Circular Business Models: Overcoming Barriers, Unleashing Potentials

acatech/Circular Economy Initiative Deutschland/SYSTEMIQ (Eds.)

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Executive Summary

The Circular Economy (CE) represents a disruption of today's linear 'take-make-waste economic' paradigm. It is not an end-of-pipe approach to tackling 'waste'. Turning the dominant linear structures into value cycles requires a rethinking by all involved actors. It starts with circular product redesign and demands a consistent realignment of all subsequent business processes of value creation, delivery, and return.

Overall objectives, mission of the working group

The aim of this report was to **develop a scientifically based practical manual for the successful implementation of business practices for advancing a Circular Economy**. Taking a system perspective, the task of the related *Circular Economy Initiative Deutschland* (CEID) working group on 'Circular Business Models' (CBMs) was

a. to identify and describe **actor-specific circular business models** (CBMs) and their interactions in business ecosystems
b. to provide an **integrated presentation of existing barriers** to CBMs
c. to identify **digital and regulatory enablers** of CBMs
d. to derive **specific recommendations for action** addressed to decision makers in the areas of politics, business and science in order to accelerate system transition towards a Circular Economy.

Key findings and positions of the working group

Circular business models

- Business models are a key lever for companies to embrace the Circular Economy. Ideally, a business model aligns circular value creation activities with opportunities to capture economic value. Greater adoption of CBMs in business practice by pioneers and followers is **crucial to triggering** the desired transformation process of industries and society **towards a Circular Economy and generating a self-reinforcing momentum.**
- The isolated optimisation and profit-maximisation of individual actors' business models no longer satisfies the demands of a Circular Economy. Effectively transforming existing value chains into value cycles requires **a holistic view and the designing of circular ecosystems** consisting of complementary value-generating actors. The CBMs of actors within the value cycle have to be aligned, with one of the actors taking the role of a centralised orchestrator, so that the combined value creation activities can indeed reach circularity at the system level. This requires all actors in the value cycle to not only share a vision of circularity, but also to distribute **profits in a way that ensures the long-term commitment of contributing actors**. Digital technologies will play a crucial role in moving towards and further reinforcing value cycles.
- To reduce the complexity of CBMs and make them applicable in business practice, the working group proposes a **typology of 22 CBM patterns** covering both business-to-business and business-to-consumer markets. The patterns provide practitioners with a comprehensive overview regarding their respective focus, circular potential, and product design needs (see the 'Business model patterns overview' figure below). The patterns can be combined by a single actor to build a more comprehensive business model and interlinked across actors in the value cycle to build business model ecosystems. The typology is structured **along three dimensions**:

1. Actor roles: Different actors, with their traditional roles in the value chain, are confronted with **actor-specific challenges and opportuniti**es when implementing CBMs. The transformation towards a Circular Economy leads to **considerable dynamic change in industries** and actors may have to go beyond their traditional roles: The positioning in the value cycle changes when actors **take on additional roles** (e.g. producers may cover recycling operations) or when **entirely new actors and roles emerge**. In order to extend their business practices towards other stages of the value cycle, focal actors preferably follow **strategic choices of vertical integration (make) or networking (ally)**, as outsourcing (buy) does not provide sufficient potential for integrating learning and related feedback into product redesign.

2. Circular strategies: Grounded in an understanding which focuses primarily on technical cycles as closed-loop systems, the working group derived the following core circular strategies: **maintenance and upgrading, repair, reuse, remanufacture and recycle**. While actors' business models are rooted in a core circular strategy, they are usually complemented with further supporting strategies which, combined, constitute a **circular strategy configuration**. By ensuring better circulation of products and

Actor's main role	Circular strategy	Id	Business model pattern	Service Level (sub-pattern)		
				Product-oriented	Use-oriented	Result-oriented
Supplier (molecules/ materials)		A1	Circular raw materials supplier	Molecule & material recycling	Materials bank	–
		A2	Process molecule service provider	–	Molecule & material leasing	Molecule & material performance
Supplier (mechanical engineering)		B1	Machines/components 'as new'	Machines/components 'as new'	Rental machines/ components 'as new'	Pay per reman machine performance
		B2	Machine/component remarketing	Used machines/ component sales	Rental machines/ components	→ see B1 Pay per reman machine performance
Producer		C1	Proprietary material cycles	Waste cherry picking	Materials bank partnership	–
		C2	Product 'as new'	Selling Products 'as new'	Product leasing 'as new'	→ see C6 Total care producer
		C3	Used product remarketing	Used product sale	–	–
		C4	Out-of-warranty repair service	On-demand repair	→ see C6 'Leasing producer'	→ see C6 Total care producer
		C5	Upgrades, spares & accessories	Modules & accessories shop	Upgrade subscription	–
		C6	Maximising product uptime	Fee-based maintenance	Leasing producer	Total care producer
Retailer & service points		D1	Retailer as cycle manager	Retailer as cycle manager	→ see C1 Materials bank partnership	–
		D2	Retail remarketing & reman	Used goods on sale	Rent-a-wreck fleet manager	–
		D3	One-stop shop (retail)	Integrated service point	Rental retail	Total care retail
Repair provider		E1	Repair gap exploiter	Repair transaction	Repair-based rental	–
Prosumer		F1	Prosumer support system	Do-it-yourself repair	Peer-to-peer sharing	–
Logistics provider		G1	Material reverse logistics	–	–	Pay per recycling logistics performance
		G2	Refurb logistics services	–	–	Pay per refurb performance
		G3	Spare parts management	–	–	Pay per spare part performance
Recovery manager		H1	Revitalised products	Used goods bargain	–	–
		H2	Coordinator of informal collection	Fair-trade recyclates	–	–
Intermediary		I1	Recycling platform	Recycling platform	–	–
		I2	Used goods & sharing platform	Used good platform	Sharing platform	–
Emerging actors	All	J1...x	?	?	?	?

Table 1: Overview of circular business model patterns and sub-patterns (Source: based on Hansen et al. 2020a, p. 13)

incorporated materials, a Circular Economy aims to **avoid waste in the first place** and achieve an absolute reduction of resource use at the level of the circular system and economy as a whole, not necessarily at the level of the individual product.

3. Product service system type: The service level of CBMs is represented by a continuum covering **product-, use- and result-oriented services**. It is assumed that the **maturity of CBMs generally increases as one moves from product- towards result-oriented service levels**. This is because higher service levels usually emphasise material productivity over mere product turnover. They also provide a conducive contractual infrastructure for capitalising on digital enablers of circularity (e.g. preventive maintenance) as well as for preventing discarded goods from becoming waste (e.g. a contract requiring the return of leased products to the lessor).

Barriers

- Barriers to the implementation of CBMs are usually divided into categories such as **regulatory, financial, technical, organisational, value chain and consumer barriers**. However, in the 'real world', it is **the mutual relationships between providers** (supplier, producer, retailer, repair provider, logistics provider, etc.), **users** (professional users such as businesses as well as consumers) **and the product** (i.e. technology, design) **and related services** which lead to **sets of nested barriers**. On the basis of this framework, an integrated solutions approach is introduced for each circular strategy.

Digital enablers

- While the **application of digital technologies** to business practice has thus far mainly focused on improving production processes in terms of efficiency (often referred to as 'Industry 4.0'), digital technologies can also play an important role in overcoming barriers to CBMs and **enabling the operationalisation of circular material, component, and product flows**. Simply put, they are the 'glue' connecting the CBMs of value cycle partners and related stakeholders through data sharing and increased transparency. Thus, digital service elements become the basis for **smart maintenance/repair, smart reuse, smart remanufacturing, and smart recycling strategies**. For instance, component monitoring enables a producer to collect a product at the exact point in time when it is worn out, but not yet broken, so that remanufacturing is technically and economically feasible. In this way, **digitalisation addresses the 'information gap'** that currently often prevents circular strategies from being effective.
- Depending on the level of an organisation's digital maturity, data and **digital technologies can be used to provide either hindsight, oversight or foresight value** for an organisation. While hindsight and oversight value are obtained by revealing trends and understanding events and behaviours, foresight value is obtained by generating predictions about how to best optimise the use of products and resources. Digitally-enabled CBMs therefore move away from descriptive to more prescriptive approaches to analysing CE-relevant data.

Policy enablers

- While Germany and the European Union have a long tradition of waste legislation, there is no consistent Circular Economy regulatory framework in place. Instead, **CE-related aspects are scattered across different, sometimes conflicting, legal areas such as waste legislation and EU ecodesign legislation** (currently applicable to only a small range of electrical devices). It is therefore important to develop a **more holistic policy framework** that emphasises prevention through the extension of product lifetimes, reuse, and remanufacturing **based on circular product design requirements and standards.**
- The report sets out a **Circular Economy policy toolbox plotting the wide variety of instruments identified in prior studies and those developed within the working group along two dimensions: instrument type and coverage of Circular Economy strategies.** Types of instruments include economic (dis)incentives, regulation, voluntary standards (i.e. self-regulation), information, and government procurement. These instruments can either address CBMs more broadly or individual Circular Economy strategies of maintenance/repair, reuse, remanufacturing, and recycling in a more focused way.
- While CBMs aim to avoid waste in the first place, this is often hindered because the legal concept of waste carries significant and often detrimental consequences for the application of circular strategies and, thereby, impedes economically successful CBMs. **Policy enablers should prevent products from becoming waste** by facilitating longer service life of products (e.g. extended warranties), mandatory take-backs by producers, or higher-level service business models in which **customers use products (e.g. rental) instead of owning them**. As a consequence, CBMs focused on **value-sustaining circular strategies such as repair, reuse, and remanufacturing are incentivised** and can gain momentum.

Use case: Circular televisions

While each aspect presented above is an important piece of the puzzle, it is their **interrelationships and combined effect** which provides the full picture. By referring to the **example of television sets**, the report explores the **three levels of service business models introduced in the CBM typology: i) product-oriented TV after-sales services, ii) use-oriented TV leasing and iii) result-oriented pay-per-view**. For each service level, the role of digital and policy enablers in overcoming barriers to the development of CBMs and related ecosystems is demonstrated.

Recommendations

The transition to a Circular Economy requires **a paradigm shift in business, politics, science and society in general**. The working group commonly agreed on **seven core actions** for further implementation. The first one highlights the **leadership role of industry**, the subsequent five recommendations describe the **government's role in establishing a policy mix** consisting of economic, regulatory, self-regulatory (i.e. standardisation), information and public procurement instruments, and the last recommendation addresses the **long-term governance** of the transition (a detailed list of specific measures can be found in the 'Recommendations' chapter of this report):

1. **Business model experimentation:** Industry needs to lead and invest in business experimentation with radically more circular service business models and related advances in circular product designs, circular service processes, and partnerships across the value cycle.

2. **True-cost pricing and further economic incentives:** Governments should develop an economic market framework with true-cost pricing based on established Ex'Tax reform principles: a zero-sum game where costs of labour are decreased and costs of natural resources and related emissions are increased proportionally. This allows manpower to be used in labour-intensive circular strategies (e.g. remanufacturing) instead of primary resources and energy. Additionally, there is a need for targeted support for product-, use, and result-oriented service business models which combine circular product design with related circular (service) strategies (e.g. maintenance, repair) in order to accelerate the transition.

3. **Advanced regulation based on a circular product policy framework:** Isolated reforms of current waste management and ecodesign policies do not appear to be enough to overcome the current dominant focus on waste and to ensure circularity is truly embraced. In contrast, a coherent circular product policy framework is needed which ensures a level playing field for global competition. This requires i) all products to comply with minimum circular design characteristics (e.g. reparability) as part of product registration for the European market, ii) straightforward digital accessibility to product characteristics through a common product ID, iii) greater responsibility of producers/retailers along the product life cycle through approaches such as extended warranties and mandatory take-back, and iv) preventing waste status of products where circular strategies remain reasonable. In addition, high-quality recycling should be promoted by Safe-by-Design policies and by linking qualitative criteria to the existing quantitative quotas.

4. **Standardisation:** Government and industry need to support the development and/or harmonisation of standards for i) the condition of used, refurbished, and remanufactured products and components, ii) high-quality post-consumer recyclates, and iii) open data formats for exchanging relevant circular characteristics between actors (e.g. product or material passports).

5. **Information, awareness and user skills:** Strengthening the decision-making capability of customers and users requires increased literacy in circularity, to be established through training courses and educational programmes in schools, vocational training centres, and universities. Increased information needs regarding the circular characteristics of products and services must be addressed through better product labelling and declarations at the points of sale (e.g. average product lifetime).

6. **Government procurement:** Public institutions should lead by example by establishing strategic targets and quotas for used, remanufactured, and recycled products. Moreover, vendors with service business models offering services such as advanced maintenance, repair, and take-back should be prioritised over those vendors limiting their services to compliance (i.e. repairs based on legal warranty). This also includes removing barriers to procurement regarding use- (e.g. leasing) and result-oriented (e.g. pay-per-performance) service business models.

7. **Long-term institutionalisation:** Provide science-based guidance for the transition to a Circular Economy through the establishment of a national and European central body that aligns the outlooks of politics, industry and society across legislative (and financial) periods in the long term.

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1 Introduction

Making changes to industrial and societal practices in order to successfully transition to a Circular Economy (CE) is of central importance in addressing pressing grand societal challenges. Relatedly, circular production and consumption patterns are also addressed by the United Nations (UN)'s Sustainable Development Goals (SDG).[1] **Resource-saving circular economies** can be an **important element in tackling the worsening climate and environmental crisis** by significantly reducing resource consumption and greenhouse gas emissions.[2] For Germany and the European Union (EU), successful implementation of a CE is key in order to reduce global raw material dependencies, maintain domestic value creation through regional economic cycles, and expand competitiveness through targeted technology and market leadership.[3] The potential gains arising from a change in our economic activity away from a linear 'take-make-waste' philosophy towards more circular economic activity – namely from value chains to value cycles – are therefore increasingly becoming the top priority among political decision makers. For example, in its Circular Economy Action Plan (CEAP),[4] the European Commission explicitly identifies the development of a **Circular Economy as a main pillar in its announced European Green Deal** which outlines the core strategic priorities for the upcoming legislative period. Finally, given the increasingly obvious vulnerability of our global supply chains in times of global crisis (e.g. the coronavirus pandemic), the idea of a less resource-dependent economy based on circulation of products, components and materials, which is also more resilient to global supply issues, is currently gaining additional momentum.[5]

While the potential gains are manifold, CE practices have so far only been slowly adopted in businesses, both large and small.[6] Against this background, it seems necessary to better align circularity with organisations' business models. **Circular business models** (CBMs), on the basis of various CE strategies such as repair, reuse, remanufacturing and recycling, simultaneously generate (economic) value for the individual company *and* make a systemic contribution to the creation of a CE. This holistic view goes far beyond mere recycling and follows the **Ellen MacArthur Foundation**[7] by identifying a variety of CE strategies to slow and close[8] product, component, and material cycles as well as increase resource productivity. The present report aims to contribute to **overcoming the existing 'implementation gap' regarding the CE in business practice** by outlining the potential gains and challenges of specific business models customised to specific actors within the value cycle. It does so by explicitly addressing the interrelationships of the digital and socio-ecological transformation.

In order to successfully exploit the potential of a Circular Economy, it appears essential to **link this transition process to the digital transformation** of our economy and society at large. Digitally-enabled solutions and services such as digital platforms, data-driven material and product tracking, digital twins, internet of things (IoT), and blockchain technology could potentially play an important role in the transition to a future Circular Economy.[9] Digitally-enabled solutions **can help to dematerialise our economy**, for example by increasingly selling digital services to the end customer instead of material products. Such solutions can use data collected in the course of digitalisation to provide decision-making tools for the optimal reuse and recycling paths of products both from an ecological and economic point of view. They are a prerequisite for sharing data and information in real time, thus enabling new and potentially more circular forms of economic activity, such as repairing or refurbishing products. Furthermore, they also offer considerable empowerment potential for end customers, who can leave their passive role as mere consumers behind by making CE-informed purchasing decisions as active prosumers, becoming important value-generating links within the product life cycle. Digital transformation should therefore be put to use in CE transitions and thus also help to achieve or even exceed environmental and climate policy goals such as Europe's proclaimed objective to become greenhouse gas neutral by 2050. This digital potential needs to be tapped while containing the negative environmental side-effects of poorer recyclability of products which include electronic components, increasing volumes of electronic waste and rising energy consumption.[10]

1 | See United Nations SDG.
2 | See European Commission 2019.
3 | See Weber/Stuchtey 2019.
4 | See European Commission 2020a.
5 | See European Commission 2020b.
6 | See Takacs et al. 2020.
7 | See https://www.ellenmacarthurfoundation.org/.
8 | See Bocken/Short 2016.
9 | See European Policy Centre 2020.
10 | See BMU 2020b.

Objectives and added value of the report

This report aims to contribute to the successful implementation of CBMs in business practice[11] and pursues a dual objective: First, the report is intended to **enable and inspire decision-makers from business and politics to create conducive conditions for the implementation of CBMs**. The starting point for this endeavour is the development of an actor-specific typology of CBMs, which **allows a company to determine its individual role within the value cycle** and to derive a suitable CE-relevant business model. The identification of a company's current *and* possible future positioning within the value cycle are of equal importance in this context.[12]

Second, the report also strives to go beyond the individual firm perspective. **Value creation processes, value delivery and value propositions in a CE usually cannot be realised by a firm working alone**. Collaboration among actors across the value chain – and their business models – in 'circular ecosystems' is a necessary basis for the implementation of a CE.[13] This provides a more systemic understanding that locates a single actor's business model along the entire product life cycle and **understands circularity as the interaction of different actors with their respective CE-promoting business models**. In line with this more integrated understanding of the CE, the working group is composed of actors from different areas of society (science, business and civil society) and roles within the value cycle (see Appendix I for a complete list of working group members).

The added value of the report of this working group lies first and foremost in the **analysis and design of cross-sectoral framework conditions and recommendations for action**, providing decision-makers from business and politics with guidance in the form of a practical handbook.[14] In order to address the existing implementation gap described above, this **report presents CBMs which have already been successfully implemented and discusses their applicability in new contexts**. So far, successful examples of CBMs can be found primarily in business-to-business or in sustainability-oriented niche markets. In these markets, circular business practices are often highly professionalised, contractually defined and, due to the focus on total cost of ownership, economically attractive to the actors involved. However, if a more comprehensive transformation toward a CE is to succeed, the applicability of these CBMs must also be examined for consumer mass markets. The success of CBMs in business-to-consumer markets and the associated significance of the consumer as an important link within the value cycle are of particular importance in this report.

With its strong emphasis on the *implementation* of business models in practice, this final report also complements more research-oriented funding programmes in Germany, such as *'Resource efficient Circular Economy – Innovative product cycles'* (ReziProK), initiated by the Federal Ministry of Education and Research.[15]

Structure of the final report

In order to achieve the outlined objectives, this report is structured as follows: **Chapter 2** briefly presents the basic understanding of a CE on which the working group is based and outlines the role of business models in the implementation of a CE. **Chapter 3** then explains key dimensions necessary to characterise and differentiate circular business models. This provides readers with the tools to make an initial self-assessment of their own companies along the three dimensions 'actor roles' 'circular strategies' and 'product-service system type' and thus identify possible CE-related optimisation potential for their own company. Moreover, the chapter presents an integrated ecosystem perspective on the various actors' circular business models and explains how actors can cooperate and build partnerships with each other in order to achieve a high degree of circularity for the entire system. **Chapter 4** showcases the circular business model typology by providing an overview of the 22 main circular business model (CBM) patterns that have been prepared in detail. These detailed circular business model patterns for each actor in the value cycle can be looked up in the appendix to the report. In this context, the most relevant CE strategies for the central actors within the value cycle are presented, possible servitisation potential (i.e. higher levels of service orientation) is indicated and reference is made to existing success cases in business practice.

11 | The report is the result of a ten-month multi-stakeholder process of the Circular Business Models working group within the *Circular Economy Initiative Deutschland* (CEID). For a comprehensive overview of the members and operating principles of the working group see Appendices H and I at the end of this report.

12 | See Hansen/Revellio 2020.

13 | See Konietzko et al. 2020a.

14 | While the final reports of the other two working groups within CEID each have a specific application context as the object of analysis (see Traction Batteries working group and Packaging working group.

15 | See BMBF 2019.

Chapter 5 then turns to the status quo by discussing current barriers regarding the implementation of a CE. Based on existing approaches that discuss CE-relevant barriers along various dimensions (e.g. technological, regulatory and economic), a 'configuration approach' is presented, which identifies bundles of interrelated barriers and shows how these can block the implementation of a CE in business practice. For each CE strategy, specific configurations of barriers are identified, and an integrated approach to a solution discussed. Based on this comprehensive analysis of barriers, **Chapters 6 and 7** subsequently discuss possible enablers for CBMs, the first chapter dealing with the role of digital enablers and the second offering an overview of policy enablers and regulatory framework conditions.

Chapter 8 then integrates the developed findings around CBMs, barriers and enablers in an application, taking television sets by way of example. This 'use case' was chosen by the working group to better illustrate the potential and existing constraints on implementing CBMs. Finally, **Chapter 9** provides a synthesis of action-oriented insights and sets out concrete recommendations in the form of a roadmap.

2 Conceptual background

2.1 Circular Economy

The **Circular Economy (CE) has become the major paradigm for advancing sustainable development**. It is intended to overcome the destructive 'take-make-waste' value creation paradigm which has developed and thrived in the post-Second World War era by advancing the restorative use of products, components, and materials in the highest possible qualities over multiple cycles.[16]

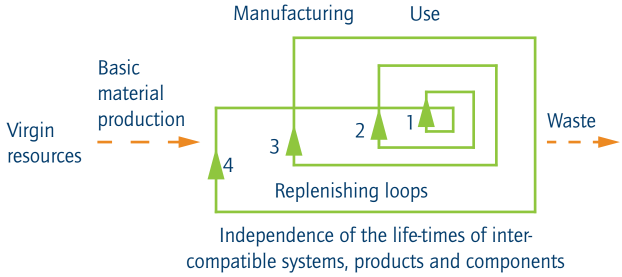
From a product perspective, the CE represents an **extension of life cycle-oriented innovation** in which products are designed, managed, and evaluated along the entire value chain from resource provisioning to recovery.[17] Product circularity is rooted in 4R frameworks[18] and can be grouped into slowing (e.g. repair, reuse, remanufacture) and closing (i.e. recycling) strategies.[19] It aims to extend lifetime at a product, component, and material level, and is facilitated through new product designs.[20]

The result is a self-replenishing system in which losses (i.e. waste) and virgin resource inputs (including energy) are minimised (see Figure 1).

To advance the CE, **a systems innovation approach to sustainability is required,**[21] in which environmental benefits are achieved by interconnecting producers, service providers, users, and recovery organisations (and related infrastructure) through repeated restoration cycles.

Two general approaches to the Circular Economy exist:[22]

- the industrial CE (e.g.products remanufactured by the producer) and
- the local, user-driven CE (e.g. Do-It-Yourself (DIY) repairs and repair cafés).



Note: (1=Reuse; 2=Repair; 3=Recondition; 4=Recycling)

Figure 1: Circular Economy as a self-replenishing and restorative system (Source: Stahel 1984)

Focusing on commercial business models, this report primarily addresses industrial aspects, while paying some attention to a user-driven CE (e.g. a business model for 'upgrades, spares & accessories' in support of users' self-repair[23]).

There are four crucial levers for advancing a Circular Economy:[24]

- skills in circular product design,
- business model innovation,
- building and managing reverse cycles, and
- enabling cross-cycle and cross-sector performance.

While all four levers are important and interlinked, we take a business model perspective here.

2.2 Business models as enablers for the Circular Economy

While pioneers such as Ricoh and Interface and their successful transformations towards CE-based business practices have been studied for some time,[25] such practices have not yet come into more widespread use in industry and society. It has been increasingly understood that **more significant progress towards the CE,** as exemplified by the above pioneers, **requires considerable, if**

16 | See Morseletto 2020.
17 | See Ny 2006; Hansen et al. 2009.
18 | See Kirchherr et al. 2017.
19 | See Bocken et al. 2016.
20 | See Hopkinson et al. 2018.
21 | See Adams et al. 2012.
22 | See Stahel 2019.
23 | See section 3.1.
24 | See Ellen MacArthur Foundation 2013.
25 | See Hopkinson et al. 2018; Luqmani et al. 2017.

not radical business model changes to adapt the way companies create value while striving towards more circular business practices.[26] The business model has therefore become a key construct in studying transitions towards the CE[27] and sustainable development more broadly.[28] It is the goal of the present report to explore radical business model designs for the CE, i.e. circular business models (CBMs).

The business model is crucial for the commercial introduction of innovations based on the product life cycle.[29] It has therefore become of major interest to CE research and practice[30] and several reviews were recently published on the subject.[31]

At the core of CBMs, as with business models in general, is the ability of organisations to create, deliver (or transfer), and capture value (see Figure 2):

- Value creation in a CE is directly linked to circular strategies such as repair, reuse, remanufacturing, and recycling – as well as the necessary redesign for circularity (and related 'design-for-x' practices such as design-for-disassembly, design-for-reuse, and design-for-recycling). These circular strategies address the 'how aspects' of value creation and define the operational activities with which organisations close loops.[32]
- Value delivery/transfer describes the product and service offerings, customer relationships, and related communication exchange with customers, also regarding how circularity is addressed in the marketing mix. Value delivery and related value propositions to the customer differ depending on the type of offering, i.e. traditional transactional sales or product-as-a-service.[33] More intensive collaboration between firm and customers can be expected in a CBM.
- Value capture is about appropriating a share of the total value created, from the perspective of the focal actor (e.g. a retailer of recycled products). The captured value must be compared to the opportunity and resource costs related to creating value. Again, value capture differs in transactional sales vs. products-as-a-service offerings because they lead to different modes of payment.[34]

Value creation, transfer, and capture in CBMs can be facilitated by cross-cutting practices and technologies. **Digital technologies stand out for their potential to significantly transform circular value creation, transfer, and capture, or for making these possible in the first place.**[35] They can enable smart circular strategies such as smart repair, reuse, and remanufacturing[36] and also contribute to servitisation.[37]

While pioneering organisations demonstrate the economic feasibility of CBMs, broader diffusion of successful CBMs can probably only be achieved when contextual factors such as policies, market frameworks, and broader institutions are adapted towards circularity,[38] which also highlights the systemic nature of CE innovations.[39]

26 | See Hopkinson et al. 2018; Lüdeke-Freund et al. 2019.
27 | See Lüdeke-Freund et al. 2019; Fraccascia et al. 2019.
28 | See Schaltegger et al. 2016; Schaltegger et al. 2012; Bocken et al. 2014; Boons/Lüdeke-Freund 2013.
29 | See Hansen et al. 2009.
30 | See Bocken et al. 2016; Guldmann et al. 2019; Fraccascia et al. 2019; Hopkinson et al. 2018.
31 | See Galvão et al. 2020; Pieroni et al. 2019; Pieroni et al. 2020; Lüdeke-Freund et al. 2019.
32 | See Lüdeke-Freund et al. 2019.
33 | See Urbinati et al. 2017.
34 | See Centobelli et al. 2020; Tukker 2015.
35 | See Centobelli et al. 2020; Rosa et al. 2019; Alcayaga/Hansen 2019.
36 | See Alcayaga et al. 2019.
37 | See Stahel/MacArthur 2019.
38 | See Centobelli et al. 2020.
39 | See Pinkse et al. 2014.

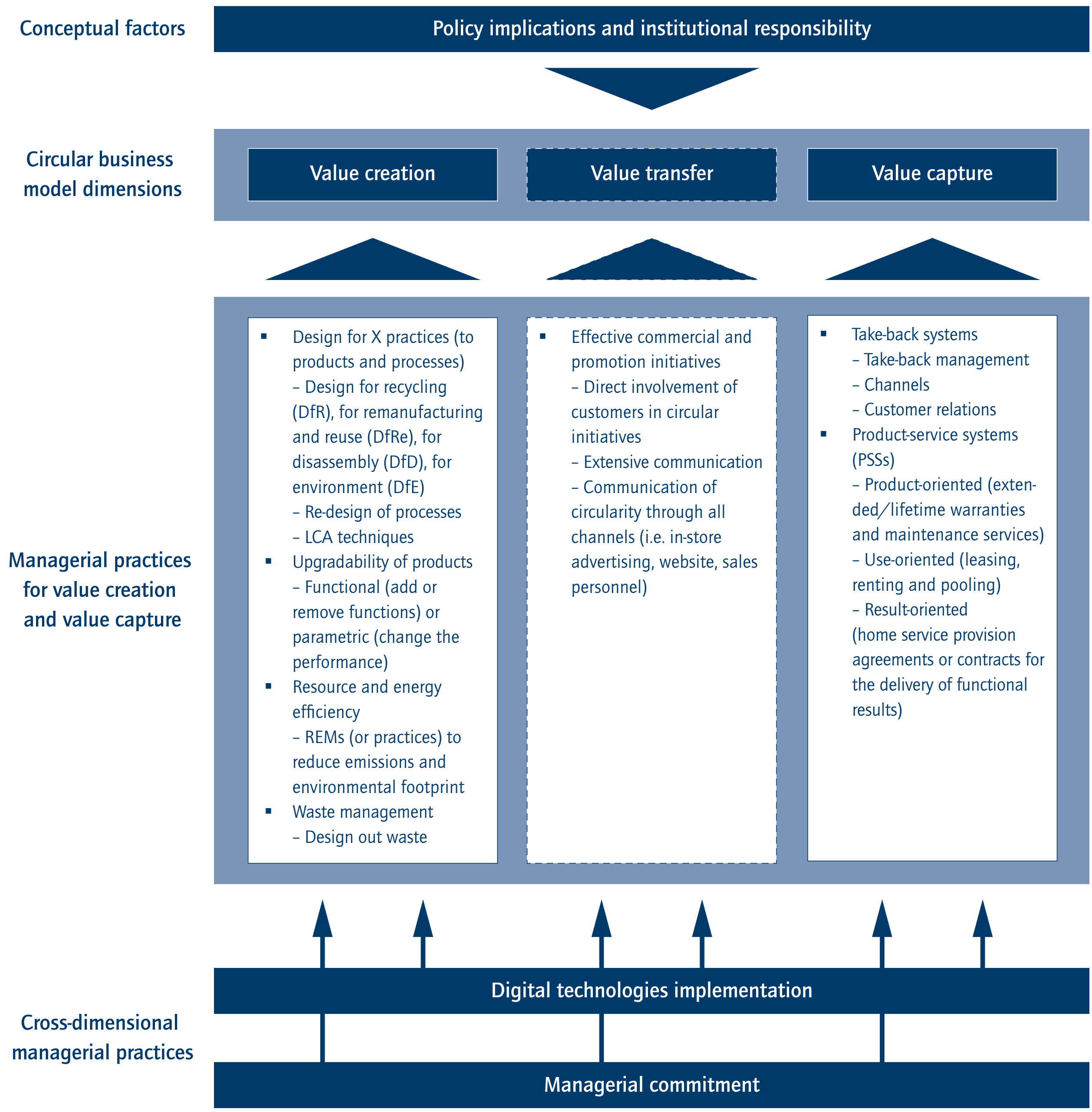


Figure 2: Circular business models: dimensions, managerial practices, digital enablers, and policy context (Source: Centobelli et al. 2020)

3 Circular business models: Key dimensions

Key to advancing circular business models (CBMs) in organisations is grasping their diversity and complexity. This is facilitated by classifications (e.g. typologies, taxonomies) of generic CBMs.[40] What these classifications have in common is that circular strategy (i.e. from recycling to maintenance) and service level (i.e. from product-oriented to result-oriented product-service systems) are key dimensions of CBM designs. Sometimes, the position of the focal actor in the value cycle is also considered.[41] Against this background, **this report's understanding of a CBM is built on three dimensions: actors, circular strategy, and product-service system type**. Each dimension is further explored below.

3.1 Dimension 1: Actor roles

The actor role, though less often tackled in the business model literature, is crucial for identifying relevant circular business models (CBMs) and understanding their specific characteristics as well as their enablers and barriers.

3.1.1 From business-to-business to business-to-consumer markets

A key distinction which is often made is whether CBMs are applied in business-to-business (B2B) or business-to-consumer (B2C) settings. **So far, B2B settings are more apparent in the literature and seem to be more successful in practice as examples in managed print services and chemical leasing show**.[42] Some of the reasons are:

a. Circular strategies such as maintenance or repair are in the 'DNA' of business actors; hence, close relationships between sellers and business customers along the entire product life cycle are typically the norm.
b. The incentives to engage in higher service levels, such as performance-based pay, are often somewhat compatible with the desire of business customers to decrease the total cost of ownership over the entire timespan of using a good.
c. Sales practices used to approach business customers offer more room for communicating complex offerings such as more advanced product-service systems.

If the goal is to diffuse CE practices more widely, **CBMs must be advanced in B2C settings** as well, but this is often hampered by consumer preferences. In particular, advancing to higher service levels often fails due to consumers' resistance to partially giving away control over products to service providers[43] or transaction costs related to return flows.[44]

3.1.2 A dynamic view of actor roles

Beyond distinguishing between B2B and B2C, **the adoption of CBMs leads to new roles in the value cycle,**[45] for example:

- A circular resource company may expand its value cycle coverage from mere (non-renewable) virgin resource extraction to resource recovery and related recycling practices.
- Circular manufacturers, based on vertical integration, extend from mere transactional sales of products to distribution, use-related services, or end-of-life services.
- Usage-extending or sufficiency-advocating retailers may extend from mere retailing to services during use (e.g. repair) and take-back.
- New third-party refurbishment and recovery service providers collect used devices and, if possible, repurpose and remarket products, or otherwise forward them to recycling.

In principle, all existing actors can extend their businesses towards other stages of the value cycle.[46] In addition, new actors can enter the value cycle at any stage. Overall, this leads to **significant dynamics in the actors' setting, their positions in the value cycle, and the roles they play**. As a consequence, in addition to the original or dominant role a given actor plays in the value cycle, further roles may be taken to address circularity. This can be done either with own resources through vertical integration ('make'), by partnering with others ('ally'), or through rather short-term contractual relationships via the market ('buy'). A change of actors' positions in the value chain has traditionally

40 | See Kortmann/Piller 2016; Lüdeke-Freund et al. 2019.
41 | See Zufall et al. 2020.
42 | See Kortmann/Piller 2016; Hopkinson et al. 2018; UNIDO 2011.
43 | See Tukker 2015.
44 | See Stahel 2010.
45 | See Zufall et al. 2020; Hansen/Revellio 2020.
46 | See Kortmann/Piller 2016.

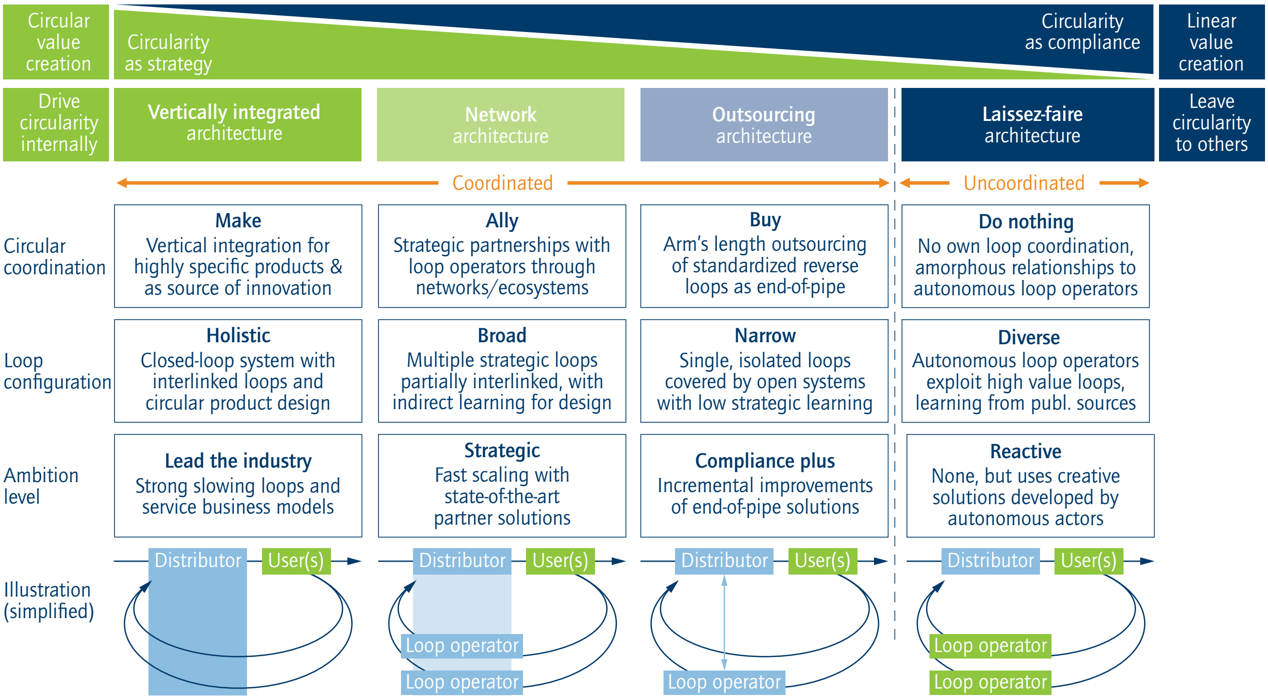


Figure 3: Make, ally, buy, and laissez-faire in circular value-creation architectures (Source: Hansen/Revellio 2020)

been considered a major competitive force.[47] If focal actors refrain from offering any voluntary circular business in the market, they take a 'laissez-faire' approach and leave more room for new entrants to address circularity in the market.[48]

For the proposed CBM typology, we consider the following actors based on their main or dominant role in the value cycle (next to their dominant role, actors may take additional roles, which then results in fewer actors still covering the entire value cycle):

- Suppliers (raw materials): actors providing raw materials and other substances needed for production processes.
- Suppliers (machines and equipment): actors producing components and machines needed by producers.
- Producers:[49] actors producing proprietary materials, components, and products.
- Retailers (and wholesale): actors selling products.
- Repair providers: actors offering repair services.
- Prosumers: non-market actors organising Do-It-Yourself (DIY) and other informal activities.
- Logistics providers: actors providing logistics services and spare parts management.
- Recovery managers: actors recovering, managing, and sorting materials.
- Intermediaries: actors operating platforms for coordinating recycling, used products, or sharing activities.
- Emerging actors: this umbrella category contains additional actors in support of the key actors' business models (e.g. financial service providers) and leaves room for entirely new types of actors yet to be identified.

3.1.3 Collaboration in the business model ecosystem

Circular solutions usually cannot be successfully implemented by one firm alone, even when high degrees of vertical integration are

47 | See Porter 1980.
48 | See Hansen/Revellio 2020.
49 | We consider the producer to be responsible for product design, production, and downstream circular service operations, even when the entire production is actually outsourced to a third-party original equipment manufacturer (OEM).

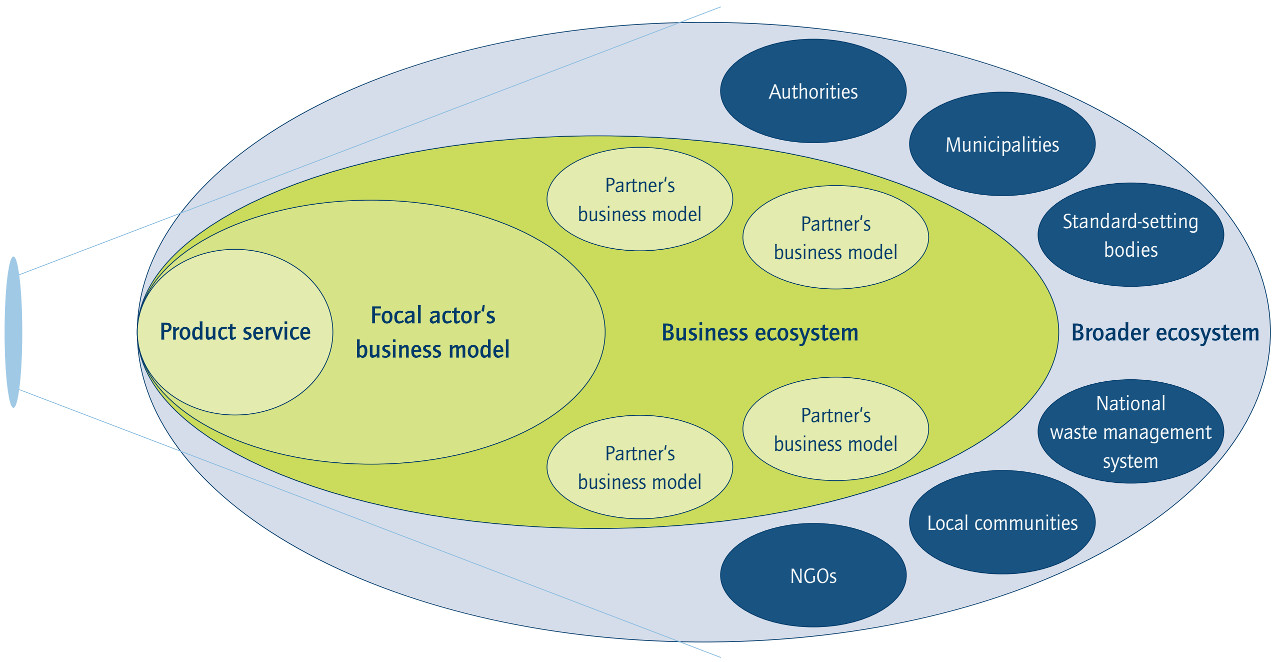


Figure 4: Ecosystem perspective on circular business model and example (Source: own presentation, based on Konietzko et al. 2020b)

pursued. Still, the traditional business model concept represents the 'focal firm's plan' for creating, delivering and capturing value.[50] Traditionally, the focus is on the focal firm, not on the actor constellation participating in the activities.[51] However, as already emphasised, **circular solutions can often be considered systems innovations and cannot be successfully implemented by one firm alone.**[52]

This is reflected in the circular ecosystem perspective,[53] which also takes partners' business models into consideration.[54] The isolated optimisation and profit-maximisation of the focal actor's business model must be overcome and replaced with the right configuration, optimisation, and distribution of profits within the ecosystem (see Figure 4).

An ecosystem can be defined as 'the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialise'.[55] Against this background, 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'.[56]

The ecosystem can serve complex customer needs that one company could not fulfil alone.[57] The role of each partner in the ecosystem becomes relevant at different points in time, because CE solutions are of a long-lasting nature and subject to time lags. While product design and commercialisation may be achieved relatively early, material loops may close only much later once products become out of use (with the exception of fast cycling goods such as packaging). For this reason, the role of **the lead firm or orchestrator of the ecosystem** (which could, in theory, be any actor in the value cycle) cannot be overstated as it **can provide a good vison and narrative as well as sufficient incentives for the ecosystem to develop** in the long term.[58]

50 | See Adner 2017.
51 | See ibid.
52 | See Adams et al. 2012.
53 | See Konietzko et al. 2020a; Takacs et al. 2020.
54 | See Adner 2017.
55 | See ibid.
56 | See Takacs et al. 2020.
57 | See ibid.
58 | See ibid.

As well as the more micro-level business ecosystem focused on core partnerships for delivering circular solutions, the meso- and macro-level stakeholder ecosystems may include further relevant parties in the relevant communities, municipalities, nations, and cultures and are therefore linked to diverse institutional structures.[59]

3.2 Dimension 2: Circular strategies

Circular strategies are at the core of circular business model (CBM) development.[60] They **describe how actors approach the challenges of loop-closing and hence the concept of circularity**. These activities are in turn derived from different types of cycles.

3.2.1 Technical and biological cycling

The well-known 'butterfly framework' developed by the Ellen MacArthur Foundation[61], based on foundational concepts such as cradle to cradle[62], distinguishes technical and biological spheres of the industrial metabolism:

- Technical cycling is about continuously cycling and restoring products, components, and materials in the circular system through maintaining, repairing, reusing, remanufacturing, and recycling.
- Biological cycling refers to organic feedstock (i.e. renewable inputs) as a basis for developing biodegradable or compostable products. They are called 'products of consumption' because they can be safely returned to the natural environment and even become nutrients for living systems.[63]

Biological cycling is important because, with proper product design in place, it potentially adds product characteristics such as biodegradability and compostability and can therefore be a strategy for preventing environmental problems such as marine littering. It is also relevant because replacing fossil-based resources with renewable biogenic feedstock can lower environmental impact in the category of climate change – however, at the same time, it can increase environmental impact in other dimensions (e.g. impacts of industrialised agriculture, loss of biodiversity, direct and indirect land use changes) and can therefore thwart sustainable development efforts.[64] Hence, products made of renewable feedstock should also be subject to a maximisation of material productivity and therefore technical cycling before they are biodegraded or otherwise treated in the biological cycle.[65] Against this background, irrespective of resource origin, **technical cycles are at the core of the CE and are therefore the focus of the present report**.

3.2.2 Circular Economy strategies

Based on this understanding of closed technical cycles, we consider the following circular strategies relevant for guiding the development of CBMs:[66]

- Repair, maintenance, and upgrade: Offering prolonged usability and functionality of products through maintenance, repair, and/or control services which reduce the need to buy and switch to new products. Optionally, products are upgraded with new features or advanced performance.
- Reuse & redistribution: This strategy requires that used products flow (back) to service providers, either directly or via an intermediary. The used products are then directly (re-)sold, perhaps in slightly enhanced form after cleaning, minor repairs, and repackaging, leading to new forms of value capture.[67]
- Remanufacturing & refurbishment: With remanufacturing, value creation processes change considerably. Used or malfunctioning products are returned to the producer (or third-party provider), completely disassembled and reassembled with all parts, and the resulting product is restored to quality equal to or better than the original product (i.e. quality 'as new'). This may include technological upgrading of selected modules. In the light version of refurbishment, instead of disassembly, only selected repairs and reconditioning activities are carried out.
- Recycling: At the level of materials, recycling comes into play. It is less preferred than repair, reuse, and remanufacturing, because a large proportion of the embodied energy and labour is lost.[68] In principle, material recycling is about reusing

59 | See Koskela-Huotari et al. 2016; Volkmann et al. 2019.
60 | See Lüdeke-Freund et al. 2019; Bocken et al. 2016.
61 | See Ellen MacArthur Foundation 2013.
62 | See Braungart et al. 2007.
63 | See ibid.
64 | See Weiss et al. 2012.
65 | See Lüdeke-Freund et al. 2019.
66 | See ibid.; Morseletto 2020; Hansen/Revellio 2020.
67 | When referring to circular strategies such as repair and maintenance, it should be mentioned that this is not about compliance-based services, such as those based on product warranties, but is instead about voluntary, proactive strategies such as out-of-warranty repairs (Hansen/Revellio 2020).
68 | See Ellen MacArthur Foundation 2013; Stahel 2010.

