CIRCULAR ECOSYSTEMS

White Paper

Business Model Innovation for the Circular Economy

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When Schoeller Textil AG, a Swiss producer of textile fabrics, realised that the environmental problems in their industry could not be solved alone, they looked beyond their company's borders and began to build a circular ecosystem with customers, complementors and competitors. Coming from the innovation potential of its own business model, Schoeller formed this circular ecosystem in collaboration with seven companies, eventually naming their ecosystem wear2wear™. The aim was creating solutions to change the polluting, resource-consuming and waste-producing textile industry into a more sustainable one. Their approach was understanding and envisioning the product life cycle of the product and creating a shared value proposition for the whole ecosystem. wear2wear™ specifically designs their textiles in a way that enables maintenance and recycling at the end of the product's life so that no material degenerates into waste ('design2recycle'). To do this, they decided to produce fully circular functional work wear using a synthetic polymer (100% polyester), thereby massively reducing the waste of resources. The remarkable aspects are how they dealt with design in a collaborative way (e.g., avoiding mixed materials and embracing modular tailoring) and how they built their ecosystem around it. They developed the product design through collaboration arrangements of individual offerings. The product design builds the anchoring point for the change – and analogous to the ecosystem concept – adds value for the customers [1,2].

The pioneering case of wear2wear™ shows us how companies can innovate their business models to implement a circular economy (CE) in an ecosystem and how a common vision of how to solve a global problem can be realised. You can find more details about the wear2wear™ case in the Appendix. The present White Paper provides a condensed glimpse into the core elements of our forthcoming book, ***The Circular Navigator****. The Circular Navigator describes a systematic way to design, validate and implement business models in a circular ecosystem.*

About the Research

The present paper is inspired and enriched by our work with the LACE project (Laboratory for Applied Circular Economy) – a large, interdisciplinary research project funded by the Swiss National Science Foundation. The project is a cooperation of the University of St. Gallen, the University of Lausanne, the ETH Zurich and the EMPA. Using an interdisciplinary research approach allowed us to identify under which economic, legal, political and technical conditions a sustainable CE can be ecologically beneficial and economically profitable for companies. The joint efforts of the partner universities have been enriched through cooperation with various companies and organisations, such as Losinger Marazzi, V-Zug AG, Entsorgung- & Recycling Stadt Zürich, Schoeller Textil AG, Sympatex, Carl Weiske and Rehau.

We base our results on extensive literature research, conceptual work, interviews with company representatives, and a series of workshops with companies and various individuals from different consulting and academic institutions.

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Executive Summary

A growing number of companies are focusing on sustainability. However, a closer look reveals a 'big disconnect' [3,4] between the actions propagated at the corporate level and the deterioration of the state of our planet and global society.

By design, waste and other negative environmental externalities have become an integral part of our industrialised consumer society. The circular economy (CE) is a way to move away from the linearity of our current industrial and economic systems. The aim of a CE is to keep products, components and materials at their maximum utility and value at all times [5]. To overcome the 'big disconnect', the present article provides an actionable path for companies to design, validate, and implement a circular ecosystem with suitable business models that enable sustainable solutions that are beyond the reach of single companies. Our easy-to-navigate framework consists of the following seven steps:

I. Impulse: Capture the need for change from a company perspective for reasons such as changing consumer behaviour and legislation, a possible reduction of resource dependencies and costs and increased motivation for current and future employees. (p.4)

II. Identify: Assessing the environmental and social impact of the current company's business model and of the entire linear value chain. This is achieved by combining the three spheres of sustainability (planet, people and profit) [6] with the magic triangle concept of business models [7]. (p.5)

III. Ideate: Creating ideas for circular ecosystems that go beyond existing solutions with 38 *Circular Ecosystem Patterns* – blueprints from other industries that support organisations in the design of their own circular ecosystem. The blueprints are based on more than 200 mini case studies from different industries. (p.6)

IV. Integrate: Designing a circular ecosystem by consolidating the generated ideas into a circular logic. The *Circular Canvas* provides the structure and flexibility to design and – more importantly – work with the big picture needed to realise the CE. (p.8)

V. Imagine: Expressing the vision and motivation for a circular transformation in one's company, as well as for partners in the circular ecosystem. (p.9)

VI. Incorporate: Approaching the ideal partners and incorporating them into the ecosystem. This aspect is of particular importance for the success of circular solutions because no company can deliver or create all the needed products, services or guidelines alone. (p.10)

VII. Implement: For each company, implementing the ecosystem takes place at the individual business model level. Following the current best practices of de-risking and assumption-based testing for validating new business models, as well as adapting these regarding the specific requirements of the CE, are the key elements to realising the designed ecosystem and reaping the benefits of such a unique offering. (p.10)

The inherent logic and structure of the approach allows companies to create circular solutions without being overwhelmed by the complexity of the endeavour. This is critical because companies that want to stay ahead of the competition need to be able to create such solutions not only for their customers, but also for their employees, our planet and our society as a whole.

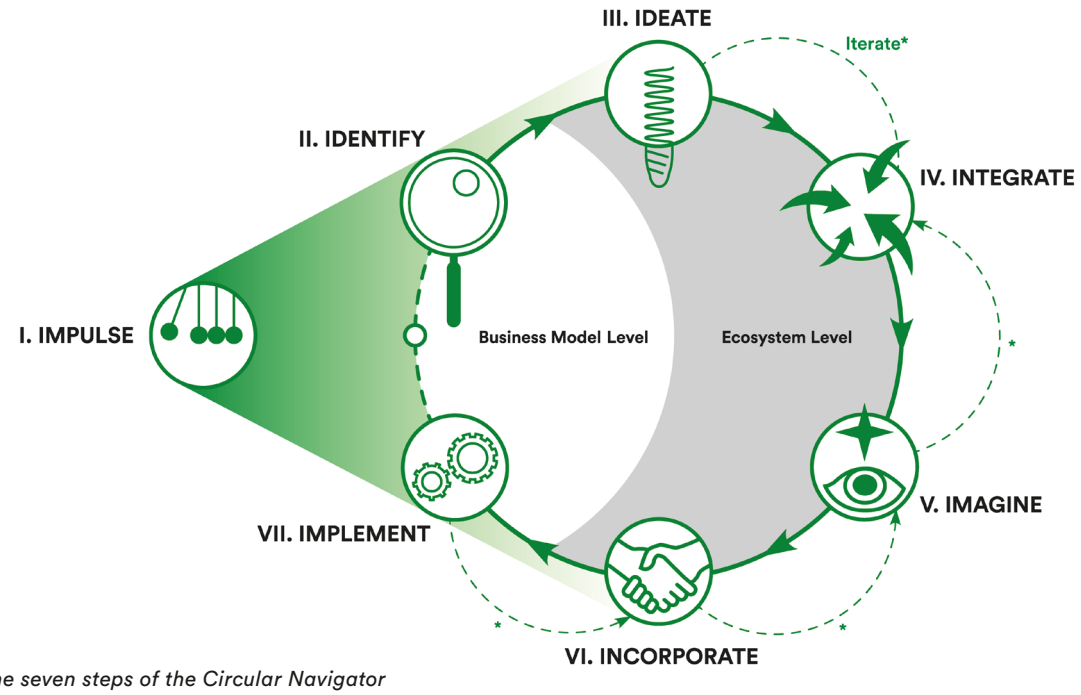

Fig. 1: The seven steps of the Circular Navigator

Why Do We Need a Circular Economy?

