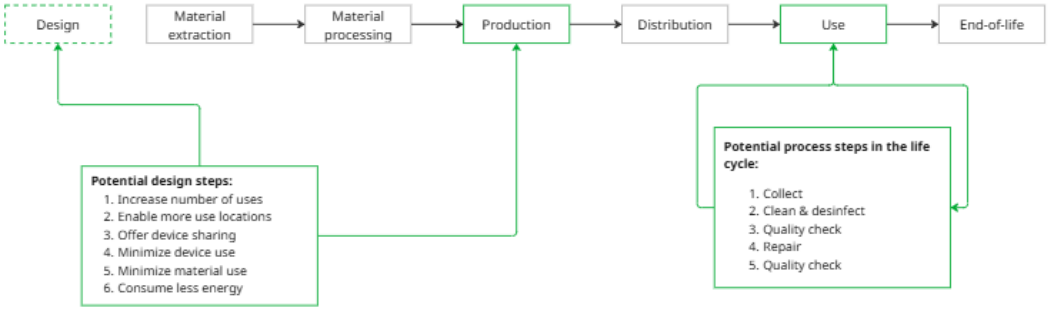
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

A facilitation of C2C or B2B product/equipment sharing that otherwise tends to be underutilized. This intensifies their usage. Sharing can be facilitated through a digital platform.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

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References

Intensifying Circular Business Model Identity Card

As-a-service

By Iris Borst

Value Creation
Value is created by enabling (temporary) access to equipment, offering flexibility and performance reliability while reducing the need for individual ownership.

Value Delivery
Value is delivered through service offering and access to product.

Value Capture
Value is captured through a subscription that yields a continuous, recurring revenue stream or reduces costs associated with machine idle time.

About the Cards

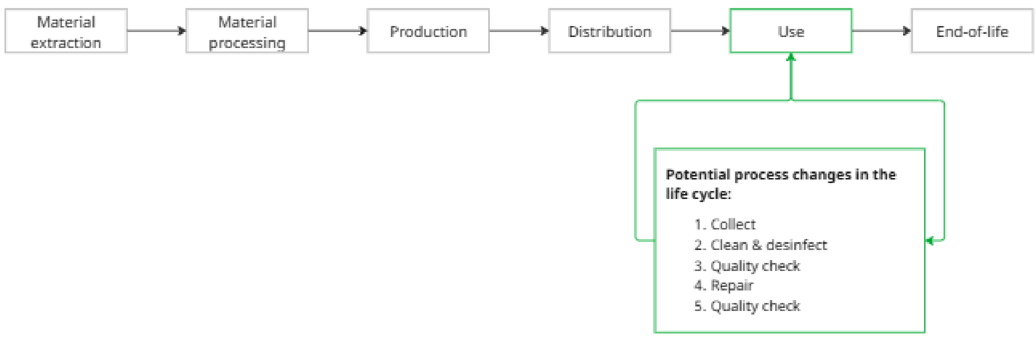
These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

The provision of temporary access to a product or piece of equipment, including company equipment, in an idle state. This intensifies product usage.

Product Lifecycle Orientation

Below is a visual representation of a basic product lifecycle. This representation highlights potential activities that are needed to achieve the model. Design is not a standard step in the traditional product lifecycle, therefore activities related to design are show separately [1].



Effective Strategies

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Flip the card for the definition
Reuse
Flip

Flip the card for the definition
Repair
Flip

Flip the card for the definition
Rethink
Flip

References:
[1] [illegible]
[2] [illegible]

. . .

Intensifying Circular Business Model Identity Card

Performance and use-oriented

Value Creation
Value is created by providing (temporary) access without the need for individual ownership, ensuring reliable uptime, and enabling users to only pay what they actually consume.

Value Delivery
Value is delivered through product performance or agreement on result.

Value Capture
Value is captured through a pay-per-use agreement or performance-based charging, which results in a continuous revenue stream.

About the Cards

These identity cards classify various (circular) business models by providing their definitions, potential lifecycle changes, and strategies that enhance their value chain. They provide guidelines and through explorative exercises, you'll explore how the model fits the context best.

Definition

Customers do not pay for ownership of the products, but for their performance or use cycles, with guaranteed uptime to drive increased utilization, which intensifies the loops.

Product Lifecycle Orientation

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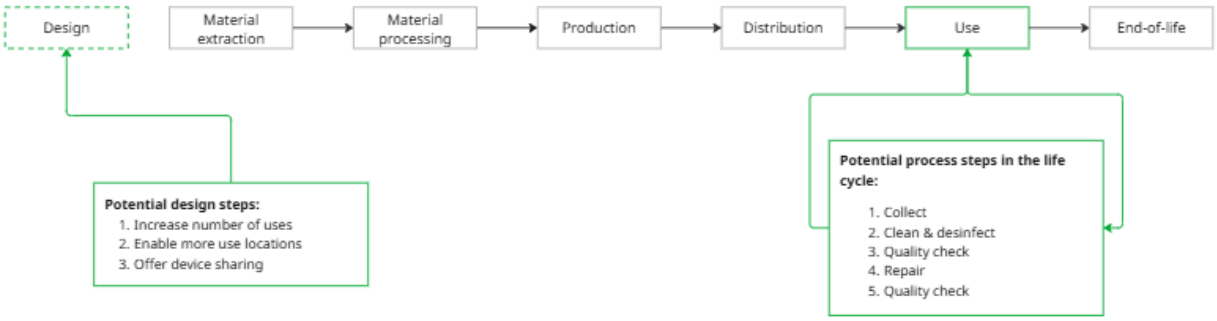

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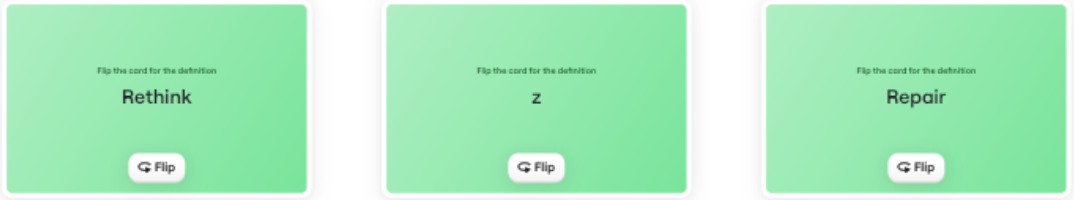

References