Loop type	Level of analysis	CE strategy (technical loop)	Recovery strategy	Recovery activities	Value creation
Slowing (product integrity)	Product/ components	**Maintain/ repair/ upgrade**	Maintaining	Maintain product and parts (incl. software)	Maintaining product functionality and value over time
			Upgrading	Provide users with upgrades (e.g. exchange modules, software)	Improve product-in-use and extend use cycle and lifetime.
			Repairing	Detect defects and replace defect parts utilising spare parts	Restoring defective product to original function
		Reuse	Reusing/ redistributing	Inspect, clean, and redistribute a functioning product (cosmetic repairs only)	Reselling for second/consecutive use phases, also to users with lower performance requirements
			Harvesting	Extract functioning modules or parts for later reuse	Reusing modules/spare parts in new or used products
		Remanufacture	Refurbishing	Inspect critical modules and restore product to specific quality level	Repairing/replacing critical modules to restore product functionality
			Remanufacturing	Inspect all modules and parts. Restore to 'like new' quality level	Combining harvested and/or new parts into a (new) product with potential upgrades
Closing (material recovery)	Material	**Recycle**	Closed-loop recycling	Consecutive large-scale processes to recover inherent material properties (functional recycling)	Replacing virgin materials with high-quality recyclates for the original purpose or in products with similar performance requirements to displace primary production
			Open-loop recycling	Shredding and sorting (downcycling)	Partially recovering material value; reusing materials in low-grade products in different industries

Table 2: Circular Economy strategies defined (Source: based on Hansen/Revellio 2020 p. 1252)

materials for the same or different purpose (excluding incineration).[69] Today's recycling processes often considerably reduce material utility and quality and can therefore be considered 'downcycling'.[70] New business models and related product design changes aim to retain material quality over multiple cycles and long periods of time so that primary materials can be replaced, i.e. 'upcycling'.[71] From a business model perspective, recycling leads to new value creation (return and processing of products/materials) and value capture (e.g. potentially cutting costs by using or creating new revenues by selling secondary materials) processes.

In line with Stahel's established inertia principle (and similar to the waste hierarchy[72]), these loops are ranked with their environmental and economic benefits in principle decreasing from slowing strategies (i.e. repair, reuse, remanufacturing) to closing/ recycling strategies.[73] The inertia principle states:

69 | In this working group, recycling (like the other CE strategies) is generically covered across all relevant materials (e.g. metals, minerals, plastics, woods). It applies a dynamic understanding of a progressive expansion of mechanical recycling through improved product designs (i.e. design for recycling and circularity), business models (e.g. better return flows), sorting/recycling infrastructure (e.g. advanced colour separation), and policy frameworks (e.g. the EU's CE Action Plan and related policy packages demanding design for recyclability). Following the current line of the federal government, chemical recycling (depolymerisation) was not covered in this working group, because its environmental characteristics and technical feasibility are still unclear and need further time and research (| See Ellen MacArthur Foundation 2016b; UBA 2020). Furthermore, it is mainly relevant for plastics and therefore beyond the generic focus of the working group (a more detailed discussion regarding chemical recycling is currently under way in the CEID working group on packaging). Last but not least, the environmentally reasonable application of this technology is limited to certain materials for which a recovery with environmentally friendly mechanical recycling is not feasible (with an expected shrinking share of these materials, if the dynamic understanding covering product, business model, technology, and policy *re*design as followed in this working group is adopted and indeed implemented in practice).

70 | See Ellen MacArthur Foundation 2013.

71 | See ibid., p. 23.

72 | The waste hierarchy is defined in the EU waste management framework distinguishing prevention (e.g. buying fewer products, direct reuse of products, or less resources per produced unit), preparing for reuse, recycling, recovery, and landfill on a preferential scale. | See van Ewijk/Stegemann 2016.

73 | See Stahel 2010; Kirchherr et al. 2017; Ellen MacArthur Foundation 2013. Still, slowing strategies are not perfect either. They may also lead to rebound effects; Makov et al. 2019.

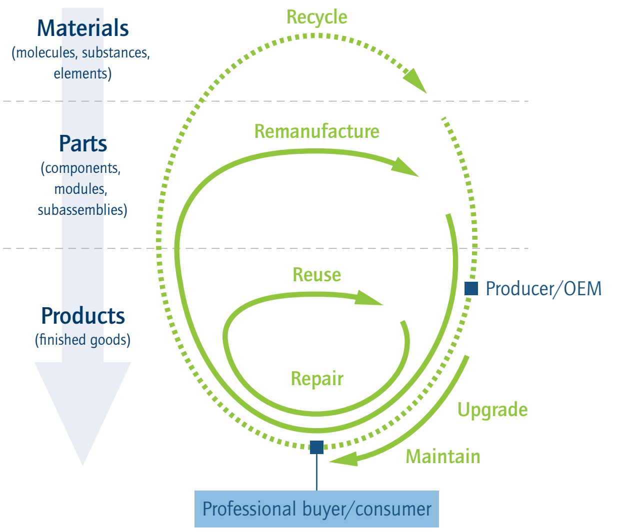


Figure 5: Main circular strategies and their relation to resource states (example of producers) (Source: own presentation, based on resource states framework by Blomsma/Tennant 2020)

'Do not repair what is not broken, do not remanufacture something that can be repaired, do not recycle a product that can be remanufactured.'[74]

Value creation potential in each of these CE strategies can be maximised by ensuring a certain purity and quality of products/components and by keeping toxic materials out of the product design.[75]

The four CE strategies in focus can be further differentiated according to the resource state, which refers to the level of products, components, or materials. The different natures of the CE strategies has an influence on value creation, transfer, and capture within CBMs.

Organisations usually have to choose a core circular strategy and complement it with supporting strategies, which together represent a circular strategy configuration[76] or loop configuration.[77] The choice between different core circular strategies is important, because in general their potential environmental impacts will differ (see the concept of CBM maturity below).

Based on the identified circular strategies and further considerations of related approaches, **the following core circular strategies are included in the proposed typology:**

- Maintain, repair, and upgrade[78]
- Reuse
- Remanufacture
- Recycling

3.2.3 Closed- vs. open-loop cycling

Beyond the differentiation into the above CE strategies, **moving from open- to closed-loop systems has considerable environmental benefits.**[79] Moreover, closed technical loops also **provide strong incentives for individual organisations to fully embrace the CE**, because they demand considerable changes to their own CBM and related value creation activities (e.g. use of secondary as well as primary materials, remanufacturing as well as primary production, reused as well as new goods sales). And because products, components, and materials then ultimately return to the same organisation, it becomes necessary to introduce more circular and higher quality materials, components, and products into the market in the first place. In contrast, open-loop circularity can be distributed across the value chain or economic setting, i.e. while one organisation remains in the 'linear' economy producing waste as usual, another organisation specialises in reutilisation of that waste for other purposes (e.g. wool used in clothing is repurposed as insulation material in buildings), consequently creating new dependencies on waste.

At the level of materials, open-loop recycling usually leads to lower quality and lower value materials, used for applications with lower performance needs.[80] In contrast, closed-loop systems are based on 'technical nutrients' maintaining quality over time:

'A technical nutrient ... may be defined as a material ... that has the potential to remain safely in a closed-loop system of manufacture,

74 | See Stahel 2010.
75 | See Ellen MacArthur Foundation 2013.
76 | See Blomsma/Tennant 2020.
77 | See Hansen/Revellio 2020.
78 | It should be borne in mind that maintenance, repair, and upgrading strategies are not always fully distinct in practice. The typology presented in Chapter 4 may therefore combine them where appropriate.
79 | See Dubreuil et al. 2010; Hansen/Revellio 2020; Haupt et al. 2017.
80 | See Ellen MacArthur Foundation 2016a.

recovery, and reuse ..., maintaining its highest value through many product life cycles.'[81]

It is particularly the ambition for closed-loops systems which instils more radical product and business model innovation and is therefore considered crucial here. This focus on closed-loop business models also explains why we do not here explicitly consider cascading across industries and related repurposing (e.g. a cotton T-shirt becomes an insulation material, before it is ultimately composted)[82] as additional, stand-alone circular strategies (still, we do not rule out open loops in the recycling strategy, which, in effect, can then also include material cascading).

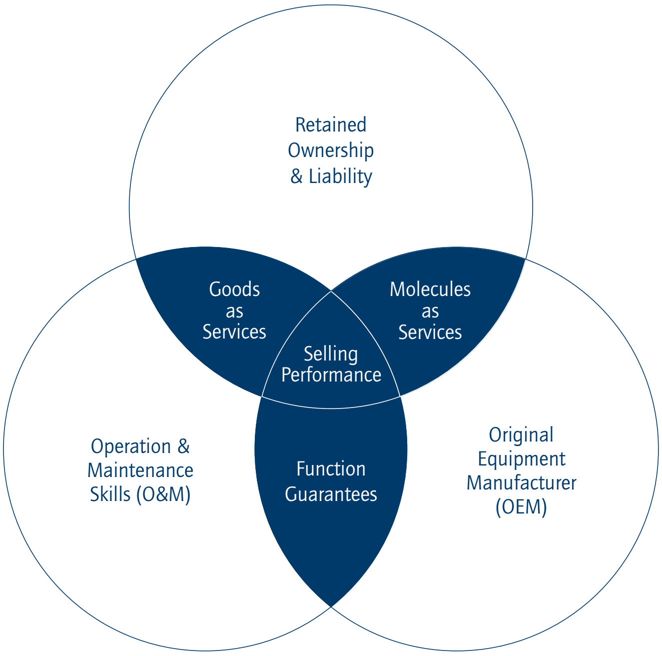
3.3 Dimension 3: Product-service system type

Product-service systems (PSS) have been used to promote sustainable development for several decades[83] and the concept has recently been reframed as business model types for the Circular Economy (CE):

'In product-oriented business models firms have the incentive to maximize the number of products sold. This is their principal method of boosting turnover, increasing market share, and generating profits. However, in service-oriented business models, in theory the incentive differs. Firms then make money by being paid for the service offered, and the material products and consumables that play a role in providing the service become cost factors. Hence, firms will have an incentive to prolong the service life of products, to ensure they are used as intensively as possible, to make them as cost- and material-efficiently as possible, and to reuse parts as far as possible after the end of the product's life. All of these elements could lead to a minimization of material flows in the economy while maximizing service output or user satisfaction.'[84]

Against this background, increasing service levels as represented by 'materials banks'[85] or the 'servitising manufacturer'[86] have become the focus of attention in CBM research. **Many CBM frameworks therefore propose putting PSS at the core of the business model**[87]. Servitisation changes the value proposition made to the customer and how value is captured.[88] Stahel, one of the seminal authors and promoters of the servitisation perspective, has emphasised a servitisation approach based on the levels of molecules, materials, and goods and distinguishes performance business models of goods/molecules as services, function guarantees, and selling performance (see Figure 6).

81 | See Braungart et al. 2007.
82 | See Lüdeke-Freund et al. 2019; Ellen MacArthur Foundation 2013.
83 | See Tukker 2004; Braungart et al. 2007.
84 | See Tukker 2015.
85 | See Braungart et al. 2007.
86 | See Kortmann/Piller 2016.
87 | See Yang et al. 2018; Alcayaga et al. 2019; Urbinati et al. 2017.
88 | See Urbinati et al. 2017.



In addition to integrating the era of ´R´and era of ´D´of the CIE, economic actors of the PE retain the ownership of goods.

As retained ownership implies retained liability for costs of risks and waste, the PE is the most sustainable strategy of the CIE.

As selling performance enables to exploit efficiency, sufficiency and systems solution, it is potentially the most profitable CIE strategy.

Figure 6: Circular business models from a servitisation perspective (Source: Stahel 2019, p. 67)

The scope of product-service systems (PSS) can probably be best understood by using Tukker's continuum of product-oriented, use-oriented, and result-oriented PSS (see Figure 7).

Result-oriented product-service systems (PSS) are seen as those with the greatest potential for the CE, but also require the most radical changes to the business model, and have therefore

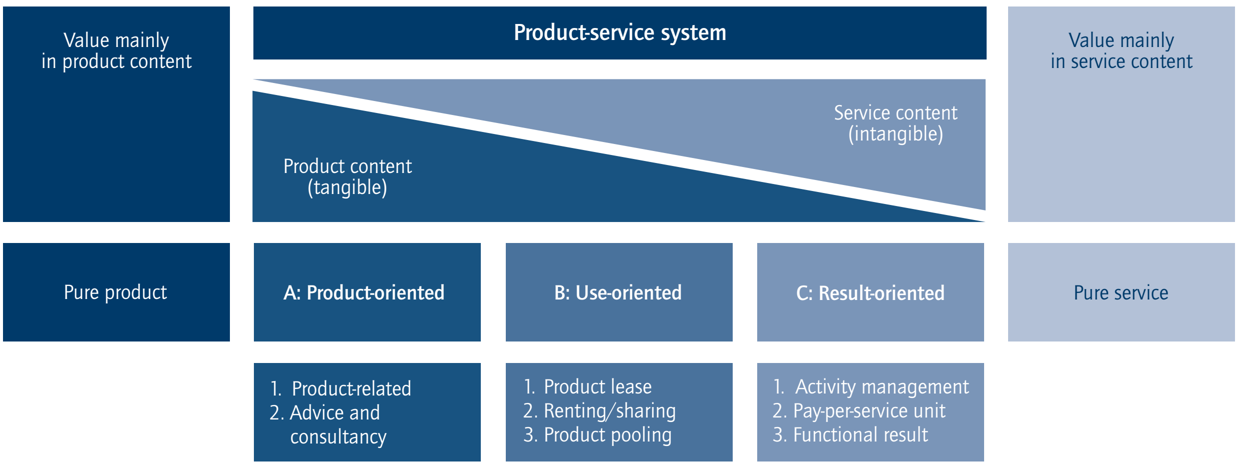


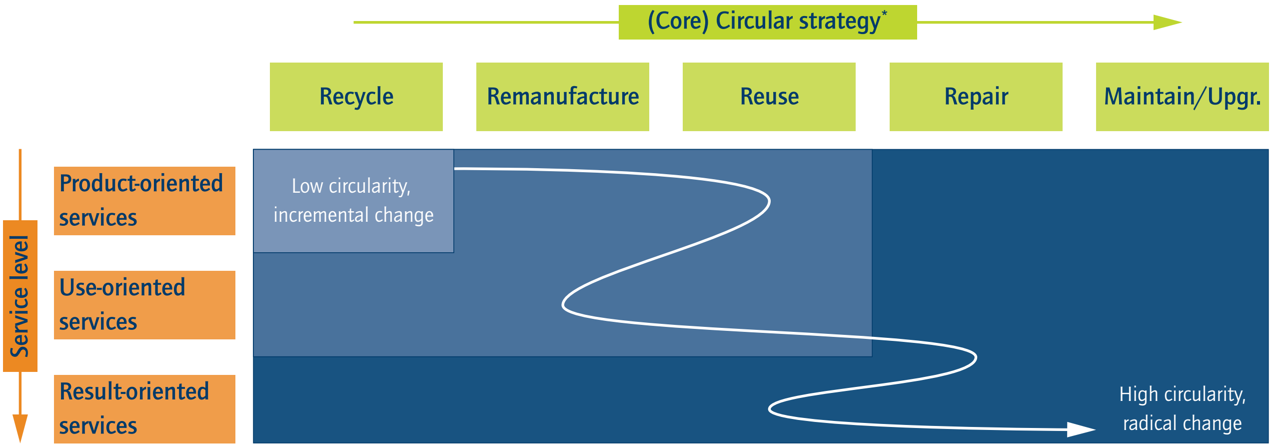
Figure 7: Eight types of product-service systems (Source: Tukker 2004, p. 248)

so far not come into widespread use.[89] As a side note, the type of PSS business model will most likely determine whether and how organisations can capitalise on digital enablers – the more servitised the business model, the more connections and data exchange between producers, consumers, and their products will be possible.[90]

It should be mentioned that applying PSS is not a panacea, neither for environmental impact more broadly, nor for circularity in particular.[91] Instead, both depend on how exactly the PSS approach is intertwined with circular strategies. As a negative example, a financial leasing approach – i.e. a use-oriented PSS – is often employed by companies because of tax benefits, but is rarely used to leverage the circular potential from the take-back of leased goods and their reuse in the form of products-as-is or incorporated components and materials (unfortunately, companies sometimes even use service business models as a vehicle to ensure product take-back and destruction in order to prevent secondary markets).

3.4 The circular business model maturity grid

Combining the aforementioned circular strategies and the three main types of product-service system (PSS) allows the construction of **a maturity matrix that can be used to estimate the maturity of circular business models (CBMs)**. It is assumed that the circular potential of a CBM increases both with more ambitious (core) circular strategies and more ambitious service levels (see Figure 8).[92]



Note: *Higher-level strategies include the possibility of pursuing lower-level strategies simultaneously, increasing the synergistic potential for circularity

Figure 8: Circular business model maturity grid: choice of a core circular strategy and product-service-system level (Source: Hansen et al. 2020a, p. 12)

89 | See Tukker 2015.
90 | See Alcayaga et al. 2019.
91 | See Tukker 2004.
92 | See inertia principle by Stahel 2010; see van Ewijk/Stegemann 2016 for the preferential order in the waste hierarchy.

4 Circular business models: Typology

The concept of 'patterns' is used as the basis for developing a meaningful typology of circular business models (CBMs). They are commonly used to generalise and classify the various business models that are available.[93] A pattern can be understood as follows:

'Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.'[94]

The advantage of following a **pattern approach** lies in the fact that it allows the identification and generalisation of domain-specific business models, here circular business models, and that these can **serve as a source of inspiration for various types of organisation, across industries and geographical contexts.** CBM developers can use these patterns to come up with their own interpretations and solutions adapted to their specific cases and contexts.[95]

The CBM typology is not exhaustive but focuses on those patterns which:

- do indeed require business model changes (e.g. in-plant recycling may contribute to circularity, but is more an internal production-related improvement practice which doesn't touch upon the business model) and
- go sufficiently beyond compliance (e.g. warranty-based repair) and other mainstream practices (e.g. conventional maintenance practices in the business-to-business (B2B) environment).

4.1 Business model patterns: the pattern profile

Each business model pattern of the typology can be specified in detail along the dimensions covered in Figure 9. While an overview of the patterns is presented next, the complete list of detailed profiles of circular business model (CBM) patterns is listed in the Appendix D.

93 | See Abdelkafi et al. 2013; Remane et al. 2017.
94 | See Alexander et al. 1977.
95 | See Lüdeke-Freund et al. 2019.

4.2 Overview of business model patterns

Table 3 provides an overview of the 22 main circular business models (CBMs) plus the emerging actor class with CBMs yet to be defined. These are classed according to an actor's role (first column), circular strategy (second column), resulting CBM pattern (third column), and sub-patterns differentiated by the type of product-service systems (PSS). As in any classification scheme, patterns, while analytically distinct, may partly overlap in practice.

Each of the CBM patterns is briefly described below:

Suppliers (molecules/materials)

- **A1 Circular raw material suppliers:** Suppliers vertically integrate – via strategic partnerships or own investments – into recovery and/or processing of secondary raw materials. Using both primary and secondary materials, suppliers can flexibly respond to customer demand under fluctuating availability regarding quality and quantity of secondary inputs. Diversified suppliers who have hitherto focused on primary raw materials and entrepreneurial firms with a circular mission are covered.
- **A2 Process molecule service provider:** Process molecules or materials, usually with additional equipment (e.g. containers for solvents), are provided as a service to direct customers, thus boosting the performance and quality of the application. Materials are stored on the customer's premises and returned when necessary. Instead of increased sales volumes, this business model aims to maintain a given amount of materials for as long as possible and is now well established as chemical leasing.

Suppliers (machines/mechanical engineering)

- **B1 Machines/components 'as new':** Machines/components are taken back from customers, quality is checked, the machines/components are fully disassembled, worn parts/materials replaced, after which the machines/components are fully reassembled. Remanufactured machines have identical or superior quality at lower cost.
- **B2 Machine/component remarketing:** Used machines/components are taken back, quality-checked, reconditioned or repaired where necessary, and reintroduced onto the same or other markets to new customers with lower performance

expectations at competitive prices, thus extending machine/component lifetime with additional use cycles.

Producers

- **C1 Proprietary material cycles:** Producers introduce a product design with specific premium materials, resulting in higher customer value (e.g. durability, health, visual appearance) but at acceptable costs. Higher virgin material costs are offset (or overcompensated) by company measures to keep their own premium materials in closed loops and make continuous reuse of them for their own production.
- **C2 Product 'as new':** Companies offer products with 'quality as new' (i.e. equal or better quality than 'virgin' products), but at more competitive prices. Customers receive financial incentives to return products (e.g. deposit; discounts). Returned products are then quality checked and fully disassembled, worn parts/materials are replaced, after which the products are reassembled. Reman activities are usually centralised and are similar/remain close to primary production.
- **C3 Used product remarketing:** Producers (or retail partners) take used products back from customers, carry out quality control and optionally conduct minor refurbishment activities, and remarket used goods in the same or other markets at lower prices. Warranties are provided, but usually not with the same terms as new products.
- **C4 Out-of-warranty repair service:** Producers of premium quality goods incentivise extended use by customers by offering accessible, affordable, and competitive out-of-warranty repair services ('repair pays'), as a centralised, decentralised, or home delivery service. Products are supported in the long term through related availability of consumables, spare parts, necessary software upgrades, and, optionally, technological upgrading.
- **C5 Upgrades, spares & accessories:** Producers provide spare parts, tools, and related services for their core products, either through own online or offline sales channels, or by partnering

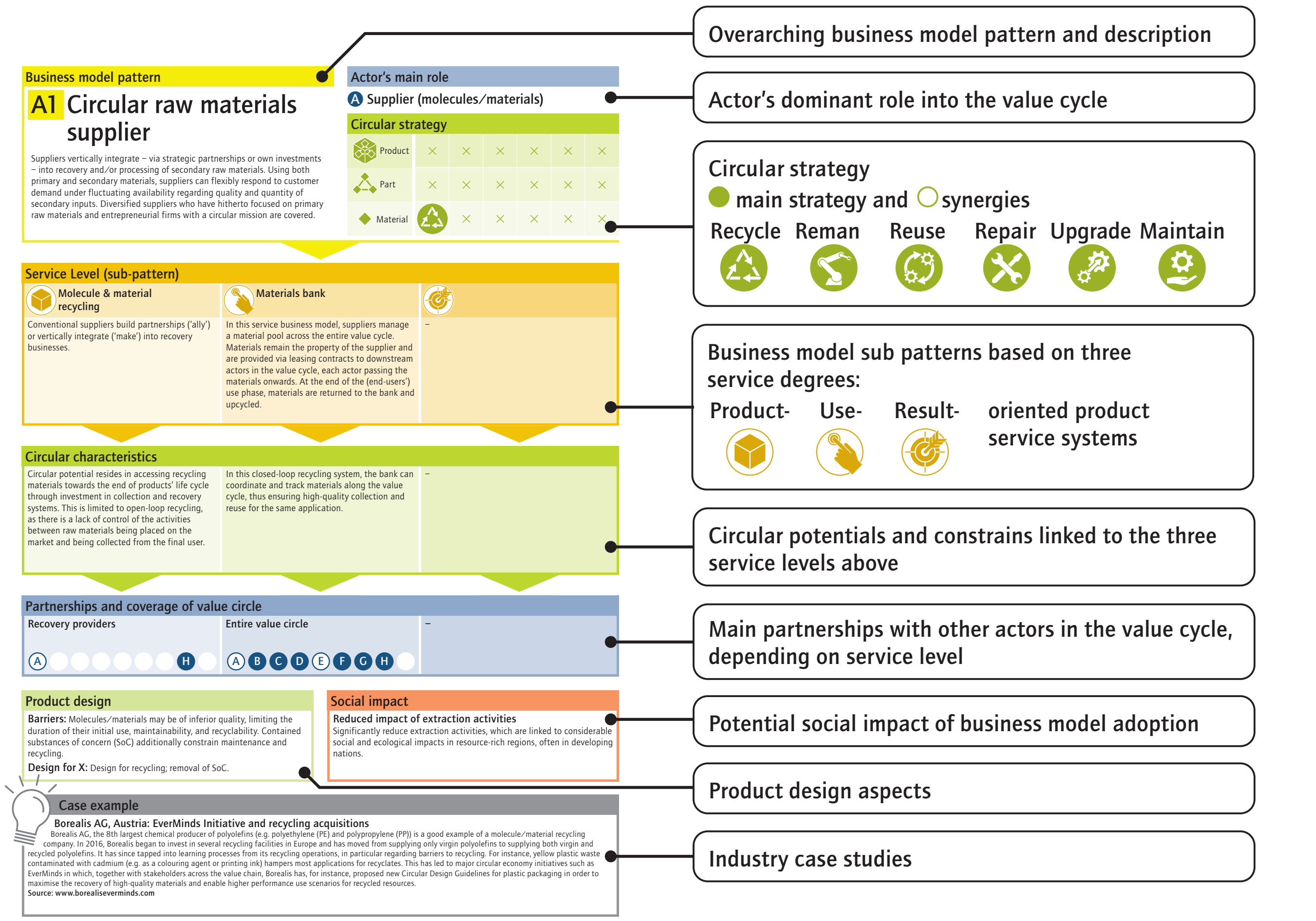


Figure 9: Guide to using the detailed specification of the business model patterns (Source: own presentation)

Actor's main role	Circular strategy	Id	Business model pattern	Service Level (sub-pattern)		
				Product-oriented	Use-oriented	Result-oriented
Supplier (molecules/ materials)		A1	Circular raw materials supplier	Molecule & material recycling	Materials bank	–
		A2	Process molecule service provider	–	Molecule & material leasing	Molecule & material performance
Supplier (mechanical engineering)		B1	Machines/components 'as new'	Machines/components 'as new'	Rental machines/ components 'as new'	Pay per reman machine performance
		B2	Machine/component remarketing	Used machines/ component sales	Rental machines/ components	→ see B1 Pay per reman machine performance
Producer		C1	Proprietary material cycles	Waste cherry picking	Materials bank partnership	–
		C2	Product 'as new'	Selling Products 'as new'	Product leasing 'as new'	→ see C6 Total care producer
		C3	Used product remarketing	Used product sale	–	–
		C4	Out-of-warranty repair service	On-demand repair	→ see C6 'Leasing producer'	→ see C6 Total care producer
		C5	Upgrades, spares & accessories	Modules & accessories shop	Upgrade subscription	–
		C6	Maximising product uptime	Fee-based maintenance	Leasing producer	Total care producer
Retailer & service points		D1	Retailer as cycle manager	Retailer as cycle manager	→ see C1 Materials bank partnership	–
		D2	Retail remarketing & reman	Used goods on sale	Rent-a-wreck fleet manager	–
		D3	One-stop shop (retail)	Integrated service point	Rental retail	Total care retail
Repair provider		E1	Repair gap exploiter	Repair transaction	Repair-based rental	–
Prosumer		F1	Prosumer support system	Do-it-yourself repair	Peer-to-peer sharing	–
Logistics provider		G1	Material reverse logistics	–	–	Pay per recycling logistics performance
		G2	Refurb logistics services	–	–	Pay per refurb performance
		G3	Spare parts management	–	–	Pay per spare part performance
Recovery manager		H1	Revitalised products	Used goods bargain	–	–
		H2	Coordinator of informal collection	Fair-trade recyclates	–	–
Intermediary		I1	Recycling platform	Recycling platform	–	–
		I2	Used goods & sharing platform	Used good platform	Sharing platform	–
Emerging actors	All	J1...x	?	?	?	?

Table 3: Overview of circular business model patterns and sub-patterns (Source: based on Hansen et al. 2020a, p. 13)

with retailers and local service shops. This requires core products to follow a modular design which makes them easily repairable either directly by consumers ('do it yourself') or by decentralised service points without any need for special training.

- **C6 Maximising product uptime:** Instead of increasing sales volumes, producers focus on long use based on high-quality products and intensive servicing. Preventive maintenance, sometimes with digitally-enabled monitoring, ensures product and component integrity and reduces the risk of failure. Intensive customer ties are developed, and further services (e.g. upgrades, repair, and take-back) can be added according to customised service level agreements.

Retailers & service points

- **D1 Retailer as cycle manager:** Retailers adopt a proactive role in managing packaging and related materials through vertical integration into or strategic partnerships with the recovery sector. They coordinate material flows between producers, retail, customers, recovery managers, and logistics firms with the vision of establishing closed (packaging) loops, both in technical loops (i.e. recycling) and biological loops (i.e. composting/biodegradation). Particular relevance for fast-moving goods sectors (e.g. food retail), where packaging considerably contributes to total product impact.
- **D2 Retail remarketing & reman:** Retailers specialise in or differentiate into used goods to access cost-sensitive customer groups. Used goods are of various conditions and qualities, but are provided with warranties. Some degree of refurbishment is usually also carried out (e.g. cleaning; repairs) and may even extend to full remanufacturing operations. Discarded goods are either sourced from own customers trading-in devices, or through larger business-to-business partnerships in which bulk quantities of discarded devices are acquired (e.g. when firms upgrade to new device generations).
- **D3 One-stop shop (retail):** As well as conventional sales, retailers offer extended services such as maintenance, repair, upgrading, and take-back.

Repair providers

- **E1 Repair gap exploiter:** Third-party service provider for repair and maintenance (possibly refurbishment) operating either in cooperation with producers and retailers (i.e. service partnerships), or – if no or no attractive offers are available from focal actors – working independently as 'gap exploiters'. Services may be offered online with national or even international reach, at local service points, or as a delivery service.

Prosumers

- **F1 Prosumer support system:** Alternative non-market circular model based on self-sufficient lifestyles, self-help, and the 'right to repair'. It is supported by several non-commercial initiatives (e.g. repair cafés) and commercial support business models (e.g. C5 Upgrades, spares & accessories). New technologies such as 3D printed spare parts additionally enable self-help by users. Producers lose control over products, except when providing commercial support services themselves (e.g. spare parts).

Logistics providers

- **G1 Material reverse logistics:** Reverse logistics providers specialise in recycling logistics. They collect materials (as incorporated in products) from customers or retail, conduct value-added activities (e.g. pre-sorting, cleaning, recycling), and deliver the secondary material to either the original source of the materials (e.g. producers, materials banks) or resell them on (electronic) markets, sometimes via intermediaries and related platforms. Depending on the value-added activities, logistics providers may themselves act as recovery managers.
- **G2 Refurb logistics services:** Logistics providers plan and operate product returns for producers or retailers. They link returned products from customers or points of sale and value-added services such as refurbishment with remarketing channels by producers, retailers and/or recovery managers. On the basis of an initial quality check of returned goods, logistics providers make decisions about the best possible circular strategy: direct reuse, some degree of refurbishment (e.g. repair, polishing, repackaging), or, if technical or economic reasons prevent reuse, material recycling.
- **G3 Spare parts management:** Based on clients' outsourcing, service providers manage spare part-related activities (this may include modules for upgrading) including delivery, exchange/repair, return management, reuse or refurbishment of used parts, and recycling of waste components/materials. Spare parts logistics either supports the clients' own infrastructure/assets (i.e. to maximise uptime) or after-sales services for their products in the market (e.g. car repair). Specialised logistics providers leverage economies of scale across clients.

Recovery managers

- **H1 Revitalised products:** Actors from the recovery/waste management sector refurbish publicly collected products/materials, carry out quality controls, and put used goods/recyclates back on the market on either a non-profit or for-profit basis.

- **H2 Coordinator of informal collection:** The coordinator serves as a hub for informal waste pickers and organisations with demand for recyclates. Waste pickers collect materials from littering or households and sell it to the coordinator. The coordinator may sell pooled materials directly or engage in various value-added activities as a secondary raw materials producer and then sell recyclates on the market.

Intermediaries

- **I1 Recycling platform:** Business-to-business platform business model which provides electronic marketplaces to match supply and demand for residual, used, or wasted materials.
- **I2 Used goods & sharing platform:** Platform business models provide an electronic marketplace to match supply and demand for used products or components. The electronic platform minimises transaction costs for sellers and buyers (e.g. search, communication, and negotiation costs).

4.3 Combinations of business model patterns

It is important to bear in mind that a circular business model (CBM) pattern is not necessarily a complete business model. Most CBM patterns refer to certain aspects of a business model (e.g. its value creation philosophy, or a certain approach to transferring value), meaning they can be viewed as partial business models. Therefore, it is **important to consider combinations of different patterns** (e.g. the producer's 'maximising uptime' business model pattern can be combined with the 'proprietary material cycles' pattern), which means that a huge variety of overall CBM designs can be derived from the proposed typology. Synergistic use of a number of patterns (and related circular strategies) will advance circularity more holistically and increase positive environmental impact. Moreover, CBMs from various actors have to be combined and orchestrated in an ecosystem in order to make long-term business sense.

5 Barriers to circular business models

As presented in the previous chapter, there is a broad spectrum of possible business models that support the transition towards a Circular Economy (CE). Nevertheless, the actual implementation and diffusion of circular business models (CBMs) is still slow and is hindered by a broad variety of different barriers.

In order to analyse and understand why CBMs often still remain in a market niche and are not yet the business norm today,[96] we must first introduce a barrier framework and an overview of potential barriers. This is helpful as a starting point and can spur reflection and discussion about relevant barriers and serve as a basis for prioritising the most relevant factors hindering the implementation, scaling, and diffusion of CBMs. However, in the '**real world**', **actors in the value chain are interrelated in multiple ways** and are therefore confronted with a variety of interlocking or nested settings that – sometimes separately but often jointly – present barriers. These 'nested realities' or configurations will be the focus of the following sections. The outlined 'real-world configuration approach' is integrative in nature and is applied to the five selected circular strategies already presented in the previous chapter. We will thus analyse and **discuss relevant barrier configurations** in relation to maintenance/upgrading, repair, reuse, remanufacturing and recycling. On the basis of these main interrelated barrier patterns, we will identify integrated solution approaches and recommend short-, medium- and long-term measures to overcome them.

5.1 Barrier framework and overview of potential barriers

On the basis of an extensive literature review and a survey of working group members**, we identified sets of more than 80 barriers that are potentially hindering the implementation and diffusion of circular business models** (CBMs). The literature proposes different schemes and categories for classifying single barriers.[97] These comprise categories such as cultural, institutional, regulatory, policy, market, value chain, financial, business model, organisational, technological and individual barriers. Based on evolutionary economics and insights into path dependencies, the literature on the diffusion of environmental product and service innovations also suggests path-related barriers.[98]

We have examined the overlap and consistency of different categories and checked whether individual barriers can be assigned sufficiently clearly and validly to specific categories. As already explained in Chapter 3.1, we take an actor's perspective. Therefore, we considered how well a barrier category can be related to key actors and actor roles in the transformation towards a CE. On this basis, we derived six categories which we consider to be appropriate for the purpose of our analysis of barriers to the implementation and diffusion of CBMs. Four of these categories directly relate to key actors of a CE such as policy making and governmental institutions (regulatory barriers), companies (financial and organisational barriers) and consumers (consumer barriers). Two additional categories address cross-cutting factors and issues such as value chain-related barriers and technical barriers. On this basis, we classify barriers as follows:

1. **Regulatory barriers**: These comprise policy-related and institutional factors and primarily relate to policy making and governmental institutions.

2. **Financial barriers**: These comprise factors that influence the funding and revenue model of CBMs negatively. They relate to companies providing circular products and services.

3. **Organisational barriers** consist of corporate actors (incumbents of various sizes as well as start-ups) and respective organisational factors that are hindering the implementation or scaling of CBMs.

4. **Consumption-related barriers** are linked to the perceptions and practices of end users which considerably hinder or slow down the implementation or scaling of CBMs.

5. **Value chain barriers** comprise all market- and network-related factors and aspects along the value chain that are hindering the implementation or diffusion of CBMs. Because consumers and users are a key actor group, we have classified consumption-related barriers in a separate category (see above).

6. **Technical barriers** relate to the life cycle of materials and products (research & development, design, production, take-back etc.) and comprise technical factors that hinder CBMs.

96 | See European Commission 2015.

97 | See Jesus/Mendonça 2018; Guldmann/Huulgaard 2020; Henry et al. 2020; Kirchherr et al. 2018; Kissling et al. 2013; Mont et al. 2017; Ranta et al. 2018; Rizos et al. 2016; van Eijk 2015; Hansen/Schmitt 2020.

98 | See Clausen/Fichter 2019.

These categories suggest that not all barriers relevant to CBMs are on a corporate level. The implementation and diffusion of CBMs is also heavily influenced by other actors in the value chain and the ecosystem and should be conceptualised as part of a multi-level-system of a transition process towards a CE.[99]

A complete list of the identified potential barriers to the implementation, scaling and diffusion of CBMs is shown in the Appendix E.

5.2 Real-world configurations of barriers: An integrative approach to analysing hindering factors

Typologies of barriers to the CE often set apart different single factors or elements for reasons of clarity and overview. We do this in Table 18 (see Appendix E). This is helpful as a starting point and can spur reflection and discussion about relevant barriers and act as a basis for prioritising the most relevant hindering factors for the implementation, scaling and diffusion of circular business models (CBMs). Typologies typically focus on different actors or stakeholders along the value chain or discuss specific dimensions of barriers separately. In the 'real world', however, actors in the value chain are interrelated in multiple ways and are confronted with a variety of nested settings that – sometimes separately but often jointly – present barriers.

These 'nested realities' or configurations will be the focus of the following sections. Configurations are defined here as an arrangement of parts or elements that are mutually related and act for example upon the practices of producers or users of products. As shown in Figure 10, **we take account of the mutual relationships of providers** (supplier, producer, retailer, repair provider, logistics provider, etc.), **users** (professional users such as businesses as well as consumers) **and the product** (i.e. technology, design) **and related services**, each characterised by particular properties. We treat products and services as discrete agents in the triangle, since their properties (design, materials, functions etc.) have a particular influence on the success of business strategies and business models, which merits specific investigation. The interrelations and interactions of these three agents on the market are embedded in a range of settings that frame and influence their practices. These are political, cultural and market (or infrastructural) settings as well as technology research and development and the business sector.

This conceptualisation connects us to the three core components of our CBM typology (see Chapters 3.1-3.3). We accordingly

- apply an actor's perspective and focus on different types of provider roles and user roles,
- follow the understanding of physical products and material flows as part of product-service systems,
- and use the five circular strategies identified in Chapter 3.2 as a central reference point for the integrated consideration and analysis of barriers as they arise in the real world for those who want to implement and scale circular business models. The key role of design for circularity relates to all five circular strategies and is considered as integral element of these strategies.

99 | See Flynn et al. 2019; Geels et al. 2016.

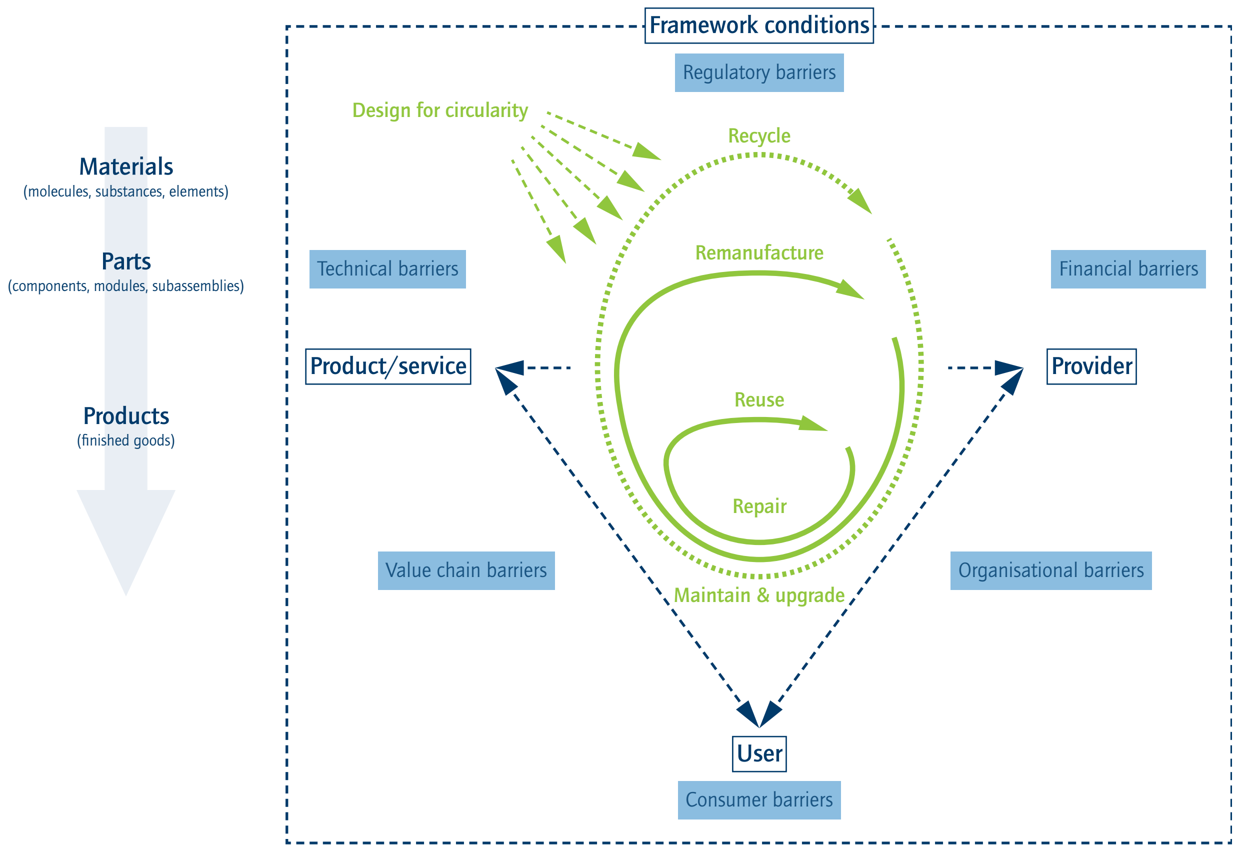


Figure 10: Barrier framework (Source: own presentation, based on resource states framework by Blomsma/Tennant 2020)

5.3 Barriers to maintenance and upgrading

5.3.1 Relevant business model patterns

We have identified the following business model patterns (see overview in Chapter 4.2 and patterns in detail in Appendix D) as relevant to the CE strategy of maintenance and upgrading:

- Process molecule service provider (A2)
- Upgrades, spares & accessories (C5)
- Maximising product uptime (C6)
- One-stop shop (retail) (D3)
- Prosumer support system (F1)

5.3.2 Main interrelated barrier patterns that need to be tackled

One particular major challenge for maintenance services derives from the nature of the practice itself: **maintenance is an ongoing process, requiring continuous monitoring of the product and its performance and proximity between maintenance providers and objects to be maintained, e.g. through local service points.** This challenge meets a configuration of barriers that create a considerable structural distance between users and providers. The concept of value proposition from manufacturers is mostly product-oriented, which also determines customer relationship management:[100] the main and often only interface between product manufacturers and users is the point of sale, whereas the provision of maintenance services relies on interfaces during the use phase of products. These interfaces need to be established in terms of procedures and infrastructure: a maintenance provider needs to define for example processes for exchanging information about the status of a product and the maintenance intervals and tasks. Furthermore, infrastructure such as service centres and a field workforce network need to be established. A major challenge is that these kind of procedures and infrastructure have tended to be more on the decline than the increase in recent decades. **Product manufacturers and users have become more and more remote** and alienated from each other in this process, despite

100 | See Ryan et al. 2014.

brand loyalty being an important marketing objective of many companies.[101] The structural and geographical distance between producers, service providers and users is a key barrier to maintenance and upgrading offerings.

Additionally, the distance between producers, service providers and users is also of a social nature and creates **a knowledge gap between the information that is required for maintenance and the information that is available**. This knowledge gaps connects to several barriers. The possibility and ease of **maintenance is often not considered in the product design and decisions about maintenance requirements** build on a particular knowledge base that is often not present in product development teams.[102] Thus, knowledge about proper maintenance builds up from user experience, but due to the lack of interfaces between product/service providers and users, it is costly and time-consuming to gain the necessary information. These information and exchange requirements mean that establishing maintenance services is mainly perceived as a burden and financial risk.[103] This is why product design is today mostly optimised for initial user benefit including price and not for maintenance and longevity.

Knowledge barriers can also be found on the **part of the product users**: A considerable number of consumers describe their **knowledge on proper product maintenance as rather** low, they sometimes even have incorrect beliefs about the possibilities open to them for prolonging product lifetime.[104] If maintenance is provided in combination with leasing or renting a product, consumers also tend to overuse or misuse products.[105] An additional element in the user-related issue is price sensitivity to maintenance costs in comparison to product cost.