We have a problem

Companies are the engines of modern societies. They create value for society, bring prosperity and technical innovation and develop solutions for burning issues. They offer people purpose, jobs and secure incomes. In addition, companies increasingly address their environmental and social responsibility, as seen in corporate social responsibility (CSR) initiatives or sustainability reports; they invest in actions to increase eco-efficiency or commit themselves to more sustainable practices. Managers are increasingly emphasising the advantage of being active in sustainability as a company. Cost savings, risk reduction or brand reputation are highlighted as important drivers for the commitment to more sustainability [3,8].

Unfortunately, a closer look reveals a striking discrepancy between the actions propagated at the corporate level and the deterioration of the planet and global society. This 'big disconnect' [3,4] is reflected by a lack of progress regarding environmental sustainability and achieving the *sustainable development goals (SDG)* as set by the United Nations [9]. Six of the nine planetary boundaries that define the safe operating space for humanity on earth are already considered to be exceeded, thus endangering the resilience and stability of the earth's system [10,11]. The concentration of CO_2 in the atmosphere is at a record high, which is being accompanied by a continuous increase of the annual temperature [11,12]. It is predicted that without changes, one million species will face extinction in the coming decades [13]. The amount of waste produced daily – a relevant part of it ending up as municipal waste in waters and oceans – is estimated to grow from 3.5 million tonnes per day today to 6.0 million tonnes per day in 2025 [14].

Overcoming the big disconnect

So why is this 'big disconnect' happening? One credible explanation for this effect is that companies contribute to sustainability in varying extents and with different efforts. Reducing unsustainable practices delivers different environmental results than increasing sustainable practices [3,15]. However, most firms choose only to reduce unsustainable practices to varying degrees [16]. By contrast, increasing sustainability would actively address the current problems relevant to society and the environment, and solve them. However, it is not only about the degree of sustainability, but also about the underlying economic logic: the way we create value in industrial systems, how the value chains are structured, and how the resources in these systems flow. How do we extract, process, consume and (not) return products after their end of life?

Since the beginning of industrialisation, there has been a linear relationship between these steps of resource usage, also known as the 'take-make-use-dispose' relationship [17–19]. The causal consequence of this linearity is not only the production of unwanted material at the end of a product's lifetime, which is also known as waste, but also the acceptance of resource scarcity and further negative impacts along all steps (e.g., CO_2 emissions, micro plastics or soil poisoning) [20–22]. This results in a situation where current and further economic growth depends on massive resource extraction [19,22]. By design, waste has become an integral part of our industrialised consumer society [17], so much so that incremental changes or efficiency measures do not offer acceptable solutions.

'If we want to do something to get this catastrophic pollution under control, then we have to tackle it fundamentally'. (Thomas Weiske, Carl Weiske)

Fundamental business model innovation for a circular economy

To really tackle the big problems mentioned above, firms need to fundamentally change their business model – their underlying way of doing business. Instead of focusing on traditional linear-oriented business models, companies need to develop business models that allow for sustainable and closed resource loops in their industry [19,23,24]. If designed properly, this circular change leads to a regenerative industrial economy, (re-) capturing the enormous volume of finite and renewable resources to use them again and again [17]. The goal of the CE is to keep products, components and materials at their maximum utility and value at all times [5]. Therefore, the product design is crucial for success [17]. This, in turn, allows for the decoupling of economic growth and material extraction [19,22]. Although practitioners and academics speak of a '*circular business model*' [25–30], this is a rather illusory view considering the business activities that must be undertaken along all life cycle phases of a product. In our understanding, a business model itself can only lead to circularity as part of an ecosystem of business models, thereby enabling a circular flow of resources along the ecosystem [27].

A (business) ecosystem is an organisational form with a modular architecture that is composed of independent complementors working towards a shared value proposition. This coordination allows an ecosystem to serve complex customer needs that one company could not fulfil alone [1,31]. A circular ecosystem coordinates itself across the business models of different complementors to create sustainable value propositions with closed resource loops that are based on an aligned product design. Based on this, the CE can be seen as the interplay of complementing business models along a circular ecosystem. Therefore, companies need to design and create these ecosystems to make the CE work.

Definition of a circular economy:
A CE is a model adopting a resource-based and systemic view, which aims to take into account all the variables of the system earth, in order to maintain its viability for human beings. It helps society achieve well-being within the planetary boundaries. It achieves this through business model innovation and technology, providing the goods and services required by society and thus leading to long-term economic prosperity. These goods and services are powered by renewable energy and rely on materials that are either renewable through biological processes or that can be safely kept in the technosphere, requiring minimum raw material extraction and ensuring the safe disposal of inevitable waste. (based on *Desing et al*., 2020)

Schoeller alone would not have been able to design the circular ecosystem; it was a joint effort by all members. This included the innovation of material, product design and processes. This joint innovation was crucial to ensure the durability of the work wear and the safe recycling of the raw materials at the end of a product's life cycle.

However, shifting from a traditional business model to a circular ecosystem with suitable business models for the involved complementors is not easy, and current strategy frameworks are of little help. It is important to change the perspective from a micro view of supply chains to an integrated macro view that focuses on the value creation of different partners as part of an ecosystem [2]. The 'big disconnect' can only be solved if companies widen their perspective and accept that their products will create an impact throughout their whole life cycle. This necessitates moving away from an isolated view of buying and selling along the supply chain towards an integrated, systemic view where companies need to coordinate their actions and align their processes on a shared value proposition.

Based on our research, we developed a step-by-step navigator that allows companies to build and implement circular ecosystems. For this purpose, we initiate change from a systemic perspective, which enables the innovation of individual business models and embeds them in an aligned ecosystem. Therefore, companies need to go through seven steps.

I. Impulse: Why should we care?

Why should companies care at all? First, we give the simple answer: the basis of our existence as human beings is a functioning earth system in a resilient and accommodating state [11]. Today, we are moving away from this state. We run the risk of producing irreversible changes, such as the destruction of natural ecosystems (e.g., coral reefs, mangrove forests and wetlands) and more extreme weather events [32,33]. People are becoming increasingly aware of these facts – also because of movements like *Friday for Future*, which increases pressure from different sides for firms to act. Beyond these macro needs, there are four concrete benefits for companies investing in CE.

'Sustainability is not a megatrend; it is an existential necessity'. (Dr. Rüdiger Fox, Sympatex)

1. Changing consumer behaviour and regulation: Consumer preferences change over time – the demand for sustainable products is linked to personal norms and sustainability preferences [34,35]. Younger generations display an increasing awareness of climate change and sustainability. This could not only change consumption behaviour, but also create regulatory pressure (such as the EU ban on several single-use products made of plastic [36]). CE measures would allow companies to create competitive advantages as first movers while preventing issues with upcoming regulations. In addition, it has been repeatedly observed that companies that commit to sustainability display better financial performance and profitability [8,37–39]. A driving impact behind *Schoeller* creating the ecosystem *wear2wear™* together with its first partners *DutchSpirit*, *Carl Weiske* and *Märkische Faser* was the changing public tenders in the Netherlands, where because of growing awareness, the state suddenly demanded a renunciation of linearly processed garments in work wear.

2. Reduction of resource dependency: Resource availability is one of the most important factors for the long-term prosperity of businesses. The growing global demand for raw resources increases scarcity and drives up prices and volatility. The resulting pressure on corporate supply chains can become an existential threat to companies [17,40]. CE measures could also massively reduce dependence on the fossil feedstock [40–42]. We see this within the *wear2wear™* case, where all companies depend on synthetic polymers.