The organisational routines of many producers to date mainly **lack proper implementation of maintenance-related practices and infrastructure.**[106] A literature review also reveals a lack of training, commitment and empowerment of employees concerning maintenance tasks.[107] This can be due to another configuration of barriers that we refer to as 'economic devaluation of maintenance and upgrading. One main cause of the mentioned lack of procedures and structures might be the general perception of maintenance and upgrading services as a costly add-on rather than added value. Maintenance is mainly treated as something that needs to be done to keep the product functioning and not as an important value proposition. In addition, product users perceive maintenance as additional costs,[108] instead of as an inherent part of handling products. This devaluation is also revealed by the fact that measures of success and good performance are mainly product-oriented (e.g. sales volumes[109]), and there are few indicators available for observing and measuring the effectiveness of maintenance services.[110]

One important barrier that cuts across all the configurations above is that **maintenance and upgrading strategies are often not part of corporate cultures.**[111] Traditional manufacturing values focus on efficiency and economies of scale,[112] which means that the value proposition should be as standardised and predictable as possible. But **providing maintenance and upgrading requires flexibility and variety as a driver of profit**, these being service-oriented values focusing on innovation and customisation. Much like the value proposition, manufacturers' knowledge and communication management is product-centric,[113] with the product mainly being seen as a static object that is handed over to the buyer at the point of sale. Maintenance and upgrading services are linked to the performance of the product during use, which changes over time, and therefore requires a more flexible and dynamic management of customer relationships. These requirements could lead to a perception of the unsurmountable costs of flexibility and a resistance to change on the part of producers and consumers alike.[114] It is important to note that the increasing number of smart and digitalised products is making the question of maintenance and upgrading ever more topical. The question of how long producers should for example provide users with software updates and upgrades is increasingly considered in the Ecodesign and other product-related directives. Similarly, the 'downsides'

101 | See Fuchs et al. 2016.
102 | See Bertoni/Larsson 2010.
103 | See Kuo et al. 2010.
104 | See Jaeger-Erben 2019; Jaeger-Erben/Hipp 2018.
105 | See Sjödin et al. 2017.
106 | See Singh et al. 2016.
107 | See ibid.
108 | See Mont 2002.
109 | See Ryan et al. 2014.
110 | See Singh et al. 2016.
111 | See Ryan et al. 2014.
112 | See ibid.
113 | See ibid.
114 | See Kuo et al. 2010.

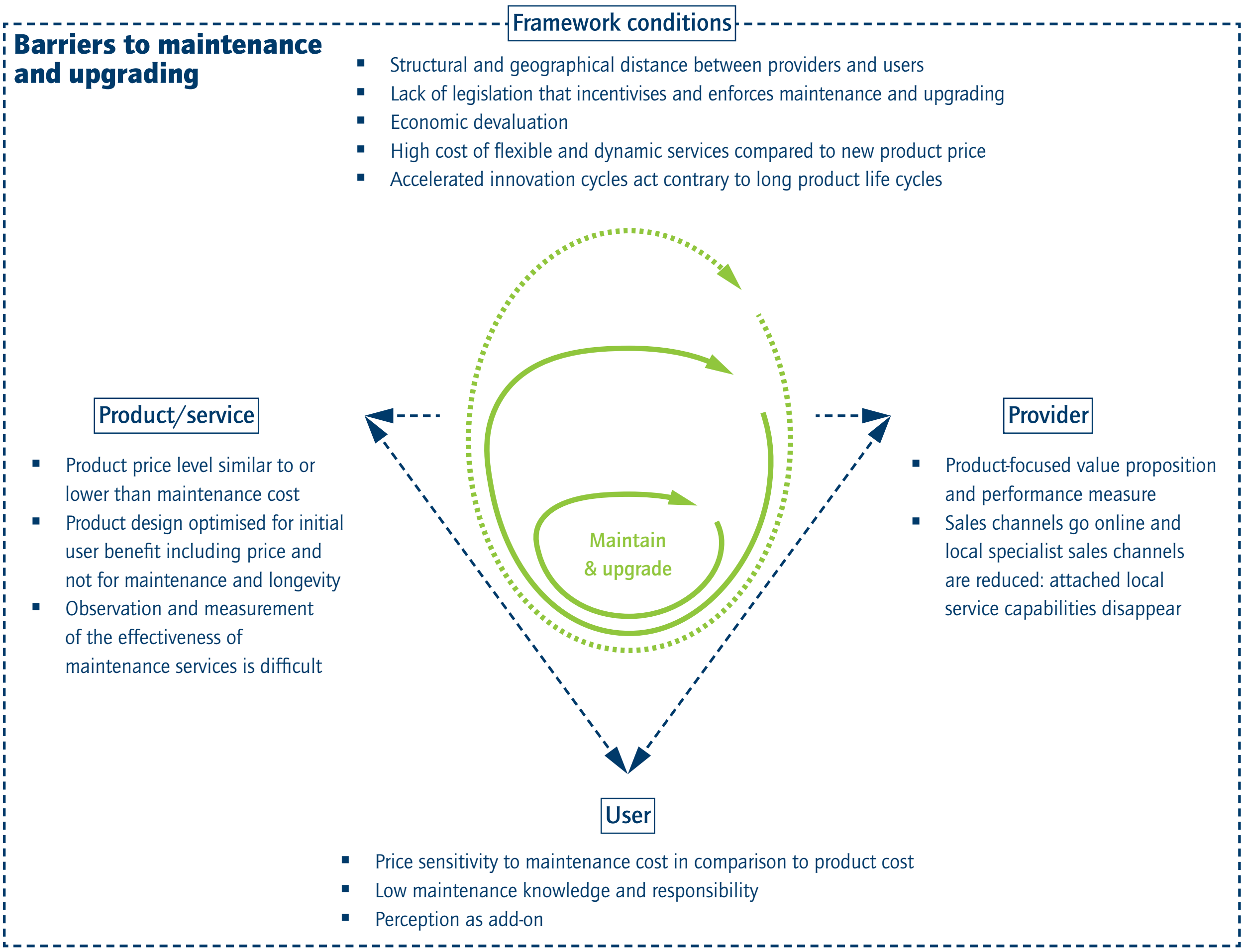


Figure 11: Barriers to maintenance and upgrading (Source: own presentation)

of hardware upgrades in new versions of a product (e.g. new interfaces and standards) should also be critically considered as these are sometimes used to create technological obsolescence in former product versions. Part of the provider-related issue is that sales channels are increasingly going online and local specialist sales channels are reduced. The unavailability of local service capabilities then represents another barrier to maintenance and upgrading services.

5.3.3 Integrated solution approaches[115]

In the short term, integrated strategies to **establish maintenance as an asset and not a burden to product and services providers** are important for reducing barriers to maintenance as a service. A fairly easy to implement strategy could be to foster practices and structures of knowledge sharing and knowledge production for providers as well as users of products and services. The creation of wikis or other knowledge-sharing platforms[116] or of a maintenance-related app (following the example of the iFixit-app for repairs) could be two examples here. Furthermore, the 'point of sale' might be an important entry point not only for the provision of knowledge from providers to consumers, but also for training staff to perform maintenance or small repairs as a service. A more demanding strategy would be to invest more in maintenance-related research and development, e.g. with appropriate research funds and investment policies that cover both the design for maintenance and maintenance-related technological and business innovation. Also demanding but with high potential are organisational strategies for the establishment of service hybrids that combine maintenance and upgrading with other product services

115 | The integrated solution approaches derive from the analysis of barriers and joint discussions in the working group's taskforce on barriers and were elaborated against the background of existing literature.

116 | See Ryan et al. 2014.

Difficulty	Short-term importance 'Maintenance as an asset not a burden'	Medium-term importance 'Invest in service innovation instead of product innovation'	Long-term importance 'Build architecture of product responsibility'
Low	▪ Foster knowledge sharing and joint knowledge production (e.g. maintenance wikis, "ICareForIt" app)	▪ Organise fairs for innovations in maintenance and upgrade services	▪ Increase proximity between providers and users by providing better access to (virtual) service points
Medium	▪ Enhance relevant knowledge with maintenance/upgrade-related research and development ▪ Create legal and technical frameworks for easy product monitoring	▪ Implement economic policies to nudge service innovation (instead of product innovation)	▪ Create policies for citizen consumers
High	▪ Create service hybrids that combine maintenance and upgrades with other product services (i.e. renting)		▪ Integrate consumer responsibilities in service contracts (and reward them)

Table 4: Integrated solution approaches to maintenance and upgrading (Source: own presentation)

like renting or leasing. Even though this model is common in the B2B sector, it is uncommon in the B2C sector, despite the fact that several studies suggest that, through bundling product-and-service components, manufacturers could fulfil their customers' needs more effectively, increase their satisfaction and ensure long-term competitive advantages by adopting this model.[117]

In the medium term, integrated strategies that **enhance a general orientation towards service innovation instead of product innovation** are important. The fact that business strategies and practices are mainly oriented towards products should be counteracted by drawing attention to product-service systems.[118] Organising and promoting fairs or trade shows on service innovations, particularly for maintenance and upgrading services, could be a low-hanging fruit here. This form of 'maintenance marketing' could support more structural measures like economic policies that nudge incumbents as well as start-ups to invest more in developing and establishing service innovation (rather than product innovation).

Strategies with a long-term perspective could aim towards **building architectures of product responsibilities among all market participants, allowing the sharing of risks between providers and users.**[119] These responsibilities could be enhanced by virtual and physical infrastructure that enable greater proximity and a better flow of information between product/service providers and product users.[120] Since this infrastructure requires a sound legal framework, e.g. regarding data protection and ownership issues, it must be a long-term endeavour. Long-term policies could also enhance the self-perception of users as 'citizen consumers'.[121] A strategy which is more difficult to implement could be to integrate user responsibilities into service contracts to formalise shared product responsibility. In the same way as health or car insurance policies reward healthy lifestyles or careful driving, these contracts could reward careful consumers.

5.4 Barriers to repair

5.4.1 Relevant business model patterns

We have identified the following business model patterns (see overview in Chapter 4.2 and patterns in detail in Appendix D) as relevant to the CE strategy of repair:

- Out-of-warranty repair service (C4)
- Upgrades, spares & accessories (C5)
- One-stop shop (retail) (D3)
- Repair gap exploiter (E1)
- Prosumer support system (F1)
- Refurb logistics services (G2)
- Spare parts management (G3)

117 | See Gullstrand-Edbring et al. 2016.
118 | See Mont 2002.
119 | See Sjödin et al. 2017.
120 | For a detailed analysis of the potential gains from data sharing among actors along the entire life cycle of traction batteries in the context of e-mobility solutions, see also the published report of the CEID working group on traction batteries; see acatech/*Circular Economy Initiative Deutschland*/SYSTEMIQ 2020.
121 | See Schrader 2007.

5.4.2 Main interrelated barrier patterns that need to be tackled

The overall configuration that creates barriers to business models based on repair is the **cultural marginalisation of repair in modern societies**. In recent decades, repair practices have undergone a gradual structural change that runs contrary to the goals of a CE.[122] Repair professions are in decline[123] and repair businesses seem to be only worthwhile if repair is undertaken as a secondary business.[124] In B2C markets, users have few skills in and little knowledge about device repair and functionality and many do not have the know-how and support to be able to assess the reparability of damage.[125] Even in a B2B context, condensed knowledge about machines used for many years dwindles over time, due to e.g. insufficient knowledge transfer during employee changes. Thus, a disintegration of collective repair knowledge can be observed as a part of the cultural marginalisation of repair. At the same time, the behavioural costs in terms of time, effort and money appear to users to be much lower for new purchases than for repair.[126]

These cultural and knowledge barriers are closely related to a structural difficulty of repair that tends to inhibit rather than enable repair. **Currently, the profitability of repair is relatively low for the various market participants** (customers, repairers, retailers and manufacturers), **especially for low-value products.**[127] Business models built on repair services are heavily reliant on cooperation and collaboration with other market stakeholders, which is a challenge in a highly competitive market.[128] Independent repair businesses for example depend on knowledge of manufacturers' design plans and the availability of and access to spare parts from component suppliers across the value creation network.[129] Particularly in the case of long-lasting products, there is a significant problem of component discontinuation which even relatively large market players regularly face.[130] Producers, on the other hand, are unwilling to give insights into their product designs, as they might reveal business secrets that could lead to a loss of competitive advantage. **While access to and an efficient exchange of information and low transaction costs are basic to functioning markets, the repair market seems to be dysfunctional in this regard.**[131] In addition, operating a worldwide flexible spare parts network, which provides short-term access to product modules and repair services for several years, is associated with a substantial cost structure and also causes environmental costs (e.g. provision of facilities, air and temperature regulation) that could offset the ecological benefits of longer lifetimes. One consequence which can be observed is a decline in small regional repair businesses and associated capabilities.

Poppe (2016) has shown that despite the infrastructural and economic relevance of repairs, there have been significant shifts in the cost ratio in the area of commercial repairs over the past decade. Sales growth for repair services is mainly due to rising expenses for materials and the gross added value is significantly below average across all economic development. This structural difficulty leads to **high transaction costs for all participants in repair endeavours**. Meanwhile intensive technology research and development has brought about more and more complex products; even simple consumer electrical goods such as kettles are increasingly equipped with electronic gadgets like touchscreens or wireless connection. Many products are not designed for reparability or easy dismantling.[132] Miniaturisation, modularisation and the increasing importance of waterproofness make repair a cost- and time-intensive endeavour. The dominance of linear product designs thus increases transaction costs and reproduces the structural difficulties. Even though political interest in repair, particularly as a strategy relevant to the CE, has grown considerably in recent years, the described barriers are to some extent due to long-term political neglect of repair, despite its major significance in economic systems.[133]

5.4.3 Integrated solution approaches

Despite the discussed difficulties and barriers to business models built on repair, preserving and improving repair potential have

122 | See Paech N. et al. 2020; Deloitte 2016; Bizer et al. 2019; Poppe 2014.
123 | See CEID 2020; Poppe 2014.
124 | See Poppe 2014.
125 | See Jaeger-Erben et al. 2020.
126 | See Sabbaghi et al. 2016; McCollough 2009.
127 | See Deloitte 2016.
128 | See Poppe 2014; Bizer et al. 2019.
129 | See Hansen/Revellio 2020.
130 | See for example the German industrial interest group 'Component Obsolescence Group' which deals with the challenge of obsolescence management, https://cog-d.de/.
131 | See Deloitte 2016.
132 | See Pickren 2014.
133 | See Krebs et al. 2018.

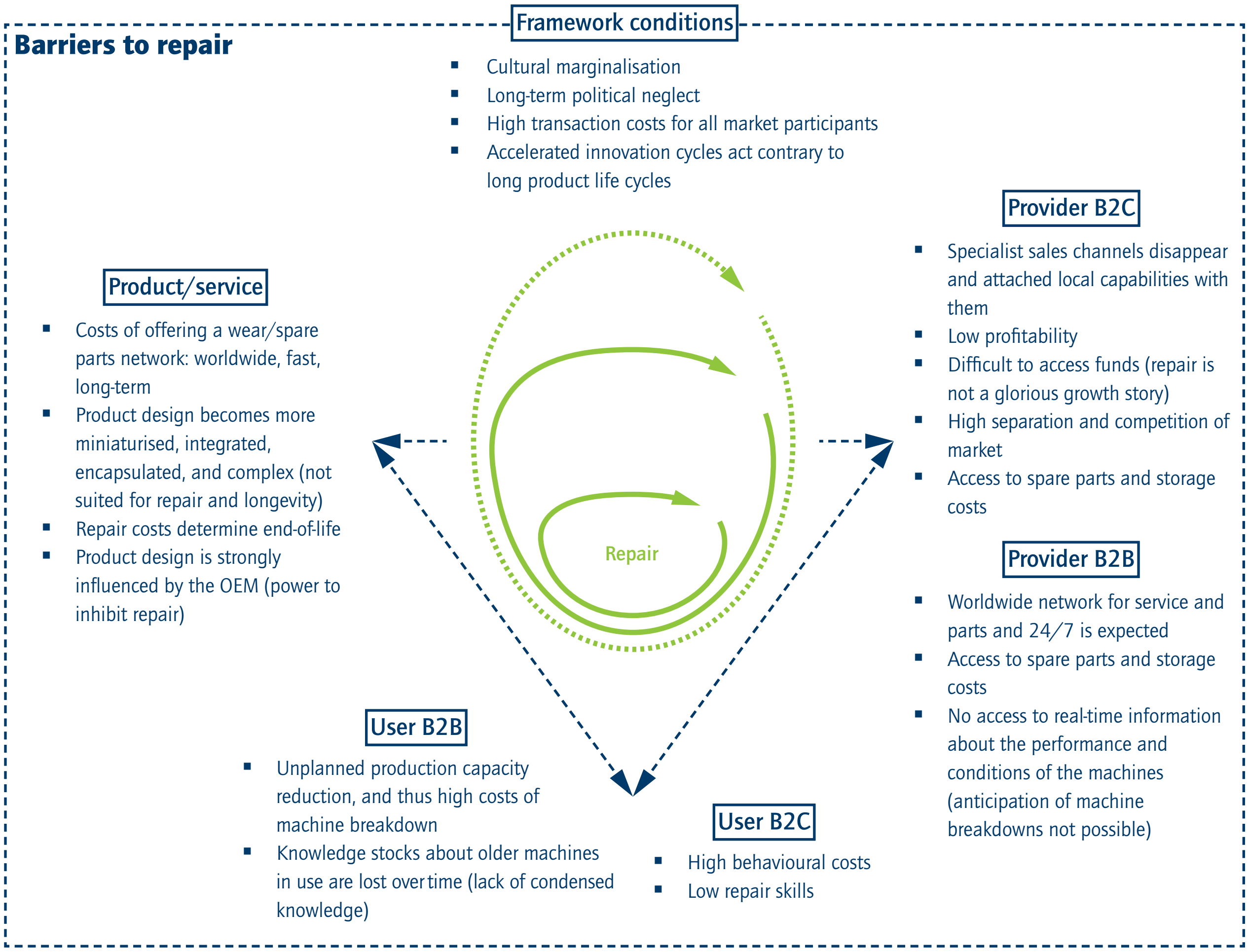


Figure 12: Barriers to repair (Source: own presentation)

become increasingly important as key economic and technological factors in recent years.[134] Intelligent configurations of solutions to overcome existing barriers should be built upon these promising foundations.

Concerted strategies to **decrease transaction costs for all participants in the value chain** are of short-term importance. These might involve combinations of regulations, tax reductions and subsidies that favour repair and facilitate the adoption of repair business models.[136] Strategies that enhance design for repair can be integrated into product-related regulations while, at the same time, the relevant knowledge base should be created, e.g. by encouraging open-source design and knowledge sharing. Important medium-term strategies are those that build structures and networks of repair in the economy and society. Examples could be the formation of repair alliances between different sectors and stakeholders in the market (incumbents, start-ups, research institutes, NGOs, policy makers, consumer associations, etc.) at a national or European level. These alliances could be scaled up to global networks and formalised along the value chain. Furthermore, new digital technologies can play an important role in the effective practical implementation and design of business models based on repair. For example, modularly designed products or machines can feature integrated sensors that make it possible to obtain real-time information about the current status, performance and condition of the equipment. The data obtained through big-data analyses could identify potential failure mechanisms in advance and reveal vulnerabilities in order to anticipate machine breakdowns/product failures and derive measures for extending their lifespans.

134 | See European Commission 2019; BMU 2019.
135 | See Krebs et al. 2018.
136 | See also the scenarios on the socioeconomic impacts of increased repairability developed by Deloitte (2016) for the European Commission.

Difficulty	Short-term importance	Medium-term importance	Long-term importance
Low	▪ Integrate repairability into the Ecodesign Directive ▪ Increase visibility and accessibility of repair services	▪ Form a national or Europe-wide intersectoral repair alliance	▪ Carry out concerted political, business and NGO information campaigns for the 'right and duty to repair'
Medium	▪ Offer tax cuts and subsidies for repair business models ▪ Adopt a stewardship role (function- and service-oriented product system solutions) ▪ Encourage open source design and knowledge sharing ▪ Create legal and technical frameworks for easy product monitoring	▪ Stabilise formal repair networks along global value creation networks ▪ Adopt new digital technologies, e.g. to enable real-time production condition management ▪ Establish public funds for business ventures following repair strategies ▪ Arrange experimental spaces for organisational realignment (at business level)	▪ Make transaction costs for repair lower than for producing/buying new
High	▪ Increase availability and accessibility of spare parts	▪ Professionalise the repair sector ▪ Make repair a basic skill in school education	▪ Foster a renaissance of repair as a cultural technique ▪ Measure business success using balanced ecological, social and financial performance indicators ▪ Overcome the economic growth imperative

Table 5: Integrated solution approaches to repair[135] (Source: own presentation)

More difficult to implement, but with a promising long-term effect, are integrated strategies to **foster training and education for repair.** These could be formal training programmes to re-establish the repair profession but also the inclusion of repair as a basic skill in school education. Important long-term strategies are those that sometimes require and rely on more or less evolutionary processes to foster a comeback of repair into mainstream economic and social practices.

5.5 Barriers to reuse

5.5.1 Relevant business model patterns

We have identified the following business model patterns (see overview in Chapter 4.2 and patterns in detail in Appendix D) as relevant to the CE strategy of reuse:

- Machine/component remarketing (B2)
- Used product remarketing (C3)
- Retail remarketing & reman (D2)
- Refurb logistics services (G2)
- Revitalised products (H1)
- Used goods & sharing platform (I2)

5.5.2 Main interrelated barrier patterns that need to be tackled

The overarching hurdle that must be overcome to create sustainable and economically viable business models based on a reuse strategy is **the ubiquitous mantra of product novelty**. The new is perceived as desirable, it is socially undisputed; it gives a sensation of being modern and progressive and of not being left behind in an accelerating society.[137] In contrast, an 'already used condition' is associated with attributes such as backwardness, antiquity and dispensability. The desire for something new and the strong social emphasis on novelty means that consumers tend to prefer new purchases over the reuse of existing products.[138] Various studies show that customers consider products with an extended lifetime to be less attractive.[139]

At the business level, the current dominant understanding of innovation and the creation of competitive advantage focuses on new product development and associated technical innovation. Providing this leads to the development of innovative products which are sustainable and durable, this is no problem. **At present, new product development is too often linked to 'fast-moving products' that are worn out after a short time** and then have to be discarded and absorbed into the cycle. With this dominant innovation philosophy, firms must shorten innovation

137 | See Rosa 2005; Steffen et al. 2005.
138 | See Höfner/Frick 2019.
139 | See Govindan/Hasanagic 2018; Masi et al. 2017; Tura et al. 2019; Vermunt et al. 2019.

cycles, reduce time-to-market and maximise the number of newly developed products within a certain period of time to survive the competition of technological change. It is thus often argued that firms will cannibalise their own markets for newly launched products if they launch business models based on reuse strategies. Cannibalisation effects result from the competing marketing of slightly modified products at different prices by the same firm. This may lead to the cheaper reused product displacing the new incrementally altered product version, thus potentially decreasing the sales of the newly launched product.[140]

Another important barrier to the diffusion of the reuse strategy is the **existing power asymmetries between the participating actors in value creation networks**. Crucial to the success of value creation modes following reuse patterns is product design, which is strongly influenced by the producer of the product.[141] Therefore, the design decision determining whether a product is reusable lies with the producer of the product. For independent reuse organisations, it might become more difficult, less cost effective or even impossible to carry out reuse value creation modes.[142] **In some cases, producers proactively obstruct or prohibit the redistribution of their low-priced used equipment**, since they fear negative effects on the market for new products (e.g. the case of Sonos speakers).

Essential to the reuse strategy is access to and the collection of discarded products through the organisation of take-back systems and reverse logistics. A key challenge facing reuse value creation modes is the **sourcing of sufficient volumes of good quality used products**. The timing and quantity of the returned products

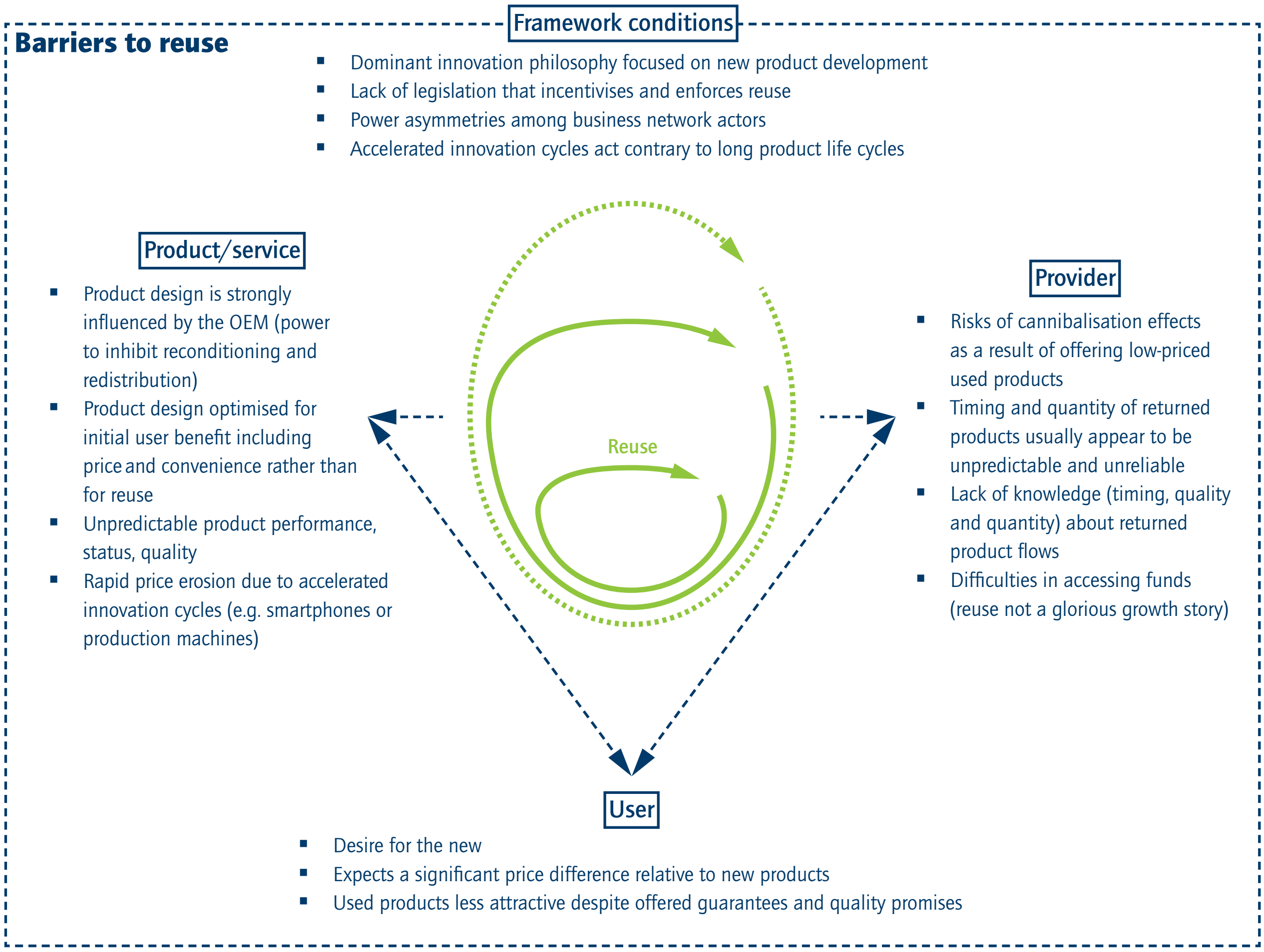


Figure 13: Barriers to reuse (Source: own presentation)

140 | See Matsumoto et al. 2016.
141 | See ibid.
142 | See Kissling et al. 2013; Govindan/Hasanagic 2018.

usually appear to be unpredictable and unreliable.[143] Moreover, it tends to be difficult to access products with reuse potential as this obviously depends on the usage behaviour of the previous owner.[144] As indicated by Kissling et al. (2013), the barriers which hamper the successful establishment of redistribution systems are reinforced by a lack of legislation that incentivises and enforces value creation modes involving reuse strategies. For example, current public and industry organised collection schemes are designed mainly for achieving recycling quotas and, while reuse goals do exist, shortfalls in mandatory quotas lead to ever decreasing reuse rates.[145]

There are no comprehensive economic and political structures that systematically support value creation modes built on reuse practices. Reuse, like repair and maintenance, suffers from cultural marginalisation and economic devaluation in a modern society where the promise of human progress is grounded in novelty.

5.5.3 Integrated solution approaches

To overcome barriers to reuse, various actor-specific and structural measures exist. Among others, Bocken et al. (2016), Hofmann (2019) and Lüdeke-Freund et al. (2019) point out that firms might adopt a stewardship role to reduce dependence on other value creation network actors, and therefore **reduce power concentration by shifting from selling physical products to providing function- and service-oriented system solutions**. Manufacturers and service providers who assume a stewardship role value the product, product components, and natural resources as capital assets rather than consumables. To perform an effective stewardship role, firms should establish reverse logistics systems to ensure access to and return flow of products to recapture the product's remaining inherent value. Function- and service-oriented system solutions combined with reverse logistics enable reuse strategies, with the expectation of dematerialising production and consumption patterns. In addition, through the application of new technologies (e.g. product tracking systems, identification technologies), firms can generate real-time information to monitor and manage them.[146] Access to the product's state, location, use intensity, and availability is obtained and can thus improve product reusability. As in the case of tackling barriers to maintenance and upgrading, **leasing and renting contracts (function-oriented system solutions) should be designed to ensure that users treat products with care and attention**.

Obviously, data protection and data security must be emphasised to prevent surveillance and discrimination, and so prevent individual network actors from accumulating knowledge and concentrating power.[147] Building and restoring the trust of the various value creation network actors then becomes a critical

Difficulty	Short-term importance	Medium-term importance	Long-term importance
Low	▪ Increase visibility and accessibility of used products	▪ Increase visibility and accessibility of function- and service-oriented product system solutions (instead of promoting product sales)	▪ Carry out concerted political, business and NGO information campaigns in favour of reuse products to boost their attractiveness
Medium	▪ Tax reductions and subsidies for reuse business models ▪ Adopt a stewardship role (function- and service-oriented product system solutions) ▪ Encourage open-source design and knowledge sharing ▪ Create legal and technical frameworks for easy product monitoring	▪ Adopt new digital technologies ▪ Establish public funds for business ventures following reuse strategies ▪ Arrange experimental spaces for organisational realignment (at business level) ▪ Establish public funds to promote service innovation (instead of product innovation)	▪ Integrate consumer responsibilities in service contracts (and reward them)
High		▪ Reinforce collaboration among global business networks	▪ Measure business success using balanced ecological, social and financial performance indicators

Table 6: Integrated solutions approach to reuse (Source: own presentation)

143 | See Linder/Williander 2017; Kissling et al. 2013.
144 | See Shi et al. 2019.
145 | See Verbraucherzentrale Bundesverband e.V. 2019.
146 | See Alcayaga et al. 2019; Franco 2017.
147 | See Hofmann et al. 2019.

success factor.[148] Strategies to foster or encourage **knowledge sharing and transparency as well as practices such as open design and open-source approaches could strengthen collaboration** within value creation networks **and positively affect the diffusion of reuse strategies**. At the same time, strategies (such as codes of conduct, reconciliation of interests) are needed to counteract possible imbalances between more and less powerful stakeholders and an unfair distribution of the risks of increased sharing of information and data.

5.6 Barriers to remanufacturing

5.6.1 Relevant business model patterns

We have identified the following business model patterns (see overview in Chapter 4.2 and patterns in detail in Appendix D) as relevant to the CE strategy of remanufacture:

- Machines/components 'as new' (B1)
- Products 'as new' (C2)

5.6.2 Main interrelated barrier patterns that need to be tackled

Remanufacturing has great potential to contribute to a sustainable transition of the current industrial system with its linear orientation because it can radically decrease resource and energy needs as well as related emissions while providing quality products at a fraction of the original costs. Against this background, the increased worldwide interest in remanufacturing in recent years is understandable. However, **many firms are still reluctant to integrate the remanufacturing strategy into their business model due to the associated uncertainties.**[149]

Remanufacturing refers to a multi-component product that is 'disassembled, checked, cleaned and when necessary replaced or repaired in an industrial process'.[150] As with the reuse strategy, firms need access to discarded products through the organisation of take-back systems and reverse logistics. Hence, the collection of sufficient volumes of used good quality products is of vital importance. In addition, remanufacturing also requires effective redistribution channels and a corresponding marketing of the reprocessed and reconditioned products. Hence, **the difficulties in implementing the remanufacture strategy partially overlap with those of reuse**. These include the potential to cannibalise own markets for newly launched products by offering reprocessed products that feature the same value proposition at a lower price; the fact that the timing and quantity of the returned products usually appear to be unpredictable and unreliable, which may lead to inadequate production planning, operations scheduling, and financial forecast; and a lack of legislation that incentivises and enforces value creation modes following remanufacture strategies.

However, the required technological expertise, the product-, and process-based knowledge stocks and the need for tangible assets (machinery) differ between remanufacture and reuse strategies.[151] Whereas reuse value creation activities aim to collect and redistribute used products without correcting their condition, remanufacturing entails replacing or repairing entire product models**. The availability and the storage costs of spare parts is a major challenge to businesses that pursue remanufacturing.**[152] Independent remanufacturers are heavily dependent on collaboration with producers who are willing to share design plans and bills of materials in order to enable and support effective reprocessing of the returned products. This leads to power imbalances based on the specific product designs and policies of producers. In addition, the architecture of most products tends to be optimised for initial user benefit, including price and convenience aspects, rather than for remanufacturing. Another hurdle associated with product specifications is the **unpredictable performance status, quality and lifespan of products and their components**. The repurchasing of used products and product modules for reprocessing and remarketing poses a major financial risk due to potential hidden costs. Since customers expect that remanufactured products will function and perform like new ones, the loss of reputation and image of providers (independent remanufacturer or producers) could be enormous in the long run, if the products do not meet the communicated quality standards.

As Bocken and Short (2016), Hofmann (2019), Merli et al. (2018), and Zink and Geyer (2017) indicate, value creation strategies that actively seek to prolong product utilisation time and intensify product usage (maintain and upgrade, repair, reuse, and remanufacture) to reduce the absolute system-wide negative impact on nature, require a more profound change in consumption and production patterns. These strategies do not seem appropriate in an economy based on accelerated innovation cycles, newism,

148 | See Kissling et al. 2013.
149 | See Matsumoto et al. 2016.
150 | See Reike et al. 2018.
151 | See Vermunt et al. 2019.
152 | See Matsumoto et al. 2016.

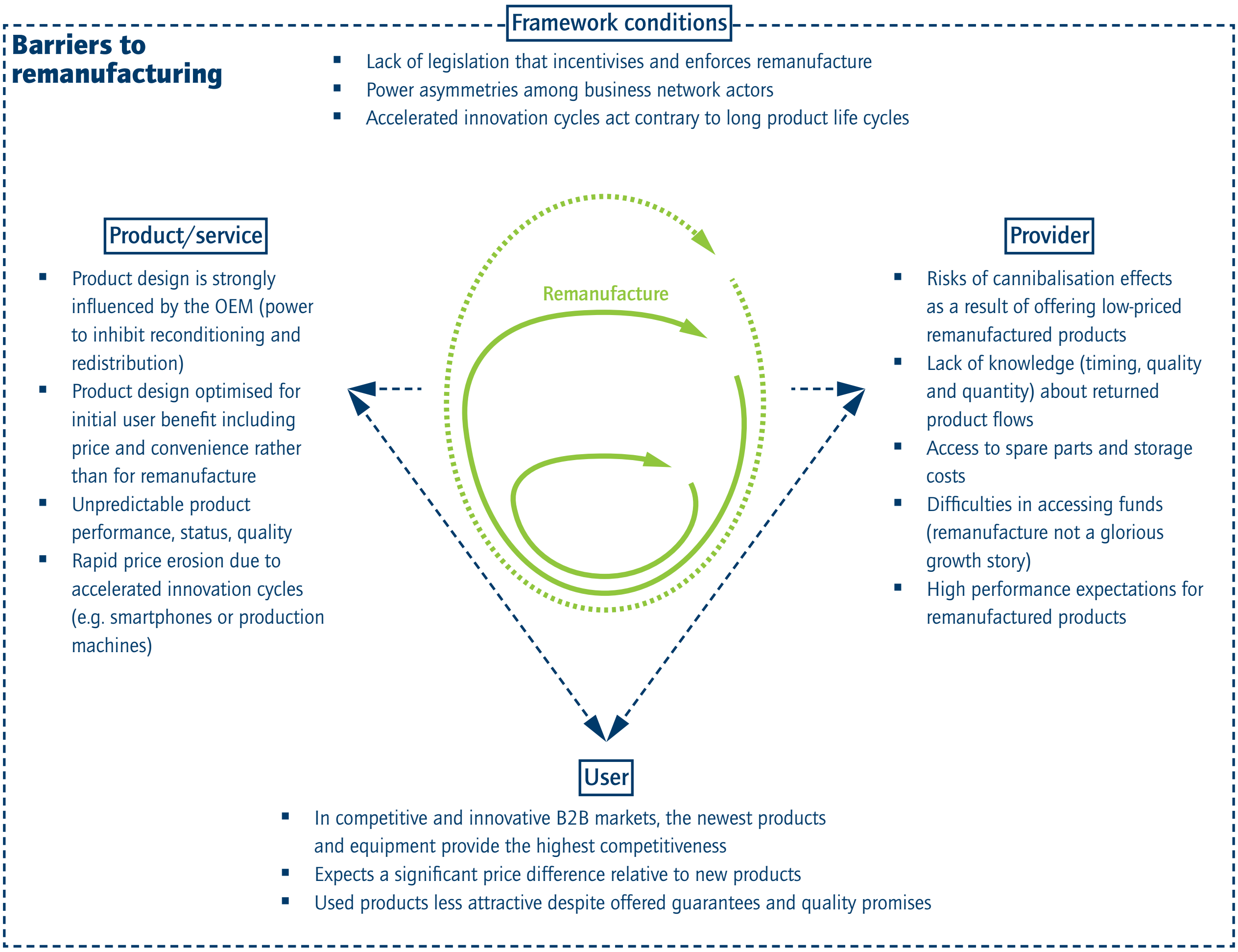


Figure 14: Barriers to remanufacturing (Source: own presentation)

Difficulty	Short-term importance	Medium-term importance	Long-term importance
Low	▪ Increase visibility and accessibility of remanufactured products	▪ Increase visibility and accessibility of function- and service-oriented product systems solutions (instead of promoting product sales)	▪ Carry out concerted political, business and NGO information campaigns in favour of remanufactured products to boost their attractiveness
Medium	▪ Tax reductions and subsidies for remanufacture business models ▪ Adopt a stewardship role (function- und service-oriented product system solutions) ▪ Encourage open-source design and knowledge sharing ▪ Create legal and technical frameworks for easy product monitoring	▪ Adopt new digital technologies ▪ Establish public funds for business ventures following remanufacture strategies ▪ Arrange experimental spaces for organisational realignment (at business level) ▪ Establish public funds to promote service innovation (instead of product innovation)	▪ Integrate consumer responsibilities in service contracts (and reward them)
High	▪ Increase availability and accessibility of spare parts	▪ Reinforce collaboration among global business networks	▪ Measure business success using balanced ecological, social and financial performance indicators

Table 7: Integrated solution approaches to remanufacturing (Source: own presentation)

and consumerism, in which fast approaches (fast fashion, fast food, etc.) dominate economic logic and lifestyles**. As the above strategies do not narrate a glorious growth story, it tends to be difficult to attract investors, to convince shareholders, and to persuade corporate decision makers** to invest in such long-term and sustainably oriented endeavours.

5.6.3 Integrated solution approaches

Given the uncertainties and financial risks of the remanufacturing strategy in an economic environment characterised by accelerated innovation cycles and power asymmetries in business networks, the government must enforce various regulatory measures and create market incentive structures to promote business ventures built on remanufacturing.

In addition to the above integrated solution approaches (see maintenance and update, repair, reuse) to overcoming the identified barriers, such as adopting a stewardship role; encouraging knowledge sharing and open-source approaches in business networks; applying new digital technologies; increasing the availability and accessibility of spare parts, bills of materials, and design plans; and facilitating access to financial capital, **firms need spaces to collaborate, learn, and experiment.** While this point is relevant to all described strategies, it is particularly important for those strategies that have not stabilised on the market yet, such as remanufacturing and refurbishment.[153] Launching CBM innovation requires new spaces for organisational realignment, so there is a need for a kind of prepared value creation space for experimentation, in which the future of the incumbent is tested, negotiated, and evaluated. A lack of theoretical and practical knowledge about CE innovation processes reinforces organisational rigidity and structural inertia, which, in turn, limits a firm's strategic ability to navigate CBM innovation. The development of viable CBM innovations might fail due to a lack of imagination regarding CE strategies, since traditional knowledge of how to manage, structure, and organise firms prevents the successful design and implementation of CE strategies. In order to transform the hitherto unimaginable into potentially economically viable business models following remanufacturing (or the other CE strategies), **newly established experimental spaces should facilitate and even incite unorthodox economic thinking. Such spaces could support firms** in navigating **a world of changing socio-ecological parameters**, and thus also shifting economic circumstances, in which previous experience, knowledge assets, technological expertise and loyal customer bases are not survival variables.[154]

5.7 Barriers to recycling

5.7.1 Relevant business model patterns

We have identified the following business model patterns (see overview in Chapter 4.2 and patterns in detail in Appendix D) as relevant to the CE strategy of recycling:[155]

- Circular raw material supplier (A1)
- Proprietary material cycles (C1)
- Retailer as cycle manager (D1)
- Material reverse logistics (G1)
- Coordinator of informal collection (H2)
- Recycling platform (I1)

5.7.2 Main interrelated barrier patterns that need to be tackled

As listed above, recycling offers a variety of business model opportunities for different actors, including recovery managers providing secondary materials, producers shifting towards recyclable products and packaging, reverse logistics providers closing the material loop and intermediaries offering platforms to match supply and demand for secondary materials. Despite being distinct business models implemented by different actors, their viability is highly interdependent, one major reason being **the need to simultaneously establish supply and demand for recyclates and an associated business ecosystem** (see Chapter 3.1.3).

The first major issue is that **competition with (often cheaper) virgin materials make the business case for recovery managers relatively uneconomic** and leads to higher costs for producers adopting secondary materials. Recyclables have to compete with long established, highly international and competitive virgin material markets[156] which, although sometimes stated to be becoming more volatile and depleted[157], to date still offer the same product at a (more) reliable quality and usually at lower prices. Costs for collection and logistics, high upfront investment in advanced recycling technologies, uncertainty in

153 | See Bocken et al. 2018; Hofmann/Jaeger-Erben 2020; Vermunt et al. 2019.
154 | See Hofmann/Jaeger-Erben 2020.
155 | For a detailed definition of the working group's underlying understanding of recycling see Chapter 3.2.2
156 | See Wilts et al. 2014.
157 | See Ellen MacArthur Foundation 2013.

materials supply and low demand for secondary materials add further challenges to the business case for secondary material suppliers.[158]

Beyond these financial and market-related barriers, more technical and value chain barriers lead to a second barrier configuration: high information asymmetries and high transaction costs along the value chain for secondary materials.

Considerable information asymmetries exist along the value chain in terms of **insufficient information and communication about material composition, recyclability and toxicological characteristics** from suppliers, producers, and recovery managers in relation both to primary materials (i.e. the source of recyclates) and the secondary materials themselves.[159]

The second major issue is related to high transaction costs. As proposed by the cradle-to-cradle design concept,[160] the recyclability of materials contained within a product has to be planned at the design stage and impacts not only the choice of materials but also their composition.[161] **However, the present structure and centralised nature of the recycling industry**, where materials from all producers are mixed up, **does not reward improved product designs by individual producers.** Furthermore, building 'proprietary material cycles' (see business model C1) by returning own materials **leads to high transaction costs for producers.** This limits producers' interest in designing for recyclability and using secondary materials.[162]

This low level of interest is further diminished by additional costs to be incurred in acquiring knowledge and skills for circular design.[163] Although design guides have lowered knowledge gaps, the challenge remains how the information about recyclability is transmitted to and appropriately processed at the recycling facility. At this point 'technological externalities', where one firm manufactures a product in a way that increases the cost of recycling for the downstream processor, further limit viability for recovery managers.[164]

Additionally, given that product-oriented value propositions prevail where products are discarded after use, proper recycling relies on the support of consumers in disposing materials (products) in the appropriate manner. Establishing separated or product-specific collection systems would further increase the transaction costs of recyclates. **However, it remains debatable, and is also highly dependent on the specific context (sector), whether the barrier to better recycling is actually linked to consumer practices regarding preparation for recycling or rather the waste management system's lack of advanced sorting technologies** (which would render additional efforts by consumers and other actors obsolete).

The third issue is located at the other end of the circular material chain and strongly influences the use of recyclates from producers. In contrast to virgin materials, the **quality of secondary materials is much more difficult to assess and to guarantee, leading to higher risks for potential customers.**[165] In order to use a recyclate as a resource, the material flow needs to have the status of non-waste.[166] However, the responsibility is on the recycler to prove the quality of the recyclate, making sure it is not contaminated. Apart from a lack of control over the disposal phase on the part of the recovery manager, high prices for the disposal of hazardous waste provide an incentive to waste collectors to overstate the quality of waste composition.[167] The buyer has only limited or highly costly opportunities to control the stated quality, leading to great challenges in securing material uniformity and quality for potential customers. For secondary materials to be considered actual substitutes for virgin materials, quality assurance needs to be ensured. Although it is technologically possible to produce recyclates suitable for closed-loop recycling,[168] **few standards for secondary materials exist, weakening market transparency and trust between agents.**[169] Further, to date, depending on the material, the potential for

158 | See Cramer 2018.
159 | See Hansen/Schmitt 2020.
160 | See McDonough/Braungart 2003.
161 | See Braungart et al. 2007.
162 | See Guldmann/Huulgaard 2020.
163 | See ibid.
164 | See Söderholm/Tilton 2012.
165 | See Wilts et al. 2014.
166 | See de Romph 2018.
167 | See ibid.
168 | See Rigamonti et al. 2018.
169 | Some exceptions exist, for instance: the RAL quality seal 'RAL-GZ 720, % Recycling Kunststoff' for packaging from post-consumer waste; cradle-to-cradle certified standard specifies strict toxicological controls for recyclate content and is applied in various sectors; Cradle to Cradle Products Innovation Institute 2016.

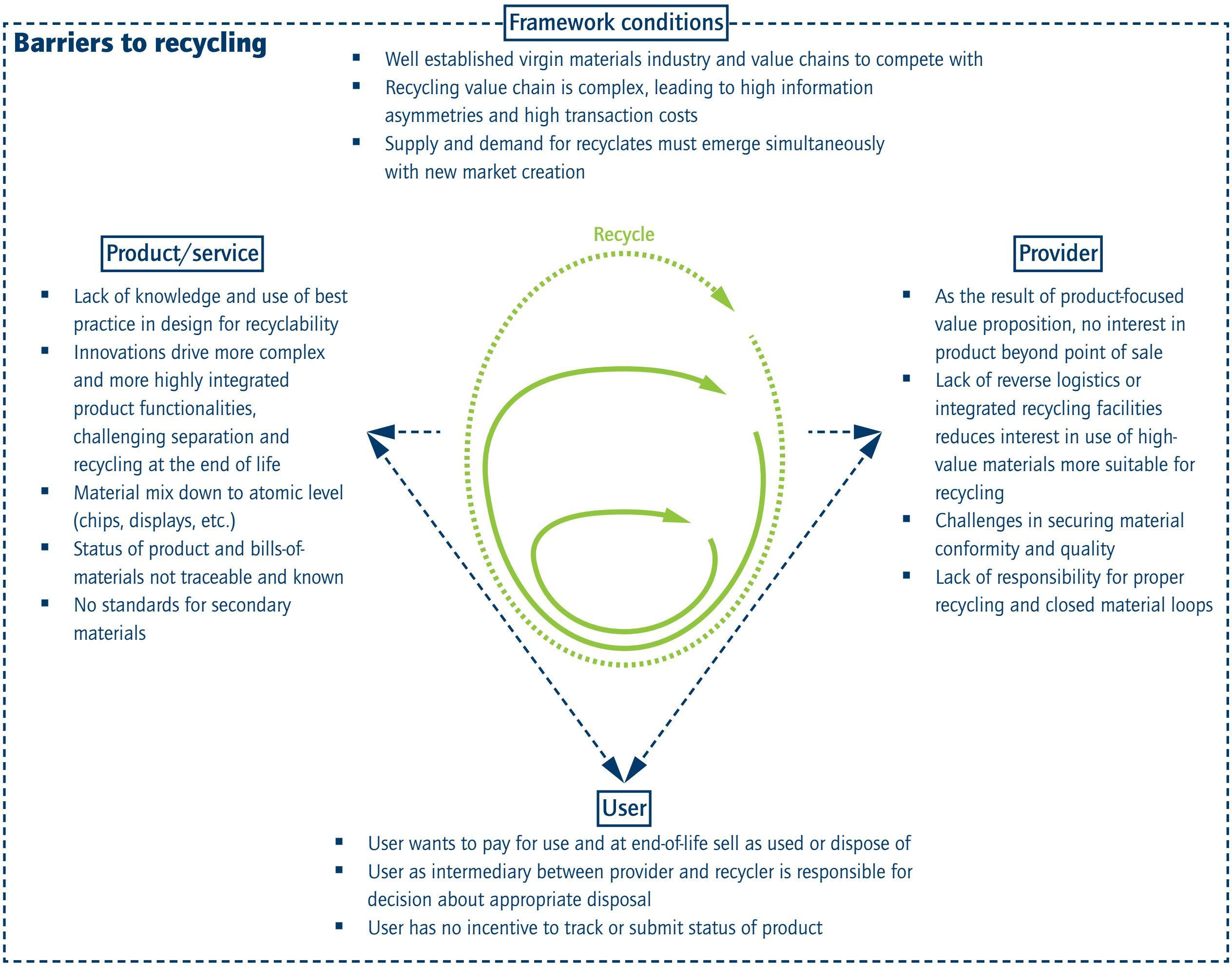


Figure 15: Barriers to recycling (Source: own presentation)

offsetting loss of material quality with further additives is limited, which permits only a certain number of recycling loops. Finally, the lack of strict regulations on e.g. the use of specific hazardous substances in primary materials leads to additional fears on the part of recyclate users because they are liable for the potential contamination of secondary materials.[170]

5.7.3 Integrated solution approaches

In the short-term, **circular procurement could increase demand for secondary materials** and thereby enhance the business case for recovery managers.[171] In this context, specific eco-labels could for example serve as minimum requirements for public procurement.

Constant further investment in technological innovation, **including effective techniques for collecting, separating and recycling discarded materials, can improve the quality and price of the recycled materials** in the medium term. Additionally, **focusing on the development, diffusion and acquisition of skills in designing for recyclability** using circular design guidelines and software across industries is a key factor in facilitating high-quality recycling and appropriate material supply. To increase the attractiveness of such investment for producers, **leasing models could be considered** which make it possible to retain ownership of products and hence materials and so ensure a direct backflow of materials (see e.g. the 'materials bank' and 'materials bank partnership' business models in A1 and C1). This would require investment in company-specific reverse logistics systems, which could be accompanied

170 | See Cramer 2018.
171 | See ibid.

by either vertical integration of recycling managers or contractual agreements for individualised material streams.

In the absence of binding standards, enhancing collaboration and building trust between actors along the material chain and, and organising funding high-grade recycling could overcome many obstacles to the development of CBMs.[172] Important partners also include municipalities, knowledge institutes and other relevant actors.[173]

In the long term, **standards are central to creating trust between unknown market actors and ensuring quality control.** Binding design requirements (e.g. negative or positive lists of additives, colours, substances of concern, etc.) and more advanced recycling standards could improve the competitiveness of secondary materials and help address problem patterns. For instance, **scaling existing design standards**, such as cradle-to-cradle certification and the use of product design software tools integrating recyclability, could be considered. Product standards e.g. regarding recycled content in products, for instance in packaging, would further support recycling CBMs. Careful consideration should be given to introducing higher standards for waste given the alternative of exporting waste, which would lead to an outflow of materials and so reduce circular potential.[174] Greater international cooperation is required in order to avoid such unintended consequences. Finally, consideration should also be given to interlinking quality standards for secondary materials with products that incorporate those materials and quality standards for virgin materials.

Difficulty	Short-term importance	Medium-term importance	Long-term importance
Low	▪ Increase the percentage of recycled products in public procurement significantly	▪ Establish bilateral recycling contracts ▪ Invest in design knowledge and advanced recycling technologies	▪ Establish product standards requiring recycled content
Medium	▪ Campaign for the acceptance of recyclates on social media	▪ Implement servitisation to retain ownership of high-quality materials and facilitate reverse logistics	
High	▪ Create a product label (e.g. "recycling champion") that increases visibility	▪ Enhance collaboration and establish trust among actors in the material chain	▪ Implement binding design standards (use of existing standards)

Table 8: Integrated solution approaches to recycling (Source: own presentation)

172 | See Guldmann/Huulgaard 2020; Hansen/Schmitt 2020.
173 | See Cramer 2018.
174 | See Rigamonti et al. 2018.

6 Digital enablers for circular business models

Digital technologies are key to developing the Circular Economy (CE). They can help overcome the barriers that hinder the implementation of circular strategies, product-service systems (PSS), and circular business models (CBMs). The information availability and transparency generated by product life cycle data open up tremendous possibilities for prolonging the service life of products, maintaining them at the highest value during their lifetime, and closing material loops. But if this potential is to be developed, the foundational digital technologies, infrastructure, and skills must be in place.

6.1 The digital transformation: Status quo and obstacles

There is still considerable room for improving **the adoption of digital technologies** in business practice, particularly in Germany. For example, the Digital Economy and Society Index (DESI) of the European Commission ranks Germany only in the 12th place in digital competitiveness regarding indicators such as connectivity, human capital, use of internet services, integration of digital technology, and digital public services.[175] Similarly, a study of 200 medium-sized companies from eight European countries (mostly from Germany) indicates that just a small number of them already have clearly defined (digital) corporate strategies.[176] Moreover, many companies in German-speaking countries still emphasise process innovations (e.g. cost savings[177]) over business model innovations, resulting in relatively low exploitation of the potential of digital technologies.[178] Factors hindering the implementation of digital technologies include:[179]

- Organisational:
  - Lack of digital infrastructure (e.g. efficient data centres, data processors and platforms for common data collection and sharing)
  - Lack of digital knowledge and training (e.g. skills for predictive maintenance or use of AI)
  - Reluctance to adopt technological change due to organisation's hitherto success and cultural inertia

- Technical:
  - Current product designs not ready for digitalisation

- Financial:
  - High costs and unclear benefits/uncertain ROI related to the implementation of digital technologies

- Value chain:
  - Lack of transparency and trust regarding issues of data security/privacy
  - Lack of willingness among actors to provide common data access (partly due to unclear aspects of data ownership)
  - Lack of interoperable data standards and related regulations

The following pages detail the potential of digital technologies as enablers for CBMs. In the first subchapter, we discuss the role of digital technologies in the operationalisation of the Circular Economy and we introduce relevant concepts such as digital enablers and smart products. Subsequently, we discuss how digitally-enabled services are the bridge that connects the worlds of digitalisation and the Circular Economy. We continue with the fundamental elements of this chapter: smart circular strategies. In the fourth subchapter, we touch upon the idea of digital maturity. Next, we present a dashboard that integrates the ideas of smart circularity and digital maturity to give practitioners a starting point in their journey towards a truly smart circular business model. Finally, we conclude this chapter with a summary that identifies key functions of digital technologies for the transition towards a CE.

175 | See European Commission 2020c, p. 3.
176 | See Kaul et al. 2019, p. 15.
177 | See ibid.
178 | See Cisco Systems GmbH 2019, p. 8.
179 | See Porter/Heppelmann 2014; Porter/Heppelmann 2015; Atzori et al. 2017.

6.2 Digital technologies and the Circular Economy

6.2.1 Digital technologies

The application of digital technologies – such as the internet of things (IoT), digital twins, digital product passports, online platforms, blockchain technology, big data, analytics, and artificial intelligence[180] – could **play an important role in enabling the operationalisation of the CE.**[181] Digital technologies may allow the **information gap** that currently prevents circular strategies from being effective or from being adopted altogether to be addressed. For example, a unique identifier or tracking code (e.g. barcode, radio-frequency identification tag, or molecular marker) could be used to label products, components, and materials. The product passport (or more narrowly the material passport) delivers information about the origin, composition (including substances of concern), repair and disassembly instructions, and end-of-life handling guidelines to actors in the value cycle.[182] Life cycle information for specific products could also be recorded and saved in associated databases. For instance, **the health of products and components could be assessed** with sensors in order to determine how much longer they can be used for. Moreover, usage and performance data could help to identify opportunities for redeployment of assets or for matching supply and demand in secondary markets. Ultimately, with the application of digital technologies, firms could **route products through the value cycle, uncover new circular value propositions, and implement new circular offerings.**

6.2.2 Smart products, components, and materials

Digital technologies can be **applied to products, components and materials alike**, creating a range of 'smart things'. Smart things cover simple products like textiles enhanced with identification tags, tag readers and information systems to store, analyse, and integrate life cycle information (i.e. the minimum requirement for a smart thing is a unique ID as the link to the IT infrastructure). They also include complex products like televisions that have a wider set of sensors, and actuation and control systems.[183] Gathering detailed information about the product enables specific functions such as remote control. Managing the product remotely means that visiting the customer on-site is not necessary. In this way, smart products can facilitate **monitoring and location tracking services**. Monitoring when and how often a product is used can be done through integrated sensors, or through the addition of an external monitoring box. Such monitoring makes it possible to assess whether products are in use, whether they are being used in the right way, and whether they are underused. This **facilitates decisions with regard to use optimisation**, thus optimising asset productivity and revenue.[184] Moreover, location tracking of mobile products can improve data transparency along the value chain. Such information could be used to improve inventory management and give real-time insight into product location in order to **streamline reuse activities and asset redeployment**. Firms could also use data about a product's history to assess the performance of suppliers and aim at products of higher quality and with longer lifetimes.[185]

Similarly, smart components – components equipped with sensors and connectivity – can be remotely monitored to track usage cycles and performance data. Firms can **use sensors to detect deviations** such as mechanical overloads, abnormal vibration, or unusual temperature rises that indicate failure. Breakdowns can be registered directly to speedily trigger maintenance requests and reduce downtime. The installation of new smart components could be validated through verification protocols, ensuring the use of high-quality parts. The information about component 'health' can furthermore be used to offer other life-extending services. Data analytics, when combined with usage data and real-time condition monitoring, can serve to compile and analyse past failure patterns and anticipate when wear-and-tear is expected to reach critical levels. This enables **the deployment of predictive maintenance solutions to anticipate and prevent failure**. These approaches further reduce downtime due to the elimination of unanticipated disruptions, and they can be used to reduce maintenance costs and optimise the acquisition of spare parts. In addition to this, it becomes possible to harvest parts and reuse them depending on their estimated remaining useful life.[186]

Finally, and in addition to the benefits of smart products and components, the closing of material loops through recycling could be enabled by smart materials. For example, combining clothing

180 | Appendix G provides a detailed list with definitions of key digital technologies and their respective contributions to the Circular Economy.
181 | See Alcayaga et al. 2019; Kristoffersen et al. 2020b; Rosa et al. 2019; Jabbour et al. 2019; Ellen MacArthur Foundation 2016a; Ellen MacArthur Foundation 2019; Nobre/Tavares 2017.
182 | See Sachverständigenrat für Umweltfragen 2020a, p. 159; McDonough/Braungart 2003; European Commission 2019.
183 | See Langley et al. 2020; Porter/Heppelmann 2014.
184 | See Grubic 2014; Vadde et al. 2008.
185 | See Alcayaga/Hansen 2019; Derigent/Thomas 2016; Iacovidou et al. 2018.
186 | See Kothamasu et al. 2006; Prajapati et al. 2012; Selcuk 2017.

items tagged with **smart labels and readers in recycling systems could be used to convey information about the materials** of a garment, supporting automated waste sorting, identification of where and how to best recycle the item, and tracking of the item through the recycling value cycle. In this way, **high-quality recycling outcomes could be achieved**, instead of downcycling the materials, while at the same time optimising the recycling process.[187]

6.2.3 Smart products and infrastructure

Smart products, components and materials do not exist in isolation, they are interconnected through digital technologies with the manufacturer of the (smart) product (in product-oriented business models) or with the service provider (in rental, sharing or pay-per-use models). The manufacturer or service provider also relies on an ecosystem of partners to provide digital and circular services while the product is in use.[188] It is the application of digital technologies in the value cycle that brings us to the idea of digital enablers. **Digital enablers amplify the value-generating function of products, components, materials, and the business models** of the actors of the ecosystem. Digital enablers, therefore, **truly act as building blocks** that can be combined to enable a specific business case.[189]

As shown in Figure 16, digital enablers can be divided into physical and digital components. Physical components (or hardware) include sensors, actuators, and infrastructure. Digital components (or software) include mobile applications, platforms, and digital services like location tracking, data analytics, and condition monitoring. In addition, there are enablers internal to the product, e.g. a tag or a sensor, and external ones, e.g. a reader. This distinction is relevant for **differentiating between simple products like textiles and complex ones like televisions or washing machines**. A textile tagged with a radio-frequency identification (RFID) chip would require an external RFID reader to capture location information, while a television could process this information through internal components. Although all products require external IT infrastructure, complex products with internal components can achieve higher levels of autonomy.[190]

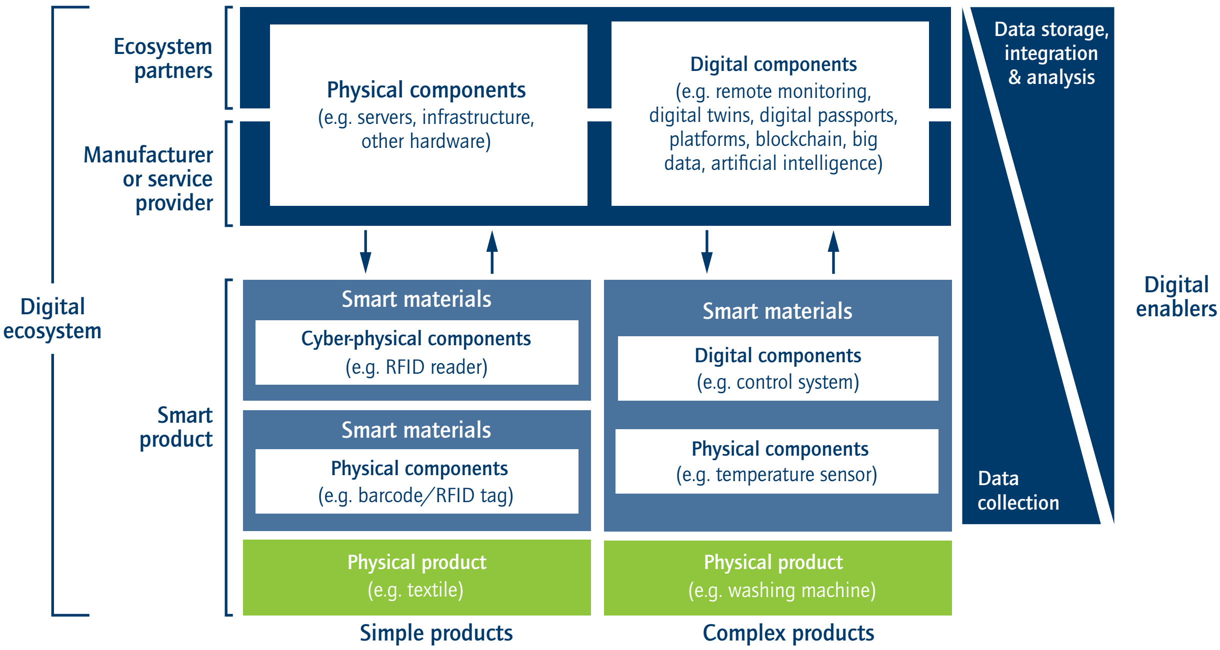


Figure 16: Digital ecosystem for a smart Circular Economy (Source: own presentation, based on Alcayaga et al. 2019)

187 | See Alcayaga/Hansen 2019; Binder et al. 2008; Luttropp/Johansson 2010.
188 | See Porter/Heppelmann 2014; Porter/Heppelmann 2015.
189 | See Porter/Heppelmann 2014; Noll et al. 2016.
190 | See Alcayaga et al. 2019.

6.2.4 Potential rebound effects of digital technologies

While digital solutions are a critical enabler of a Circular Economy, environmental and social rebound effects[191] should be taken into consideration during their development and implementation. Currently, smart things are on the rise, and with it, the demand for resources including rare earths and conflict minerals.[192] Secondly, most devices are not designed from a circular perspective that considers longevity or reparability. Thirdly, technological advances shorten product lifetimes, making products ever more quickly obsolete. As a result, there is an increase in e-waste each year, and an associated increase in resource usage.[193] In addition, the IT infrastructure (e.g. data centres) supporting digital solutions is still largely powered by fossil fuels and requires huge amounts of energy, leading to climate change-related rebound effects.[194] **In order to counter these effects, new smart products should follow stricter circular product design criteria and be powered by renewable energy whereever possible.**

6.3 Smart circular strategies

6.3.1 The foundation: Smart use

The ability of smart products to make crucial information available and to link this information with decision-making processes can support different services at different life cycle stages. **An integrated value proposition requires certain digitally-enabled services, i.e. 'smart use services', for the use phase.**[195] Some examples of these services include remote condition monitoring, online platforms, and remote or autonomous product control. Although these services are not directly related to the Circular Economy, they **act as the interface between the digitalisation of the company and the operationalisation of the Circular Economy:**

- Remote condition monitoring involves the remote collection of data about the performance and usage of the product during the use phase to determine its current condition, location, and performance. This information is vital for enabling further circular services such as maintenance, repair, reuse, remanufacturing, and recycling.[196]
- Online platforms serve as a crucial customer touchpoint, helping to increase the adoption of circular services. Firms could use the data gathered during the use phase to display product information on a dashboard and enable additional services like product upgrades.[197]
- Remote and autonomous product control allows manufacturers and service providers to personalise the customer experience remotely. With regard to autonomous control, complex products could acquire capabilities such as self-diagnosis, self-coordination, or autonomous operation. For example, a smart washing machine could automatically identify its need for repair and autonomously generate a service request.[198]

6.3.2 Smart circular strategies

After developing smart use services, the focal actor can move towards the operationalisation of '**smart circular strategies**' (see Figure 17).

The Figure takes account of the following smart circular strategies and related feedbacks into product design:

- **Smart maintenance and repair:** A maintenance service might be offered in various flavours such as condition-based maintenance or predictive maintenance. While the former is implemented adaptively to avoid downtime and reduce unnecessary replacement of parts, the latter uses prognostics and machine learning algorithms to improve the future behaviour of the product. Even if maintenance and repair are carried out manually, recording these activities in a database or digital passport would be an application of digital technologies.[199]
- **Smart reuse:** The focus of reuse lies on tracking, identifying, and classifying products. This leads to an improvement in inventory management, product take-back, and product redistribution. Product tracking and identification are a fundamental enabler of a closed-loop reuse system. In open-loop systems, the use of platforms for reuse enables more efficient

191 | See Berkhout et al. 2000; Hertwich 2005; Sorrell/Dimitropoulos 2008.
192 | See Tukker 2014.
193 | See Nobre/Tavares 2017; Cooper/Gutowski 2017.
194 | See IPCC 2018.
195 | See Alcayaga et al. 2019; Alcayaga et al. 2020.
196 | See Grubic 2014; Grubic/Peppard 2016; Stahel 1991.
197 | See Berg/Wilts 2019; Konietzko et al. 2019.
198 | See Borgia 2014; Lee/Lee 2015; Porter/Heppelmann 2014; Porter/Heppelmann 2015.
199 | See Kothamasu et al. 2006; Prajapati et al. 2012; Selcuk 2017.

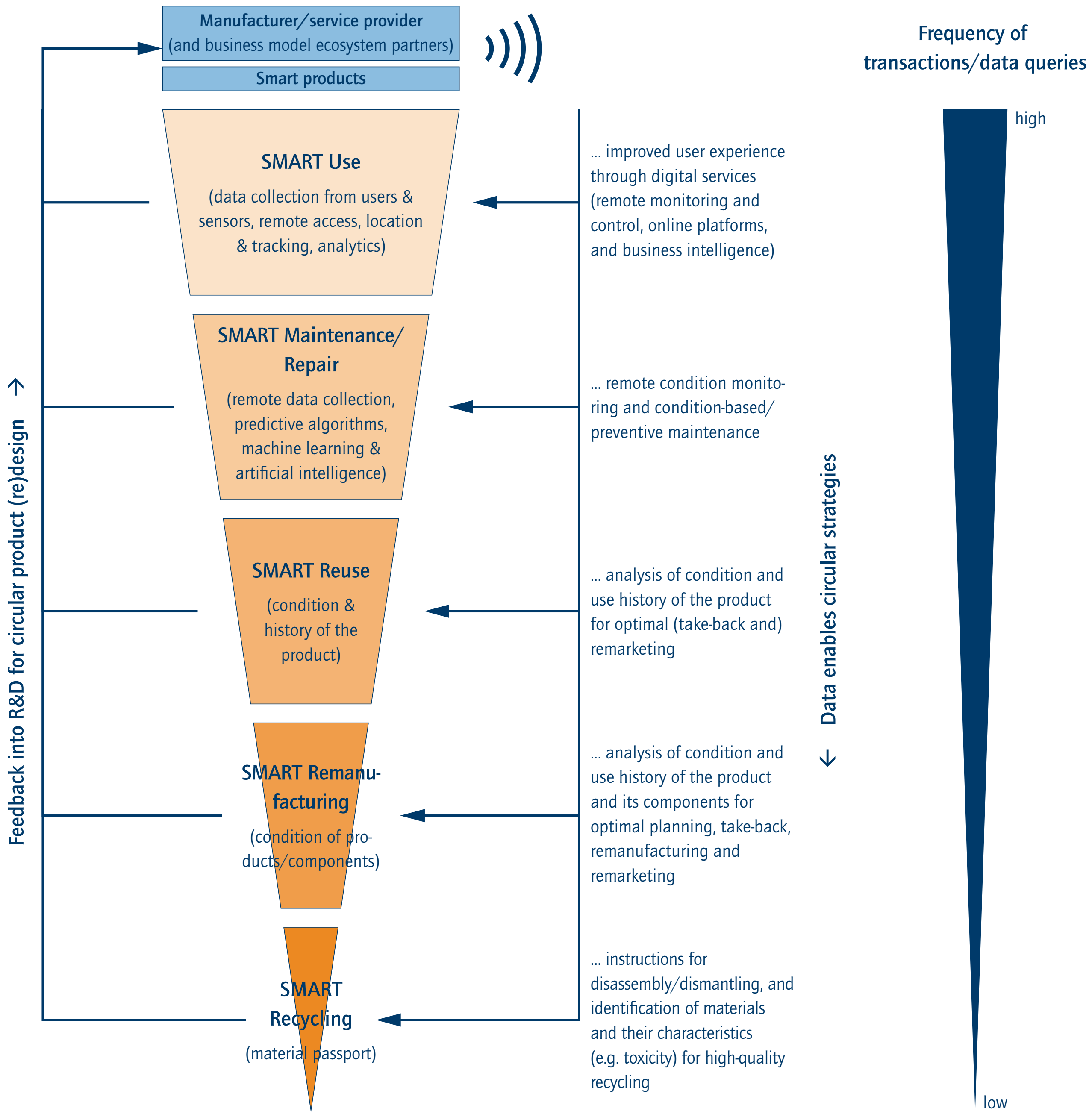


Figure 17: Smart circular strategies, data flows, and feedbacks into product design (Source: Hansen et al. 2020b; see also Alcayaga et al. 2019, 2020)

coordination of supply and demand, and better access to secondary markets.[200]

- **Smart remanufacturing:** The use of product history facilitates the planning of product take-back and decision-making for the remanufacturing process, thereby increasing the availability and quality of remanufactured products. The use of identification technologies and automated processing can facilitate disassembly and reduce operational costs of remanufacturing activities. Finally, obtaining product information in advance also enables better predictions of future demand for remanufactured products.[201]

200 | See Alcayaga/Hansen 2019; Cooper/Gutowski 2017; Iacovidou et al. 2018; Ness et al. 2015; Vanderroost et al. 2017.
201 | See Butzer et al. 2016; Ondemir/Gupta 2014; Zhou/Piramuthu 2013; Kerin/Pham 2020.

- **Smart recycling:** Sorting and disassembly are costly processes, the economic benefit of which is sometimes unclear. Digital material passports (as one element of product passports) or related registers can considerably increase the potential gains from recycling, as the quality and quantity of the materials are known in advance. This information allows better planning and the use of more specific material recovery processes to maintain high quality (i.e. upcycling). Moreover, location tracking can potentially support the recycling logistics system.[202]
- **Feedback into product (re)design:** Digital technologies enable the use of product life cycle data to improve the circular design of future product generations. A continuous feedback process allows more agile learning processes with iterative design and prototyping cycles. In addition, firms could use digital passports to perform a complete analysis of product history and address issues related to material quality directly with the corresponding supplier.[203]

The shape and **descending order of smart strategies in the pyramid** is based on three aspects:

- **Stage in the product life cycle:** When considering the product life cycle, activities such as condition monitoring and maintenance are operationalised earlier in the lifetime of a product than recycling, which is typically performed at end-of-life, and later stages are accordingly shown further down in the figure. While life cycle stages and related smart strategies become relevant at different points in a product's lifetime, we would nevertheless suggest developing multiple smart circular strategies simultaneously as this can increase their synergistic potential, improve the value proposition of the focal actor's business model, and offer higher cost efficiencies across strategies.[204]
- **Frequency of transactions:** The nature of smart circular strategies means that **the frequency of transactions and of related data queries declines**. During a product's lifetime, maintenance is usually carried out continuously, remanufacturing usually takes place a few times across long time frames, and recycling is only done once product status is lost. Similarly, data collection and analysis to assess the need for maintenance is carried out regularly, while data collection and analysis for remanufacturing or recycling occur after many use cycles and are typically carried out on request.[205]
- **Priority of circular strategies:** Similarly to the waste hierarchy, circular strategies for maintaining product integrity such as reuse and remanufacture (i.e. prevention) usually have greater environmental value than material-level recycling strategies.

It should be noted that **smart circular strategies and higher service levels within CBMs reinforce each other:** digital technologies provide opportunities to develop new CBMs and to focus (more) on service-oriented rather than product-oriented business models.[206] To foster service-oriented CBMs, it is important to take an ecosystem perspective and encourage collaboration among the actors of the value cycle (see Chapter 3.1.3). Track-and-trace technologies for the entire life cycle, real-time product data availability, and digital passports can help the focal actor to effectively orchestrate the value cycle and the services offered around the product. At the same time, higher service levels as represented by use- and result-oriented business models facilitate the adoption of digital technologies.

6.4 Digital maturity and data-driven culture

For smart circular strategies to work, it is not sufficient to merely have sensors in place and to collect, store, and analyse data. Focal actors and ecosystem partners should operate a data-driven culture. This means that supporting processes should be in place to manage, interpret, and use data, so that circular strategies can be operated effectively. Depending on the digital maturity of each organisation, they could be positioned in three different categories, defined **as 'smart', 'smarter', and 'smartest'**. These categories reflect how data and digital technologies are used to provide either hindsight, oversight, or foresight value, respectively (see Figure 18).[207]

- Hindsight value can be obtained with a descriptive or diagnostic approach that provides information about what happened to the product and why. This approach is intended to reveal the cause and effect of events and behaviours.

202 | See Binder et al. 2008; Luttropp/Johansson 2010; Luscuere/Mulhall 2019; Wang et al. 2015.
203 | See Alcayaga/Hansen 2019; Ellen MacArthur Foundation 2016a; Ingemarsdotter et al. 2020.
204 | See Alcayaga et al. 2020.
205 | See ibid.
206 | See Ardolino et al. 2017; Coreynen et al. 2017; Kowalkowski et al. 2013; Valencia et al. 2015.
207 | See Kristoffersen et al. 2020a; Kristoffersen et al. 2020b.

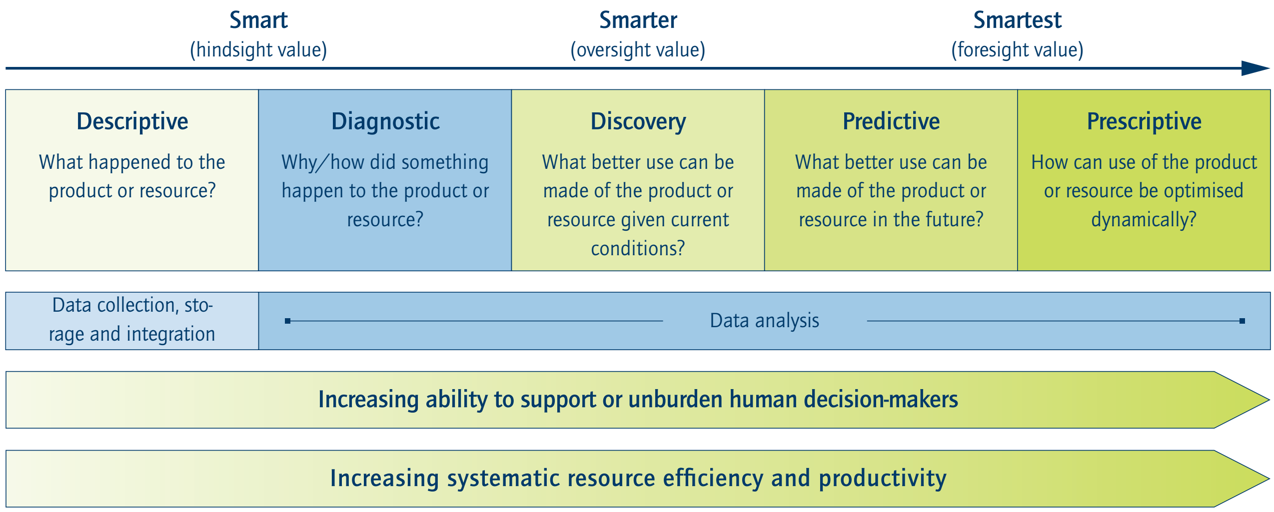


Figure 18: Digital maturity of the focal actor (Source: own presentation, based on Kristoffersen et al. 2020a, 2020b)

- When oversight value is generated, however, information about a product or resource allows the discovery of trends and clusters. This information is used to optimise the use of a product or resource given its current condition.
- Foresight value, on the other hand, refers to a predictive and prescriptive use of data, allowing for predictions about how to make the best use of resources in the future and optimise their use dynamically – in real time.

At each maturity level, the ability of digital technologies to unburden human decision-makers increases, as does the potential for increased resource efficiency and productivity.[208]

6.5 A dashboard for implementation

Throughout this chapter, different ideas and examples have illustrated how digital technologies can support different circular strategies at different life cycle stages. Figure 19 is intended to integrate the knowledge presented in this chapter in the form of **a dashboard, indicating the potential of digital technologies for respective smart circular strategies**. The dashboard could steer action by practitioners and policymakers while they operationalise a truly smart Circular Economy.

Note that the contents in the fields of the dashboard below are **not comprehensive**, nor are they intended to systematically cover essential aspects of each pair of circular strategies and digital maturity levels. The contents provided below are **exemplary business practices** that might help the reader understand how to apply the dashboard. Each focal actor will have to develop a specific configuration of smart circular strategies customised to own circumstances. Each of these configurations might be unique because **several circular strategies are carried out simultaneously in real-life scenarios** and depend on a myriad of factors such as business model, industry, and geographic location.

Overall, digital technologies can significantly support the transition towards a CE. They help focal actors, customers, and other stakeholders of the value cycle to overcome barriers to CBMs (see Table 19, Appendix F).

6.6 Summary

Digital technologies can take on various functions in a Circular Economy (CE). In particular, digital technologies can be thought of as the **glue** between value chain partners and other stakeholders by enabling data sharing and improving transparency along the value chain. Digital technologies have the capacity to take away the friction that would otherwise be involved in generating and managing the information flows that are needed to facilitate circular resource flows. Digitalisation thus allows actors to work together more closely, hence facilitating circular strategies. It also allows circular value to be captured more easily and more practically.

Digital technologies are also a **catalyst** that enables the improvement of existing circular approaches that focus on waste management, expanding them to implement new circular processes and

208 | See Kristoffersen et al. 2020b.

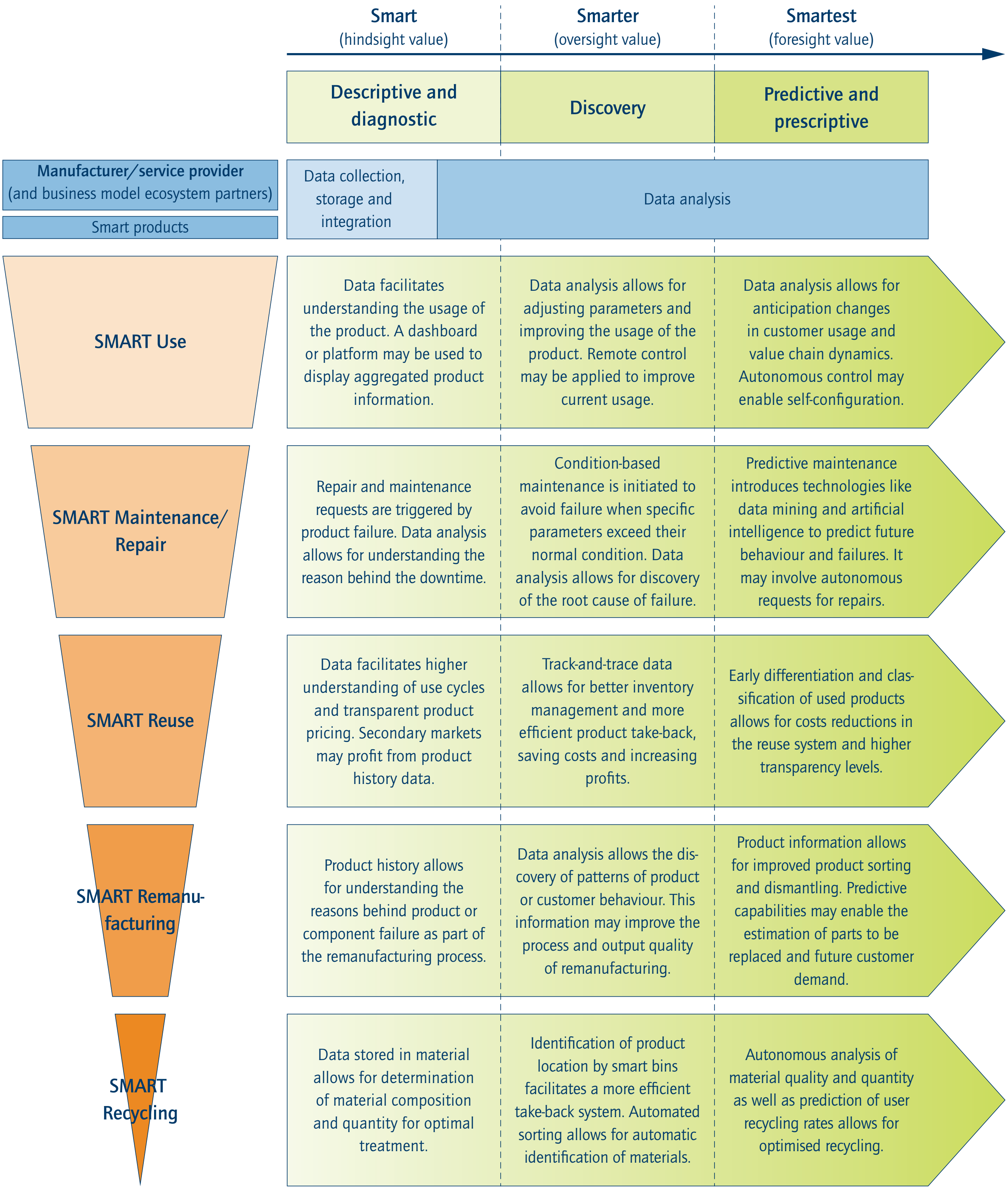


Figure 19: Dashboard indicating the potential of digital technologies for smart Circular Economy strategies (Source: own presentation, based on Alcayaga et al. 2019, 2020; Hansen et al. 2020b and Kristoffersen et al. 2020b)

ecosystems that use the full range of circular strategies. At the same time, they are an **amplifier** that reveals improvement opportunities in process, product, and component design by identifying inefficiencies and weaknesses, as well as likely failure modes. As a result, smart circular strategies can go further – becoming more efficient and enabling more value to be captured – compared to approaches that do not draw on digital technologies.

Similarly, digital technologies are the **looking glass** through which new solution spaces can be identified. For example, they enable a better understanding of customers, and why and how they use resources. Waste that occurs as a result of a lack of understanding between value chain actors can thus be identified. This means that it becomes possible to go beyond current products and services, to examine core functions and find alternative ways to achieve them. This reveals new sustainable and circular offerings, such as the development of product-service systems and service business models, while ensuring that these models truly deliver a positive impact.

Finally, digital technologies can serve as a **key** that unlocks new ways of working by striking a balance between protection and democratisation. On the one hand, technologies can protect intellectual property by keeping sensitive information secret and, on the other hand, they can democratise, standardise, and make information freely accessible for all to use. In this way, the complete stock of resources, their location, and application can be managed in a way that always has their next use in mind.

7 Policy enablers for circular business models

Favourable market and regulatory frameworks are necessary for introducing and diffusing Circular Economy (CE) business models in the market. Moreover, some aspects of circularity, such as product design and managing return flows of products, are – for some industries – at least partially governed by specific legislation (e.g. Waste Electrical & Electronic Equipment (WEEE)).

The following pages will outline different approaches to CE business models and identify policy enablers and barriers. Should business models not be compatible with current law, proposals for changes to legislative requirements will be examined. Section 1 will provide insights into the current regulatory environment in Germany. Section 2 will explore policy instruments and their mixes to advance the CE.

7.1 Background: Condition of existing regulatory framework

While Germany has a long tradition of waste law, to date, **Germany still does not have a consistent Circular Economy regulatory framework**. Instead, CE-related aspects are scattered across various legal areas. The legal level at which one operates plays a major role in environmental legislation. Pursuant to the Treaty on the Functioning of the European Union (EU),[209] the EU has legislative competence for environmental law and therefore plays a prominent role. **Two legislations stand out: the product-oriented ecodesign legislation and waste legislation.** Various other relevant regulations also link into the CE, for instance, product liability (e.g. regarding used or remanufactured goods) as part of civil law.[210]

7.1.1 EU ecodesign legislation

In its original form, the Ecodesign Directive provides a framework for setting minimum requirements for energy-related products in terms of their environmental impact. Accordingly, the implemented regulations have so far mainly addressed energy efficiency. The directive's full potential to **address broader environmental impacts beyond energy efficiency and throughout the life cycle of products** has hardly been exploited. Still, as part of the Circular Economy Action Plan (CEAP),[211] the EU Commission plans to table a legislative proposal for a sustainable product policy initiative in 2021, to address some of these shortcomings. This will be achieved by extending the Ecodesign Directive beyond energy-related products (though it would still remain limited to selected product categories).

Additional elements to be addressed are product durability, repairability, and recyclability. Ecodesign requirements can be considered an important regulatory lever for encouraging manufacturers to produce more sustainable and increasingly circular products. Despite their regulatory character, the respective requirements are not simply 'imposed' on producers but are developed by the EU Commission in close cooperation with producers and other stakeholders. This offers opportunities for continuous improvement.[212]

The Ecodesign Directive is complemented by mandatory (energy) labelling requirements which, as part of the reforms set out in the Circular Economy Action Plan, may also include circular criteria such as reparability in the future.[213] Ecodesign and labelling requirements cover a wide range of energy-related products, from air conditioners, electrical lamps and household washing machines to electronic displays and televisions, vacuum cleaners and refrigeration appliances.[214] Since **ecodesign requirements are established at the EU level**, and are based on the internal market legal competency, there is not much scope for the national legislator to make provisions for further rules.

209 | See Art. 191 et seq., EU 2012: Consolidated version of the Treaty on the Functioning of the European Union, OJ C 326, 26.10.2012, 2012.
210 | See Weber/Stuchtey 2019, p. 22f.
211 | See European Commission 2020a.
212 | See ibid., p. 6. The CEAP proposes following the Japanese 'top runner' policy progamme to accelerate and institutionalise continuous improvement: top-runner models are characterised as the best design in the market and then become the basis for mandatory targets for the entire industry; Nordqvist 2006.
213 | See European Commission 2020a.
214 | See Directive 2009/125/EC of the European Parliament and of the council of 21 October 2009 establishing framework for the setting of ecodesign requirements for energy-related products Official Journal of the European Union 10, European Commission (EC) 2009.

7.1.2 Waste law

Essential framework conditions are provided by the overarching Waste Framework Directive (WFD),[215] which is complemented by sector-specific directives covering waste electrical & electronic equipment (WEEE),[216] batteries,[217] and packaging.[218] **Implementation primarily occurs at the national level**, in Germany, governed by the Closed Substance Cycle and Waste Management Act (KrWG),[219] the Electrical & Electronic Equipment Act (ElektroG),[220] Battery Act (BattG),[221] and the Packaging Act (VerpackG).[222] In contrast, the national level is of less importance for ecodesign because the decisive regulations for implementation are set out by the EC regulations at EU level. Furthermore, the broader international (i.e. global) law level is still relatively underdeveloped.

Since it also takes a life cycle approach, **waste law** with the above-mentioned regulations **competes to a certain extent with ecodesign law** or, in other words, the interface between waste and product-related ecodesign regulation becomes more important.[223] Waste legislation follows the extended producer responsibility (EPR) principle.[224] This involves producer guidelines for product design or resource use and obligations of producers beyond the consumption phase, such as taking back the product, preparing it for reuse, or its proper disposal.[225] To a great extent, EPR is not mandatory, and the opportunities provided in Art. 8 Waste Framework Directive (WFD) and Sections 23 et seq. KrWG are by no means exhausted. To date, waste law instruments are not sufficient for establishing a CE and need to be complemented by product legislation that defines EPR for sustainability along the whole life cycle of products. For example, secondary raw materials should be used more often and at a higher quality, and producers should in principle organise the take-back of their products and provide repair service networks. The objective of EPR understood in this sense should in the first place be to prevent waste; however, the current EPR philosophy kicks in only after waste has been generated. The waste hierarchy regards **waste prevention as a priority**; however, this goal is **only met in Germany and the European Union.**[226]

Waste status

The **decisive factor for the application of waste legislation is whether and when a product actually becomes waste**. Section 3 KrWG determines whether the waste law regime should be applied, and is primarily **understood from the last user's subjective perspective**. This can be demonstrated by the example of used electrical equipment as regulated in the ElektroG when implementing the WEEE Directive:

a) **When used goods are *categorised as waste*, they fall under the complex waste law regime**. Despite the declared aim of promoting a Circular Economy, the **over-complexity** of the regime's challenging requirements (see Figure 20), especially in Germany**, often stands in the way of circular business models**.

b) If, on the other hand, the equipment is **a 'normal' (i.e. non-waste) economic good,** it **can continue to be used without complying with the complex waste law requirements**. The reuse of a product by, for example, trading used television sets directly on a secondary market, would be entirely in line with the primary objective of avoiding WEEE pursuant to Section 1 ElektroG and the prevention level of the waste hierarchy pursuant to Section 6 KrWG. For owners of television sets and their distributors/manufacturers, it is therefore particularly important to know whether

215 | See Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (text with EEA relevance), p. 3; Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, OJ L 150, 14.6.2018, p. 109.

216 | See Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (text with EEA relevance), OJ L 197, 24.7.2012, p. 38.

217 | See Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC, OJ L 266, 26.9.2006, p. 1.

218 | See Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste, OJ L 150, 14.6.2018, p. 141.

219 | See Closed Substance Cycle and Waste Management Act of 24 February 2012 (Federal Law Gazette I p. 212), last amended by Article 2(9) of the Act of 20 July 2017 (Federal Law Gazette I p. 2808).

220 | See Electrical and Electronic Equipment Act of 20 October 2015 (Federal Law Gazette I p. 1739), last amended by Article 12 of the Act of 28 April 2020 (Federal Law Gazette I p. 960).

221 | See Battery Act of 25 June 2009 (Federal Law Gazette I p. 1582), last amended by Article 6 Paragraph 10 of the Act of 13 April 2017 (Federal Law Gazette I p. 872).

222 | See Act on the further development of the separate collection of reusable household waste, of 5 July 2017 (Federal Law Gazette I p. 2234).

223 | See Pouikli 2020.

224 | See Pouikli 2020.