'The business models we have right now will change within the next five to fifteen years because we will not be able to rely on the supply chains we have right now. We need crude oil [...], and we throw materials away at the end. This business model will not work anymore'. (Madeline Brey, Sympatex 2019)

3. Competitive advantage: Implementing innovative business models in a circular ecosystem with complementor companies will create a competitive advantage for the companies who work together. For example, *wear2wear™* has developed a holistic solution in the field of polymer recycling, which pushes all companies

in the ecosystem further up the learning curve compared with unorganised competitors. Working with partners allows all firms within the CE to benefit from more customer insights, something that is not always possible when conducting linear supply chains. The textile industry has one of the worst ways of handling resources after usage, with less than 1% of materials being recycled [20]. The cost-saving potential of material recycling combined with new forms of customer relationships in the CE is not being exploited, and huge benefits can be reaped for those willing to pursue this. Indeed, estimates predict that the European Union alone could achieve annual economic benefits of up to EUR 1.8 trillion and create 2 million additional jobs by 2030 [41,42]. CE measures such as waste prevention, the recovery of materials or new product designs could have annual net benefits for EU companies of up to EUR 600 billion [43].

4. Talent attraction and employee motivation: Challenging and solving environmental problems as a company creates intrinsic motivation for employees. Studies show that employees identify more strongly with their company when it acts responsibly [44]. In this way, CSR, as well as a company's reputation in terms of environmental issues, increases the attractiveness of a company on the labour market [45–47].

II. Identify: Where do we stand today?

After the initial impulse, the CE transition starts at the business model level before moving to the ecosystem level with potential partners. Therefore, creating an understanding of the environmental and social impact of all business models involved in the liner value chain ('take-make-use-dispose') is a crucial step. Only then can the firm decide which dimensions need to be adopted. Because the product design is a key aspect to enable circular solutions, an analysis of the current design and its consequences along the life cycle is central [48]. Finally, it is necessary to fully understand what happens to the products after the end of their lifetime and how the company is currently involved with that aspect [17,49,50].

'We looked for the person behind. That's what I always wanted. When I do business, I want to do it fair and not while other people suffer to make me rich'. (Erik Toenhake, DutchSpirit)

This identification can be done by taking a detailed look at one's own and all other relevant business models along the value chain. To do this, companies need to link the business model concept with the *Triple Bottom Line* [6] concept and the three spheres of sustainability (planet, people and profit). A business model consists of the following four dimensions [7]:

- **Who** are the business model's customers?
- **What** is offered the customers, and what is the customer value proposition [51]?
- **How** can the value proposition be made available (value chain) – what processes, activities and resources are required, and what are their costs?
- Why is the business model financially **valuable**, and how are revenues generated (revenue model)?

These dimensions are not only the key levers of business model innovation along the potential circular ecosystem, but also the cause for the impact on the three spheres of sustainability (both positive and negative):

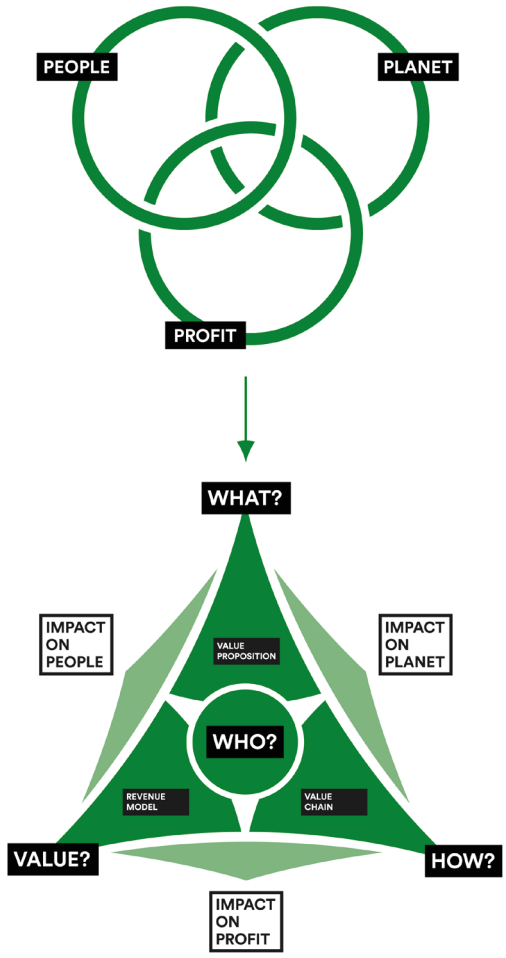

Fig. 2: Merging sustainability and business model innovation

- **Impact on the planet** (results from the *what & how* dimension): What is the offer to our supply chain customers (e.g., material composition), and what does the design consist of (e.g., material choice)? *How* do we create our products (e.g., manufacturing methods), and how do we provide them (e.g., choice of logistics)?

- **Impact on people** (results from the *what & value* dimension): *What* influence does the product have on people, and which (intended and unintended) side effects are a result [52]? Why is the business model financially viable, and how does the revenue

model affect customers? Consequently, the design of the revenue model directly influences the people because it limits access and availability.

- **Impact on company's profit** (results from the *how & value* dimension): The impact on a company's profit is described as the way a company converts the delivered value into profit [53]. The revenue model and the design of the cost structure are of crucial importance [51]. Why is the revenue model valuable in the long term, and what influence does the structure of the value chain have? How do production processes generate costs?

This holistic integration of sustainability across all the business models of a value chain reveals inherent trade-offs not only between the three spheres of sustainability, but also within each sphere. Any adjustment within one business model dimension has a direct impact on two spheres of sustainability. For example, actions to reduce toxicity during the manufacturing process (*how* dimension) have an impact on profit (e.g., through the costs for the necessary new machinery) and an impact on the planet (e.g., through less toxic gas emissions). The change from fossil materials to biodegradable ones in the product design (*what* dimension) has a direct effect on the planet (e.g., through reduction of CO_2 emissions) and on people (e.g., through new product handling).

It is important that companies not only do this for their own business model, but also for the business models of the other companies involved in the entire development process of a product. In the *wear2wear*™ case, *Schoellers*, as the lead company, did this analysis for itself and all parties involved in the creation of its work wear, including everyone from yarn producers and garment sewers to the operators of collection logistics and recyclers. This assessment needs to be enriched with an analysis of future possible threats and benefits of industry-relevant megatrends. Considering the 'use' phase regarding the customers and their needs is also central when developing new solutions.

III. Ideate: Moving beyond existing solutions

Based on the identification of the shortcomings along the linear value chains with all the business models involved, we now change perspectives to the ecosystem level. Here, the lead company needs to come up with fundamentally new value propositions and value creation mechanisms along a circular ecosystem. Ideally, the lead company does this exercise together with potential partner companies because this leads to a higher level of innovation. Often, companies have trouble thinking outside the box because they are caught in the dominant logic of their existing business. Statements such as '*We have always done it this way*' or '*This is how the industry works*' are clear evidence for a deeply rooted and dominant thinking pattern. However, to realise a CE, one has to break through these thinking patterns and redesign the value creation mechanisms of the entire industry, as we know from business model innovation research [7].

In our research, we identified 38 *Circular Ecosystem Patterns*, a blueprint of successful circular ecosystem elements that helps in designing a circular ecosystem for a company's industry. The patterns are based on a broad literature review and successful cases of companies that have created sustainable and circular solutions in their industries. This helps to break out of dominant thinking patterns and come up with fundamentally new business models for each involved company to create a circular ecosystem.