225 | See Beyer/Kopytziok 2015.

226 | See Sachverständigenrat für Umweltfragen 2020a.

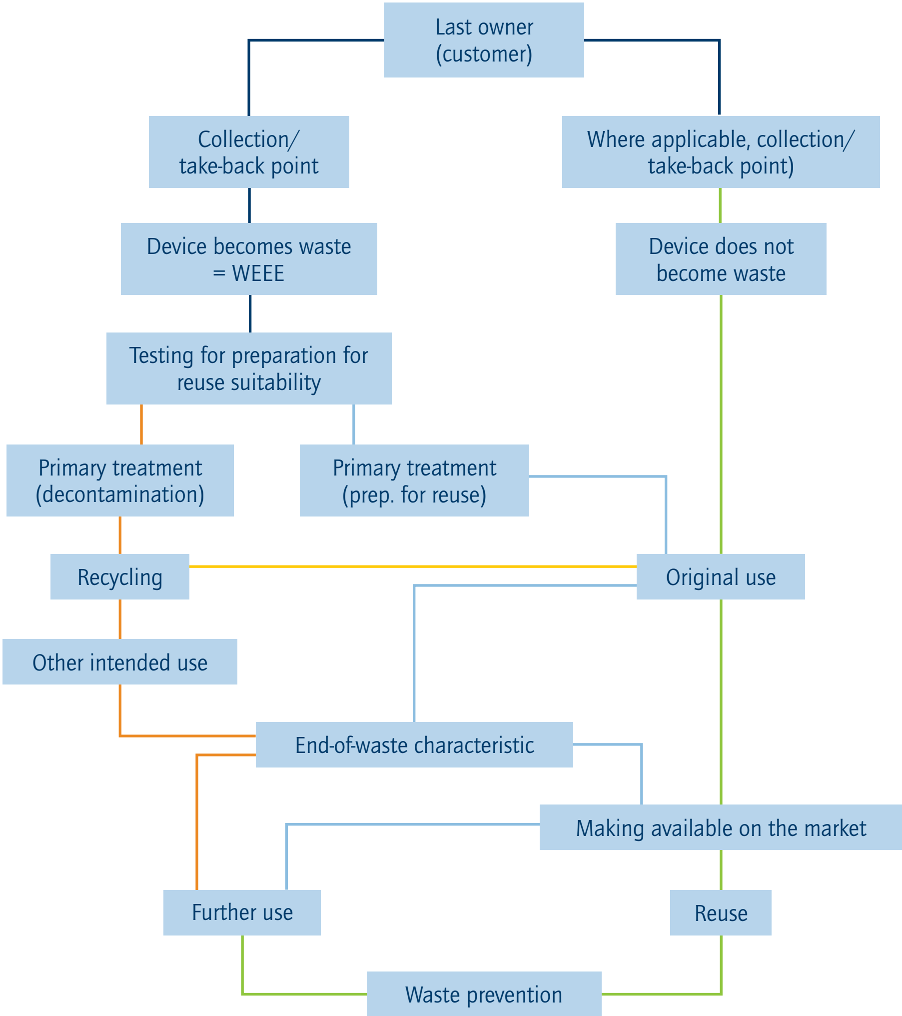


Figure 20: Waste definition and treatment procedure (Source: own presentation, based on Sander et al. 2019, p. 196)

a willingness to dispose of the set is to be assumed (waste), or whether the last owner wants to sell it for further use (non-waste/prevention). For television sets containing environmentally hazardous substances such as chlorofluorocarbons (CFCs), the objective definition of waste may also be relevant, because such objects must be decontaminated (if not omitted in the first place at the design stage).

Waste status and its practical implementation is the focus of considerable legal discussion. The European Court of Justice (ECJ) judgment in the Tronex BV case on the export of electrical appliances (kettles, steam irons, fans and shavers) to Tanzania ruled in favour of a strict interpretation of the term 'waste´ and emphasised that an object becomes waste if it no longer has any use or benefit for its owner. The court also clarified that objects with a residual market value can nevertheless fall under the definition of waste.[227] Such a strict interpretation may hinder the reuse of products, even when technically and economically possible. WEEE must be treated in accordance with the ElektroG-requirements. Sections 16 and 17 ElektroG provide take-back obligations for manufacturers and distributors. The last owner can also offer the device directly to the public waste disposal operator (Section 12 ElektroG), where containers are provided according to the relevant categories such as television sets. WEEE must then be collected by the manufacturers responsible for proper disposal, or the public waste disposal operator can also opt to do this himself. This is followed by a preliminary test to determine whether the equipment is suitable for preparation for reuse, and then by the

227 | See Judgment of the Court (Second Chamber) of 4 July 2019, Openbaar Ministerie v. Tronex BV, Case C-624/17, ECLI:EU:C:2019:564.

'initial treatment', either for the purpose of preparation for reuse or for the removal of contaminants, which may only be carried out by a certified initial treatment facility (Section 20 ElektroG). The next step is the actual treatment. Re-placing on the market is only permissible when end of waste characteristics according to Section 5 KrWG has been fulfilled, i.e. when the recycling process has been completed and a safety check etc. has been carried out. As illustrated in Figure 20, this procedure is highly complex and sometimes excessively challenging for the stakeholders involved.

Waste regulation is sometimes bypassed in international trade, distorting competition in the EU. For instance, some imports of unregistered electronic equipment via online marketplaces can be considered illegal, and the ban on the export of WEEE is not always consistently implemented and complied with.[228]

Extended waste hierarchy

Based on the planned development of the Ecodesign Directive towards including broader product-level CE aspects and its increasingly strong intersection with waste legislation, **the German Advisory Council on the Environment proposed an extension of the established waste hierarchy of the KrWG to a 'Circular Economy hierarchy'.**[229] The key assumption is that circular product design is a prerequisite for both prevention of waste (e.g. producer-led repair and remanufacturing) and

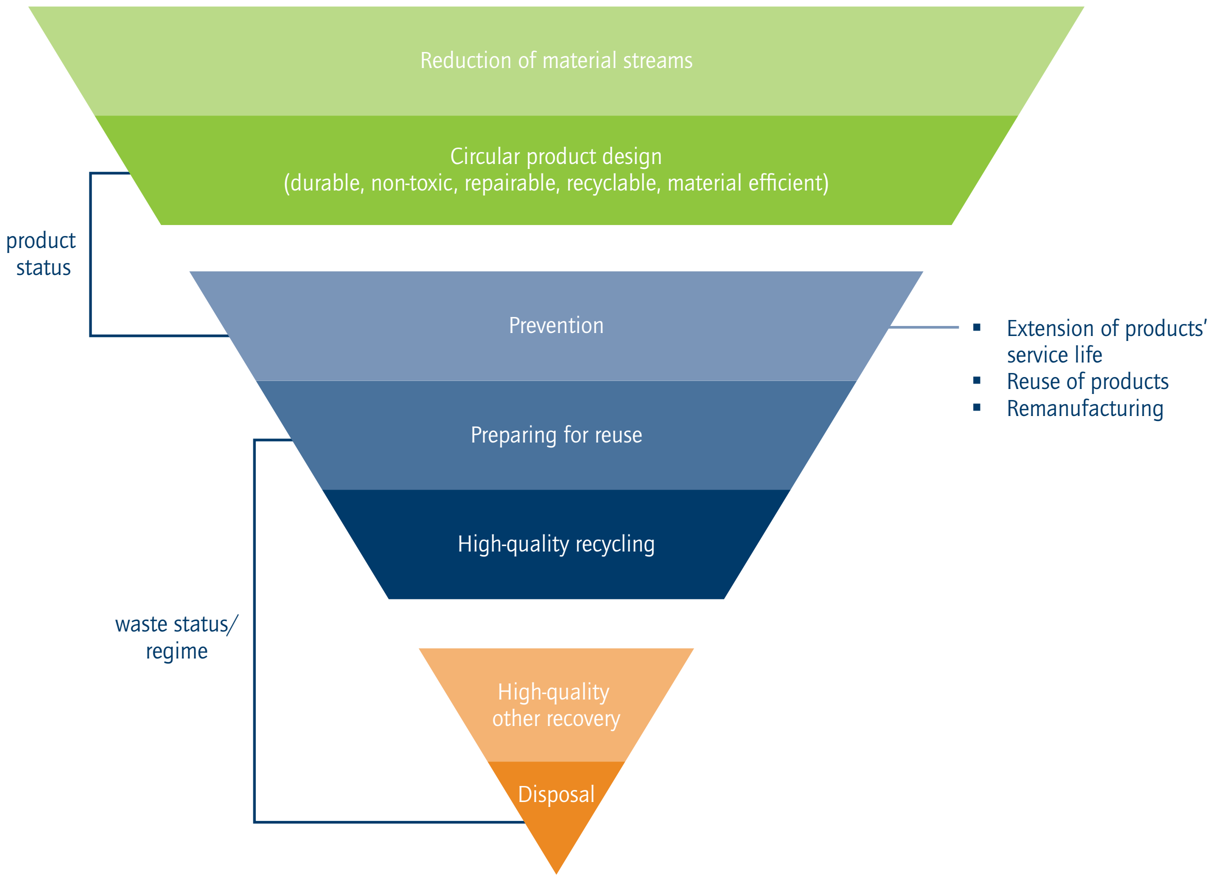


Figure 21: Circular Economy hierarchy as extended waste hierarchy (Source: own presentation, based on Sachverständigenrat für Umweltfragen 2020b, p. 7)

228 | See Schomerus/Hermann 2020, p. 108.
229 | See Sachverständigenrat für Umweltfragen 2020a, p. 13.

subsequent levels in the hierarchy belonging to the waste regime (preparation for reuse).[230]

Overall, while extensive legislation has been developed since the first KrWG in the 1990s, it is still driven from a waste management perspective and therefore often conflicts with the more modern CE-understanding emphasising prevention through the extension of product lifetimes, reuse, and remanufacturing.[231] It is for this reason that recently **policy promoted as part of CEAP has pushed towards a circular product policy framework based on circular design.**[232] Such developments must be supported by and further intensified through regulatory and complementary policies.

'Using instead of owning' and its impact on waste status

The most sustainable way of achieving a CE would be to avoid waste in the first place. **Concepts should be preferred according to which the customer does not receive the product as property, but only rents or uses it.** When renting or leasing the product to the customer, the distributor/manufacturer or any other intermediary purchases the asset (product) and retains ownership throughout the period of use. **Returning the product to the distributor/manufacturer or any other intermediary is an action under civil law which would not turn the product into waste**, as the customer does not want to 'get rid of' the product but only return it to the owner. The product's lifespan would then be prolonged through potential repairs or upgrading activities performed by the product owner.

7.1.3 Product liability with regard to reused and remanufactured goods

Liability for used products could constitute a barrier to CE business models. For instance, if a product is repaired in a repair café and then put on the market again, the question arises as to whether liability requirements could create legal seller/customer problems.[233] Product liability is mainly governed by the Product Liability Act.[234] According to Section 1 of this act, the producer is liable for compensation if 'a defect in a product causes a person's death, injury to his body or damage to his health, or damage to an item of propert'. 'A product has a defect when it does not provide the safety which one is entitled to expect, taking all circumstances into account' (Section 3).

Additionally, the Product Safety Act deals with every product made available on the market.[235] According to Section 3 of this act, products should 'not put at risk the safety and health of persons or other legal goods'. Further liability regulations result from general civil law, in particular from contractual and tortious liability, for example from Sections 823 et seq. of the German Civil Code. Overall, these existing laws case doubt on repair and related circular operations because the liability for such goods could be challenged by producers.

Overall, while extensive legislation has been in development since the first KrWG in the 1990s, it is still driven from a waste management perspective and therefore often conflicts with the more modern understanding of the CE, which emphasises prevention through extension of product lifetimes, reuse, and remanufacturing.[236] Further policies are required to support the transition to a CE.

7.2 Policy enablers: Types of policy instruments

Legal governance of a Circular Economy (CE) often comes up against certain limits. An overarching concept of a CE cannot be based solely on legal regulations, but requires a paradigm shift

230 | Prevention is defined as 'any measure taken before a substance, material or product has become waste and which serves to reduce the quantity of waste, the harmful effects of the waste on man and the environment or the content of harmful substances in materials and products. This includes, in particular, the recycling of substances within the plant, low-waste product design, the reuse of products or the extension of their service life, as well as consumer behaviour aimed at the purchase of low-waste and low-pollutant products and the use of reusable packaging.' However, given that, in the extended waste hierarchy, prevention is considered subordinate to circular design requirements, measures targeting product material efficiency (e.g. 'low-waste product design') should not be traded-off against material circularity (e.g. low weight products which are difficult to recycle mechanically).

231 | See Weber/Stuchtey 2019, p. 19.

232 | See European Commission 2020a; Maurer 2020a.

233 | See De Schoenmakere/Gillabel 2017.

234 | See Product Liability Act of 15 December 1989 (Federal Law Gazette I, p. 2198), last amended by Article 5 of the Act of 17 July 2017 (Federal Law Gazette I p. 2421), implementing Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products, Official Journal L 210, 07/08/1985, P. 0029.

235 | See Act on making products available on the market of 8 November 2011 (Federal Law Gazette I p. 2178, 2012 I p. 131), as amended by Article 435 of the ordination of 31 August 2015 (Federal Law Gazette I p. 1474), implementing Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety, Official Journal L 011, 15/01/2002 P. 0004 and further Directives.

236 | See Weber/ Stuchtey 2019, p. 19.

in politics, economics, science and, last but not least, in society in general. **A broad set of policy instruments is required to tackle CE from a systems perspective** and ensure a related transition.

A distinction can be made between '**technology push**' **policy instruments** – which support research and development and related innovation processes **– and** '**demand pull**' **policy instruments** – which encourage demand in the market via regulation, standards, public procurement, awareness raising, and demand-side subsidies/tax exemptions.[237] While technology push alone may suffer from too little commercialisation and diffusion, demand pull alone may overemphasise incremental over radical innovation.[238] A transition to the CE (as with sustainability more broadly) most likely requires a systems approach in which all relevant actors (e.g. innovating firms, users, recovery organisations) and positions in the value cycle are addressed with a configuration including both technology push (e.g. R&D grants for modularised product design) and demand pull (e.g. lower value-added tax (VAT) for repair services) policies.[239] Based on acatech's preliminary study,[240] and other relevant policy studies in the environmental area, we consider the following types of policy instruments which together cover both push and pull (Table 9). While a purely economic approach would focus exclusively on instruments for adjusting the market framework and conditions (e.g. changes to the tax system, removal of harmful subsidies) and leave the decision to firms on how to adapt to these new realities, **in policy-making practice it seems more apt to combine several instrument types in a designated policy mix.** For instance, while a tax reform (e.g. zero VAT for repair services) may provide economic incentives to users and firms to facilitate product repair, complementary regulation may specify minimum expectations regarding reparability on introduction to the market and accompanying government information campaigns may increase user awareness.

As the table above shows, **policy instruments include both 'hard law', represented by regulation, and the 'soft law' of voluntary standards**.[241] Indeed, **standardisation** on national, european, and international levels is considered a critical aspect in the European Union's CEAP.[242] Standards are important because criteria for judging CE-related properties must be transparent in order to enable customers to make informed decisions. This can only be achieved by establishing standards as they are the only way of ensuring that the statements of different manufacturers are not

Instrument type (primary)	Description	Example
1. Economic instruments	Fiscal instruments aimed at true-cost environmental pricing and the polluter-pays principle (e.g. tax changes, removal of harmful subsidies) and dedicated funding to facilitate specific CE practices.	Reduced value-added tax (VAT) for repair services.
2. Regulatory instruments (command & control)	Statutory regulations or ordinances which oblige producers and consumers to take a certain course of action.	Inclusion of reparability criteria in Ecodesign Directive.
3. Voluntary standards	Quality standards for products, materials and processes are developed by industry, institutions of research and higher education, and civil society. Companies adopt standards voluntarily to demonstrate quality leadership, differentiate, and gain competitive advantage.	Development of international remanufacturing quality standards.
4. Information and awareness-raising instruments	Policies may stimulate and fund educational campaigns to raise awareness of potential users in both business-to-consumer and business-to-business markets.	Campaign to increase consumer literacy in CE; product labels (e.g. recycled content).
5. Government procurement	As public institutions, national and local governments and authorities have the responsibility to lead the transition to a CE through their own procurement practices. This can stimulate innovation and further the growth of pioneering products and services.	Set target for the share of products/ services with CE-related quality label (e.g. in tenders).

Table 9: Types of policy instruments (Source: own presentation)

only for marketing purposes but are also subject to transparent and comparable criteria. Examples are reparability, recyclability, percentage of recycled materials, or the expected lifetime of a product. In general, the **terms used in the CE should also be standardised to ensure that all stakeholders have the same understanding**. At the same time, the process of defining standards is often time-consuming and a balance between speed and level of detail in standard setting must be achieved.

Green procurement by public authorities may be an important field of future Circular Economy activities. About 14% of EU GDP

237 | See Edler/Georghiou 2007.
238 | See Hansen et al. 2019.
239 | See ibid.; Peters et al. 2012; Rogge/Reichardt 2016.
240 | See Weber/Stuchtey 2019.
241 | See Edler/Georghiou 2007; Weber/Stuchtey 2019.
242 | See European Commission 2020a, p. 17.

(approx. EUR 350 billion) is represented by public procurement, and the **potential for Circular Economy models is far from exhausted.**[243] Public authorities are required to act as role models with regard to the use of sustainable products. SDG 17.2 'Ensure sustainable consumption and production patterns' emphasises this, and the New Circular Economy Action Plan of the EU Commission as part of the 2020 European Green Deal provides for 'Mandatory Green Public Procurement (GPP) criteria and targets in sectoral legislation and phasing-in mandatory reporting on GPP'.[244] Legislative initiatives are needed not only at EU but also at Member State level.

Policy interventions and related macro-level measurement frameworks and indicators have so far often focused on recycling, particularly in Germany.[245] A more holistic view of the CE, however, involves recycling only as the last resort, with repair and related product life-extension measures, reuse, and remanufacturing taking priority.[246] **Policy levers should therefore carefully address all relevant circular strategies**.

7.3 A Circular Economy policy toolbox for developing policy mixes

7.3.1 Policy sources reviewed

There are a wide range of policy instruments for tackling the innovation and diffusion of Circular Economy business models. A review of existing CE (policy) strategies, programmes, and standards shows that various instruments have already been designed, evaluated, and in some cases tested (e.g. in country case studies). An overview of the review is presented in Table 10. Additionally, acatech's working group conducted various workshop sessions to explore and discuss policy options.

7.3.2 The policy toolbox

The 'CE policy toolbox' presents the most relevant policy instruments plotted along two dimensions: type of policy instrument and CE strategy (Table 11). By making each circular strategy explicit and systematically analysing relevant policies, this toolbox is intended to enable policy makers to go beyond the existing recycling focus in policy-making. Moreover, distinguishing different policy types for each circular strategy enables the development of a holistic policy mix for each circular strategy, from economic incentives and regulations to information and public procurement while at the same time enabling both technology push and demand pull.

Beyond the general policy categories introduced earlier, the table makes the following distinctions:

- **Financial instruments** are subdivided into fiscal instruments and funding/grants and (funding of) professional training. Training is considered to be a funding measure for industry, because public support of workforce education facilitates the uptake of CE in organisations.
- **Regulatory instruments** are subdivided into the most important areas of regulation: EU ecodesign, waste law, and other regulations.

The numerical indexes (superscripts) after each policy instrument link to the source in our review (see Table 10).

243 | See Maurer 2020a.
244 | See European Commission 2020a.
245 | See Weber/Stuchtey 2019, p. 27.
246 | See Weber/Stuchtey 2019, p. 27.

ID	Source	Title	Year	Type
1	Sachverständigenrat Umwelt (SRU)[247]	Umweltgutachten	2020	Policy consultation
2	Bundesministerium für Umwelt (BMU)[248]	Deutsches Ressourceneffizienzprogramm (ProgRess) III 2020 – 2023	2020	Government programme
2b	WWF Deutschland[249]	Stellungnahme zu ProgRess III	2020	Policy consultation
3	Prof. Dr. Jur. Helmut Maurer, Senior Legal Expert, European Commission[250]	Rahmengesetzgebung für eine nachhaltige Produktpolitik	2020	Policy concept
4	Ellen MacArthur Foundation (EMF)[251]	A toolkit for policymakers	2015	Policy toolkit
5	Beyer & Kopytziok[252]	Abfallvermeidung und -verwertung durch das Prinzip der Produzentenverantwortung	2005	Policy consultation
6	Ex'Tax Project[253, 254]	Europe: A fiscal strategy for an inclusive, Circular Economy	2014, 2016	Policy toolkit
7	European Commission[255]	Circular Economy Action Plan (CEAP)	2020	Government programme
8	Schrack & Hansen[256]	Perspektivenbericht: SDG 12 – Verantwortungsvolle Konsum- und Produktionsmuster	2020	Policy consultation
9	Cradle to Cradle Products Innovation Institute (CCPII)[257]	Cradle to Cradle Certified Product Standard: Version 3.1	2016	Standard
10	European Union[258]	Promoting Remanufacturing, Refurbishment, Repair, and Direct Reuse	2017	Policy consultation
11	acatech[259]	Pathways towards a German Circular Economy: Lessons from European Strategies	2019	Policy consultation
12	Allen & Overy LLP[260]	EU Circular Economy and Climate Mitigation Policies	2017	Policy consultation

Table 10: Sources for the Circular Economy policy review (Source: own presentation)

247 | See Sachverständigenrat für Umweltfragen 2020a.
248 | See BMU 2020a.
249 | See WWF Deutschland 2020.
250 | See Maurer 2020a.
251 | See Ellen MacArthur Foundation 2015.
252 | See Beyer/Kopytziok 2015.
253 | See Groothuis/Ex'Tax Project 2014.
254 | See Groothuis/Ex'Tax Project 2016.
255 | See European Commission 2020a.
256 | See Schrack/Hansen 2020.
257 | See Cradle to Cradle Products Innovation Institute 2016.
258 | See European Union 2017.
259 | See Weber/Stuchtey 2019.
260 | See Allen & Overy LLP 2017.

Circular Economy policy enablers		Circular strategies				
		Cross-strategy	Maintain, repair & upgrade	Reuse	Remanufacture	Recycle
I. Economic instruments	Fiscal	▪ Ex'Tax reform: offsetting higher resource taxes with lower labour taxes [4, 6, *] ▪ Significantly higher CO_2 prices and application in all relevant industries [1, 6, *] ▪ Primary raw material taxes[1, *] ▪ Flat VAT rate of 22%, except for reduction/exemption for labour-intensive services (repair sector) and best practice products[6] ▪ Link value added tax (VAT) to environmental characteristics[2] ▪ Elimination of harmful subsidies to the CE (e.g. tax exemption for non-energetic use of fossil fuels)[1, 2] ▪ Tax exemption for R&D personnel in circular innovations[6] ▪ Tax exemption for selected products with quality seals[5] ▪ Increased incineration taxes[4]	▪ Zero or reduced value-added tax (VAT) for labour-intensive repair and maintenance services[1, 2, 2b, 6] ▪ Partial refund (Repair Bonus) on repair costs[8]	▪ Disincentives for short-lived goods[3] ▪ Promotion of Reusable Systems (e.g. packaging, shipping)[2] ▪ Tax incentives to prepare goods for reuse[1] ▪ Fiscal instruments to support peer-to-peer exchange of goods[2]	▪ Reduced value-added tax (VAT) for remanufactured goods[*]	▪ Advanced recycling fees ("pre-cycling") for producers paid when goods are introduced to the market[1] ▪ Link participation fees ("Beteiligungsentgelte") for packaging more strongly to circular criteria[2]
	Funding/ grants & training	▪ Government funding of leasing, sharing, and other product-as-service models (e.g. consultation, matchmaking, contract consulting, matchmaking, contract design)[2, 2b, 5], also sector specific (e.g. chemical leasing)[2, 7] ▪ Provide dedicated funding for research and innovation for the circular economy[2] ▪ Gearing municipal economic development towards resource efficiency and closing regional material cycles[2] ▪ Provide funding and consultancy for digital business models and start-ups for the CE (e.g. web-based recyclate trade; preventive maintenance; 3D-printed spares)[2] ▪ Make resource efficiency/ circularity a requirement across all funding schemes in national programmes (e.g. Federal Government, KfW, State-level programmes)[2]	▪ Funding of repair cafes and facilities[2, 5]	▪ Funding of reuse facilities and second hand shops, including social/municipal outlets[2, 5] ▪ Fund research on and practical implementation of second-life business models for traction batteries and set a collection rate[2]	▪ Strategic funding (e.g. National Institute of Remanufacture), remanufacturing programmes, funding reman pilots, and consultancy [4, 5] ▪ Encouraging establishment of reman training programmes[4] ▪ Industry information campaigns[4]	▪ Grants for the development and demonstration of advanced high-tech collection/sorting technology to improve recycling quality and quantity[1, 2, *]

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Circular Economy policy enablers		Circular strategies				
		Cross-strategy	**Maintain, repair & upgrade**	**Reuse**	**Remanufacture**	**Recycle**
II. Regulatory Instruments	Eco design law	▪ Extension of Ecodesign Directive to further product categories (e.g. furniture, clothing, etc.)[1, 2]	▪ Strengthen Design for Reparability, Modularity and Upgradability Requirements[1, 2b, 3], also for electronic goods[7] ▪ Discrimination-free accessibility of manuals, spare parts, and repair tools also for third party repair facilities[1, 2, 2b] ▪ Ensure that repair is more economical than new products[2b] ▪ Mandatory use of standardised, user-exchangeable batteries in electrical/electronic devices.[*]	▪ Minimum lifetime of goods and critical components[1] ▪ Strengthen Design for Longevity and Reparability (to support reuse)[1]	▪ Strengthen Design for Disassembly/Reparability Requirements[4]	▪ Strengthen design-for-recycling requirements (high quality recyclability, recycled content)[1] ▪ Prioritise designs with single materials with composite materials as exception[3] ▪ Increase recyclate quality by eliminating/reducing human and environmentally toxicologically harmful substances (design of lowest toxicity)[2b, 3, 7]
	Waste law	▪ General obligation for producers to take back products (combined with EPR) to prevent waste status[1, (2), 2b, 3] ▪ Extend EPR to expand goods categories (e.g. furniture, textiles, construction materials)[1] ▪ Ensure registration of foreign producers active in online marketplaces to ensure their participation in EPR[1] ▪ Circular/electronic product passports (product composition incl. toxins; repair, dismantling, and recycling properties/procedures)[4] as extended information requirements for market access[1] ▪ Redefine definition of waste, when a product becomes waste, and end-of-waste status[7, *]	▪ Guaranteed timeframes for availability of spare parts of 30 years[3] ▪ Operation of or financial contribution to a nation-wide repair network[3]	▪ Damage-free collection of (electrical) goods[2] ▪ Preliminary examination provided for in Section 20 ElektroG with the aim of preparing the WEEE for reuse should be carried out at the collection point before the first transport of all collected WEEE[13] ▪ Certified re-users should have access to the collection points[13] ▪ Accumulators/batteries not embedded in the device may remain there until a decision has been made on their reusability.[13] ▪ Binding quantitative targets for preparation for reuse.[1, 13, *]	▪ Explicit integration of remanufacturing definitions and standards so as to prevent waste status of returned components/cores (i.e. returned "cores" are not waste) and distinguish product categories of remanufactured, used, and newly manufactured goods in international trade.[10]	▪ Assure defined and optimised input qualities into recycling streams through harmonisation of polymers into base polymers vs. additives[2b] ▪ Include quality-based definition of recycling in revision of waste law[*] ▪ Qualitative recycling quotas to prevent downcycling[1] ▪ Link required recycling quality to achievable output qualities of recovery/recycling facilities (take account of technological progress)[1] ▪ Add definitions of the state-of-the-art of and processes for recovery operations[1] ▪ Introduce further material-specific recycling quotas to drive quality[1]

Circular Economy policy enablers		Circular strategies: Cross-strategy	Maintain, repair & upgrade	Reuse	Remanufacture	Recycle
	Other regula-tions	▪ Assessment of circular criteria in EU product registry for market access (i.e. "Conformité Européenne"/ CE marking)[3] including declaration of toxins[1]/non-toxic composition (SVHC)[3] ▪ Mandatory producer deposit systems for products reflecting raw material intensity of e.g. technical devices, electronic goods, clothing[3] ▪ Set absolute reduction targets for selected material streams[1, *] ▪ Set absolute waste prevention targets in general and for specific product groups[1, *]	▪ Extend legal warranties to planned technical lifetime, to three years for all goods, or five years for selected goods[1, 8] as incentive for service business models ▪ Extended commercial producer warranties[2b] to planned technical lifetime[1] or five years[3] ▪ Reversal of the burden of proof in legal warranties[2] ▪ Implement warranty statement obligation of manufacturers, and extension of the limitation period for warranty claims[2, 2b] ▪ "Right to repair" by users and autonomous repair facilities[7, *] including right to update (obsolete) software[7, *]	▪ Differentiate new vs. used goods in international trade statistics[1] ▪ Mandatory use or quota for retailers to use standardised reusable packaging[1] ▪ Extension of single-use plastics policy to more goods[2] ▪ Prohibition of destruction of returned products from online shopping[3]	▪ Duty to remanufacture complex technical products if economically and environmentally reasonable[3] ▪ Remove nation, EU, and international regulations which put reman at a disadvantage (e.g. health and safety regulations; regulations prohibiting sale of remanufactured products as "new")[4] ▪ Adopting a government strategy for reman with associated targets and milestones[4]	▪ Introduce positive lists and "safe-by-design" chemicals into the EU's product and chemicals regulations[1, 7, 9] ▪ (Candidate) substances of very high concern (SVHC) in materials are declared in safety data sheets with higher resolution (100 ppm instead of REACH's 1000 ppm)[9] ▪ Stricter REACH regulations regarding inclusion of substances of very high concern (SVHC) and their elimination from products[9]
III. Standards		▪ Supporting the development of broader CE standards (e.g. ISO/TC 323)[*] ▪ Supporting open-source standard for CE data and information[2]	▪ Standardisation of components and connectors especially in electronic products[2] ▪ Standardisation of replaceable battery form factors for high impact good categories (e.g. mobile phones)[*]	▪ Supporting the development of quality standards for used goods by national bodies (e.g. Roundtable Reparatur)[2] ▪ Standardisation of universal electric devices (e.g. chargers)[7, *] ▪ Further standardisation of returnable packaging systems (e.g. standardised bottle)[1]	▪ Developing quality standards and labels for the reliability of remanufactured products/components[4] ▪ Development of international remanufacturing standards (e.g. RIC001.1-2016)[10] and diffusing them through linkage with environmental management systems and standards[3, 5]	▪ Development of new and reference to existing standards and certification systems for high quality recyclates with transparency regarding physical, chemical, biological properties and quality assurance regarding toxicological properties (e.g. RAL, cradle to cradle)[1, 2]

Circular Economy policy enablers	Circular strategies				
	Cross-strategy	Maintain, repair & upgrade	Reuse	Remanufacture	Recycle
IV. Informational instruments & awareness raising	▪ Extend efficiency label towards circular label with repair, reuse, reman and recycling characteristics[3] ▪ "Second price tag" or product footprint showing environmental burden for good categories with high impact (e.g. clothing)[1, 11, *] ▪ Increase visibility of best practice through awareness-raising campaigns[1] ▪ Promote awareness and diffusion of existing CE quality standards on materials and products (e.g. RAL post-consumer plastic; OK biodegradable; cradle to cradle) levels.	▪ Declaration of reparability score[2] or introduction of a repair index[7, *] ▪ Create eco-label for software addressing resource-efficiency and software-based obsolescence of products[2]	▪ Declaration of average product life at point of sale[1, 3]	▪ Quality labels for reman[4]	▪ Declaration of products' recyclability class and recycled content (including recyclate source to prioritise closed post-consumer material loops) on packaging[1, 2, 2b] ▪ Awareness-raising campaigns for post-consumer recyclates and related quality seals (e.g. RAL Gütezeichen, Global Recycling Standard)[*] ▪ Full declaration of product formula for eco labels (e.g. Blue Angel)[2b]
V. Government procurement	▪ Strengthen the role of ecological (circular economy) characteristics in public procurement[1, 2] ▪ Preference for service contracts (e.g. print-as-a-service, sharing) with specified criteria for circularity over product ownership[3] ▪ Strengthen national expertise and consultancy for sustainable public procurement and provide training for procurement personnel[1] ▪ Pledges by national or state-level authorities regarding targets for shares of sustainable procurement[1]	▪ Revise guidelines on the useful lifetime, discarding, and recycling of IT equipment and software in the Federal Administration[2]	▪ Preference or quota for the procurement of used goods with full guarantee (e.g. IT hardware)[3]	▪ Preference or quota for the procurement of remanufactured "quality as new" goods (e.g. furniture)[3, 5]	▪ Preference or quota for the procurement of goods with high levels of certified, high-quality recycled content (i.e. labelled)[2] ▪ Preference for recycled building materials in government construction projects[2]

Note: [*]acatech Circular Business Models working group.

Abbreviations:

EPR: Extended Producer Responsibility

RAL: RAL Deutsches Institut für Gütesicherung und Kennzeichnung - German Institute for Quality Assurance and Certification

REACH: Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

SVHC: Substances of very high concern (as specified by European REACH regulations)

Table 11: Policy toolbox using the dimensions of instrument type and Circular Economy strategy (indexes refer to sources in Table 10) (Source: own presentation)

8 Moving towards circular business models: The case of television sets

8.1 From linear to circular business models for television sets

Many electronic devices in Germany, and around the world, are still primarily located in a linear production and consumption model. One commonly owned product is the television set (TV). Since **current business models around TVs are considered to exhibit low circularity**, and are moving only incrementally towards a more circular setup, the TV is an illustrative use case to demonstrate the challenges faced when moving from linear to circular business models (CBMs).

The aim of this chapter is to **show how linear business models for TVs can be transitioned to circular ones** and how existing barriers can be overcome in order to enable the implementation of Circular Economy (CE) strategies for TVs. The chapter will start by showing why the TV is a useful demonstration case, discussing the status quo of the value chain of TVs and then defining future scenarios of CBMs that would be favourable when moving through the three service levels of CBMs:

- Service level 1 focuses on **selling the TV as a product** with complementary services.
- Service level 2 demonstrates a business model based on **selling the use of the TV**.
- Service level 3 is based on **selling the performance of the TV**.

An outline will be provided of how an ecosystem perspective on CBMs for the TV would support the creation of future scenarios based on the three service levels. For each scenario, barriers that currently hinder the implementation of the proposed CBM will be identified. An illustration will then be provided as to how the transition from one service level to the next can be aided by different digital enablers. Finally, specific regulatory enablers that will support the success of the presented business model ecosystems will be identified for each scenario.

8.1.1 Suitability of TVs as a use case

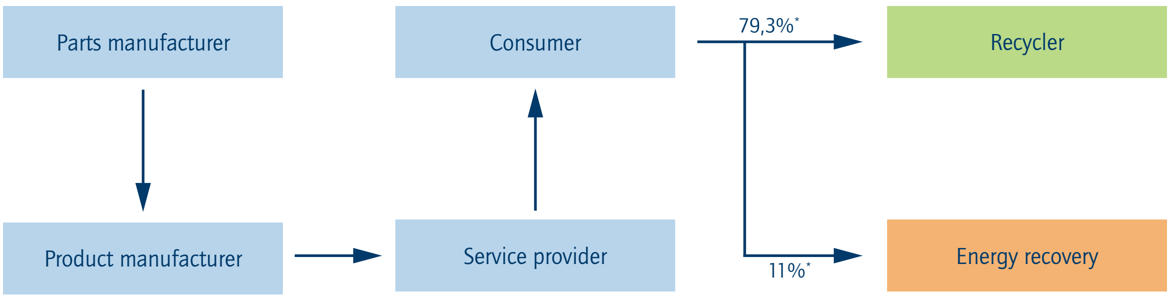
The TV has **a reasonably long service life and a relatively long overall product innovation timeline**, meaning that CE strategies like repair and reuse are applicable. It must be borne in mind, however, that there are high-tech components in a TV that have rather short innovation cycles, while other components innovate slowly and should therefore be long-lasting. The TV is thus a **good example for demonstrating the benefit of modularity that enables technological upgrading.**[261] By allowing the replacement of quickly innovating components by implementing a modular product design of the TV, the uptime of the TV can be prolonged. As TVs become more and more digitally-enabled, the possibility of using software upgrades to keep the technology updated is a very useful tool for increasing product uptime. Since TVs have a significant economic value, **the value added by implementing CBMs is reasonably high** and there is an incentive to reuse, repair and refurbish TVs, if efficient processes are established. Lastly, a lot of applicable data is readily available, as TVs have been on the market for an extensive period of time, which enables its evaluation. However, there are also some limitations to the generalisability of the chosen use case. TVs sold on the German market are not usually produced in Germany or even Europe. Consequently, most of the activities in the current TV value chain take place outside Europe. This poses the risk that important process steps cannot be adequately taken into account in a true value cycle, as they extend beyond the European area of action. Furthermore, more innovative electronic products like smart phones and tablets are increasingly competing against the TV, a dynamic known as 'convergence', which could potentially result in a total abandonment of the TV in the long term.

8.1.2 Status quo of the linear value chain of a TV

Currently, the life cycle of TVs is primarily linear. **TVs are mostly produced, used and disposed of with a minimal amount of the materials being recycled, reused or refurbished**, despite being subject to Extended Producer Responsibility (EPR) regulations in many developed countries. The current value chain is represented by the graphic below and includes a material manufacturer, a product manufacturer, a service recovery in the distribution channel, the consumer, a recycler and a waste disposal factory. The percentages are based on the end-of-life treatment of all e-waste in Germany and are therefore not specific to TVs.

The parts manufacturer produces and delivers the parts to the product manufacturer, who produces the TV and sells it directly to the end customer or delivers it to the service provider of the

261 | See Stahel 2010, p. 189.



Note: *percentages refer to end-of-life treatment of all e-waste in Germany and are not specific to televisions

Figure 22: Status quo of TV value chain (Source: own presentation, based on BMU 2018)

distribution channel. In the simplified linear model, the product is sold in a B2C model to the consumer, who obtains full ownership of the product. This means that the producer's incentives to repair, upgrade and maintain the product are not as high as they otherwise could be. After the use phase, the TV is generally disposed of. Currently, most of the components of TVs have lower recycling rates than average, just like many other electrical components, as only 79.3% of all e-waste was recycled in 2015. The amount that is indeed recycled is mostly downcycled, because e-waste is treated with low specificity: devices are shredded in large-scale facilities regardless of product type, brand or model so that only very few (pure) quality raw materials can be retrieved that can actually be reused for production.[262] The recovery of TVs also poses health and environmental risks as the TV screens are often broken upon collection, releasing the toxic chemical mercury which is used in the screen production.[263] This is particularly problematic when illegal exports of e-waste surface in developing nations and are treated by the informal sector without any protective gear and standardised processes.

Producers currently push a product-focused value proposition, focusing more on the product than the experience a customer has as a result of the product. This can and should change, such that there will be business models around TVs that are use- and-result-oriented, with high circularity and radical change in terms of the value proposed to the customer.

8.1.3 Future scenarios for circular business models for TVs

The transition from a linear to a circular business model is linked to three progressing service levels: **product-oriented service, use-oriented service and result-oriented service** (see CBM typology in this report). It is assumed that the circular potential of a CBM increases both with more ambitious service levels and more ambitious circular strategies, i.e. maintaining and upgrading products instead of merely repairing, and remanufacturing and reusing components or products before recycling. Even recycling strategies can be dramatically improved in more service-oriented CBMs, since when retailers/producers get their own products back they can implement more product- and model-specific recycling practices (consider for instance, Apple's pilot recycling robots for iPhone disassembly).[264]

As business models develop along the service levels, they become more and more detached from the product itself and start emphasising the use and the expected result of the product sold. This increases flexibility and the ability to perform effective and quick research and development. Furthermore, it increases the incentive to engage in CE behaviour, such as offering repair, maintenance and upgrading services, as the provider of the TV (producer/retail/other) will retain ownership of the TV and will be incentivised to set the basis for a long useful lifetime of the TV.

The value ecosystem perspective on CBMs

Based on the value ecosystem perspective on CBMs outlined in Chapter 3.1.3 of this report, three scenarios for a TV-specific ecosystem will be illustrated according to the three defined service levels. A value ecosystem in CBMs will be different from the linear flows presented before because collaboration and material as well as communication loops will be created between the numerous actors forming the ecosystem. There is a need for a change of perspective on the part of TV providers as well as

262 | See Hansen/Revellio 2020.
263 | See BMU 2018.
264 | See Hansen/Revellio 2020.

Scenarios	CBM	Core circular strategies	Focal actor	Other relevant actors in the value ecosystem
Scenario 1 Selling circular TVs	**Selling circular TVs + repair** Product-oriented CBM for TVs	Recycle, repair	**Producer** Improving the recyclability of used materials by aligning product design requirements for efficient recycling	**Repair providers** Recyclers Intermediaries for downstream processes Data platform provider
Scenario 2 Selling the use of circular TVs	**TV rental or leasing + service** Use-oriented CBM for TVs	Reuse, remanufacture, repair/maintain	**Retailer** Incentivise strong collaboration with downstream partners to maximise value recovery from used TVs	Repair/maintenance providers Recyclers/refurbishers/recovery managers Redistributors Intermediaries Data platform providers
Scenario 3 Selling the performance of a TV	**Pay-per-view + full service** Result-oriented CBM for TVs	Reuse, upgrade, repair/maintain, remanufacture	**Content provider** Full-service offering (incl. software upgrades) to user, who pays for the result provided rather than the product	As above May outsource any activity other than providing the content

Table 12: Scenarios for a ecosystem perspective on circular business models for TVs based on three service levels (Source: own presentation)

consumers. **The value proposed to consumers should no longer be based mainly on the material value of the TV but on the value of selling the use or the performance of the TV** that is fulfilled through the use of the TV. As a result, TV manufacturers as well as other relevant actors forming the value ecosystem will face transitions in their way of doing business. This will create incentives for new actors to emerge that may base their business model on adding or improving services that are not yet offered or fulfilled satisfactorily.

Table 12 and Figure 23 present an overview of three illustrative scenarios. Figure 23 shows the changed set of actors and circular strategies in the ecosystem of participating actors upon transition to higher service levels in the three scenarios. The graphic shows that **more CE strategies will be implemented when the focal actor's business model is transitioning, and more actors become part of the ecosystem**:

- In scenario 1, the grey inner circle covers the CE strategies repair and recycle;
- In scenario 2, the green circle sees the addition of the strategies maintain, reuse, and remanufacture, and finally;
- In scenario 3, the blue circle (scenario 3) implements all strategies, creating a closed loop.

The relevant actors for each scenario are mapped around the circle. In each scenario, a **different focal actor will be the orchestrator** of the processes managed by the actors involved:

- In scenario 1, the producer orchestrates an ecosystem that involves a retailer, the user, a recycler and a recycling platform;
- In scenario 2, all the actors mapped around the green circle jointly form the ecosystem;
- Scenario 3 finally encompasses all the defined actors in this scenario analysis.

The detailed presentation of the three scenarios in the following sections (8.2 to 8.4.) will employ **three perspectives**, reflecting the overarching approach of this report:

- First, **barriers** will be identified that are currently blocking the road to implementing the proposed CBM for TVs in practice or which are inhibiting their successful implementation on a larger scale;
- The second step of the analysis will identify **digital enablers** that have the potential to pave the road to CBM for TVs;
- Finally, **regulatory enablers** that are considered to enable the success of the presented business models will be identified.

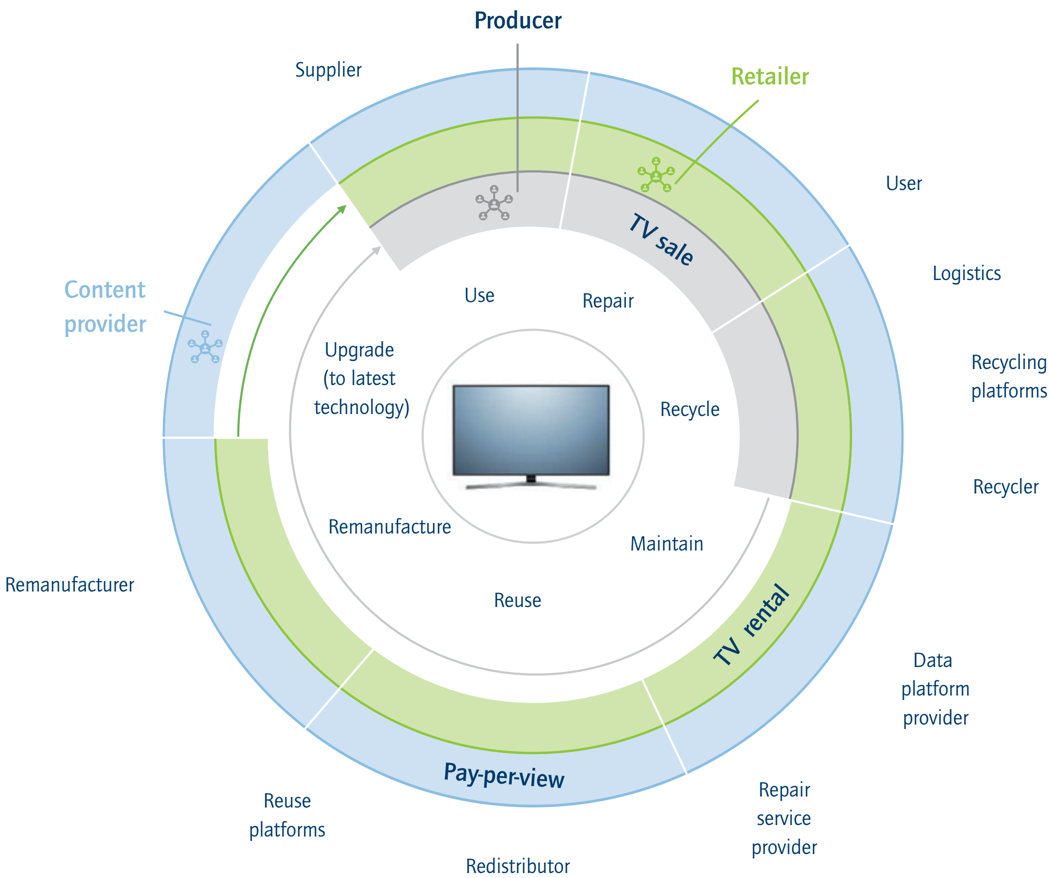


Figure 23: Changes to set of actors in circular business model ecosystems on transition from service level 1 to 3 (Source: own presentation)

8.2 Scenario 1: Selling circular TVs

Ecosystems perspective on a **product-oriented** CBM for TVs – service level 1

Focal actor: Producer

CBM of the focal actor: Selling circular TVs

Circular strategies: Recycle, repair

The exemplary CBM for TVs on service level 1 is based on selling the physical product. Improvements to the previously described status quo of a TV's value chain are made by increasing the circularity of the TV's components and materials by **aligning product design with requirements for quality-driven recycling processes and improved repairability**. Take-back programmes and reverse logistics need to work efficiently and recycling processes need to be optimised in terms of cost, quality and environmental efficiency. The producer will no longer mainly rely on primary resources in the production but will adapt to the use of recycled materials.

With regard to production, producers ensure that the circular design of the TV they are selling permits resource-efficient end-of-life-treatment of TVs. This needs to happen in **collaboration with downstream actors, especially recyclers and recovery managers in order to understand their requirements for the product design when the intention is to retrieve more materials of higher quality from discarded products**. Consumer feedback and data from the TV's use phase can additionally be exploited to improve the circular product design as well as end-of-life product treatment.

The producer will offer repair services that go beyond the currently provided warranty-based services and make sure that they are attractive and accessible to consumers. Therefore, a producer may establish own repair networks and remote services or collaborate with independent repair service providers. The goal is to reduce the transaction costs of repair processes for consumers and thus boost demand for them.

8.2.1 Barriers

The following barriers are relevant to the implementation of a product-oriented CBM for TVs:

- Current economic incentives (e.g. low prices for oil or other commodities) are not sufficient to trigger a mass-use of recycled material and reusable components and do not cover the cost of maintenance.
- There is limited funding of CBMs by producers (they focus on one-time sale rather than lifetime product financing).
- Sales channels are shifting online and repair/maintenance is becoming more remote from the user. This leads to possibly increased costs of product processing (specialised facilities in a few locations in the EU).
- There is limited repair expertise and a shortage of skilled workers.
- There are shortcomings in the regulatory framework which make it cheaper to use virgin materials rather than recycled materials in the new product.
- Ensuring the quality of recycled material (e.g. plastics performance, colour, other specifications are challenging as new control mechanisms and technologies are needed in the redefined supply chain.
- There are complex international regulations (EPR for WEEE) that lead to free riding and shirking of responsibilities e.g. foreign manufacturers who import TVs to Europe, but do not participate in the disposal systems (online trading being a particularly grey area).
- Recycling and disassembling LCD panels is extremely difficult and, in comparison with sourcing virgin materials, is not economically viable.
- The costs of materials relative to the total costs of a TV are very low and have no impact on changing behaviour (production accounts for 2% of costs, the remaining 98% being logistics, marketing, sales and distribution).
- The TV market is very price-sensitive and (most) consumers are not prepared to pay more for a 'circular TV'.
- Costs are constantly being optimised within specific process steps, inadequate attention is paid to overall costs and linear thinking still prevails.
- There are high costs (also environmental) associated with take-back programmes (e.g. pickup locations and repair/maintenance centres).

8.2.2 Digital enablers

The dashboard presented in Chapter 6.5 will be used here to explain how digital technologies enable the implementation of circular strategies.

As is apparent from the dashboard, an organisation can use digital technologies to develop a particular combination of smart circular strategies. For instance, an organisation may have a well-developed predictive maintenance service and a rather simple recycling service while another organisation may have the opposite in place.

The following subsections take a developmental approach to show how digital technologies enable circularity for the three different service level types. We start by describing the product-oriented service level as having a somewhat low or 'smart' level of maturity and give a few indications of the second level of maturity, 'smarter'. We then advance towards the final level of maturity, 'smartest', with descriptions of the use-based and result-based service levels. Even though higher service levels allow greater proximity to the customer with the subsequent opportunity to develop an integral service offer, an organisation may still achieve the highest level of maturity for all smart circular strategies with a product-oriented business model in place.

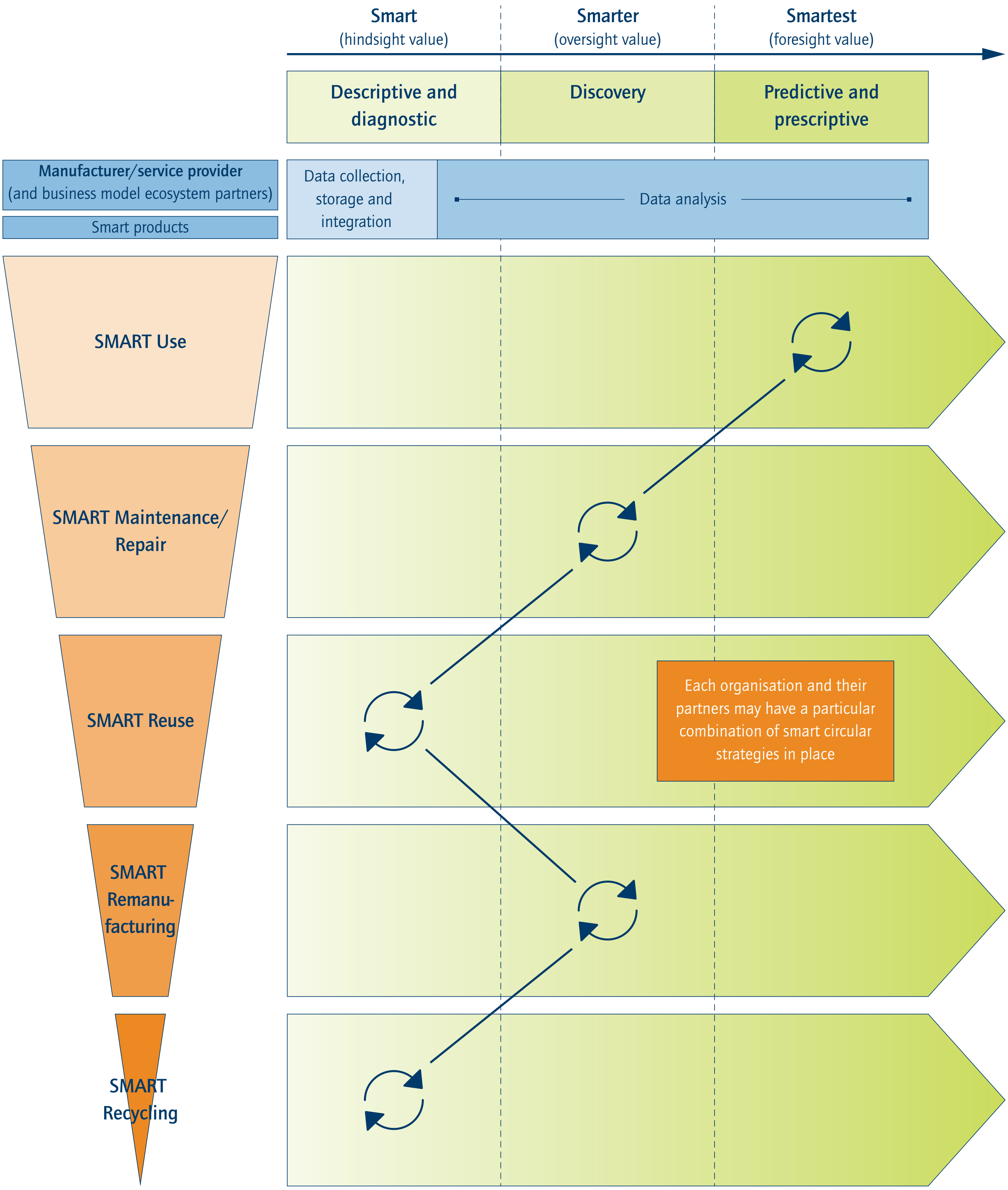


Figure 24: Dashboard for the implementation of smart circular strategies (Source: own presentation, based on Alcayaga et al. 2019, 2020; Hansen et al. 2020b and Kristoffersen et al. 2020b)

	Smart	Smarter	Smartest
Smart use	A digital passport in the TV stores information about the life cycle of the TV. Moreover, the TV recognises automatically when components are replaced and saves this information on the passport.	Blockchain technologies are used to enhance the digital passport with information about the supply chain. Track-and-trace (for future take-back) may be activated by the customer.	
Smart mainte-nance & repair	During normal usage, the customer can access the information on the passport through the main menu of the TV. In the event of failure, the service technician can read and update the information on the passport using external hardware.		
Smart reuse	The customer can upload the information on the passport to second-hand platforms before selling the TV. This enables greater transparency about repairs and remaining useful life.		
Smart recycling	Data from the manufacturer stored on the digital passport enables the determination of material composition and quantity.	Image recognition can be used to detect different materials and improve sorting. If the customer activates the track-and-trace function, recyclers can plan the arrivals and request information in advance.	

Table 13: Digital enablers for the product-oriented circular business models for TVs (Source: own presentation)

8.2.3 Regulatory enablers

Regulatory[265] enablers suggested to support product-oriented CBMs for TVs and their potential effects are the following:

- "Ex'Tax" reform: offsetting higher resource taxes with lower labour taxes (e.g. higher CO_2 and consumption taxes, removal of harmful subsidies, lower value-added tax (VAT) for repair services, lower income taxes) will increase the cost of virgin materials and decrease the cost of secondary materials and repair services.
- Supporting the progressive reform of the EU Ecodesign Directive with additional criteria of longevity, reparability/disassembly, upgradability, reusability, recyclability, and non-toxic design and link these circular criteria to the EU Product Registry for Market Access to establish a level playing field. This measure will encourage the further development and design of more circular TV sets, which enables more profitable and effective CBMs.
- Supporting open-source standards for CE data and information and link them to product passports. This informational instrument will offer information within one value chain and over the product's life cycle to support the CBM of the original producer and give information to the consumer that encourages preferring more circular products at the point of sale.
- Declaration of average product life at point of sale will allow consumers to select the TV set with the desired durability and thus encourage design for durability and business models centred around product life extension.
- A product repair score including physical and digital components (i.e. upgradability) and related (mandatory) product labelling, will also offer information for consumers, encouraging them to prefer the products with better repairability.
- Targets/quotas for government procurement regarding used, remanufactured, and recycled products will create market pull for more circular TVs.
- Providing funding to producers or third-party actors for the operation of nation-wide repair networks will decrease the cost of repair and the distance between users of TVs and repair facilities, thus increasing the environmental and economic efficiency of repair.
- The shift to 'safe-by-design chemicals' with the progressive substitution of hazardous substances which is to be addressed at the interface of REACH, ecodesign/product, and waste legislation, as well as the development of new and/or harmonisation of existing standards/certification systems (e.g. RAL, cradle to cradle) for high-quality recyclates with transparency

265 | We use the term 'regulatory' here for the whole policy mix of regulations, economic and informational instruments, standardisation and green public procurement measures the state can initiate, implement and support.

regarding physical, chemical, biological properties and quality assurance regarding toxicological properties as a basis for product declaration will enable straightforward use of recyclates in the design of new TV sets.
- Advanced and circularity-modulated recycling fees for producers to be paid when goods (covering various sectors/goods types) are introduced to the market encourage producers of TV sets to design for recycling and circularity to reduce the fee they have to pay.

8.3 Scenario 2: Selling the use of TVs

Ecosystems perspective on a **use-oriented** CBM for TVs – service level 2

Focal actor: Retail (option 1) or producer (option 2)

CBM of the focal actor: Rental or leasing business model

Circular strategies: Repair/maintain, remanufacture, reuse

Option 1: The ownership of TVs stays with the retailer when the TV is delivered to a user. This will require changes to TV retailing, as **leasing and/or rental contracts will replace sales contracts**. The advantage of this business model is the incentivisation for strong collaboration of the TV owner with recyclers, refurbishers and/or redistributors to maximise value recovery from used TVs. The retailer will be economically incentivised to maximise the uptime of the TVs he provides to extend the life of the asset. The retailer will be the orchestrator of reverse logistics processes and the treatment of used TVs. The retailer will take used TVs back from customers, may collaborate with partners that will carry out quality control and optional minor refurbishment activities, and remarket used goods in the same or other markets at lower costs. The retailer may also establish collaboration with reuse platforms to match supply and demand for used TVs. The electronic platform minimises transaction costs for sellers and buyers (e.g. search, communication, and negotiation costs). In the ecosystem, retailers may combine their business model with business models of new actors, for example app developers/providers for monitoring the use and condition of the TV, provide support with maintenance, repair and upgrades making recommendations to the consumer when maintenance or repair is needed, and perhaps even provide guidance through the repair process so that consumers can make small repairs themselves.

Option 2: The TV manufacturer retains ownership of the TV and will take back used TVs from users. The advantage of this approach is that remanufacturing activities remain close to primary production. With the business model transition from selling a TV to offering leasing or rental contracts, TV manufacturers will be incentivised to offer repair and maintenance services and to enable remanufacturing and reuse of the TV or its components. This will in turn incentivise a focus on design for durability of TVs, their components and materials as well as design for modularity in the production process, as well as maximising product uptime. Implementing this approach demands strategies for sophisticated repair and maintenance services aligned with user requirements. If these services are not integrated internally by the producer (e.g. by building up own repair fleets or taking over other independent actors), partners have to be sought to participate in the ecosystem. For example, previously autonomous repair providers could become partners. Communication links between the producer and suppliers, retailers, users and recyclers, etc. are of increased importance to help keep up with the technological changes necessary to fulfil user demand, and to ensure product longevity. This could either be facilitated and managed by the producer itself or by a data platform provider.

8.3.1 Barriers

The following barriers apply in addition to the barriers identified for the product-oriented CBM for TVs:

- Producers currently push a product-focused value proposition, not a use-based value proposition.
- Information about product status/quality/performance is unpredictable, which leads to high risks when launching such a CBM.
- TVs are designed for an optimised initial use (complex and embedded components which are difficult to disassemble) with limited product modularity and resulting challenges for product upgrades.
- The distance between TV users and existing processing facilities leads to higher costs (also environmental costs) and there is a general lack of appropriate TV processing (refurbishment, servicing) facilities.
- There is limited repair/refurbishment expertise and a shortage of skilled workers.
- Innovation cycles of high-tech components of TVs are very quick and upgradability/maintenance models cannot keep up.
- Companies will need to stock spare parts or reusable components, leading to increased capital investment.

- The current structure between producer and retailers (sales channels) creates a conflict through potential cannibalisation on the secondary market.
- There could be lower potential revenue from sales in the secondary markets (currently retailers have considerable bargaining power over producers).
- There is a lack of definitions and standards for responsibility for quality, safety and performance of a returned TV that is intended for second use.
- There are shortcomings in the regulatory framework which make it cheaper to use virgin materials rather than recycled material or reusable components in the new/refurbished product.
- There is a limited amount of knowledge among consumers, industry and regulators about the secondary market and its dynamics e.g. pricing and price development over time.
- The user may expect and perceive the refurbished product to be of lower quality.
- The consumer wants to be the owner of the TV (regarding it as an asset that they can resell or give to another family member).
- There is a lack of commonly accepted Circular Economy indicators.
- There is limited knowledge about the total life cycle calculation.

8.3.2 Digital enablers

Higher service levels allow greater proximity to the customer with the subsequent opportunity to develop an integral service offer. The paragraphs highlighted in blue indicate which digital technologies are added for the scenarios of use-oriented circular business model CBMs for TVs.

	Smart	Smarter	Smartest
Smart use	A digital passport in the TV stores information about the life cycle of the TV. Moreover, the TV recognises automatically when components are replaced and saves this information on the passport.	Blockchain technologies are used to enhance the digital passport with information about the supply chain. Track-and-trace (for future take-back) is active as part of the rental or lease contract.	
Smart maintenance & repair	During normal usage, the customer can access the information on the passport through the main menu of the TV.	Failure is not expected since a condition-based maintenance service is part of the service contract. The TV or its components are replaced when parameters reach a certain level (e.g. excessive temperature).	
Smart reuse	The manufacturer can upload the information on the passport to second-hand platforms before selling the TV. This enables greater transparency about repairs and remaining useful life.	Track-and-trace and inventory management tools enable better management of the whole assortment. The manufacturer can extend the lifetime of the TV by serving different customer segments.	
Smart remanufacturing	The life cycle information about the TV on the digital passport helps the manufacturer understand the root cause of failure.	The root cause of failure Is addressed using customer usage patterns, information from the supply chain, quality analysis of components and materials. These sources of information improve decision-making before remanufacturing or upgrading the TV. Track-and-trace and life cycle information enable planning of the take-back service. The remanufacturing workshop can adapt their capacity according to current and future arrivals.	
Smart recycling	Data from the manufacturer stored on the digital passport enables determination of material composition and quantity.	Image recognition can be used to detect different materials and improve sorting. The track-and-trace function enables more efficient coordination with recyclers.	

Table 14: Digital enablers for use-oriented circular business models for TVs (Source: own presentation)

8.3.3 Regulatory enablers

The following regulatory enablers are especially relevant to use-oriented CBMs for TV sets:

- Supporting an open-source standard for CE data and information will provide information across value chains and allow several new actors in cooperation with and/or in addition to the original producer to offer pay-per-use models with new or used TV sets.
- Targets/quotas for government procurement regarding preference for service contracts (i.e. product-as-a-service) over goods purchase increase the market pull for use-oriented CBMs.
- "Ex'Tax" reform: offsetting higher resource taxes with lower labour taxes (e.g. higher CO_2 and consumption taxes, removal of harmful subsidies, lower VAT for repair services, lower income taxes) will increase the cost of virgin materials and components as well as new products and decrease the cost of secondary materials and components and of labour. Thus, all services around maintenance, take-back, refurbishment, remanufacturing etc. will be more cost effective and make more business sense.
- "Ex'Tax" reform will also decrease the cost of services and thus can make use-oriented business models economically more attractive to consumers than buying a new TV set.
- Strategic funding of remanufacturing institutions (e.g. National Remanufacturing Institute), programmes, pilots, and consultancy will support producers in developing successful remanufacturing technologies, design strategies and business models.
- Explicit integration of remanufacturing definitions/standards in waste legislation to prevent waste status of returned used components/cores will create many more take-back and remanufacturing options within one value chain/for the original producer.
- Developing quality standards and labels for the reliability of remanufactured products/components will make it much easier to include used components in the design of new TV sets.
- Prohibiting the destruction of returned products from online and offline shopping will encourage business models around reusing these products in use-oriented business models.
- Advanced and circularity-modulated recycling fees to be paid by producers when goods (covering various sectors/goods types) are sold can encourage producers to offer their products in use-oriented CBMs rather than selling them.
- Providing funding to producers or third-party actors for the operation of nation-wide repair networks will decrease the cost of repair and the distance between users of TVs and repair facilities, thus also allowing for more efficient maintenance of TVs used in use-oriented CBMs.
- Developing quality standards and labels for the reliability of remanufactured products/components will make it much easier to include used components in TV sets, which also supports the repair and upgrade of TV sets in use-oriented business models.

8.4 Scenario 3: Selling the performance of TVs

Ecosystems perspective on a **result-oriented** CBM for TVs – service level 3

Focal actor: Content provider

CBM of the focal actor: Pay-per-view

Circular strategies: Repair/maintain/upgrade, remanufacture, reuse

This scenario involves a CBM that is detached from the physical product. It is not a product but instead a result (or a 'function'; see box) in a full-service offer that is sold to users by a content provider. **The business model is thus based on selling the result on a pay-per-view basis.** The content provider can choose (used) products and technologies which deliver the best result and has full responsibility for their deployment, maintenance (incl. consumables), repair, replacement and take-back. **The TV will then be one of potentially several devices that enable the user to be entertained by watching TV programmes and related content (i.e. the function)**. In the full-service offer, the TV will be provided to the user for free or against a small service fee and ownership will stay with the content provider, who ensures that the user is provided with a fully operational device at all times. The content provider will take care of repair, maintenance and software upgrades and will exchange the devices if required. The content provider leverages synergies from maintenance/repair activities by reusing components and materials. He ensures take-back after service as the basis for deployment at other customers' sites, remarketing or recycling. He may manage a pool of devices and spare parts and partners up with redistributors or has own remarketing channels.

'Digression': The Functionality Economy[266]

This digression briefly outlines the aims of a result-oriented CBM. The concept of a 'functionality economy' is based on the idea of putting the functionality of a product at the centre of any circular business model consideration. The value proposed to a user is the functionality (e.g. mobility) and not the product (e.g. car) itself. Creating a CBM based on functionality requires new ways of thinking about circularity. To analyse functionality, we answer key questions such as: what is the core function we want to provide and how can we fulfill it?

A tangible example is the functionality of mobility: automotive manufacturers are starting to think about business models around selling the service of mobility and focusing less on the car itself. The car is only one out of several options to provide mobility to a user. New CBMs that have emerged out of this approach are sharing concepts and collaboration between providers of different transportation modes. The business model is based on selling the service of travelling from A to B, which can include several transportation modes offered by different service providers. This results in advanced requirements for digital technologies to enable the orchestration of service-oriented CBM, for example enabling continuous and real-time data availability to steer processes and services and manage collaboration between the actors involved.

The ecosystem builds upon the structures and collaboration that have been formed for the previous service levels. The content provider may outsource any activity other than providing the content to partners in the ecosystem and may use platforms for coordinating recycling, remarketing of used products, or sharing activities. Collaboration and strong communication links between the actors are essential to orchestrating the value ecosystem. Open data platforms can enable decentralised and secure availability of data between the actors.

8.4.1 Barriers

The following barriers apply in addition to the barriers identified for the use-oriented CBM for TVs:

- Producers currently push a product-focused value proposition, not a performance-based value proposition.
- Information about the product status/quality/performance is unpredictable, which leads to high risks in launching such CBMs.
- The business model is unknown and potentially risky for producers (which typically sell only TVs) vs. selling product use. It leads to a potentially long learning and restructuring process on the part of the producer.
- The cooperation structure (including ownership and responsibilities) between content providers, consumers and manufacturers has not been developed and tested on the mass market.
- Data exchange structures between stakeholders have not yet been defined or developed.

8.4.2 Digital enablers

A pay-per-view business model allows for real use data, enabling the implementation of smartest strategies. The paragraphs highlighted in blue indicate which digital technologies are added for the scenario of result-oriented CBMs for TVs.

266 | See Sakao et al. 2008; Stahel 1997.

	Smart	Smarter	Smartest
Smart use	A digital passport in the TV stores information about the life cycle of the TV. Moreover, the TV recognises automatically when components are replaced and saves this information on the passport.	Blockchain technologies are used to enhance the digital passport with information about the supply chain. Track-and-trace (for future take-back) is active as part of the rental or lease contract.	Under a pay-per-use service level, manufacturers may analyse usage information from the customer base to predict usage patterns and coordinate more efficient energy plans with local energy providers. They can also generate better estimates of remaining useful life and product degradation.
Smart maintenance & repair	During normal usage, the customer can access the information on the passport through the main menu of the TV.		Failure is not expected as predictive maintenance is part of the service contract. The TV may execute self-optimisation algorithms according to customer usage and order a component replacement automatically.
Smart reuse	The manufacturer can upload the information on the passport to second-hand platforms before selling the TV. This enables greater transparency about repairs and remaining useful life.	Track-and-trace and inventory management tools enable better management of the whole assortment. The manufacturer can extend the lifetime of the TV by serving different customer segments.	Under a pay-per-use service level, prediction algorithms that analyse usage patterns can offer advantages for planning the take-back process and the allocation of TVs to the customer base. E.g. customers with high usage may receive a more efficient TV than customers with low TV viewing time.
Smart remanufacturing	The life cycle information about the TV on the digital passport helps the manufacturer understand the root cause of failure.	The root cause of is identified using customer usage patterns, information from the supply chain, quality analysis of components and materials. These sources of information improve the decision-making before remanufacturing or upgrading the TV. Track-and-trace and life cycle information enable planning of the take-back service. The remanufacturing workshop can adapt their capacity according to current and future arrivals.	A pay-per-use service level allows optimal planning of the remanufacturing service because customers pay for the TV viewing time and not for a specific device. TVs can be exchanged and reallocated, allowing for seamless remanufacturing and upgrading. Digital technologies enable automatic scheduling and anticipation of changes in the value chain, ensuring minimal disruption to remanufacturing operations.
Smart recycling	Data from the manufacturer stored on the digital passport enables the determination of material composition and quantity.	Image recognition can be used to detect different materials and improve sorting. The track-and-trace function enables more efficient coordination with recyclers.	Artificial intelligence may enable autonomous cost-benefit analysis at end of life based on the quality of the materials and components of the TV.

Table 15: Digital enablers for result-oriented circular business models for TVs (Source: own presentation)

8.4.3 Regulatory enablers

The following regulatory enablers are especially relevant to result-oriented CBMs.

- "Ex'Tax" reform: offsetting higher resource taxes with lower labour taxes (e.g. higher CO_2 and consumption taxes, removal of harmful subsidies, lower value-added tax (VAT) for repair services, lower income taxes) will decrease the cost of services and can thus make performance-based business models more economically attractive to consumers than buying a new TV set.
- Targets/quotas for government procurement regarding preference for service contracts (i.e. product-as-a-service) over goods purchase might increase market pull for performance-based CBMs.
- Supporting an open-source standard for CE data and information will provide information across value chains and allow a number of new actors in cooperation with and/or in addition to the original producers to offer performance-based CBMs with new or used TV sets – or with any other suitable product.
- Providing funding to actors for the operation of nation-wide repair networks will decrease the cost of repair and the distance between users and repair facilities, thus also enabling

more efficient maintenance of products used in result-oriented CBMs.

- Developing quality standards and labels for the reliability of remanufactured products/components will support the repair and upgrade of products in performance-based business models.
- Prohibiting the destruction of returned products from online and offline shopping as well as advanced and circularity-modulated recycling fees for producers to be paid when goods (covering various sectors/goods types) are sold might encourage business models that are no longer based on selling products but on selling performance.

8.5 Summary

Today, producers still predominantly push a product-oriented value proposition, focusing more on selling the product rather than selling the experience a customer receives as a result of the product. The illustrative use case of TVs demonstrates how higher service levels (use- and result-oriented services) enable the implementation of more advanced (smart) Circular Economy strategies.

A digital passport in the TV stores information about the life cycle of the TV (product-oriented), track-and-trace technologies, activated as part of the rental or lease contract, may feed in additional information about the supply chain (use-oriented) and in a pay-per-use business model, the manufacturer can even analyse relevant usage information (result-oriented). The availability of this set of data enables a significant improvement in CE-relevant decision-making e.g. before remanufacturing components or upgrading the TV.

With regard to how policy-related instruments are enabling CBMs for TVs, there is a strong need to offset higher resource taxes with lower labour taxes to incentivise service offerings for and labour-intensive treatment of returned TVs, develop quality standards and labels for the reliability of remanufactured products/components and support the reform of the EU Ecodesign Directive with the addition of criteria for longevity, reparability/disassembly, upgradability, reusability, recyclability and non-toxic design.

9 Recommendations

A successful transition to a Circular Economy (CE) requires **a paradigm shift in and close collaboration between businesses, governments, science and society.** This requires an understanding of comprehensive system transformations, or the 'great transformation'.[267] In line with such a **systemic point of view**, the recommendations developed in this chapter should not be understood as singular measures, but as bundles of integrated actions which together represent **a carefully drafted 'policy mix'**, ensuring coherence and complementarity. In this way, possible synergies in the implementation process can be exploited and conflicts between individual measures avoided. Ensuring a transdisciplinary dialogue between politics, business, science and civil society can ensure a coordinated approach during the implementation period and makes sure that goals and achievements are continuously monitored and reassessed.

9.1 Overarching policy recommendations

Successful transformation toward a CE, as with sustainability more broadly, requires policy makers to specify and adhere to long-term goals, create new markets and niches, align innovation with exnovation,[268] and provide necessary complementary public infrastructure (e.g. collection schemes).[269] Against this background, the working group commonly agreed on **seven core actions for further implementation.** The first one highlights industry's leadership role, the next five recommendations set out the government's role in establishing a policy mix consisting of economic, regulatory, self-regulatory (i.e. standardisation), information and public procurement instruments, and the last recommendation addresses the long-term governance of the transition:

(1) Industry needs to lead and invest in experimentation with new CE-oriented (service) business models and related radical innovations in products, processes, and organisational forms

In order to drive innovation and accelerate the transition to a CE, companies need to proactively embrace the transition, realign their strategies and R&D goals, and generally invest more time and resources. Innovation spaces – within or independent of core business units – for questioning traditional linear business models, products designs, and related value chains and for engaging in radical innovation of service business models are fundamental to transforming organisations. This involves developing and strengthening cross-sector partnerships and expanding business model ecosystems towards full circles.

(2) Governments should develop an economic market framework with true-cost pricing and provide targeted support for advanced CE practices (policy type: economic incentives)

True-cost pricing is key to the further development of appropriate economic and market frameworks for circular business models (CBMs) (and sustainability more broadly). CBMs cannot come into widespread use if key economic conditions and incentives remain hostile to their development. We are therefore following other reputable reports in concluding that 'one of the preconditions for a Circular Economy is a fundamental shift in taxes from labour to the use of natural resources'.[270] A very well established and tested agenda for reform is the Ex'Tax principle, at the core of which is the aim to shift rather than increase the tax burden (i.e. a zero-sum game).[271] It describes a tax-related policy mix which combines instruments that increase the costs of the exploitation of natural resources (e.g. higher CO_2 prices) – including the removal of harmful subsidies (e.g. all kinds of tax exemptions/reductions linked to the exploitation of fossil fuels) – with instruments that lower tax burdens for labour (e.g. the reduction of employer-paid contributions to employed persons' insurance and health) and labour-intensive services contributing to circularity (e.g. zero value-added tax (VAT) for repair and maintenance services).

Beyond true-cost pricing, targeted funding should accelerate the transition to the CE. Most importantly, it is necessary to support the adoption and diffusion of service business models linked to circularity (e.g. chemical leasing), introduce or expand repair service operations, promote standardised reusable systems (e.g. a standard bottle), and establish and demonstrate remanufacturing operations. This can all be cross-facilitated by the implementation of digital technologies for better tracking-and-tracing of materials, components, and products along value cycles, including digitally enhanced collection and sorting infrastructure.

267 | See Schneidewind/Singer-Brodowski 2014; Schneidewind 2018.
268 | E.g. increased use of secondary raw materials also needs to be linked to reduced production of primary raw materials.
269 | See Clausen/Fichter 2020.
270 | See Groothuis/Ex'Tax Project 2014, p. 5.
271 | See Groothuis/Ex'Tax Project 2014; Groothuis/Ex'Tax Project 2016.

(3) Further develop the regulatory framework and remove related barriers (policy type: regulatory instruments)

Isolated reforms of current waste management and ecodesign policies do not appear to be sufficient to overcome the current dominant focus on waste and to ensure circularity is truly embraced. In contrast, a coherent circular product policy framework is needed which ensures a level playing field for global competition (a more detailed elaboration is given in section 9.3). This requires i) all products to comply with minimum circular design characteristics (design for longevity, reparability, recyclability) as part of the product registry for the European market, ii) straightforward digital accessibility of product (product type) characteristics through a common product ID, iii) greater responsibility of producers/retailers along the life cycle with extended warranties and mandatory take-back to provide incentives for better product design and circular service operations and iv) preventing end-of-product status where circular strategies of repair, reuse or remanufacturing remain reasonable and preventing waste status as long as recycling is feasible. The prohibition of the destruction of returned products from online and offline shopping is a precondition for circulation.

In order to promote high-quality recycling, governments should establish quality criteria in addition to quantitative recycling quotas (this includes defining and differentiating recycling with regard to quality and considering potential output qualities from sorting/recycling facilities and related treatment requirements, and more material-specific quotas),[272] establish binding minimum quality standards for recyclates, and define sector-specific requirements for minimum recycled content from post-consumer materials. It is not possible to move towards quality recycling without tightening the regulation of toxins in materials and products: the shift to 'safe-by-design chemicals' through the progressive substitution of hazardous and other substances of concern is to be addressed in the product policy framework and the EU's chemical strategy[273] and has implications for the interface of REACH, ecodesign, and waste legislation.

(4) Support the development and harmonisation of product- and material-level standards (policy type: standardisation)

The absence of standardisation hinders the more widespread diffusion of CBMs. The German government should support and, where they do not exist, initiate standardisation initiatives on national and international levels. The most important needs are i) to establish a standard for classifying the condition of used, refurbished, and remanufactured goods and components, ii) to develop quality standards and labels for the reliability of remanufactured products and their incorporated components, iii) to harmonise and diffuse quality standards and labels for high-quality post-consumer recycled materials (recycled content in products) with transparency and quality assurance regarding physical, chemical, biological, and toxicological properties, and iv) to establish standards for open data formats (e.g. product passports) and related standardised exchanges of circularity-related data. Standards should preferably be open rather than proprietary.

(5) Strengthen user skills and information availability regarding circular products and services in the market (policy type: informational instruments)

CBM uptake is often slow due to a lack of awareness of circular characteristics and existing offerings. Governments should help in diffusing awareness, knowledge and skills relating to circularity and CBMs. This involves establishing better information availability through product labelling and declarations (based on standards) at the point of sale regarding average product lifetimes, product reparability (i.e. reparability score), and advanced eco-labelling based on the circular requirements of the EU product registry and/or the Ecodesign Directive. Awareness-raising campaigns should also increase the literacy of users and consumers in Do-It-Yourself (DIY) or assisted repairs (e.g. repair cafés), contributing to a shift from consumers to circular prosumers. The basis for translating better information into better decisions is training and educational programmes in schools, vocational training centres (e.g. consumer electronics repair), and universities (e.g. master's programmes in CE). Education has the dual effect of increasing user literacy and building the skills of the future specialised workforce required by companies in the transition to a CE.

(6) Make public institutions lead by example through government procurement (policy type: government procurement)

Governments and public authorities have a responsibility to lead the transition into the CE. We recommend strategic targets and quotas for used, remanufactured, and recycled (and simultaneously recyclable) products differentiated by goods category. Moreover, vendors with service business models offering services such as advanced maintenance, repair, and take-back should be prioritised over those vendors limiting their services to compliance (i.e. repair based on legal warranty). This also includes removing barriers to procurement regarding use- (e.g. leasing) and result-oriented (e.g. pay-per-performance) service business models, which have considerable potential to advance circularity, but which vendors often have difficulty in diffusing on the market. Central procurement guidelines and centres of expertise should support these practices.

272 | See Sachverständigenrat für Umweltfragen 2020a, pp. 163-167.
273 | The EU is currently working on the initiative 'Chemicals – strategy for sustainability (toxic-free EU environment)', in which these aspects are discussed.

(7) Institutionalise the transition to a Circular Economy in the long-term, by establishing a national and European coordination body

Provide science-based guidance for the transition to a CE through the establishment of a national and European central body that aligns the perspectives of politics, industry and society across legislative (and financial) periods in the long term.

9.2 Detailed policy recommendations for each Circular Economy strategy

The following table gives an overview of the recommended actions developed in the working group on the basis of existing policy studies and joint discussions. Each of the recommendations is further specified by indicating which policy type the measure can be subsumed under, which Circular Economy strategy it promotes, by when the measure should be implemented and which political/societal actors bear decisive responsibility for implementing it.

Policy instrument	Policy type					Responsibility	Possibly effective in* …		
	Economic	Regulatory	Standards	Informa-tional	Government procurement		2021-23	2024-26	2027-29
Meta level									
Foundation and funding of a national and European central body that aligns perspectives of politics, industry and society across legislative periods.	×		×	×		National government, multiple ministries incl. Research, Environment, Economy, Finance	×		
Support the creation of university, vocational and school educational programmes for the CE (and related positions as professors/teachers) including digitalisation as a lever for smart maintenance, repair, reuse, reman, and recycling. This covers all levels including apprenticeships [dual training] and higher education (e.g. integration of CE-modules in established business, engineering, social science, and political science programmes).	×			×		F.M. of Education and Research	×		
Advance the framework conditions for Circular Business Models across all CE strategies (maintain/repair, reuse, reman, recycle)									
Ex'Tax reform: compensating for higher resource taxes with lower labour taxes (e.g. higher CO_2 and consumption taxes, removal of harmful subsidies, lower VAT for repair/maintenance services, reduction of employer-paid contributions to social security, lower income taxes).	×					Broad participation of F.M. (e.g. Economy, Environment, Finance, Labour)	×	×	×
Invest in new corporate and interorganisational innovation spaces for developing, experimenting with, and evaluating radical new service business models linked to circular value creation (e.g. maintenance, upgrading, repair).						Industry	×		
Ecodesign Directive: Support the ongoing progressive reform of the EU Ecodesign directive with additional criteria of longevity, reparability/disassembly, upgradability, reusability, recyclability, and non-toxicity.		×		(×)		National government	×	×	

Policy instrument	Policy type					Responsibility	Possibly effective in* …		
	Economic	Regulatory	Standards	Informa-tional	Government procurement		2021–23	2024–26	2027–29
Advance the framework conditions for Circular Business Models across all CE strategies (maintain/repair, reuse, reman, recycle) *continued*									
Assessment of circular criteria (e.g. reparability, recyclability) in EU product registry for market access (i.e. ‚Conformité Européenne'/CE marking), establishing a level playing field.		×				National lobbying with EU government		×	×
General obligation for producers to take back products (combined with EPR) to prevent waste status.		×				National lobbying with EU government		×	×
Revision of Waste Legislation (KRwG) to prevent used but reusable, repairable, or remanufacturable products from being assigned waste status in the first place.		×				National government, with optional links into EU legislation		×	
Stimulate industry adoption of distributed ledger technologies (e.g. blockchain) through standards and software packages, enabling the traceability of products, components, and materials along the value cycle.	×		×			Companies/Industrial Associations; F.M. Economic Aff.		×	
Support the development of secure standards for open data formats (e.g. product passports) and related exchange of circularity-related data (e.g. product exchanges/condition, maintenance, repair).			×			e.g. F.M. of Economy, Transport/Digital Infrastructure, Environment; Standardisation Bodies	×		
Targets/quotas for government procurement regarding used, remanufactured, and recycled products and related preferences for product-as-a-service business model contracts over traditional goods purchases.					×	National/state governments, public-sector institutions	×	×	
Support, remove barriers to, and stimulate demand for a shift to CE-related product-as-a-service business models (e.g. circular leasing) which are linked to maintenance, repair, and product take-back for remanufacturing and recycling.	×	×		×	(×)	F.M. of Economy, Education/Research, Environment, Finance	×		
Advance the product-life extension through repair/maintenance, and upgrading									
Providing funding to producers or third-party actors in support of the operation of repair networks with nation-wide accessibility.	×					National government	×		
Extend legal and/or commercial warranties to planned technical lifetime, to three years for all goods, or five years for selected goods as a driver for service business models.		×				National government		×	
To prevent breaches of data privacy, producers should only collect and share data that are relevant for carrying out the specific function (e.g. maintenance). For this purpose, data should be categorised and layered in a way that such bounded access can be operationalised.			×			Companies; Industrial Associations; Standard-setting bodies	×		
Create a product repair score including physical and digital components (i.e. upgradability) and related (mandatory) product labelling.				×		National governments with links to EU Ecodesign Directive	×	×	
Increase user autonomy by engaging in repair practices & increasing repair skills (e.g. visiting repair cafés).				×		User/Civil society	×		

Policy instrument	Policy type: Economic	Policy type: Regulatory	Policy type: Standards	Policy type: Informa-tional	Policy type: Government procurement	Responsibility	Possibly effective in* … 2021-23	Possibly effective in* … 2024-26	Possibly effective in* … 2027-29
Advance the reuse of products (and components)									
Promote reusable systems (e.g. packaging, parcels) and evaluation of extensions (more product categories) of Single-Use Plastics Directive to additional product categories and materials.	×					National governments, partly EC	×		
Prohibition of destruction of returned products from online and offline shopping.		×				National government	×		
Declaration of average product life at point of sale.				×		National government		×	
Standardise and improve statements on the condition of reused, refurbished, and remanufactured products/components based on traceable data (e.g. product history tracking, product passport) and their quality assurance in order to improve transactions on online platforms and increase the confidence of market participants.			×	×		Industry; Consumer protection agencies	×	×	
Advance the remanufacturing of products (and components)									
Strategic funding of reman institutions (e.g. National Institute), programmes, pilots, and training.	×					National government (e.g. F.M. of Education/ Research; Economy)	×		
Support demonstration projects by companies using track-and-trace and life cycle information about products-in-use to improve take-back services, planning of remanufacturing processes, and replacement of virgin production with remanufacturing.	×					e.g. F.M. of Economy; Transport and Digital Infrastructure	×		
Explicit integration of reman definitions/standards in waste legislation and regulation of international trade to prevent waste status of returned used products/components (‚cores') and harmonisation at an international level to remove trade barriers.		×				National government (e.g. F.M. of Economy; Environment)		×	
Support the development of quality standards and labels for the reliability of remanufactured products and their incorporated components.			×			National government; Standardisation bodies		×	
Advance the high-quality recycling									
Advanced and circularity-modulated recycling fees for producers of end products across sectors to be paid when goods are introduced to the market.	×					National government		×	
Support the demonstration and diffusion of digital technologies (e.g. artificial intelligence) in the recovery sector to improve material recognition and sorting as a basis for high-quality recycling and, where necessary, cover necessary adaptations of product designs (e.g. markers as a basis).	×					Sorting infrastructure companies; Industrial Associations; F.M. of Economic Aff.		×	
Shift to ‚safe-by-design chemicals' with the progressive substitution of hazardous substances – to be addressed at the interface of REACH, Ecodesign/ product, and waste legislation.		×				National government and EC		×	×
Regulate the amount of recycled content in products (e.g. packaging) using approaches such as quotas.		×				Government		×	×

Policy instrument	Policy type					Responsibility	Possibly effective in* …		
	Economic	Regulatory	Standards	Informa-tional	Government procurement		2021–23	2024–26	2027–29
Advance the high-quality recycling *continued*									
Introduce qualitative recycling criteria and link them to existing quantitative quotas to prevent downcycling on a national or European level.		×				National government or EC		×	
Establish binding quality standards for secondary materials and recycled content in end products.		×	×			Government; Industry	×	×	
Support the development of new and/or the harmonisation of existing standards/certification systems (e.g. RAL % Recycling Kunststoff, Cradle to Cradle) for high-quality recyclates with transparency and quality assurance regarding physical, chemical, biological, and toxicological properties - as a basis for product declaration.			×	×		National government; Standardisation bodies	×	×	

Note: * Timeframe shows the earliest date possible when a policy could become effective, if policy makers start working on their planning/implementation today.

F. M. Federal Ministry
EC European Commission

Table 16: Overview of recommended actions (Source: own presentation)

9.3 A change in perspective: Advancing regulation towards a circular product policy framework

To date, neither waste nor ecodesign legislation has fulfilled the goal of achieving a Circular Economy. Despite covering not only the product's waste phase but also its whole life cycle, waste management legislation still focuses on the end of product life – and therein primarily on recycling and further waste treatment – and does not take waste prevention entirely seriously. On the other hand, ecodesign legislation is still narrow in scope, only addressing energy-related products. A significant share of the above regulatory recommendations can therefore be considered to go beyond waste and ecodesign legislation.

In order to achieve more significant progress towards a CE, and to better accommodate the various isolated policy instruments recommended above, the regulatory framework must be far more product- and producer-oriented. There would appear to be a need for **independent product legislation**, a sustainable and circular product policy framework which goes beyond the traditional areas of ecodesign and waste legislation. Such a policy framework is rooted in **a change of perspective along seven lines** (all of which have already been addressed as part of the policy recommendations above or elsewhere in this report):[274]

1. **From waste to product hierarchy:** Complementing the waste hierarchy, a 'product hierarchy' could make explicit the prioritisation of CE strategies covering in descending order (rule-exception relationship): longevity (maintainability), reparability, remanufacturability, non-toxic composition (substances of very high concern), and recyclability. This hierarchy would then also be the basis for defining financial incentives, as in the Ex'Tax reform.

2. **From end-of-waste to end-of-product status:** While the waste status of products is precisely defined in waste legislation, often presenting a barrier to higher-level circularity, an end-of-product status may better serve a CE. A product should only lose its status under certain conditions, namely when no repair, remanufacturing or reuse is possible, when it cannot be transformed into a material, substance or other product without endangering human health or the environment, and as long as illegal waste exports can be prevented in a reasonable manner. The application of end-of-product status could prevent products from falling automatically under overly complex waste management regulations at the end of

274 | See Maurer 2020a; Maurer 2020b, p. 3.

their use. Hence, other than current practice, products falling under the definition of waste should be made the exception, not the rule.

3. **From extended producer responsibility to producer responsibility for sustainability**: A further element which is to some extent being considered in the current draft of an amendment to the Closed Substance Cycle and Waste Management Act (KrWG) (Section 23 No. 11 KrWG-draft)[275] is the concept of 'producer responsibility for sustainability'.[276] In general, producers should keep control over their products and have a duty of care over their full life cycle. This includes mandatory take-back and encouraging product longevity, etc. Possible supporting policies that have already been proposed are minimum guarantee periods on products, long-term availability of spare parts, and establishing product repair and refurbishment networks.

4. **From limited product groups (Ecodesign Directive) to general design requirements:** All products, not only those falling under the Ecodesign Directive, should be designed on the basis of circular criteria.

5. **From design only to design-based after-sales services:** Product design alone does not reap the potential of circularity. Only in combination with after-sales services (e.g. repair) does circularity become a reality. This includes earlier policy recommendations such as a producer's own operation of, or financial contribution to, repair networks.

6. **From limited ex-post to general ex-ante registration schemes for market access:** In order to establish a level playing field for more demanding circular requirements, a key recommendation above includes the verification of minimum design characteristics as part of the general registration in the European Union product registry for market access.