'This means we already identified three years ago that the design of a product, whether it's a shoe or a garment, is very important in terms of sustainability. You should better make it more simple and easier from the beginning to recycle in most efficient way'.
(Herve Clerbout, Sympatex)

38 Circular Ecosystem Patterns

Based on our research, we developed a classificatory framework that categorises four types of patterns crucial to creating a circular ecosystem. Together, these four pillars shape a financially valuable and attractive offering while simultaneously achieving sustainable resource loops. The first two pillars focus on the material aspects of the CE; they enable closing the material cycle with all the associated aspects of environmental sustainability (e.g., longevity or avoidance of toxic substances). The second two pillars are business driven and focus on the monetisation of the circular solution, user excitement and possible incentives. The ideas generated with the help of the patterns are then placed (see next step) along the phases of the CE. A detailed description of the pattern and case companies are shown in Appendix I.

Close the loop

This category includes all the patterns directly or indirectly crucial for the recovery of a product, the parts of a product or the material contained therein. Closing the resource loop is an important but not an exhaustive step towards achieving a sustainable circular solution [54,55].

Monetise the loop

This category helps to identify innovative ways to capitalise and capture the value from circular solutions. These patterns help to break the link between sales and raw material extraction that predominates in the linear economy [58,59].

Improve the loop

This category is an essential cornerstone of a sustainable CE; it ensures that the new offering contributes to reducing or solving environmental problems, as well as avoiding any hidden, unwanted effects (e.g., rebound effects [56,57]) to stay within the planetary boundaries.

Excite the loop

These patterns are focused on inspired interaction with users, empowering and creating awareness for circular change, which should result in long-term relationships and improved customer loyalty. These patterns add value for users beyond the sustainability aspects, thereby further motivating them to adopt the offering.

CLOSE THE LOOP	IMPROVE THE LOOP	MONETISE THE LOOP	EXCITE THE LOOP
Product-Reuse	Increased Longevity	Pay per Use	Servitisation
Part-Reuse	Repair & Maintenance	Rent Instead of Buy	Mass Customisation
Re- & Upcycling	Smart Assets	Performance-based Contracting	Circu-Luxury
Intelligent Assembly & Modularisation	Eco-Efficiency	Subscription	Experience Selling
Biodegradability	De-Materialisation	Fractionalised Ownership	Marketplace
Waste as Input	Eco-Materials & Sourcing	Dynamic Pricing	Prosumer
Reverse Logistics	Increased Functionality	Revenue Sharing	Eco Lock-in
	Localisation	Crowdfunding	Communicate Responsibility
	Produce on Demand	Take-Back	Sharing
	Detox		Robin Hood
	Energy Recovery		
	Renewable Energy		

Fig. 3: Circular Ecosystem Patterns

IV. Integrate: Designing consistent circular ecosystems

Taking an ecosystem perspective is valuable because it allows a shift in focus not given in the classical firm–supplier relationship. Ecosystems – as a new structure of economic relationships [1] – shed light on the interdependencies between activities and technologies of different companies, where innovation becomes the unit of interest [2].

The ***Circular Canvas*** (see Fig. 4) serves to assign the ideas from the previous step to the relevant phases of the CE. The canvas helps to simplify the systemic complexity of the CE, highlighting the cross-company potentials by bringing the material science and business perspective together. The product – or in a broader sense, the shared value proposition – is at the core of the canvas, and the ecosystem is formed around it to reach that solution. To identify the potential of value creation mechanisms, the ideas can be clustered into modules on the canvas (e.g., logistics provider). As known from ecosystem research, these modules are separable and allow for interconnectivity [1], and they represent opportunities for innovative business models that together form the circular ecosystem. The *Circular Canvas* identifies future partner companies and their complementarity through the newly created business models [31]. The *Circular Canvas* contains the following phases and factors:

'Sustainability and recycling is all about cooperating together'. (Hendrikus van Es, Schoeller)

- **Core phases:** The *Make* phase covers the activities of manufacturing, sales and distribution. This is followed by the *Use* phase, where the user takes advantage of the circular solution. In the *Recover* phase, the products are collected or returned and triaged, and the recovery of the materials takes place [18,59]. The product's material, in varying states of order (e.g., parts of the product or recycled components), is then used again in a new *Make* phase, effectively closing the loop.

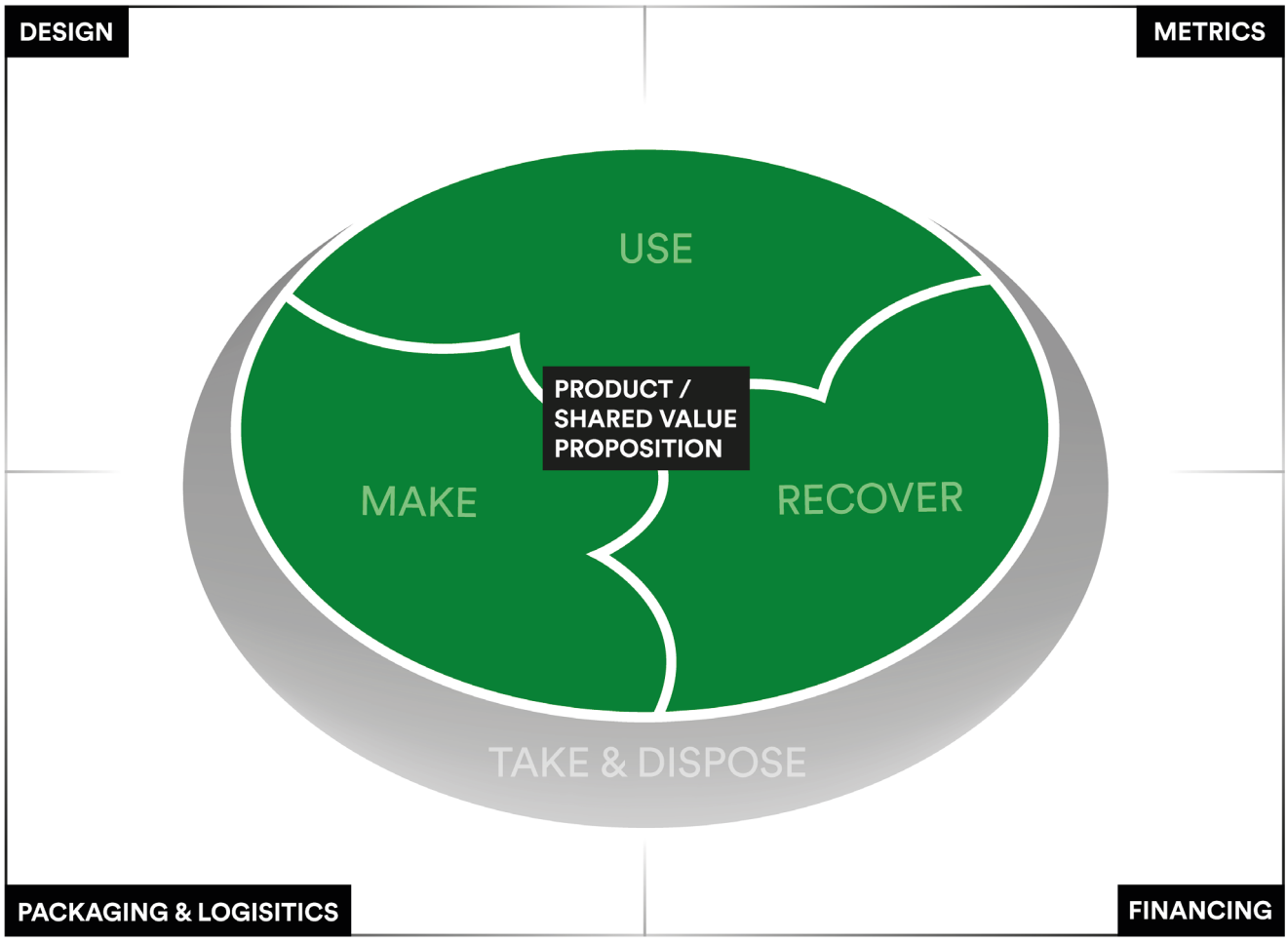

Fig. 4: The Circular Canvas

- **Surrounding phases:** The *Take* and *Dispose* phases enclose the three core phases. The material cycles often cannot be completely closed because production, usage and reprocessing deteriorate materials, for example, through degradation, dilution or contamination [54,60]. This necessitates some form of *Take*, which should consequently be minimised. In accordance with Desing et al. (2020), it is crucial that the highest possible state of order of materials is preserved in the circular flow (and with that, the 'stored' work energy) [54]. In short, product reuse is preferred over part reuse, which is preferred over recycling but still better than incineration. These aspects are in accordance with the EU waste hierarchy logic (Reduce, Reuse, Recycle, Recover and Dispose).