7. **From anonymous to digitally identifiable products:** As a basis for leveraging the various digital enablers for circularity, products marketable in the EU have to bear a visible product ID (e.g. barcode), allowing access to authorised data contained in a product passport with important circular characteristics (e.g. average lifespan, access to repair service, recyclability profile).

9.4 Leading the change in individual business organisations

The recommendations for industries and policy makers outlined above will certainly accelerate the transition to a CE. Over time, framework conditions will be ever more conducive to CE-oriented business practices and business models. Still, the strategic choices, designs and mode of implementation of CBMs in the individual organisation remain a strategic responsibility of each individual company. Companies can respond more quickly and proactively to anticipated changes in regulatory and market frameworks, or they can respond more defensively to current regulatory requirements.[277]

Proactively adopting CBMs can be an important driver of success for individual organisations if a '**Business Case for Circularity**' is developed. Six business drivers serve this end:

- costs and cost reduction
- risks and risk reduction
- sales and profit margin
- reputation and brand value
- attractiveness as an employer, and
- innovation and innovativeness.

The table below provides examples of issues which corporate decision makers can raise in order to develop viable business cases for circularity and outline exemplary measures/Key Performance Indicators (KPIs) by which their implementation rate can be monitored. In this way, the table provides some initial practical guidance for business managers seeking to strategically implement more circular business practices at an organisational level.

275 | See BMU 2019, p. 65.
276 | See Stahel (2019), p. 53. Proposes a similar 'Extended Producer *Liability*' scheme.
277 | See Schaltegger et al. 2012.

Business case driver	CE aspect	Exemplary measures	Exemplary KPIs
Costs and cost reduction	How can CE measures reduce costs?	– Increasing the use of secondary raw materials may reduce costs (if market framework reflects true costs). – Introduction of repair service packages reduces product complaints/returns.	% Share of secondary raw materials in individual product group/entire portfolio # Reduction of number of complaints/product returns.
Risks and risk reduction	How can CE measures reduce risks for the company?	– Installing take-back systems and increasing reuse of secondary materials makes companies less dependent on primary raw materials and related supply chain issues and increases resilience. – With service business models companies are able to contain the technical risks of new product designs through monitoring, (preventive) maintenance, and repair. – Reducing content made of Substances of Very High Concern (SVHC) in products will reduce risks related to customer health.	% Share of secondary raw materials in individual product group/entire portfolio # Reduction of customer complaints directed at the company or on online platforms (i.e. user ratings).
Sales and profit margin	How can CE measures increase sales margins and/or increase profits?	– New quality-as-new (i.e. remanufactured) product line can be offered at lower costs, reaching new customer groups. – Total care service contracts allow for additional (service) sales turnover over the entire use phase.	# New customers attracted by quality-as-new product line € Sales of new maintenance/repair service packages. # Total care contracts.
Reputation and brand value	How can CE strategy and measures increase reputation and brand value?	– Communication of a new Circular Business Model (e.g. 'material bank') in industry forums, stakeholder events, corporate reporting, and customer brochures. – Marketing campaign on extended warranties and related repair offerings will contribute to perceptions of the brand as a quality leader.	# Number of media articles per month mentioning the company's new circular business model and related products/services.
Attractiveness as employer	How do the company's CE strategy and measures contribute to employer branding and talent acquisition?	– Employer branding campaign highlights take-back, repair, and remanufacturing programmes as contributions to sustainable development.	% Awareness of potential employees (talent) of the company's CE strategy, programmes, or measures.
Innovation and innovativeness	How does circularity drive the company's innovativeness?	– Include circularity goals in R&D strategy (e.g. take-back systems, reusability, disassembly, recycled content)	% Share of CE-related innovation projects in the overall innovation portfolio. # Employee ideas related to the CE # 'Material Circularity Indicator (MCI) at product or company level'*

Note: * See Linder et al. 2017.

Table 17: Business case drivers for implementing circular business models (Source: own presentation, based on Schaltegger et al. 2012)

10 Conclusion

The overall objective of the present report was to identify systemic solutions for successful implementation of circular business models (CBMs). This was done in a multi-stakeholder process with representatives from science, business and civil society. The underlying conceptual basis for this endeavour was a typology of CBMs jointly developed by the working group. Differentiating between 22 actor-specific business model patterns, the report provides practical guidance to practitioners aiming at redesigning their value chains and business models towards circularity. Rising ambition levels specified for each pattern, as represented by more advanced circular strategies and service levels, inspire creativity and continuous improvement on the way towards circularity. Based on this conceptual basis, the report revealed the difficulties that arise in the practical implementation of circular business models and highlighted the importance of an integrated approach, considering different sets of nested barriers. Subsequently, the enabling potentials of digitalisation and regulatory framework conditions for a Circular Economy were further elaborated. For illustrative purposes, reference was made to the use case 'the TV' and it was demonstrated how different service levels of business models link into circularity. Finally, core recommendations for action in the form of a temporal roadmap were developed for different stakeholder groups.

This report is intended as a contribution to an ongoing transformation process towards a sustainable and Circular Economy and society. Based on the report's key findings and positions, various follow-up questions arise:

- It might be of interest to further explore the role of partnerships in CBM-related ecosystems, validate CBMs with the challenges of implementation in real companies, explore the dynamics when CBMs are adopted within the context of firms' innovation processes, and further analyse the specific economic, environmental, and societal impacts of their adoption.
- From a practical viewpoint, it could be worthwhile to further develop the typology into a digitally-enabled innovation toolkit or configurator to assist innovation managers and facilitators.

In addition to the generation of new knowledge and expertise, however, timely and consistent action toward a CE by leaders in both business and politics remains key to its successful implementation. We hope that this report proves useful for decision-makers in their work on closing the existing 'implementation gap'.

Appendices

A List of abreviations

B2B	Business to Business
B2C	Business to Consumer
BattG	German Battery Act
BMBF	Federal Ministry of Education and Research
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
CE	Circular Economy
CEID	*Circular Economy Initiative Deutschland*
CEAP	Circular Economy Action Plan
CBM	Circular Business Model(s)
CFCs	Chlorofluorocarbons
CRM	Customer Relationship Management
DIY	Do-It-Yourself
ECJ	European Court of Justice
ElektroG	German Electrical & Electronic Equipment Act
EPR	Extended Producer Responsibility
EU	European Union
F.M.	Federal Ministry
GDP	Gross Domestic Product
GPP	Green Public Procurement
IoT	Internet of Things
KrWG	German Closed Substance Cycle and Waste Management Act
KPI	Key Performance Indicator
NGO	Non-Governmental Organisation
OEM	Original Equipment Manufacturer
PET	Polyethylene terephthalate
PSS	Product-Service System
RAL	RAL Deutsches Institut für Gütesicherung und Kennzeichnung – German Institute for Quality Assurance and Certification
REACH	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
ReziProK	*Resource-efficient Circular Economy – Innovative product cycles*
RFID	Radio-frequency identification
SDG	Sustainable Development Goals
SVHC	Substances of Very High Concern (as specified by European REACH regulation)
TV	Television
UN	United Nations
VAT	Value-added tax
VerpackG	German Packaging Act
WEEE	Waste Electrical & Electronic Equipment

B List of figures

C List of tables

D Business model patterns

Guide to using the detailed specification of the business model patterns

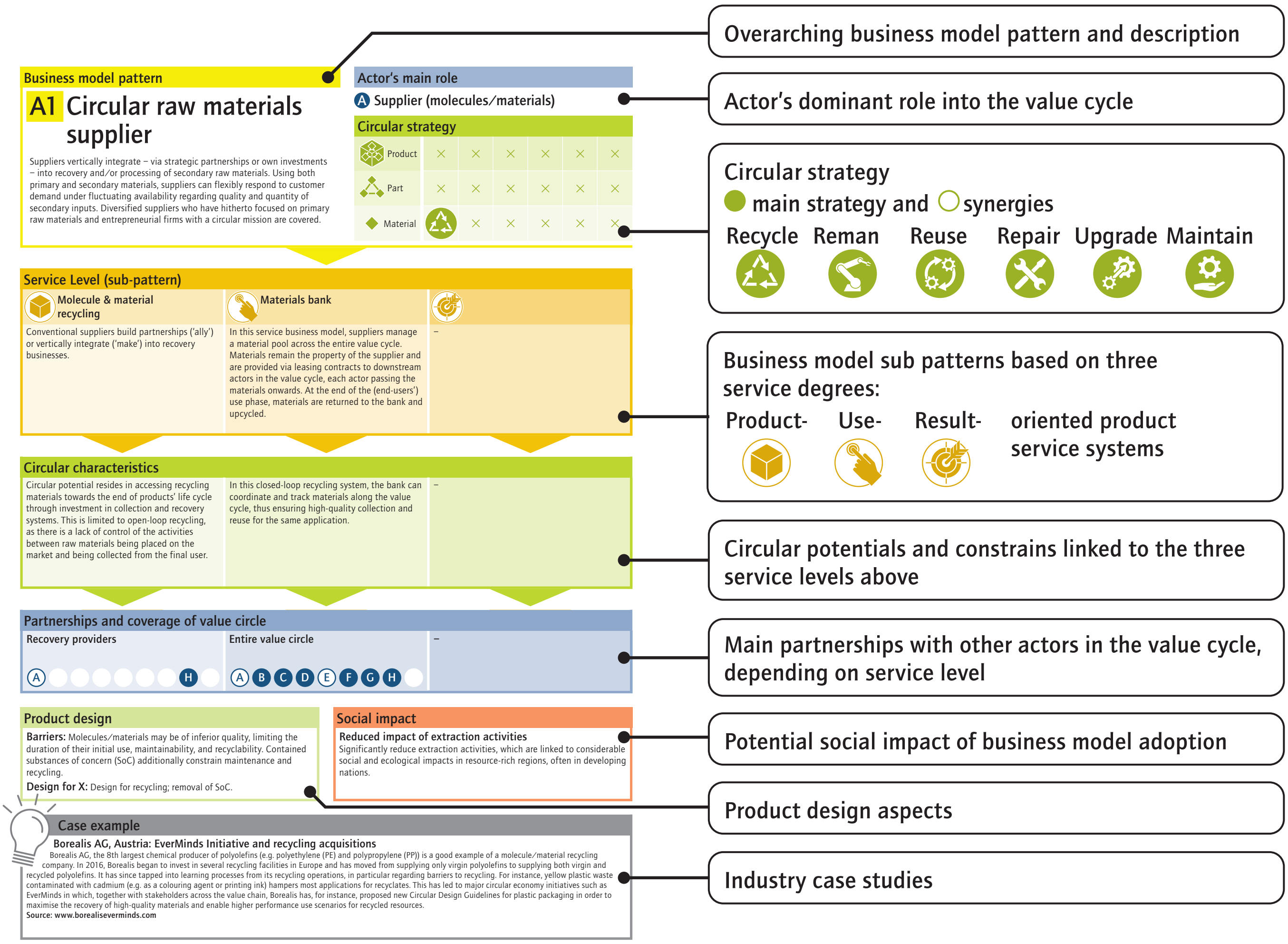


Figure 25: Guide to using the detailed specification of the business model patterns (Source: own presentation)

Circular Economy Initiative Deutschland

A) Suppliers (molecules/materials)

Business model pattern

A1 Circular raw materials supplier

Suppliers vertically integrate – via strategic partnerships or own investments – into recovery and/or processing of secondary raw materials. Using both primary and secondary materials, suppliers can flexibly respond to customer demand under fluctuating availability regarding quality and quantity of secondary inputs. Diversified suppliers who have hitherto focused on primary raw materials and entrepreneurial firms with a circular mission are covered.

Actor's main role

(A) Supplier (molecules/materials)

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material		×	×	×	×	×

Service Level (sub-pattern)

Molecule & material recycling	Materials bank	
Conventional suppliers build partnerships ('ally') or vertically integrate ('make') into recovery businesses.	In this service business model, suppliers manage a material pool across the entire value cycle. Materials remain the property of the supplier and are provided via leasing contracts to downstream actors in the value cycle, each actor passing the materials onwards. At the end of the (end-users') use phase, materials are returned to the bank and upcycled.	–

Circular characteristics

Circular potential resides in accessing recycling materials towards the end of products' life cycle through investment in collection and recovery systems. This is limited to open-loop recycling, as there is a lack of control of the activities between raw materials being placed on the market and being collected from the final user.	In this closed-loop recycling system, the bank can coordinate and track materials along the value cycle, thus ensuring high-quality collection and reuse for the same application.	–

Partnerships and coverage of value circle

Recovery providers	Entire value circle	–
A, H	A, B, C, D, E, F, G, H	

Product design

Barriers: Molecules/materials may be of inferior quality, limiting the duration of their initial use, maintainability, and recyclability. Contained substances of concern (SoC) additionally constrain maintenance and recycling.

Design for X: Design for recycling; removal of SoC.

Social impact

Reduced impact of extraction activities

Significantly reduce extraction activities, which are linked to considerable social and ecological impacts in resource-rich regions, often in developing nations.

Case example

Borealis AG, Austria: EverMinds Initiative and recycling acquisitions

Borealis AG, the 8th largest chemical producer of polyolefins (e.g. polyethylene (PE) and polypropylene (PP)) is a good example of a molecule/material recycling company. In 2016, Borealis began to invest in several recycling facilities in Europe and has moved from supplying only virgin polyolefins to supplying both virgin and recycled polyolefins. It has since tapped into learning processes from its recycling operations, in particular regarding barriers to recycling. For instance, yellow plastic waste contaminated with cadmium (e.g. as a colouring agent or printing ink) hampers most applications for recyclates. This has led to major circular economy initiatives such as EverMinds in which, together with stakeholders across the value chain, Borealis has, for instance, proposed new Circular Design Guidelines for plastic packaging in order to maximise the recovery of high-quality materials and enable higher performance use scenarios for recycled resources.

Source: www.borealiseverminds.com

Figure 26: Business model pattern A1: Circular raw materials supplier (Source: based on Hansen et al. 2020a)

Business model pattern

A2 Process molecule service provider

Process molecules or materials, usually with additional equipment (e.g. containers for solvents), are provided as service to direct customers, thus boosting the performance and quality of the application. Materials are maintained at the customer's site and returned when necessary. Instead of increased sales volumes, this business model aims to maintain a given amount of materials for as long as possible and is now well established as chemical leasing.

Actor's main role

A Supplier (molecules/materials)

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material		×		×	×	

Service Level (sub-pattern)

	Molecule & material leasing	Molecule & material performance
–	Suppliers retain ownership of the molecules/materials and sell their use by providing a solution (i.e. materials plus equipment), with the duration and frequency of use determining the leasing fee. The customer is responsible for controlling and monitoring the system in use. (Return) logistics may be complementary or optional.	Suppliers retain ownership of the molecules/materials. They sell the function performed by the molecule/material with the functional units being the basis for payment. Maximum performance can be achieved by making use of supplier expertise for configuring, monitoring, maintaining, and optimising the materials during use.

Circular characteristics

–	As ownership is retained, investment in high-quality materials becomes a business case. The provision of a closed-loop system (molecules/materials + equipment) enables continuous maintenance to maximise longevity. Mandatory return (take-back) of the system at the end of the leasing period ensures proper recycling (or disposal) of molecules/materials.	Using supplier expertise throughout material application ensures optimal maintenance and efficiency and thus maximum performance. Suppliers have a financial incentive to prevent material deterioration and waste. Optimised use phases allow materials to be taken back in the best possible condition as required for subsequent treatment (e.g. recycling, disposal).

Partnerships and coverage of value circle

–	Equipment manufacturers, logistics, and waste managers. A B G H	Equipment manufacturers, logistics, and waste managers. A B G H

Product design

Barriers: Molecules/materials may be of inferior quality, limiting the duration of their initial use, maintainability, and recyclability. Contained SoC additionally constrain maintenance and recycling.

Design for X: Design for longevity (high quality); design for recycling.

Social impact

Improved occupational health

Provision of serviced molecules/materials by suppliers, often packaged in closed-loop systems, ensures correct and safe use. Associated occupational risks such as contamination by hazardous substances are significantly reduced.

Case example

SAFECHEM - COMPLEASE™ Chemical Leasing, Germany

SAFECHEM, founded in 1992 by Dow Chemicals and a waste management firm, is a service company focusing on the innovative use of chemicals in applications such as metal cleaning, textile cleaning, and asphalts analysis. It follows the molecule leasing and performance business model. High-quality chemicals (e.g. solvents) are provided as a system in closed containers, allowing for safe transportation, storage, and handling and so ensuring the highest possible health and safety standards. Customers buy a customised performance package for a monthly fee including for instance technical consultancy, high-performance solvents and additives, safe delivery and collection, waste analysis, on-site quality monitoring system and documentation, and training. Chemical leasing can achieve a reduction of up to 93% in solvent use and 50% in energy while improving health and safety. In a service alliance with equipment manufacturers, distributors, and waste managers, all customer and regulatory demands are met.

Source: www.safechem.com

More cases: Unido Chemical Leasing Toolkit, https://chemicalleasing-toolkit.org/

Figure 27: Business model pattern A2: Process molecule service (Source: based on Hansen et al. 2020a)

B) Suppliers (machines and equipment)

Business model pattern

B1 Machine/component 'as new'

Machines/components are taken back from customers, quality is checked, the machines/components are fully disassembled, worn parts/materials are replaced, after which the machines/components are fully reassembled. Remanufactured machines have identical or superior quality at lower cost.

Actor's main role

B Supplier (mechanical engineering)

Circular strategy

Service Level (sub-pattern)

Machines/components 'as new'	Rental machines/components 'as new'	Pay per reman machine performance
Machines/components are sold in traditional form. Take-back system and infrastructure are offered.	Machines are rented or leased out instead of sold. Ownership is not transferred to the customer. Customer relationships intensify over entire use phase.	Remanufactured machines/ components are offered as a service to customers. They are closely monitored and analysed for their performance and are modified or replaced when appropriate in the light of total cost of ownership.

Circular characteristics

Financial incentives (e.g. reduced price for repeat sales; deposit) are offered in order to get products back. However, despite incentives, return of products cannot be ensured and related planning is difficult.	Rented/leased machines will usually come back to the owner after contract ends (or significant penalties apply). Scheduled take-back quantities and timeframes mean that remanufacturing processes and associated procurement of further materials/components can be optimally planned.	This service business model leads to higher reman levels because machines/components remain in the ownership of the supplier and are returned at the end of the service contract. Furthermore, suppliers will strive to optimise performance and integrate maintenance and repair to provide learning in use and feedback for research and development and associated product designs.

Partnerships and coverage of value circle

Close ties with direct customers	Close ties with direct customers	Close ties with direct customers
B C G	B C G	B C G

Product design

Barriers: Existing design may prevent disassembly, components/materials may deteriorate too quickly for reuse, and high-tech components may be technically obsolete.

Design for X: Design for disassembly; modular design (for technology upgrading); durability (parts).

Social impact

Integration of disabled people

Integration of physically disabled workers into suitable reman processes (e.g. disassembly).

Case example

SKF 'Rotation for Life', Sweden

SKF, located in Sweden, is the world's largest bearing manufacturer which and has recently embarked on a pay per reman performance business model. Bearings are crucial components in many kinds of machinery and plant. SKF has recently promoted a 'Rotation for Life' business model focusing on total cost of ownership in which payments are made on the basis of key performance indicators for the bearing. Bearings are digitally monitored, taken out once there is a risk of failure, replaced, and remanufactured.

Source: www.skf.com

More cases: TRUMPF Pre-Owned Machines; Liebherr Reman

Figure 28: Business model pattern B1: Machines/components 'as new' (Source: based on Hansen et al. 2020a)

Business model pattern

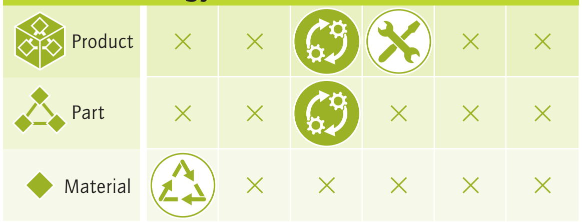
B2 Machine/component remarketing

Used machines/components are taken back, quality-checked, reconditioned or repaired where necessary, and reintroduced onto the same or other markets to new customers with lower performance expectations at competitive prices, thus extending machine/component lifetime with additional use cycles.

Actor's main role

B Supplier (mechanical engineering)

Circular strategy



Service Level (sub-pattern)

Used machines/component sales	Rental machines/components	→ see B1 Pay per reman machine performance
Used machines/components are sold at lower costs compared to their new counterparts.	A rental business for used machines/components is introduced. Customers pay rental fees with competitive pricing. Customers may be provided with complementary or optional services for maintenance, repair, and upgrading. Penalities must be payed for unappropriate use, wear, and damage.	

Circular characteristics

Financial incentives (e.g. reduced price for repeat sales; deposit) are offered in order to get products back. Reuse transactions depend on whether customers use the incentives offered by suppliers to actually return machines/components. Customers may, however, prefer to sell them on the second-hand market themselves, with goods then leaving the control of the supplier.	Given that ownership is retained by the supplier, all products are returned at defined times, allowing for better planning and management of the rental pool. Suppliers' own maintenance and repair of the returned products makes products last longer. Unfit machines/components can be cannibalised for spare parts and systematically prepared for recycling.	

Partnerships and coverage of value circle

Close ties with direct customers B C G	Partner with fleet managers operating the product pool B C D G	

Product design

Barriers: Components/materials may deteriorate too quickly for reuse.

Design for X: Design for durability; design for reparability.

Social impact

New regional service jobs

Servicing of used goods and related rental business may provide new job opportunities for low-skilled labour.

Case example

Rubble Master Rentals, Austria

Rubble Master is a leading producer of mobile recycling machines (e.g. crushers, sorters) for (de)construction waste. As well as selling new products, it operates a rental unit which gives customers access to a pool of products (i.e. rental machine business model). Rental includes training and wear, but no operation costs (e.g. fuel, operator) or transport. Some of the machines from the rental pool are later sold as used goods at lower prices so customers with smaller budgets can be served; this reveals the interrelatedness of rental and used goods business lines.

Source: www.rubblemaster.com

More cases: UMAC (EREMA Group) Used recycling machines

Figure 29: Business model pattern B2: Machine/component remarketing (Source: based on Hansen et al. 2020a)

C) Producers

Business model pattern

C1 Proprietary material cycles

Producers introduce a product design with specific premium materials, resulting in higher customer value (e.g. durability, health, visual appearance) but at acceptable costs. Higher virgin material costs are offset (or overcompensated) by measures to keep their own premium materials in closed loops and make continuous reuse of them for their own production.

Actor's main role

C Producer

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material	(recycling)	×	×	×	×	×

Service Level (sub-pattern)

Waste cherry picking	Materials bank partnership	
Producers arrange partnerships with recovery managers for the exclusive extraction of proprietary materials from pre-sorted waste streams (e.g. based on optics, tracers, digital watermarks, or even manual picking). In a more radical step forward, producers could, similar to circular raw materials suppliers (A1), vertically integrate into recovery operations to get direct access to waste streams.	Producers maintain ownership of their specific premium materials (or components).	–

Circular characteristics

Only possible for materials which the local collection and sorting facilities can clearly identify, or which can be manually collected with acceptable levels of effort. High material losses from the 'closed' loops are to be expected, due to mixed waste streams out of the producer's control.	As the ownership of materials (incorporated in products) remains with the producer (or is managed by a materials bank as in A1), once the product's (fixed) period of service is complete, materials are returned to or taken back by the producer (as a part of the service package).	–

Partnerships and coverage of value circle

Recovery managers	Materials banks	–
C D H	A C D H	

Product design

Barriers: Low-quality materials may not be optimised for continuous recycling in closed loops or not recognisable in the waste stream (missing identifiers); recycling is hampered by SoC.

Design for X: Design for recycling (including elimination of SoC).

Social impact

Improved occupational and consumer health through quality materials

The ability to source higher quality materials with no or considerably reduced SoC content eliminates occupational and consumer health and safety risks.

Case example

Frosch brand's Recyclate Initiative, Germany

Werner & Mertz is a German producer of detergent and related consumer household chemicals and applies a business model similar to waste cherry picking. It has been an eco-pioneer since the introduction of the Frosch brand in 1986. More recently, it has completely redesigned its packaging range in line with cradle to cradle quality certification, which requires the removal of SoC from the (premium) packaging materials, related labels, and printing inks, enabling high-quality recycling streams. In a cross-value cycle partnership with a recovery manager (Grüner Punkt), mechanical engineering company (UNISENSOR), converter (ALPLA), retailer (REWE), and NGO (NABU), Werner & Mertz has developed and commercialised premium recycled material (e.g. PET) and product streams. While recycling streams are not brand exclusive (i.e. packaging from multiple brands is retrieved) and thus not strictly proprietary, new R&D projects on tracer-based sorting are clearly showing the way forward.

Source: wir-fuer-recyclat.de; initiative-frosch.de

More cases: Clarios (lead-acid batteries); MUD Lease-a-Jeans; Wolford 'Aurora' biodegradable Cradle to Cradle Collection

Figure 30: Business model pattern C1: Proprietary material cycles (Source: based on Hansen et al. 2020a)

Business model pattern

C2 Product 'as new'

Companies offer products with 'quality as new' (i.e. of equal or better quality than 'virgin' products), but at more competitive prices. Customers receive financial incentives for returning products (e.g. deposit; discounts). Returned products are then quality-checked and fully disassembled and worn parts/materials are replaced, after which the products are reassembled. Reman activities are usually centralised and are similar/remain close to primary production.

Actor's main role

C Producer

Circular strategy

Service Level (sub-pattern)

Selling Products 'as new'	Product leasing 'as new'	→ see C6 Total care producer
Remanufactured products are sold in the same way as new products, but on more competitive terms (i.e. lower price tags).	Customers lease (or rent) products 'as new' for a monthly fee. The leasing product pool consists mainly of remanufactured products, but is restocked with new products, without the customer being able to tell the difference. Producers need to establish an own-product pool and financing schemes for their customers or partner with fleet operators and external banks.	

Circular characteristics

Financial incentives (e.g. reduced price for repeat sales; deposit) are offered in order to get products back. Reuse transactions depend on whether customers use the incentives offered by suppliers to actually return products. Customers may, however, prefer to sell them on the second-hand market themselves, with goods then leaving the control of the producer.	As ownership remains with the producer, all products are returned at defined times. This enables precise planning of the subsequent reman processes and the size of the product pool. It also enables better product (and user) monitoring, which can increase (and ensure a minimum) quality of returned products and so ensure that remanufacturing is possible at the lowest possible cost.	

Partnerships and coverage of value circle

Dealers for take-back C D F	Dealers for take-back or as fleet managers C D F	

Product design

Barriers: Low-cost design prevents disassembly and upgrading. Premature product, component or material failures prevent their reuse and increase remanufacturing costs.

Design for X: Design for durability of products, components, materials; design for modularity (technology upgrading).)

Social impact

Regional job growth; integration of people with disabilities

New regional jobs in labour-intensive reman processes (e.g. disassembly, quality control, recondition), which may integrate disabled people (some with special abilities) at lower labour costs (e.g. public funding).

Case example

Smart meter remanufacturing, instrument manufacturer Lorenz, Germany

Lorenz sells or leases smart meters to households (via intermediary organisations such as building management providers). The meters are designed for several use cycles, after which they are uninstalled and returned to the producer. As a financial incentive, customers receive a payment for each product returned. The smart meters are then disassembled and refabricated using specialised machinery. This is possible thanks to the product having been developed according to design for remanufacturing and modularity principles.

Source: www.lorenz-messtechnik.de

More cases: Apple 'Refurbished' (e.g. smartphones); Caterpillar Reman (heavy equipment/vehicles)

Figure 31: Business model pattern C2: Products 'as new' (Source: based on Hansen et al. 2020a)

Circular Economy Initiative Deutschland

Business model pattern

C3 Used product remarketing

Producers (or retail partners) take used products back from customers, carry out quality control and optional minor refurbishment, and remarket used goods in the same or other markets at lower prices. Warranties are provided, but usually not with the same terms as new products.

Actor's main role

C Producer

Circular strategy

Product	×	×	✓	✓	×	×
Part	×	×	✓	×	×	×
Material	✓	×	×	×	×	×

Service Level (sub-pattern)

Used product sale		
As well as new products, producers sell used products at lower prices as a form of differentiation. As sales are complemented with quality guarantees and warranties, customer awareness and confidence considerably increase, making used goods true alternatives. Trade-in programmes provide financial incentives to customers to return used products, with the value deducted from further purchases.	–	–

Circular characteristics

Used product lines enable additional use cycles of products which have not reached end of life. However, while financial incentives to return used products exist, it is not the only option customers have and therefore only a fraction of goods are returned. Disused products often remain stored in households or are sold in non-proprietary used goods markets.	–	–

Partnerships and coverage of value circle

Retail partners and retro logistics		
C D G	–	–

Product design

Barriers: Low-cost components and materials may lead to premature damage and prevent additional use cycles.

Design for X: Design for longevity.

Social impact

Accessibility through low-priced goods

Lower cost products for customer groups unwilling or unable to purchase new products.

Case example

Patagonia Worn Wear Online Shop, USA

Patagonia is a producer of high-quality outdoor clothing designed for long use under extreme outdoor conditions and was founded in 1973 on a sustainability mission. With its own shops in key cities, it builds a close relationship with customers and these shops offer local repair services. Patagonia's 'Don't buy this jacket' marketing campaign has made it widely known for its anti-consumerism approach. After a series of local 'Worn Wear' pop-up events, the company launched a permanent online store for used clothes and has sold more than 120,000 items since. Perfectly functioning items in good condition are traded-in in Patagonia's own stores or via mail with contributors receiving discounts on new purchases. Clothes are washed and put online for remarketing. Patagonia has recently also opened physical pop-up stores for Worn Wear.

Source: www.wornwear.patagonia.com

More cases: SHIFT Phones (e.g. smartphones); Samsung Certified Pre-Owned (US)

Figure 32: Business model pattern C3: Used product remarketing (Source: based on Hansen et al. 2020a)

Business model pattern

C4 Out-of-warranty repair service

Producers of premium quality goods incentivise extended use by customers by offering accessible, affordable, and competitive out-of-warranty repair services ('repair pays'), as a centralised, decentralised, or home delivery service. Products are supported in the long term through related availability of consumables, spare parts, necessary software upgrades, and, optionally, technological upgrading.

Actor's main role

C Producer

Circular strategy

Product

Part

Material

Service Level (sub-pattern)

On-demand repair

Optional repair services are provided in addition to conventionally sold goods with the aim of enabling extended use (instead of repeat purchases). Customers contact the producer's service centre on demand when a repair is necessary. Either customers pay a fixed annual service fee covering a range of repairs, or each repair transaction is paid for individually.

→ see C6 'Leasing producer'

→ see C6 Total care producer

Circular characteristics

Attractive repair offerings enable customers to use products longer. As the key contact when products fail, producers can coordinate informed decisions to repair or replace devices. Taking back broken products/components means spare parts can be cannibalised or remanufactured and fed back into repair operations or, alternatively, products/components can be professionally prepared for recycling (e.g. disassembly).

Partnerships and coverage of value circle

Decentralised repair and service operators and stores

C E F G

Product design

Barriers: Low-cost design leads to premature product, component or material failure and prevents disassembly.

Design for X: Design for reparability; modularity.

Social impact

Regional job opportunities for skilled and semi-skilled craftspeople

Emphasis on repair services requires strong service organisation with field workers and back office support, either internally organised or via partnerships. This provides opportunities for (semi-)skilled trades- and craftspeople.

Case example

Miele, Germany

Miele is a German manufacturer of white goods and other household electronics. With a reputation for high-quality consumer durables and a strong service culture, it has maintained premium prices on the market. Miele products, produced in both Europe and China, have considerably longer lifetimes than competitor products. With local retail and service partners in major cities, Miele remains close to its customers. Full customer support in local sales outlets is a key commercial differentiator. Repair and maintenance contracts can be agreed locally and are backed up by centralised online offerings. Individual components of products can usually be replaced when broken or worn and minor software upgrades can be carried out.

Source: www.miele.de

More cases: Deuter 'Lifelong repair service' for outdoor equipment; VAUDE 'Repair, don't replace' for outdoor clothing and equipment

Figure 33: Business model pattern C4: Out-of-warranty repair service (Source: based on Hansen et al. 2020a)

Business model pattern

C5 Upgrades, spares & accessories

Producers provide spare parts, tools, and related services for their core products, either through own online or offline sales channels, or by partnering with retailers and local service shops. This requires core products to follow a modular design which makes them easily repairable either directly by consumers ('do-it-yourself') or by decentralised service points without any need for special training.

Actor's main role

C Producer

Circular strategy

Service Level (sub-pattern)

Modules & accessories shop	Upgrade subscription	
Producers offer spare parts as a traditional sales transaction. Own direct sales channels or partnerships with existing retail and service points (online or offline) are used for customer contact.	New technological or non-technological modules/parts, which remain in the ownership of the producer, are provided as a service to enable upgrading of customers' core devices at defined intervals. Modules are returned once replacement upgrades are provided or customers no longer need them. New modules are provided to high-performance users and then cascaded to users with lower needs.	–

Circular characteristics

Provision of spare and upgrade modules supports decentralised repairs and upgrading with the ultimate aim of increasing a core product's longevity. Apart from the module sales transaction, the repair and upgrading processes remain strongly in the domain of the customers with little feedback to the producer, who misses learning opportunities arising from a product's shortcomings.	Extended use of core product is facilitated through preventive and technology upgrades. With producers retaining ownership of modules, opportunities arise for component and (core) device monitoring, which enables preventive maintenance. Risks of component-level fashion obsolescence or 'upgrade consumerism' need to be contained (eco impacts of cumulative upgrades vs. core product).	–

Partnerships and coverage of value circle

DIY customers; retail & repair partners, logistics C D E F	DIY customers; retail & repair partners; (retro) logistics C D E F G	–

Product design

Barriers: Current product designs focused on integration and miniaturisation prevent module replacements and related after-sales opportunities.

Design for X: Design for modularity, reparability.

Social impact

Support for DIY communities

By providing spares and accessories to users and related do-it-yourself (DIY) communities (e.g. repair cafés, informal or independent repairers), producers support a culture of care for products and reparability and foster the development of circular literacy among users and broader society.

Case example

Fairphone's online shop for spare parts, the Netherlands

Fairphone, founded in 2013, is a social enterprise with the mission to transform the electronics industry. By introducing alternative smartphones onto the market, it showcases new supply chain practices (e.g. fairly traded gold) and product designs (e.g. replaceable batteries), as well as fostering sustainability. The 3rd generation design, Fairphone 3, has recently been introduced. The modular phone is shipped with a screwdriver, with which the phone can be easily disassembled by consumers into seven main modules (e.g. battery, display, mainboard, cameras, speaker, microphone). Fairphone's online shop follows the modules & accessories business model, as it provides replacements for each of these modules, as well as for normal accessories (e.g. chargers, cases).
Source: www.fairphone.com

Figure 34: Business model pattern C5: Upgrades, spares and accessories (Source: based on Hansen et al. 2020a)

Business model pattern

C6 Maximising product uptime

Instead of increasing sales volumes, producers focus on long use based on high-quality products and intensive servicing. Preventive maintenance, sometimes with digitally enabled monitoring, ensures product and component integrity and reduces the risk of failure. While developing intensive customer ties, further services (e.g. upgrades, repair, and take-back) can be added according to customised service level agreements.

Actor's main role

C Producer

Circular strategy

Service Level (sub-pattern)

Fee-based maintenance

Products are still being sold in traditional ways, but with mandatory service agreements including maintenance (optional repair).

Leasing producer

Products are leased out, rented, or shared. Producers become fleet managers facing significant investment in infrastructure. By retaining ownership, maintenance, repair, and replacement can be monitored and timed according to the business and circular needs of the producer.

Total care producer

Instead of a specific product, a result or performance is sold to the customer. The provider can choose (used) products/technologies which deliver the best result and has full responsibility for their deployment, maintenance (incl. consumables), repair, replacement and take-back.

Circular characteristics

Maintenance interventions enable regular access to the product-in-use. However, given that maintenance intervals are long and usually driven by customers, interventions may come too late to secure components for remanufacturing or even prevent product or component failure.

With ownership maintained during use, producers get more frequent and more reliable access to the product. They collect more knowledge about user practices and product-in-use performance. This can feed back into product R&D and related redesign.

- Ensuring the correct time intervals for maintenance activities in order to maximise lifetime.
- Leveraging synergies from maintenance/repair activities by reusing components and materials.
- Ensuring take-back after service ends as the basis for deployment at other customers' sites, remarketing or recycling.

Partnerships and coverage of value circle

Service partners: C, F

3rd-party fleet managers: C, D, F

3rd-party fleet managers: C, D, F

Product design

Barriers: Low-cost design leads to premature product, component or material failure and prevents reparability.

Design for X: Design for durability, reparability & disassembly; design for modularity (upgrading).

Social impact

Opportunity for low-skilled labour

New maintenance and repair jobs create local job opportunities, particularly for less skilled labour.

Case example

Hilti Fleet Management, Liechtenstein

Hilti is a leading manufacturer and service provider for premium construction tools such as drilling machines offered in business-to-business construction markets. Tools are built to last through design for longevity and are rooted in a service culture, complemented with a wide range of services, including repairs.
Hilti Fleet Management Service, established over 10 years ago and currently covering more than 100,000 customers, is a total care business model offering tools-as-a-service. This full-service package covers all tools required by a customer including their use, service, repair, and upgrading for a fixed period of time and a monthly fee. If additional tools are required beyond the plan, they can be rented temporarily. Recently, an Internet-of-Things initiative has increased the connectedness of their tools, enabling detailed monitoring and preventive maintenance. By making sure that tools are being maintained, personnel health and safety is also assured.
Source: www.hilti.group

More cases: Ricoh Managed Print Services; Rolls-Royce TotalCare, BMW DriveNow; BlueMovement powered by Bosch, the Netherlands

Figure 35: Business model pattern C6: Maximising product uptime (Source: based on Hansen et al. 2020a)

Circular Economy Initiative Deutschland

D) Retail/wholesale

Business model pattern

D1 Retailer as cycle manager

Retailers adopt a proactive role in managing packaging and related materials through vertical integration into or strategic partnerships with the recovery sector. They coordinate material flows between producers, retail, customers, recovery managers, and logistics firms with the vision of establishing closed (packaging) loops, both in technical loops (i.e. recycling) and biological loops (i.e. composting/biodegradation). This work has particular relevance for fast-moving goods sectors (e.g. food retail), where packaging considerably contributes to total product impact.

Actor's main role

D Retailer & service points

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material	♻	×	×	×	×	×

Service Level (sub-pattern)

Retailer as cycle manager	→ see C1 Materials bank partnership	
Retailers adopt a proactive role in managing packaging and related materials. Materials (in the form of packaging) and their ownership are passed on, but different degrees of vertical integration mean that their flow can be coordinated along the cycle.		–

Circular characteristics

Under the coordination of the retailer, recycling turns from somewhat open loops into more closed loops. This enables more effective recycling in terms of quantity and quality. A strong influence on producers putting materials into the market enables better design for recycling, and may lead to a virtuous cycle, continuously improving the system.		–

Partnerships and coverage of value circle

Cross-value chain, incl. potential intermediation A C D F G H I		–

Product design

Barriers: Low-quality materials may not be optimised for continuous recycling in closed loops; Recycling of materials may be hampered by SoC.

Design for X: Design for recycling (including elimination of SoC).

Social impact

–

Case example

Schwarz Group's 'Reset Plastic' Strategy, Germany

The Schwarz Group, owner of Lidl and Kaufland and considered Europe's largest retail chain, launched the 'Reset Plastic' strategy in 2018. It is an ambitious cross-value chain strategy based on vertical integration into waste and materials management with the goal of introducing 100% recyclable packaging and reducing plastic waste. As a first building block, the Schwarz Group founded the waste management companies GreenCycle in 2009 (for managing group internal wastes) and the digital waste management platform PreZero in 2018 (to serve external partners in the market). Furthermore, starting in 2018, the Group acquired two recycling operations: Tönsmeier in Germany and Sky Plastic Group AG in Austria. The Group is the first retailer capable of coordinating material streams across the value chain through vertical integration into recovery management and recycling.

Source: www.reset-plastic.com

Figure 36: Business model pattern D1: Retailer as cycle manager (Source: based on Hansen et al. 2020a)

Business model pattern

D2 Retail remarketing & reman

Retailers specialise in or differentiate into used goods to access cost-sensitive customer groups. Used goods have different conditions and quality, but are provided with warranties. Some degree of refurbishment is usually also conducted (e.g. cleaning; repairs) and may even extend to full remanufacturing operations. Discarded goods are either sourced from own customers trading-in devices, or through larger business-to-business partnerships from which bulks of discarded devices are taken over (e.g. when firms upgrade to new device generations).

Actor's main role

D Retailer & service points

Circular strategy

Product	×	×			×	×
Part	×	×		×	×	×
Material		×	×	×	×	×

Service Level (sub-pattern)

Used goods on sale	Rent-a-wreck fleet manager	
Used goods are still sold under a conventional transactional model, but at lower prices. Customers can trade-in used devices.	Specialised service provider for the rental of used goods at lower prices as compared to more conventional offerings.	–

Circular characteristics

Given the transactional sales model, this business model often only leads to a single further use cycle. While the retailer could potentially take used goods back again, customers often do not return the goods due to the absence of financial incentives.	With ownership retained by the retailer or fleet manager, which is then operating a pool of used products, products can be maintained and their lifetime extended to a maximum degree. Spare parts can be harvested, reused, and refurbished, further contributing to life extension.	–

Partnerships and coverage of value circle

Customers, large organisations discarding goods, logistics D F G	Customers, large organisations discarding goods, logistics D F G	–

Product design

Barriers: Goods may not be designed for long use (i.e. damage prevents second use).

Design for X: Partnerships may permit the provision of design feedback to producers on the basis of (independent) refurbishment activities.

Social impact

Accessibility through low-priced goods

New regional jobs in labour-intensive reman processes (e.g. disassembly), which may integrate disabled people at lower labour costs (e.g. public funding). Affordable products for low-income groups.

Case example

AfB Social & Green IT, Germany

AfB was founded in 2004 as a social business for IT remarketing with the mission to integrate people with disabilities (and special abilities) into skilled work processes. AfB owns operations in Germany and Austria, 13 logistics operations with attached shops and two stand-alone shops. Used or discarded IT equipment is picked up from partners' sites and returned to the logistics centres, where it is prepared for remarketing (e.g. data deletion). Functioning devices are refurbished (i.e. cleaned and then repaired where necessary) while other devices are prepared for recycling. Used devices are then given to the attached shops for direct sales or promoted in the online shop, representing the Used goods on sale business model. Customer groups for used devices include both consumers and business customers alike.

Source: www.afb-group.de

More cases: Amazon Refurbished & Used products; Rent-a-Wreck (car rental)

Figure 37: Business model pattern D2: Retail remarketing and remanufacturing (Source: based on Hansen et al. 2020a)

Business model pattern

D3 One-stop shop (retail)

As well as conventional sales, retailers offer extended services such as maintenance, repair, upgrading, and take-back.

Actor's main role

D Retailer & service points

Circular strategy

Service Level (sub-pattern)

Integrated service point

Complementary or optional maintenance, repair, and insurance service components are sold together with the core product under a conventional transactional sales model.

Rental retail

The retailer leases or rents out products for a monthly fee and keeps ownership and responsibility for maintenance, repair, upgrading, and take-back. Customers profit from accessibility to most recent products.

Total care retail

Instead of a specific product, a result or performance is sold to the customer. The provider can choose (used) products/technologies which best deliver the result and has full responsibility for deployment, maintenance (may include consumables), repair, replacement and take-back.

Circular characteristics

Integrated service point: With the same point of contact and service offerings linked to or included in the original product purchase, complexity and transaction costs are reduced for the customer, and it becomes more likely that customers will return products for maintenance, repair and related services. This maximises product lifetime and environmental benefits.

Rental retail: The retailer becomes a fleet operator. Professional maintenance and repair maximises product lifetime. Once products retire, they can be professionally prepared for appropriate recycling.

Total care retail:

- Ensuring the correct time intervals for maintenance activities in order to maximise lifetime.
- Leveraging synergies from maintenance/repair activities by reusing component and materials.
- Ensuring take-back after service ends as the basis for deployment on other customers' sites, remarketing or recycling.

Partnerships and coverage of value circle

Integrated service point: Producers of goods; 3rd-party service providers

C D E F

Rental retail: Strong customer relationship; producers

C D F

Total care retail: Producers to fill product pool; close customer ties

C D F

Product design

Barriers: Low-cost design leads to premature product, component or material failure, preventing repair.

Design for X: Design for durability & reparability; design for modularity (upgrading).

Social impact

New regional service jobs

Servicing of used goods and related rental businesses may provide new job opportunities for low-skilled labour.

Case example

Telekom terminal equipment service package

Telekom, Germany's largest telecommunication provider, follows a rental retail business model by offering devices such as DSL modems (in support of Internet services) to customers for a rental fee as part of the overall service contract (e.g. Internet and/or telephony provision). Devices can be returned to service points for repair, upgrading, or disposal. In the latter case, they are then refurbished or recycled.

Source: www.telekom.de

More cases: Expert repair service (electrical and electronic goods retail)

Figure 38: Business model pattern D3: One-stop shop (retail) (Source: based on Hansen et al. 2020a)

E) Repair service provider

Business model pattern

E1 Repair gap exploiter

3rd-party service provider for repair and maintenance (possibly refurbishment) operating either in cooperation with producers and retailers (i.e. service partnerships), or – if no or no attractive offers are available from focal actors – working autonomously as 'gap exploiters'. Services may be offered online with national or even international reach, in local service points, or as a delivery service.