- **Integral and strategic factors:** There are additional factors that need to be considered when creating a circular ecosystem: these are either integral (*Design* and *Packaging & Logistics*) in how they affect the phases, or they are of strategic importance (*Metrics* and *Finance*). The latter need to be covered to measure the outcome, as well as navigate and fund the implementation. Here, the ideas that do not belong to any concrete phase of the CE become relevant.

V. Imagine: Expressing your vision

A key element of circular transformation is the formulation of a common vision that addresses the purpose of change for the whole ecosystem. Why do we need to change? The vision must fulfil three functions: identification (personal meaning), legitimation (relevance) and focusing (value promise) [61]. This vision can also serve to communicate the project within the own company. Therefore, the vision raises the topic of CE and sustainability to a normative level of argumentation. Without a convincing vision why the company should change, it will not be successful. The most common obstacles in the CE transformation process are the lack of awareness regarding the need for sustainable innovation [62,63] and a hesitant company culture [64].

It is critical to support the understanding of environmental problems and show how these issues can be tackled at the company level. Linking this understanding with the development potential of the company in an ecosystem is key. Circular transformation of the business model and the creation of an appropriate ecosystem can lead to competitive advantage, and this is an important message that needs to be given to employees. Having a vision is important to engage partners, motivate and onboard employees and excite customers. A purpose-driven narrative allows the ecosystem to better communicate the vision and offer while ensuring that it sticks. Within the process, it also allows the ecosystem to create a common understanding and helps to align all partners on further steps. A circular ecosystem, especially as a freshly designed concept, is a complex interplay of imagination, processes, assumptions and facts, resulting in varying perspectives and interpretations. The clear structure of a story helps to navigate this complexity.

A well-known example from the textile industry shows that the vision of a single person can be enough for a major change. *Ray Anderson*, founder and former CEO of *Interface*, a manufacturer of modular carpet tiles (one billion in sales annually), proves this with his *Mission Zero*®. They launched it in 1994 and continuously reduced their negative environmental impact with innovations and new products on the market. After successfully liberating the company from linearity, eliminating waste and reducing all negative externalities to the environment, *Interface* went even further: they developed a carpet with a negative CO_2 balance that contributes to decarbonisation. Through their holistic focus on sustainable CE combined with a corporate vision, they have achieved what many did not achieve until now: actively closing the 'big disconnect'.

VI. Incorporate: Identifying suitable partners

Overall, partnerships are of great importance because of the long-lasting nature of CE solutions. Interestingly, the impact created by the CE is partly time-lagged. Although the marketing and sales results will come in quickly, the material loop is typically closed after years of product use, because the products are preferably used as long as environmentally reasonable. This highlights the importance of a lead company as an orchestrator for the long-term nature of circular ecosystems.

'So we are a partner of Sympatex but we are also their customer because we buy the membranwe from them'. (Hendrikus van Es, Schoeller)

In the case of *wear2wear*™, having an orchestrator role was one of their key success factors. Developed from a business friendship, two key figures from *Schoellers* and *Dutch Spirit* were personally inspired to form the ecosystem. They saw themselves as *'the catalyser' (Toenhake, Dutch Spirit, 2019)* and evaluated the opportunities, invited potential partner companies, supported cross-company design development, excluded partners when necessary and actively acquired customers. By taking responsibility for the activities, they eased the complexity for their partners and allowed the ecosystem to grow. In market segments where they may have previously competed, they now act in a partnership and break down barriers to create a circular solution together. This necessitates the long-term involvement of all partners, which requires trusting relationships and the possible creation of incentives that stimulate this long-term cooperation. This also addresses and lowers market-relevant barriers [65,66] towards CE, such as dependencies on larger market players and destructive competition. Companies should ask themselves the following: What do our potential partners offer? What benefits does the ecosystem offer to them? Do they share the same vision?

VII. Implement: Realising a circular solution

Although the previous steps took place at the ecosystem level, we are now back at the level of the individual company business model. Thus, it is essential that companies be able to adjust their business models in practice and create shared value propositions with a measurable impact. To do so, the involved companies have to align their business model dimensions *(who/ what/ how/ value)* to form the designed circular ecosystem. Implementing circular solutions is done in the same way as the usual testing and implementation of innovation projects: falsifying and validating the hypotheses of a circular solution. This process is always iterative because the company must gradually test the involved business models and user needs, moving closer to the launch step by step. The underlying hypotheses need to be falsified by choosing and conducting adequate tests. These tests serve as the basis to adapt and iterate the offering and to update business models along the circular value chain. It is important to test the phases in parallel to ensure they work as intended. Here, MVPs and prototyping are often a necessity.

Overall, this is the longest and hardest step, where motivation, communication and coordination are key for success. In practice, these implementations often need to be accompanied (or in some cases lead to) a cultural change for the involved companies. In addition, new and suitable KPIs need to be defined to allow measuring the success of the new business model. Flagship projects are a great way to show that it is possible to create circular solutions that really pay off. Continuously measuring the success of the project, sharing what has been learned and ideally further improving the company's offerings, the company itself and the new circular ecosystem.

That is what *Schoeller* did. At first, they looked for an exchange with key companies from a technical perspective (yarn, membrane and clothing manufacturers), which inspired them to become partners in the *wear2wear*™ ecosystem. Then, even before the circular ecosystem was complete, they started with the first prototypes of recyclable yarns and fabrics. After successful testing, they were able to gain *CWS*, an established German manufacturer of work wear, as a partner for the ecosystem and thus scale their solution. Now, the entire ecosystem benefits from the extensive customer contact of CWS and its already existing (reverse) logistics infrastructure, as well as its knowledge about monetisation strategies. To close the cycle, they acquired *Decontex*, a cleaning company that uses liquid CO_2, as well as a dismantling and recycling company. This will help them remove potential toxicity and enable the recycling of garments.

'I strongly believe in the cooperation of companies. I call it the integrated textile line.' (Tommy Verminck, Decontex)

It Is Time to Act

Incremental changes in our business operations and marginal efficiency gains are no longer sufficient for companies willing to address the world's problems. If we intend to take seriously the alarming reports of climate change, the crossing of planetary boundaries and the increasing deterioration of resource valuations, we need to stop doing business as usual. Different paths lead to the design of a circular ecosystem. The benefits for society, the environment and the companies themselves would be immense. Be inspired to initiate a circular innovation process.

All interviews and discussions we held with company representatives revealed that technical barriers towards CE are relatively small or non-existent. Much more critical obstacles are corporate culture or attitudes towards change – we take this as a highly inspiring sign. Cultural obstacles should be taken seriously, but they can be overcome. Taking this into account, there is no need to wait for new technical innovations; we can begin today.

The planet does not care about intentions. A simple question can be the starting point for your company: '*What would you do differently today if you were responsible for taking back all the products you sold?*'. Internalising responsibility means standing up for one's own activities. This will build the path to comprehensive sustainability. CE, as a fundamental change in the way we deal with resources, offers the needed tools.

Appendix I: Circular Ecosystem Patterns

Close the loop

	Pattern Name	Case Companies	Pattern Description	Literature
C1	Product-Reuse	Bee's Wrap; ReCup; Dopper	The product-reuse pattern describes the reuse of products for the purpose for which they were designed. Reuse is one of the most environmentally friendly options for closing the cycle. Product reuse effectively preserves the manpower, materials, capital and energy used to produce the product while preventing further negative externalities (e.g., emissions of CO_2 or toxic substances).	17 67 68 69
C2	Part-Reuse	Apple Certified Refurbished; Bosch; eXchange	The part-reuse pattern represents a process by which used products are collected and disassembled. These parts are then either repaired or directly used to create the same or a different product. The result can be a refurbished or remanufactured product that is sold cheaper, an upgraded product with a higher quality (technologically or aesthetically) or a completely different and 'new' product. This saves a proportion of the original energy and labour that went into the production of the part.	17 55 70 71 72 73 74
C3	Re-& Upcycling	Bionic Yarn; FREITAG; I:CO	Recycling and upcycling is about maintaining or improving the material value by mechanically or chemically converting 'waste' products or materials into new materials or products. This enables a cyclical flow of resources, preserves the value of the material and even supports the production of products with higher value.	18 29 59 68 75
C4	Intelligent Assembly & Modularsation	Fairphone; Shift GmbH; ClickBrick	Intelligent assembly and modularisation describe a design pattern that is a prerequisite for further steps towards a CE. Because design influences and significantly shapes all phases of the CE, an intelligent design can use modularity, and reversible connection techniques while avoiding mixed materials to simplify assembly, improve the repair during the use phase and facilitate the disassembly of the product at the end of its life cycle.	72 76 77 78 79 80
C5	Biodegradability	Plantastic; Compostella; Dell	Biodegradability describes the effort to shift the resource composition of products towards degradation or, even better, composting in nature. On the one hand, this requires a product design that focuses on biodegradable, safe and healthy materials; on the other hand, it must be ensured that these biological resources can safely return to the biosphere and thus become valuable biochemical starting nutrients for a new cycle (e.g., via composting).	17 18 27 72 75 81
C6	Waste as Input	Full Cycle Bioplastic; Marmite; Pentatonic	Waste as an input aims to search for and develop new, ecologically and socially reasonable sources for used resources, by-products and postconsumer waste. The goal is to stop using classic virgin resources. Material that seems worthless at first can thus be given new value.	7 82 83 84 85
C7	Reverse Logistics	Cycleon; Wastebox; Resourcify	Reverse logistics includes all the logistical processes necessary for closing a loop by returning the products or materials after the use phase. This involves a comprehensive perspective on the processes relating to collection, transport, storage, handling and selection, as well as the sorting out of products or product components. In addition, environmental externalities should be minimised by optimising factors such as the vehicles used, the choice of fuel or route planning.	49 86 87 88 89 90 91 92

Improve the loop

	Pattern Name	Case Companies	Pattern Description	Literature
I1	Increased Longevity	Cutco; Davek; Feetures	This pattern aims to prevent planned obsolescence and extend the product lifetime. This can be achieved with product-related changes (e.g., surface hardening, reduction of wear parts) design changes (e.g. modular product structure, timeless look) or changes to the positioning and marketing (e.g., branding, quality, creation of customer awareness).	18 74 93 94 95

I2	Repair & Maintenance	Nudie Jeans; V-Zug; Agito Medical	This pattern describes the maintenance, early recognition of defects and repair of products during the use phase to enable the longest possible product life cycle. This is generally regarded as one of the most environmentally friendly and efficient measures in the CE to reduce overall resource consumption; it often influences the handling of warranties, changes to the product quality and construction and the involvement of customers in the process.	69 74 93 96 97 98
I3	Smart Assets	Arup; Angaza	A problem for the CE is the lack of producer knowledge about the condition and location of their sold products. The increasing, area-wide interconnection of intelligent assets and Internet of Things devices with sensor technologies creates transparency, simplifies the traceability of products or resource units and enables data-driven decision making. This simplifies patterns such as maintenance and repair and enables take-back systems.	99 100 101 102
I4	Eco-Efficiency	Interface; 3M	This pattern is about minimising the resource inputs needed for the manufacturing of products and the providing of services, thereby improving eco-efficiency. The fewer resources required, the less waste, emissions and pollution are generated during the production of the product. The resulting cost savings through reduced resource use, waste reduction and increased environmental sustainability can lead to increased revenues and competitive advantages.	59 103 104 105
I5	De-Materialisation	Blueland; Skipping Rocks Lab; Evoware	De-materialisation aims to create products that require less or no material. This can be achieved by intelligent product design that allows to remove certain materials or parts from a product while maintaining the functionality. Alternatively, technological progress enables the creation of a digital variant of a physical product or service that allows for the reduction of even more resource use and environmental externalities.	48 104 106 107 108 109
I6	Eco-Materials & Sourcing	Adnams; Allbirds; Veja	This pattern describes the reduction of environmental impact through the use of environmentally friendly eco-materials (e.g., fibre-based materials or eco-cement). These materials reduce the environmental load along the whole life cycle while maintaining a comparable performance. These materials often already exist but are not affordable or procurable in desired quantities. Attention must also be paid to the way in which raw materials or product components are sourced.	19 59 76 110 111 112
I7	Increased Functionality	Hinterher.com; Dr.Bonner; Apple Watch	By adjusting and integrating additional product functionalities into one product, the manufacturing of new products can be minimised. The efficient combination of functions can save resources in production because less products need to be produced.	84 113 114
I8	Localisation	Infarm; Rotterzwam; Wasser für Wasser	This pattern describes a holistic view of how a company – or a circular ecosystem – is embedded in a geographical context. The use of local resources in a geographically close environment reduces the negative environmental impacts and energy consumption (through e.g., reduced logistical effort). The company can also increase control over its resource procurement.	110 115 116 117 118 119
I9	Produce on Demand	Tesla; Books-on-demand	Produce on demand looks for solutions so that products are only manufactured when consumer demand has been quantified and confirmed. This can reduce overproduction, unsaleable stocks and the inefficient use of resources. By using Internet platforms, customer preferences can be clarified in advance. This also makes it possible to include customers in the development phase.	59 85 109 110 114 120
I10	Detox	S.C. Johnson; MUD Jeans; Better Life	This pattern describes the elimination of toxic substances from products and services that harm natural ecosystems. This not only involves the product itself but all the processes and activities associated with the creation and use of it. Detoxification also includes focusing on the supply chains of the suppliers and their production methods.	10 41 114 121 122
I11	Energy Recovery	HomeBiogas; Fiberight; Plastic2Oil	Energy recovery describes the conversion processes and the steps required to convert waste materials into usable heat, electricity or fuel. This can be done by incineration, anaerobic digestion or biomass gasification. It is important to note that the mere reuse of the energy content stored in the material through so-called 'thermal recycling' cannot be regarded as circular. Energy recovery opens up new sources of income for companies and reduces waste costs.	18 59 81 123 124
I12	Renewable Energy	LEGO Group; Bio familia; Bio-bean	This pattern covers all the solutions for the production, purchase and use of energy from renewable sources (solar, hydro, geothermal, wind and biomass-energy). This also includes the sustainable use of energy as a resource in the manufacturing of products or services (e.g., energy efficiency).	17 19 125 126 127

Monetise the loop

	Pattern Name	Case Companies	Pattern Description	Literature
M1	Pay per Use	Zipcar; ShareNow	Pay per use describes a revenue model in which customers no longer buy products in the traditional way but agree on a usage fee with the providers on a contractual basis. The product or service use by the consumer is measured based on a specified metric such as time or unit count. This metric serves as the basis for the payment, increasing the consumer's incentive for more efficient and economical use.	7 27 114 128 129 130 131
M2	Rent instead of Buy	Leihbar; Rent the Runway; Islabikes	The customer does not buy a product but instead rents it. This lowers the capital typically needed to gain access to the product. The company itself benefits from higher profits on each product because the company is paid for the duration of the rental period. Both parties benefit from higher efficiency in product utilisation as time of non-usage, which unnecessarily binds capital and resources, is reduced for each product. In addition, keeping ownership allows companies to retain access of them, simplifying their reuse or recycling.	53 129 132 133 134
M3	Performance-based Contracting	Signify; Rolls Royce; Xerox	Performance-based contracting enables companies to deliver a comprehensive service promise to their customers, taking into account the necessary contractual and revenue-relevant factors. The offer is aimed at providing a desired outcome or performance instead of purchasing of a product. Thus, the transfer of ownership from producers to users is avoided – producers retrain the value of the product and material.	120 129 135 136 137 138 139
M4	Subscription	Bio Bouquet; Vigga; Swapfiets	This pattern allows customers to purchase products or services by regularly paying a predefined fee. The advantage for customers is that they do not have to worry about buying products or services (time saving). It can also increase the motivation to purchase sustainable products by critical customers, thus lowering entry barriers. A regular subscription fee can be cheaper than buying the product at once or several times (money saving). For companies, on the other hand, it enables regular and predictable revenues and the development of a long-term customer relationship.	110 140 141 142
M5	Fractionalised Ownership	The Hideaways Club; Absolute Fractionals; Mobility	Fractionalised ownership is suitable for products or services that are cost-intensive and hence deter customers from purchasing them. Fractionalised ownership allows the customer to purchase only a portion of the entire product and share it with others. Usually, this happens in a kind of association, where each customer receives predefined access. In this way, access to sustainable products and services for customers can be simplified and possible prejudices reduced because different customers 'acquire' or 'use' the products together.	7 143
M6	Dynamic Pricing	Octupus Energy; Wasteless	Dynamic pricing describes a type of price management that flexibly structures the pricing of products or services. This allows for quickly reacting to demand or competition and reducing stocks or preventing waste. This pattern requires a high degree of knowledge about its own products and good data processing. It also allows for optimising capacity utilisation and preventing inefficiencies.	143 144 145 146 147
M7	Revenue Sharing	klickrent; Fairmondo	Revenue sharing refers to a firm's practice of sharing revenues with their stakeholders, such as complementors or even rivals. Because the CE can only be achieved in a circular ecosystem, this pattern allows the sharing of the additionally generated profits among the partners. This helps to create commitment in long-term circular partnership.	7 148 149 150
M8	Crowdfunding	Bettervest; Pilzkiste	A crowd of investors who wish to support an underlying idea, typically via the Internet, finances a product, a project or entire start-up. Because of the strong intrinsic motivation to realise CE solutions, crowdfunding is a suitable approach to finance the development of new, sustainable products or services, especially because of the growing public awareness.	76 151 152 153
M9	Take-Back	Eileen Fisher; Lush; Apple	Crucial to the success of the CE is how products find their way from the hands of the users into the 'Recover' phase. Without contractual agreements in place, an incentivised take-back should be in place. Two incentive systems are common: the producer charges a deposit that is paid back when the product is returned, or the producer buys back the product once the customer no longer wants to own it.	86 108 110 154 155 156 157

Excite the loop

	Pattern Name	Case Companies	Pattern Description	Literature
E1	Servitisation	Burba; Michelin	Servitisation describes the combination of an intangible service and a tangible product with the aim of comprehensively satisfying the final user's needs and intensifying the relationship with the end user. Currently, this is often achieved by modern technologies such as Big Data and the Internet of Things, which enable more efficient and satisfying offerings via data collection and analysis. Product ownership remains with the producers and increases their incentive for long-lasting products, which serves as a strong selling point for customers because since costs and effort can be reduced over the entire life cycle.	99 158 159 160 161
E2	Mass Customisation	Paris Miki; MyMuesli; My Esel	The approach of modular products and production systems has enabled the efficient and price-competitive individualisation of products. Meeting individual customer needs can support to stimulate the demand for circular products. The goal is to fulfil engineering and customer requirements, as well as circular and economic constraints.	162 163 164 165
E3	Circu-Luxury	Stella McCartney; Charlotte Bialas; Elvis & Kresse	This pattern describes the strategy with which companies can offer their customers high-end sustainable and circular solutions and, in contrast, demand a maximum price. This is about stimulating the customer's need to own an exquisite circular product. The typical target is the growing market of young, urban and sustainable consumers who want to put quality before quantity and make a statement against the disposable and consumer society with their exclusive consumption.	7 18 130 166
E4	Experience Selling	Patagonia; Vermont Teddy Bear; Polar Bottle	The value of a product or service is increased with the customer experience offered with it. Sustainable and circular products can especially benefit from an improved experience because this can increase the demand for the product and further differentiate the offering from the competition. This means that the customer experience must be adapted in accordance with the proposed value proposition (e.g., by attuning promotion, shop).	167 168 169 170
E5	Marketplace	TUTAKA; Clothing Exchange; Home Exchange	A marketplace facilitates interactions between multiple interdependent groups of customers. The value of the platform increases as more groups or individual members use it. The two sides usually come from distinguished groups (e.g., businesses and private interest groups).	85 110
E6	Prosumer	PlasticBank; Screenmend; iFixit	Users have a powerful potential to (co-)create innovative products, especially for products with a sustainable character. The prosumer pattern describes opportunities that motivate and empower consumers to become producers and to integrate themselves into value creation and preservation. This can also be done by enabling them to repair, maintain or execute reverse logistics themselves. This is particularly suitable for environmentally aware consumers who wish to conserve resources through their commitment. As a result, companies have lower investment costs for production and less overhead. This also increases the perceived benefit for consumers.	27 171 172 173
E7	Eco Lock-in	Epson; TIO Care	Customers are locked into a vendor's world of products and services, which allows to establish a sustainable and circular solution. Using another vendor is not desired because this would reduce the sustainability advantages. This lock-in can be strengthened by technological mechanisms or the substantial interdependencies of products or services.	25 29 74 108 110
E8	Communicate Responsibility	Pad&Quill; Flint and Tinder; Global Sustainable Enterprise System (GSES)	A producer taking responsibility for the full life cycle of their products is the basis for the CE. To facilitate achieving this in a profitable way, the sustainable approach can be signalled to the market. Typically, this includes certificating the products, giving long guarantees or committing to taking the product back via predefined channels. Through education, producers can increase the sustainable action taken by partners, employees and consumers.	157 174 175 176
E9	Sharing	TrendSales; Dropbox; Sharely	Sharing helps where products are either used too little and thus inefficiently or where consumers even refrain from purchasing them. The aim is to be able to share products between different users and ensure that they no longer have to spend money on purchasing them, only on using them. Companies that offer sharing solutions can thus increase utilisation rates and the sustainability of the products, while users have to pay less for the same benefit.	110 132 177 178 179 180
E10	Robin Hood	Toms; NIKIN; Robin Hood Energy	The same product or service is provided to 'the rich' at a much higher price than to 'the poor'. Thus, the main bulk of profits are generated from the rich customer base. Serving 'the poor' is not profitable per se but creates economies of scale that other providers cannot achieve. In addition, for the CE, this could be achieved by giving 'the poor' access to refurbished or reused products while extending the life cycle.	7 181

Appendix II: Journey Through the wear2wear™ Ecosystem

Observing this first-in-class approach allows us to gain insights into a concrete CE realisation, illustrating the interplay of companies and their business models along a circular ecosystem and showcasing the application of the patterns.

The journey starts with the yarn producers. In the beginning, there is no input from the *Recover* phase because the cycle has not started yet. *wear2wear™* opted for the usage of recycled polyester from used PET bottles to start the resource flow *(C6: Waste as Input)*. They guarantee clean PET that would not be contaminated with toxic substances and purchased only from safe, local bottle suppliers *(I10: Detox, I8: Localisation)*. They produce the yarn under high qualitative polyester manufacturing procedures with reduced antimony use *(I4: Eco-Efficiency, I10: Detox)*. Not yet realised, but an option for the future is the insertion of markers via additives into the polymer to increase the traceability of the material for quality control at recovery *(I3: Smart Assets)*.

Using these yarns, the fabric producer manufactures a functional fabric, coated FC-free, and brings it together with water-repellent membranes *(I10: Detox)*. They do not use mixed materials – no cotton/polyester blend that would be difficult to recycle – thus enabling a straightforward recycling process in which the garments can be melted down into one piece thanks to a uniform melting point of all the membranes and fabrics *(C4: Intelligent Assembly & Modularisation)*. The final fabrics are of high quality and designed for long and durable use *(I1: Increased Longevity)*. Here, efficient production facilities and internal factory cycles, such as for the reprocessing of dyestuffs, increase the sustainability of the whole process *(I4: Eco-Efficiency)*. The revenue between these steps is generated by product selling.

In the next step, the manufacturer of the garments design and tailors the work wear on a recycling-based concept and avoids unnecessary buttons, zippers or trimmings *(I5: De-Materialisation)*; they rely on solvable sewing threads, which facilitate the removal of zippers and hook-and-loop fasteners during recovery and thus allow for an easier disassembly in the *Recover* phase *(C4: Intelligent Assembly & Modularisation)*. This additionally simplifies repairs during the *Use* phase *(I2: Repair & Maintenance)*. If desired by the user, they can also work in radio frequency identification (RFID) codes for traceability, which helps to monitor the garments during the *Use* phase and to take back the right garments with ensured material quality *(I3: Smart Assets, E1: Servitisation)*.

The garment manufacturer acts as the interface with the customer, focusing on the design of the revenue model in combination with contractually fixed take-back *(M9: Take-Back)*. Therefore, they keep ownership and hand over the garments in a rental relationship to the customers *(M2: Rent instead of Buy)*. This simplifies the correct washing, maintenance and repair of the garments *(I2: Repair & Maintenance)*. When they collect the garments for regular washing, they immediately check for faults and repair them. During or after the *Use* phase, *wear2wear™* can offer a specialised cleaning process that allows for the cleaning contaminated garments with liquid CO_2, which is more energy-efficient and uses less water *(I10: Detox, I4: Eco-Efficiency)*. After using the work wear, the institutions collect the garments from their workforce, and the producer retrieves them in *boxes (C7: Reverse Logistics)*, evaluates them and sends them to the disassembly. The recycler then removes everything that is unusable for the polymer recycling process (e.g., metals, zippers, etc.) and melts the garments for further processing into granules and filaments *(C3: Re- & Upcycling)*. The recovered material now flows into a new cycle and thus reduces the inflow of used PET bottles.

wear2wear™ case on the Circular Canvas

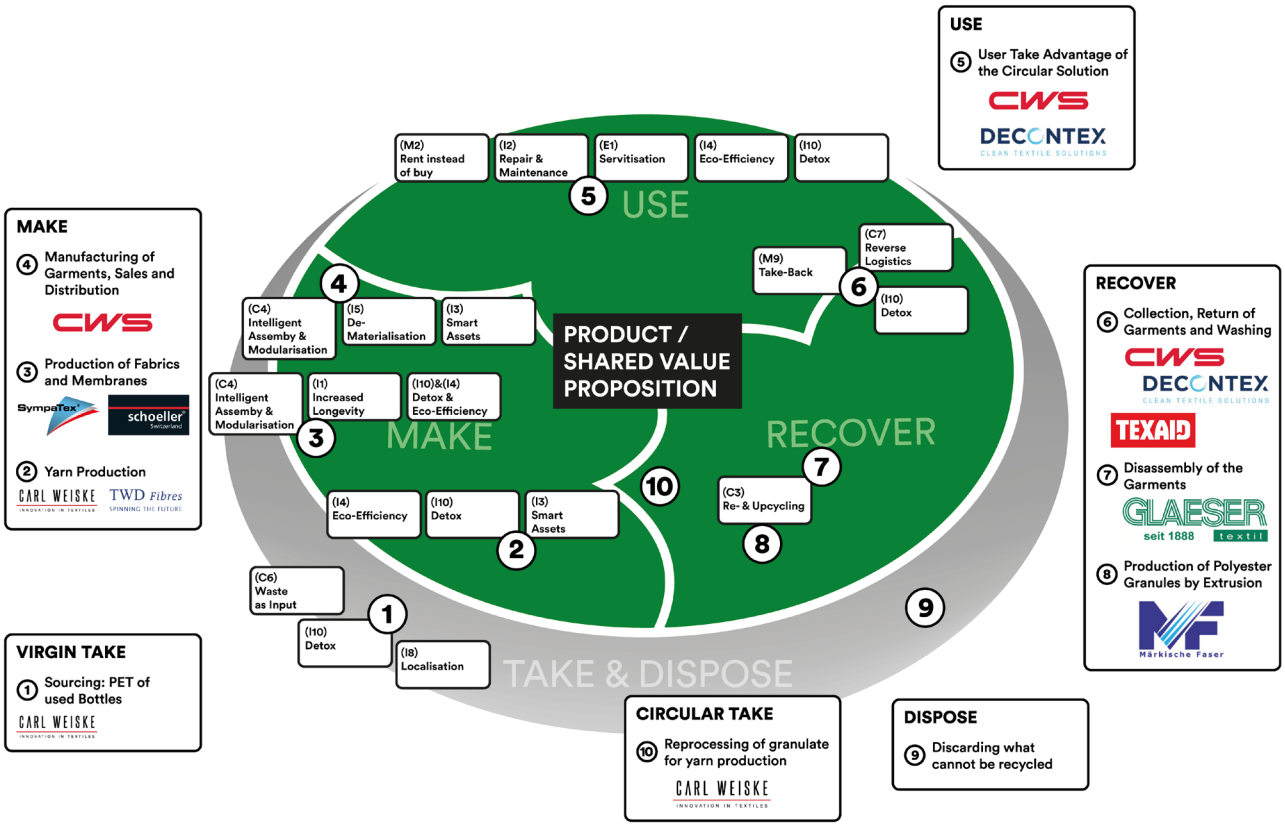

Fig. 5: wear2wear™ case on the Circular Canvas

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