Actor's main role

E Repair provider

Circular strategy

Service Level (sub-pattern)

Repair transaction	Repair-based rental	
Repair services are provided with the aim of enabling extended use (instead of new purchases). Customers contact the service point as required when a repair is necessary.	Autonomous 3rd-party service providers repair goods at own cost and use the initial repair request only as a basis for providing a use-based service for (repaired) products, thereby entering the realm of relational selling. All repair-related risks – such as repair success, actual costs of repair, long-term reliability of repaired goods, and potentially necessary follow-up repairs – are assumed by the provider.	–

Circular characteristics

Repair services address premature technical obsolescence and can significantly contribute to extended use cycles and product lifetimes. This considerably reduces the environmental impact of consumption. Single repair transactions may suffer from expensive fees and low customer acceptance, particularly when offered through official producer-related partnerships in which producers focus on repurchases rather than life extension.	Many repair transactions do not take place due to users' reluctance to pay (excessively high) repair fees. With 'rental repair', all repair-related risks are assumed by the provider and no (high) upfront repair costs are necessary, making users more likely to return goods for repair. This increases the market for repairs.	–

Partnerships and coverage of value circle

Certified service partners for producers/other retailers C D F	Strong customer relationship E F	-

Product design

Barriers: Low-cost design optimised for production prevents opening, disassembly, and repair.

Design for X: Design for repair, disassembly, modularisation.

Social impact

Regional job opportunities for skilled and semi-skilled trades- and craftspeople

Emphasis on manual repair services requires considerable labour, which creates opportunities for (semi-)skilled trades- and craftspeople.

Case example

Akkutauschen.de, Germany

Akkutauschen.de is a large online service offering toreplace batteries from various types of consumer electronics (e.g. toothbrushes, shavers, e-bikes) utilises the repair transaction business model. It additionally runs an online shop for spare parts and provides online repair manuals for self-help. Founded in 2009, today the company processes several thousand devices each year, thereby contributing significantly to the repair and extended use of goods. Every battery exchange job comes with minor maintenance and related repair activities (e.g. replacement of seals). An autonomous actor, the firm works without official relationships to producers. The service also contributes to recycling, because (waste) batteries and broken electrical devices are professionally prepared and disposed of.

Source: www.akkutauschen.de

More cases: Reparando (Smartphones)

Figure 39: Business model pattern E1: Repair service provider (Source: based on Hansen et al. 2020a)

F) Prosumer

Business model pattern

F1 Prosumer support system

An alternative non-market circular model based on self-sufficient lifestyles, self-help, and the 'right to repair'. It is supported by several non-commercial initiatives (e.g. repair cafés) and commercial support business models (e.g. C5 Upgrades, spares & accessories). New technologies such as 3D printed spare parts additionally enable self-help by users. Producers lose control over products, except when providing commercial support services themselves (e.g. spare parts).

Actor's main role

F Prosumer

Circular strategy

Product	×	×	×	✓ (repair)	×	✓ (service)
Part	×	×	×	✓ (repair)	×	✓ (service)
Material	×	×	×	×	×	×

Service Level (sub-pattern)

Do-it-yourself repair	Peer-to-peer sharing	
Own products are maintained and repaired (or even upgraded) for as long as possible and may subsequently be repurposed. In support of these self-help activities, commercial and non-commercial offerings address users' need for knowledge (e.g. 'how to repair' advice from online sources or local experts), spare parts, and tools. For instance, spare parts may be 3D printed in community centres or obtained from professional suppliers.	In this non-commercial approach, users provide goods to other users for a lump-sum fee. While this model has its origin in the offline world, most transactions have to date taken place through sharing platforms (see intermediary business models).	–

Circular characteristics

Own products are maintained and repaired (or even upgraded) for as long as possible. After the use cycle, they may be forwarded to other users in the community for second use. As a result, product lifetime is maximised and repurchases are minimised.	With sharing, products are used more intensively (less idle time) and a smaller total number of products is needed on the market. In principle, this enables the procurement of higher quality products, because investment pays off sooner.	–

Partnerships and coverage of value circle

Producers/retailers or intermediaries (original vs. used spares)	Sharing platforms	-
C D E F I	F I	

Product design

Barriers: Low-cost design optimised for production is subject to premature failure and prevents opening and repair.

Design for X: Design for reparability & modularity (consumer-level); durability.

Social impact

More budget available; supports social cohesion in local communities

Maintenance and self-repairs make new purchases obsolete and release budget for more important activities. Often supported by local initiatives or neighbourhoods, it increases social ties and strengthens a circular society.

Case example

ifixit, the US

The private company ifixit, founded in 2003 in California, the US, follows a do-it-yourself repair business model by providing online user repair guidelines and selling related spare parts and repair tools/toolkits. ifixit operates an online repair community with more than 1 million users. The company is a strong promoter of the 'right to repair' movement, which has initiated several legislative initiatives to promote own repairs by users.

Source: www.ifixit.com

More cases: RepaNet (Austria); Netzwerk Reparatur-Initiativen

Figure 40: Business model pattern F1: Prosumer support system (Source: based on Hansen et al. 2020a)

G) Logistics and transport providers

Business model pattern

G1 Material reverse logistics

Reverse logistics providers specialise in recycling logistics. They collect materials (as incorporated in products) from customers or retail, conduct value-added activities (e.g. pre-sorting, cleaning, recycling), and deliver the secondary materials to either the original source of the materials (e.g. producers, materials banks) or resell them in (electronic) markets, sometimes via intermediaries and related platforms. Depending on the value-added activities, logistics providers may themselves act as recovery managers.

Actor's main role

G Logistics provider

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material		×	×	×	×	×

Service Level (sub-pattern)

		Pay per recycling logistics performance
–	–	Based on a client's outsourcing, service providers manage activities and optimise reverse material flows for the maximum economic and/or environmental value. Specific payments may be linked to the amount of material processed or recovered, or the economic value generated from reselling. Profit sharing from reselling activities can align incentives and allows for a win-win situation for both clients and providers.

Circular characteristics

–	–	When providers specialise in reverse flows from various clients and value chains, they can generate the necessary economies of scale to make them economically viable and thereby enlarge the market for recyclates. Through the incentive system incorporated in the service contract, economic and environmental benefits should align in principle. Still, the most economically beneficial recycling activities do not necessarily unearth the full environmental potential.

Partnerships and coverage of value circle

		Interweaving the value circle
–	–	A C D F G H I

Product design

Barriers: Molecules/materials may be of inferior quality, limiting the duration of their initial use and recyclability. Contained SoC additionally constrain their use and recycling.

Design for X: Design for recycling (including elimination of SoC).

Social impact

–

Case example

Interseroh zero waste solutions and 'Recycled-Resource', Germany

Interseroh is an integrated service provider for the circular economy covering logistics and transport, waste management, sorting, recycling and plastic reprocessing operations, and secondary raw materials trading. Interseroh's 'Recycled-Resource' process for recompounding waste plastics has led to the introduction of two recycled grades, Recythen and Procyclen, for various applications.

Source: www.interseroh.de

More cases: RLG/CCR REBAT (batteries)

Figure 41: Business model pattern G1: Material reverse logistics (Source: based on Hansen et al. 2020a)

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Business model pattern

G2 Refurb logistics services

Logistics providers plan and operate product returns for producers or retailers. They link returned products from customers or points of sale and value-added services such as refurbishment with remarketing channels by producers, retailers, and/or recovery managers. On the basis of an initial quality check of returned goods, logistics providers make decisions about the best possible circular strategy: direct reuse, some degree of refurbishment (e.g. repair, polishing, repackaging), or, if technical or economic reasons prevent reuse, material recycling.

Actor's main role

G Logistics provider

Circular strategy

Product
Part
Material

Service Level (sub-pattern)

–

–

Pay per refurb performance

As part of a client's outsourcing, service providers optimise reverse product flows for maximum economic and/or environmental value. Specific payments may be linked to the number of items processed, the number of refurbished items, or the economic value generated from reselling. Profit sharing from reselling activities can align incentives and enable a win-win situation for both clients and providers.

Circular characteristics

–

–

In theory, profit sharing from remarketing activities can help to simultaneously maximise environmental potential from reuse activities. However, the economic value gained from the reutilisation of products or materials is not always aligned with the best possible environmental value (e.g. effort required for refurbishing might be excessive, leading to recycling instead).

Partnerships and coverage of value circle

–

–

–

C D F G

Product design

Barriers: Low-cost design optimised for production is subject to premature failure and prevents opening, disassembly, and repair.

Design for X: Design for durability, reparability, and disassembly.

Social impact

New regional service jobs

New regional jobs in labour-intensive logistics and refurbishing processes (e.g. quality control, reconditioning).

Case example

RLG Cycleon Refurbish & Resell, the Netherlands

Cycleon, a subsidiary of the Reverse Logistics Group, offers a refurbishment programme which aims to maximise value from product returns originating either from retailers or directly from consumers. Data-based screening and quality control of returned goods enable smart decisions on the best possible reutilisation scenario with the aim of generating the greatest possible quality of returned items: from refurbishment to 'as new' condition (includes repair, polishing, repackaging), to direct reuse, or material recycling. Reused or refurbished goods are either returned to the distribution centres of the client (i.e. a producer or retailer), or directly resold in B2B or B2C online markets.

Source: www.cycleon-revlog.com

More cases: Interseroh IT and communication refurbishing

Figure 42: Business model pattern G2: Refurb logistics services (Source: based on Hansen et al. 2020a)

Business model pattern

G3 Spare parts management

Based on clients' outsourcing, service providers manage spare parts-related activities (this may include modules for upgrading) including delivery, exchange/repair, returns management, reuse or refurbishment of used parts, and recycling of waste components/materials. Spare parts logistics either supports the clients' own infrastructure/assets (i.e. to maximise uptime) or after-sales services for their products in the market (e.g. car repair). Specialised logistics providers leverage economies of scale across clients.

Actor's main role

G Logistics provider

Circular strategy

Product	×	×	×	×	×	×
Part	×	×			×	×
Material		×	×	×	×	×

Service Level (sub-pattern)

		Pay per spare part performance
–	–	Performance-based contracts align incentives for effective and efficient repair between the logistics provider and clients. Performance-based payments may be linked to the number of spare parts covered, the availability of parts, or the prevented economic loss from downtime.

Circular characteristics

–	–	Shared incentives between the logistics provider and clients drive repair. Professional management by specialists leveraging economies of scale makes some transactions viable in the first place and enlarges the market for repair. However, incentives may be driven more strongly by economic than environmental performance so the KPIs on which the contracts are based need to be carefully designed to maximise circularity.

Partnerships and coverage of value circle

–	–	Close ties with producers or (repair) service organisations C D F G

Product design

Barriers: Low-cost design optimised for production prevents opening and repair, or makes repair activities economically unviable.

Design for X: Design for repair.

Social impact

–

Case example

TGW Spare Parts & Components, Austria

TGW provides intralogistics solutions for sectors such as fashion, grocery, industrial, and consumer goods under contract as part of a client's outsourcing efforts. TGW's Spare Parts & Component programme covers spare parts delivery as well as on-site and return-to-base repairs, returns, exchanges, and recycling. TGW not only supports circular operations such as client repairs, but also runs its own services in a circular fashion. Their 'Lifetime Services' package contains condition-based smart maintenance services, repair, and consultancy regarding the intralogistics system provided to the client.

Source: www.tgw-group.com

Figure 43: Business model pattern G3: Spare parts management (Source: based on Hansen et al. 2020a)

H) Recovery (and waste) management

Business model pattern

H1 Revitalised products

Actors from the recovery/waste management sector refurbish publicly collected products/materials, carry out quality control, and put used goods/recyclates back on the market on either a non-profit or for-profit basis.

Actor's main role

H Recovery manager

Circular strategy

Product

Part

Material

Service Level (sub-pattern)

Used goods bargain		
Recovery managers take the role of retailers, but with collected used goods. Traditional sales models are applied, namely consumers can buy and take ownership of used goods.	–	–

Circular characteristics

Through collection or take-back, recovery managers become the temporary owners of the used goods. This allows them to add selected value-added activities such as refurbishment, repair, upcycling, or repurposing depending on a product's condition.	–	–

Partnerships and coverage of value circle

With take-back organisations (e.g. producers, retailers) C D F H	–	–

Product design

Barriers: Goods may not be designed for long-term use (i.e. damage prevents second use).

Design for X: Partnerships may permit provision of design feedback to producers on the basis of independent reverse cycle activities (e.g. disassembly, repair).

Social impact

Accessability through low-priced goods

Provision of low-skilled jobs in preparation and remarketing of used goods, with potential to integrate employees with special needs; provision of used goods at affordable prices for disadvantaged population groups.

Case example

ReTuna Återbruksgalleria, Sweden

ReTuna is the world's first recycling mall, revolutionising shopping in a climate-smart way. It is operated by the municipality. Old items are given new life through repair and upcycling. Everything sold is recycled or reused. Additionally, ReTuna aims to be a public educator (e.g. events, workshops). The mall opened its doors in 2015 and is located next to the ReTuna recycling centre. It is easy for visitors to sort materials they are discarding into the containers and then drop off reusable toys, furniture, clothes, decorative items, and electronic devices in the mall's depot, called 'Returen'. In the depot, staff of the municipality perform an initial culling of what is usable and what is not. The items are then distributed to the recycling shops in the mall. The shop staff then perform a second culling, where they choose what they want to repair, fix up, convert or refine – and ultimately sell. In 2018, ReTuna generated SEK 11.7 million in sales of recycled products.

Source: www.retuna.se

More cases: ReVital products, logo, and shops (Austria)

Figure 44: Business model pattern H1: Revitalised products (Source: based on Hansen et al. 2020a)

Business model pattern

H2 Coordinator of informal collection

The coordinator serves as a hub for informal waste pickers and organisations with demand for recyclates. Waste pickers collect materials from littering or households and sell it to the coordinator. The coordinator may sell pooled materials directly or engage in various value-added activities as a secondary raw materials producer and then sell recyclates on the market.

Actor's main role

H Recovery manager

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material	♻	×	×	×	×	×

Service Level (sub-pattern)

Fair-trade recyclates		
The coordinator engages in trade-based market transactions: materials are bought from waste pickers, processed through value-added activities (e.g. sorting), and then sold in the recyclate market.	–	–

Circular characteristics

Depending on the amount of own value-added activities, the coordinator can significantly contribute to recyclate quality. For example, the internal operation of sorting processes, preparation for recycling (e.g. washing), and recycling itself can contribute to generating high-quality recyclates.	–	–

Partnerships and coverage of value circle

Supply contracts with producers or circular raw material suppliers A B C H	–	–

Product design

Barriers: Low-quality materials (e.g. SoC; composites/insufficient separation) may considerably reduce economic value.

Design for X: Usually no feedback channel to material suppliers and producers.

Social impact

Job opportunity for marginalised groups

- Additional source of income for people in need.
- Facelift for neighbourhoods thanks to removal of litter.

Case example

Mr. Green Africa

The future of recycling will be changed by alleviating the marginalisation, suffering, and large-scale disadvantage of informal waste pickers and their communities. Mr. Green Africa incentivises marginalised waste pickers and base of the pyramid stakeholders with premium prices and added benefits, to provide a continuous supply of valuable recyclables which in turn creates pathways out of poverty for them, while simultaneously creating a positive environmental impact. Mr. Green Africa then processes the recyclable material into valuable raw material and feeds it back into plastic manufacturers' supply chain to enable them to achieve their circular economy goals, and benefit from raw material cost savings.

Source: www.mrgreenafrica.com

Figure 45: Business model pattern H2: Coordinator of informal collection (Source: based on Hansen et al. 2020a)

I) Intermediaries and platform operators

Business model pattern

I1 Recycling platform

Business-to-business platform business model which provides electronic marketplaces to match supply and demand for residual, used, or wasted materials.

Actor's main role

I Intermediary

Circular strategy

Product	×	×	×	×	×	×
Part	×	×	×	×	×	×
Material	(recycling)	×	×	×	×	×

Service Level (sub-pattern)

Recycling platform		
Offers to supply residual or waste material (e.g. plastics), for example from mechanical engineering or other manufacturing, can be made on the platform to meet demand for secondary materials. Materials are characterised (amount, quality, material properties) to facilitate search. The platform provider (i.e. intermediary) charges transaction fees. Ownership transfers from the seller to the buyer.	–	–

Circular characteristics

Platforms lower transaction costs (search, negotiation, payment) for trading materials and can therefore increase the market for recycling materials. Better information and characterisation enables higher quality recycling streams and, subsequently, applications with higher performance needs.	–	–

Partnerships and coverage of value circle

Bilaterally across the value circle		
A B C D H I	–	–

Product design

Barriers: Low-quality materials (e.g. SoC; insufficient separation).

Design for X: Intermediary may influence sellers (e.g. producers) to switch to more recyclable materials to maximise intermediation success.

Social impact

May enable sale of fair-trade materials

May provide better market access to decentralised fair-trade material traders (→ see business model pattern H2).

Case example

cirplus, Germany

cirplus is a global marketplace for recyclates and plastic waste feedstock which is on a mission to make buying and selling recycled plastics easier and more efficient than before.This B2B marketplace links the plastics and recycling industries. The core focus of cirplus is to improve the qualities and quantities of recycled plastics. Additional consultancy services are offered to support companies along the value chain, for example in improving feedstocks, product design for recycling or material flows.

Source: www.cirplus.com

Figure 46: Business model pattern I1: Recycling platform (Source: based on Hansen et al. 2020a)

Business model pattern

I2 Used goods & sharing platform

Platform business models provide an electronic marketplace to match supply and demand for used products or components. The electronic platform minimises transaction costs for sellers and buyers (e.g. search, communication, and negotiation costs).

Actor's main role

I Intermediary

Circular strategy

Product	×	×		×	×	×
Part	×	×		×	×	×
Material	×	×	×	×	×	×

Service Level (sub-pattern)

Used goods platform	Sharing platform	
Reuse intermediaries provide platforms to match supply and demand for used goods in business-to-business, business-to-consumer, and consumer-to consumer contexts. The role of intermediation may be taken by 3rd-party actors, or by core actors in the value chain (e.g. retail).	Intermediaries focus on organising sharing transactions between owners of goods/infrastructure and potential users, thereby enabling access to products/infrastructure. The intermediaries operate digital platforms offering search, negotiation, rental contract design, financial transaction, and related offerings (e.g. insurance) – but they do not own or operate a pool of products.	–

Circular characteristics

By minimising transaction costs, platforms help to increase the market for reused goods. Given the nature of the platform business model, the focus is restricted to intermediating classical sales transactions between sellers and buyers (with ownership of the goods being transferred), with no additional circular potential for the intermediary.	Shared products are used more intensively (less idle time). In principle, this enables the procurement of higher quality products, because investment pays off sooner. However, given that intermediaries are not fleet managers – i.e. no central pool of products is managed – this model cannot leverage additional circular potential such as centralised maintenance, repair, upgrading, and preparation for recycling.	–

Partnerships and coverage of value circle

Users, producers/retail (i.e. take-back) or recovery managers C D F H I	Users, producers/retail (i.e. take-back) or recovery managers C D F I	–

Product design

Barriers: Goods may not be designed for long-term use (i.e. damage prevents second use).

Design for X: Design for longevity.

Social impact

New local job opportunities in remarketing

- Additional source of income for sellers.
- More affordable goods for people with lower incomes.

Case example

eBay Classified, Germany

eBay Classified, known in Germany as eBay Kleinanzeigen, is a used goods platform business model in which consumers can offer used goods for sale to other consumers, specifying a price as well as other characteristics of the item. The buyer contacts the seller, and together they finalise the transaction outside the eBay platform (i.e. the platform is just the matchmaker, but does not engage in the further transaction process).

Source: www.ebay-kleinanzeigen.de

More cases: www.floow2.com (B2B asset sharing)

Figure 47: Business model pattern I2: Used goods and sharing platform (Source: based on Hansen et al. 2020a)

J) Emerging actors

The business model patterns presented above have illustrated how the perspectives of the main actors involved in the physical product, component, and material flows. However, many more (support) actors are necessary to successfully transition into the CE. These actors can support other actors' business models as partners and adopt circular (support) business models themselves. Some of these actors are the following:

- **Non-technical service providers:** This umbrella category includes any actor providing non-technical services. While they may work in a technological context, their core service is non-technological. This may involve, but is not limited to, actors providing broader consultancy services for the CE, the facilitation of innovation processes, incubation services, and support in market intelligence and introductions.
- **Banks and financial service providers:** Particularly in support of higher-level service business models based on leasing, rental, and performance pay, companies have to invest considerable financial resources into product pools and related infrastructure. While some companies may found their own internal banks, obtaining external support from existing financial service providers may be a faster and easier step towards providing product financing to customers.
- **Circular design agencies:** They consult actors regarding how to improve product designs to maximise potential gains from a CE (e.g. design for remanufacturing, design for recycling). They may also engage in contract engineering for new or revised product designs.
- **Certification bodies:** They provide standards and certification systems for the CE to be able to credibly communicate circular properties of the product or solution in the market. They can either specialise in individual properties and life cycle stages (e.g. recycled content; biodegradability; durability) or across several properties and life cycle stages (e.g. cradle to cradle).
- etc.

Not all potential actor types have become evident yet. Moreover, the industry dynamic in the context of transitions to the CE provides extensive scope for innovation and entrepreneurship and this will certainly lead to the emergence of new actor types.

E List of identified Circular Economy barriers

Regulatory barriers	1. Policies that encourage recycling, incineration or disposal rather than other circular strategies such as reuse and repair (Mont et al., 2017) 2. Lack of tax or other fiscal instruments (e.g. CO_2 tax), lack of resource taxation (CEID, 2020; Hansen & Schmitt, 2020; Mont et al., 2017) 3. Lack of incentives for circularity investments (CEID, 2020) 4. False incentives for overproduction, e.g. in agriculture (CEID, 2020) 5. No systematic or extended international producer responsibility (CEID, 2020) 6. Unclear compliance rules on circularity (CEID, 2020) 7. Lack of old product liability (Mont et al., 2017) 8. Lack of defined circularity indicators (see e.g. EU taxonomy) (CEID, 2020) 9. Lack of concrete targets and conflicting targets (e.g. reuse vs. recycling) (CEID, 2020; Mont et al., 2017) 10. Legislation being waste- and not product-focused (CEID, 2020) 11. No uniform national and cross-border regulatory framework (e.g. choice of materials, recycling) (CEID, 2020) 12. Lack of consideration of circularity in public procurement (CEID, 2020; Kirchherr et al., 2018) 13. Lack of political interest in implementing regulatory requirements (CEID, 2020) 14. Awards and certification schemes focused on recycling (Ranta et al., 2018) 15. Lack of global consensus on CE strategies and regulation (Kirchherr et al., 2018) 16. Lack of standards/certification for circular products
Financial barriers	17. High capital or pre-financing demand, e.g. for leasing models (de Jesus & Mendonça, 2018; Mont et al., 2017) 18. Difficult access to funds (Hansen & Schmitt, 2020) 19. High transaction costs (de Jesus & Mendonça, 2018; Mont et al., 2017) 20. Uncertain return on investment and profit (de Jesus & Mendonça, 2018; Hansen & Schmitt, 2020; Mont et al., 2017) 21. Pricing issues and liquidity risks (Hansen & Schmitt, 2020) 22. The difficulty, high cost and long duration of obtaining 'secondary material' status versus 'waste' status under the existing environmental permit system 23. Possible increase in the cost of capital, as assets remain on the balance sheet, increasing financing needs and reducing the overall liquidity of the company (Mont et al., 2017) 24. Risk of not achieving cost-effective repair, reuse or refurbishment (Mont et al., 2017) 25. High costs associated with the take-back of products and high labour costs associated with product dismantling and separation of material fractions (Mont et al., 2017) 26. Difficulties in internalising legal risks (e.g. from longer warranties) beyond the extension of responsibility beyond the point of sale (Mont et al., 2017) 27. Declining sales of new products due to increased sales of repaired, refurbished and reconditioned products ('perceived' market cannibalisation) (Hansen & Schmitt, 2020; Mont et al., 2017) 28. Lack of supply (or quality) of returned products or resources (Mont et al., 2017) 29. Uncertainties about the residual value of the new products, i.e. repaired, reused, updated or refurbished (Mont et al., 2017) 30. Unpredictability of the volume of returned products can make it difficult to plan and financially forecast (Mont et al., 2017) 31. Risks in product performance, increased liabilities for reprocessed products or materials (Mont et al., 2017)
Organisational barriers	32. Hesitant corporate culture and predominant linear thinking (Kirchherr et al., 2018) 33. Lack of support from the top management (Hansen & Schmitt, 2020) and increasingly from mid management 34. Lack of fit of circular business models with existing corporate strategy (Hansen & Schmitt, 2020; Mont et al., 2017) 35. Lack of internal strategic positioning of circular business models (e.g. sales of new vs. used goods) (CEID, 2020) 36. Lack of operational incentives for investment decisions, focus on profit maximisation (CEID, 2020; Hansen & Schmitt, 2020) 37. Little evidence of financial and environmental benefits (Guldmann & Huulgaard, 2020) 38. Technical path dependency (lock-in) through long-term investments (Hansen & Schmitt, 2020) 39. ROI and similar requirements for new business projects (Guldmann & Huulgaard, 2020) 40. Lack of expertise and knowledge within the organisation, e.g. on CE business models (Guldmann & Huulgaard, 2020; Mont et al., 2017) 41. Lack of willingness to cooperate in the value chain (Kirchherr et al., 2018) 42. Difficulty in establishing cross-functional or cross-organisational cooperation (Hansen & Schmitt, 2020) 43. Unclear internal responsibilities (CEID, 2020) 44. Difficult to organise take-back logistics and lack of take-back processes (CEID, 2020; Mont et al., 2017) 45. Cannibalisation concerns (Guldmann & Huulgaard, 2020; Hansen & Schmitt, 2020) 46. Uncertainty about legislation in this area (Guldmann & Huulgaard, 2020)

Consumption-related barriers	47. Lack of consumer awareness of and interest in circularity and longevity (CEID, 2020; Kirchherr et al., 2018) 48. Lack of and/or uncertainty about consumer acceptance (CEID, 2020; Mont et al., 2017) 49. Misunderstandings regarding refurbishment, reuse, servicising, performance sales, etc. (Mont et al., 2017) 50. Linear thinking patterns (Hansen & Schmitt, 2020) 51. Lack of knowledge about CE (Hansen & Schmitt, 2020) 52. Rigidity of consumer behaviour and routines (de Jesus & Mendonça, 2018) 53. Lack of consumer information and education (CEID, 2020) 54. Lack of willingness to participate in 're-'activities 55. Expectations for low prices (CEID, 2020) 56. Customer perception that sustainability is a trade-off for price/performance (Ranta et al., 2018) 57. Prefabricated opinions that reprocessed products are inferior to new products or lack the attraction of the 'new'. 58. Mishandling of products by customers (Mont et al., 2017) 59. Customer concerns about data security (Mont et al., 2017)
Value chain barriers	60. Lack of market incentives (e.g. low raw material prices, high-quality materials not competitive in price) (CEID, 2020) 61. Lack of acceptance and transparency (e.g. costs and value of repair services) (CEID, 2020) 62. Market demand and market development unclear (Guldmann & Huulgaard, 2020; Schmitt & Hansen, 2020) 63. Dependencies in the supply chain prevent circularity (Boons & Lüdeke-Freund, 2013), OEMs may risk damaging relationships with their dealers by offering repair or refurbishment services (Mont et al., 2017) 64. More risks from dependence on unstable suppliers compared to dependence on traditional global commodity markets for new materials (Mont et al., 2017) 65. Component manufacturers and other non-OEMs can only establish circular business models to a limited extent due to their position in the value chain (Mont et al., 2017) 66. Lack of networks and/or supply chains for dismantled products and components and recycled materials (reverse logistics) (Mont et al., 2017) 67. Lack of standardisation and incorrect quality standards (e.g. best before date of food) (CEID, 2020; Kirchherr et al., 2018) 68. Lack of cooperation along the value chain, takes time to build new partnerships and mutual trust (CEID, 2020; Guldmann & Huulgaard, 2020) 69. Lack of exchange of information (Hansen & Schmitt, 2020) 70. Low quality of recycled material flows (Hansen & Schmitt, 2020) 71. Rapid innovation cycles and corresponding consumer expectations (especially regarding repair, maintenance) (CEID, 2020) 72. Increasing individualisation (e.g. packaging) (CEID, 2020) 73. Lack of a clear system of key figures comparable to the economic annual balance sheet (CEID, 2020) 74. High labour costs (Mont et al., 2017)
Technical barriers	75. Lack of standards and design requirements (materials: non-toxic ingredients, material substitution; products: modularity, design for repair/remanufacturing/ recycling) (CEID, 2020) 76. Lack of design tools for CE and circular products (CEID, 2020; Kirchherr et al., 2018) 77. Lack of data availability (material composition, ingredients, product life cycle) (CEID, 2020) 78. Lack of digital tools (CEID, 2020) 79. Lack of demonstration projects for industrial symbioses (CEID, 2020; Kirchherr et al., 2018) 80. Lack of treatment and recycling structures in countries (incl. Germany) (CEID, 2020) 81. Lack of ability to deliver high-quality remanufactured products (Kirchherr et al., 2018) 82. Too few large-scale demonstration projects (Kirchherr et al., 2018) 83. Duration between design and diffusion (de Jesus & Mendonça, 2018) 84. Lack of technical assistance and training (de Jesus & Mendonça, 2018)

Table 18: Potential barriers to the implementation, scaling and diffusion of circular business models (Source: own presentation)

F Overcoming Circular Economy barriers with digitally-enabled solutions

Table 19 explores how digital technologies can enable a transition to a Circular Economy following the classification of barriers in Chapter 5 and further includes relevant business domains to facilitate comprehension.

Barrier type	Business domain	Digitally-enabled solution
Regulatory barriers	Compliance	Digital technologies could help the focal actor, the customer, and other stakeholders involved in the life cycle of the product to collect the necessary information for satisfying current and future regulations on circular products.
	Indicators and targets	Smart products allow the gathering of data to create specific key performance indicators for the product life cycle and elaborate science-based targets to meet environmental requirements.
	Standards and certification	The connectivity provided by digital technologies could enable better integration of data from different sources (e.g. internal data from several departments and process and external data from customers and suppliers). Moreover, the usage of technology may boost the digitisation of analogue data. These standardisation and normalisation practices may facilitate the creation of industry-wide digital practices and feed certification schemes that ensure a borderless Circular Economy.
Financial barriers	Costs and investments	Digitalisation could save costs by allowing for life-extension of products, components, and materials. Digital technologies allow better measurements of the transactions and their expected returns – better data, for better business cases.
	Sources of revenue	The development of smart circular strategies offers additional revenue streams (e.g. new services like predictive maintenance). The cannibalisation of current sources of revenue generated by the longer use of circular products and components could be compensated by these additional revenue sources.
	Value of returns	End-of-life value estimates, take-back planning, and circular processing could be improved by having clear information on customer inventories and expected return dates, quantities, and quality.
	Liabilities and risks	Full data transparency and product traceability could ensure the management of liability risks and the assignment of responsibility to the parts involved.
Organisational barriers	Internal resources	The expansion of the service offer through the adoption of digital technologies allows the creation of new departments or business units and the reassignment of human and capital resources. It also encourages the transition towards a service-oriented business model.
	Internal collaboration	Digital technologies can inform about failure modes of products and components, and about the effectiveness of different circular strategies. This information may flow into the R&D department, influencing future product design. It could also steer after-sales services. This could enable greater cooperation between departments.
Consumption-related barriers	Customer needs	Data from the customer on product performance would facilitate faster recognition of customer needs. This data alone may not bring any benefits if the firms participate in an analogous environment. The availability of products with more digital components may allow higher flexibility to satisfy evolving customer needs. For example, software solutions or platforms may be adapted to specific customers according to special requests.
	Customer relationships	More frequent interaction with the customer through a smart interface enables a better customer relationship, and thus opens paths to offer circular services, training and education about circularity, and changes customer perspectives about sustainability and circularity. Secondly, platforms and other digital tools enable the streamlining of customer relationship management (CRM) linked to products, components, and materials due to the ability to automate (part of) the customer service.
	Quality assurance	Digitalisation could help ensure quality-as-new of refurbished and remanufactured products.
Value chain barriers	Cross-cycle collaboration	Data collected along the value chain supports better integration of the actors, aligning interests and allowing for unlocking shared value creation. Data standardisation, the creation of compatible software solutions, and a higher level of digital components within products would allow better integration of the actors in the value chain. This type of solution is not available to industries with somewhat analogous systems. Firms may combine their solutions or integrate their software services into one application that covers an industry or cluster rather than offering scattered solutions.
Technical barriers	Data availability and decision-making	Analysis of usage data could enable the delivery of high-quality remanufactured products before product take-back. It could also provide information about the right moment for performing an upgrade or repair. Firms could use digital product passports to select the right components, analyse component wear and tear, and reduce the complexity of the value cycle.

Table 19: Digitally-enabled solutions for overcoming barriers (Source: own presentation)

G Definition of key digital technologies and contributions to the Circular Economy

This section discusses a selection of key digital technologies and their potential contribution to a Circular Economy.

Internet of things (IoT)	**What is it?** The internet of things is 'a paradigm where everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the Internet to achieve some useful objective'.[278] **How does it enable a smart Circular Economy?** The internet of things is the infrastructure that enables the creation of connected products and resources. It is the foundation for the monitoring, tracking, and tracing of products and resources in their journey through the different loops of the Circular Economy.[279]
Big data	**What is it?** Big data are large and complex datasets and more advanced analysis methods are needed for processing such data compared to smaller datasets (smaller datasets can be easily processed using traditional tools). Big data analytics deploys advanced techniques to extract information from data that may be structured in different ways, formats, and sizes.[280] **How does it enable a smart Circular Economy?** Big data analytics makes it possible to identify patterns and trends about product usage or performance. This information can influence the design of future product generations or the offer of after-sale services, thus extending the useful life of products and resources and enabling preservation of the highest possible value.[281]
Analytics and reliability analysis	**What is it?** Analytics and reliability analysis are at the core of any advanced 'smart' strategy. Together, they are used to assess the likelihood and certainty of an event occurring.[282] **How does it enable a smart Circular Economy?** With these approaches, predictions can be made with regards to when and where products and resources will become available, as well as what the expected quality levels are. This information can be used when planning matters such as which circular strategies will be used (think of recycling versus cascading for materials, and refurbishment versus remanufacturing for products and components) and where they will will be carried out.[283]
Artificial intelligence & machine learning	**What is it?** Artificial intelligence (or AI) simulates the cognitive processes of humans, such as reasoning and learning, to turn data into information and insights. To do so, it uses example data sets – or training data – to learn what the desired outcomes are and to apply this knowledge to new cases. Machine learning and deep learning are approaches that enable machines to perform tasks relying on patterns and inference without specific human instructions.[284] **How does it enable a smart Circular Economy?** Machine learning and the related approach of deep learning allow a machine to perform a specific task without requiring explicit instructions. As a result, machines can autonomously manage a range of factors that improve their longevity. For instance, AI solutions could generate objective and cost-effective analyses to differentiate failures from cosmetic issues. In addition, cameras and sensors could feed information for robots to make autonomous decisions with when recovering recyclables from waste.[285]

278 | See Whitmore et al. 2015.
279 | See Ellen MacArthur Foundation 2016.
280 | See Kristoffersen et al. 2020a.
281 | See Ellen MacArthur Foundation 2016.
282 | See Kristoffersen et al. 2020a.
283 | See ibid.
284 | See Kristoffersen et al. 2020a.
285 | See Ellen MacArthur Foundation 2019.

Online platforms	**What is it?** Online platforms cover a range of services available on the internet, for instance, search engines, social media, and marketplaces. They can be seen as 'a digital service that facilitates interactions between two or more distinct but interdependent sets of users (whether firms or individuals) who interact through the service via the Internet'.[286] **How does it enable a smart Circular Economy?** Online platforms may connect manufacturers directly with their customers, providing them with means to better understand customer needs and offer additional services to their customers. In addition, online platforms have the capacity to connect the supply of resources – whether secondary materials, or used components and products – with actors who have a need for them. Finally, online platforms enable new circular business models based on access instead of ownership, such as sharing, renting and leasing.[287]
Cloud computing	**What is it?** Cloud computing can be seen as an advanced technique for processing, storing, distributing and managing data through the internet. It enables the usage of technology any time and anywhere by separating the applications and the related information from the physical infrastructure typically required for it (e.g. servers, databases, applications). Users have access to a shared pool of computing resources that can be rapidly activated with minimal management effort and interaction with the provider of the resources.[288, 289] **How does it enable a smart Circular Economy?** Through collecting and analysing more data, new patterns can be found that influence how products and resources are used, thus allowing for interventions that extend the useful life of these products and resources. Cloud computing may offer organisations computing capabilities on-demand. Thus, it may allow organisations to execute data collection and analysis processes more efficiently and without the need for large investments in data centres. Cloud computing is especially attractive to small and medium enterprises that do not have extensive financial resources to make such investments.[290]
Distributed ledger technology & blockchain	**What is it?** Distributed ledger technology (DLT) is essentially a database shared across multiple actors, geographies or organisations. All participants within the network can have an identical copy of this database, and changes are replicated to all copies of the ledger in a matter of minutes or seconds, allowing for decentralised transaction and data management. Blockchain is a type of DLT and is a chain of blocks linked with each other with cryptographic security. Transactions in the blockchain are immutable and make it impossible for an entity to manipulate, replace, or falsify data stored on the ledger.[291] **How does it enable a smart Circular Economy?** Together, these two technologies allow for changes in location and changes in status of resources – whether 'health status', quality, quantity or ownership – to be collected and shared in value chains over time. The trusted nature of these technologies enables decentralised and secure data management. A major application of these technologies for the Circular Economy lies in the potential traceability of products, components and materials along the value chain.[292]
Digital passports & digital twins	**What is it?** Digital passports are electronic data sets that collect the characteristics of products, components and materials.[293] A digital twin is a virtual counterpart of a product that can be used to carry out simulations of its operations.[294] **How does it enable a smart Circular Economy?** Digital passports – containing information about formulation, manufacturing technologies, additives and alternations that were made during use – enable suppliers, designers, users, service providers and other value chain actors to retain the highest possible value of the products or resources by allowing for the most adequate treatment for each circular strategy (e.g. repair).[295] Digital twins may use the information stored on digital passports to run simulations and analyse the future performance of the product during the use phase. Digital twins enable predictions to be made about remaining useful life and the best moment to perform maintenance before failure, remanufacturing or any other circular strategy.

286 | See OECD 2019, p. 11.
287 | See Berg/Wilts 2018; Ellen MacArthur Foundation 2016; Konietzko et al. 2019.
288 | See Promotorengruppe Kommunikation der Forschungsunion Wirtschaft – Wissenschaft/acatech 2013.
289 | See Whaiduzzaman et al. 2014; Mell/Grance 2011.
290 | See Ellen MacArthur Foundation 2016; Wang et al. 2015.
291 | See Walport 2016; Yli-Huumo et al. 2016.
292 | See Ellen MacArthur Foundation 2016.
293 | See Debacker/Manshoven 2016.
294 | See Gabor et al. 2016; Negri et al. 2017.
295 | See Luscuere/Mulhall 2019.

Control & embedded systems	**What is it?** Control and embedded systems, typically found in more complex products, allow these products to control their own performance, through built-in feedback mechanisms.[296] **How does it enable a smart Circular Economy?** Control and embedded systems allow product and component performance to be adjusted. This means that wear-and-tear can be reduced, and its influence on a product's or component's lifetime managed better.[297]

Table 20: Definition of key digital technologies and contributions to the Circular Economy (Source: own presentation)

296 | See Kristoffersen et al. 2020b.
297 | See ibid.

H Background to the *Circular Economy Initiative Deutschland*

The *Circular Economy Initiative Deutschland* (CEID) was founded in 2019 on behalf of the German Federal Ministry of Education and Research (BMBF) to promote Germany's transformation into a Circular Economy (CE) following a multi-stakeholder approach. The overarching goal is to develop a roadmap for Germany towards a more circular, resource-productive economy and to derive recommendations for action for politics, business and science by early 2021.

In a preliminary study published in July 2019, the office of the *Circular Economy Initiative Deutschland* derived 24 findings from a qualitative analysis of 12 European Circular Economy roadmaps, from which ten recommendations for implementation in Germany were formulated. The results of the preliminary study, which were validated by a comprehensive multi-stakeholder review, form the basis of the work of the *Circular Economy Initiative Deutschland* and will be incorporated into the preparation of the final report, which will be published in 2021.

Supported by members from business, academia and civil society as well as politics, the *Circular Economy Initiative Deutschland* offers a broad stakeholder dialogue intended to develop a systemic approach to address key challenges for the Circular Economy.

The work of the *Circular Economy Initiative Deutschland* is structured in three working groups (see Figure 48):

The Circular Business Models working group deals on a conceptual and cross-sectoral level with the potential of circular business models and digital technologies as drivers of innovation.

The Packaging and Traction Batteries working groups work on their respective sector-specific functional systems. The work in the working groups is based on a holistic life cycle approach (product development, production, use and reuse).

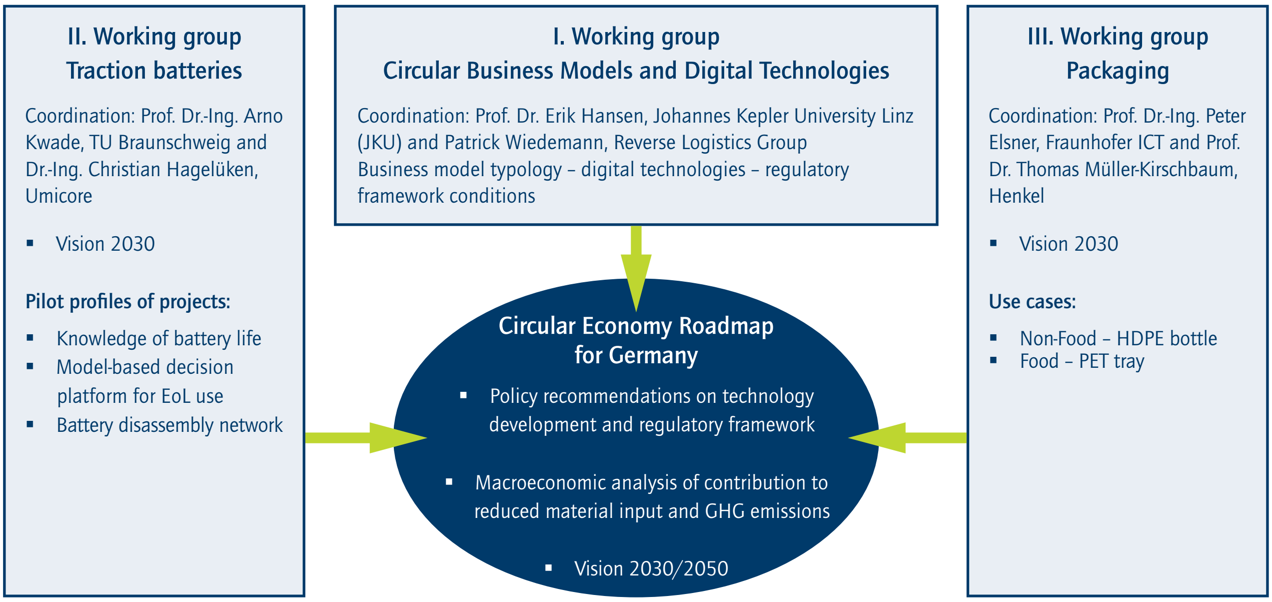

Figure 48: Presentation of the *Circular Economy Initiative Deutschland* and its three working groups (Source: own presentation)

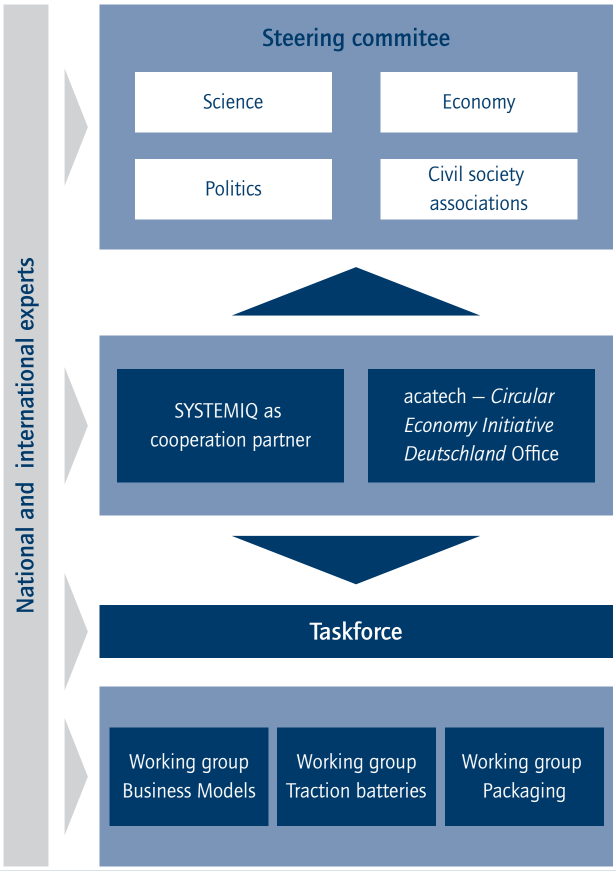

Figure 49: Organisation chart and content focus of the *Circular Economy Initiative Deutschland* (Source: own presentation)

The working and steering group of the *Circular Economy Initiative Deutschland* consists of members from science, business and civil society and the Federal Ministries of Education and Research (BMBF), for the Environment, Nature Conservation and Nuclear Safety (BMU) and for Economics and Energy (BMWi). This guarantees close coordination between clients, members and the office of the *Circular Economy Initiative Deutschland* and ensures permanent compatibility with German politics.

The office of the *Circular Economy Initiative Deutschland* – managed by acatech and SYSTEMIQ – coordinates the overall process, ensures the level of ambition in terms of content and develops the Circular Economy Roadmap for Germany.

I Background and methodology of the Circular Business Models working group

The work of the Circular Business Models working group benefited from the extensive involvement of participants from business, science, and civil society (see Figure 50 below). It consists of central stakeholders whose expertise covers large parts of the value chain:

- Top-class representatives from science and civil society provide well-founded expertise and perspectives outside the business world.
- The participation of the Ministries of Education and Research (BMBF), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Economics and Energy (BMWi) in the steering committee ensures compatibility with politics.
- acatech and SYSTEMIQ, as the office of the *Circular Economy Initiative Deutschland* (CEID), ensure both process coordination and independent and content-related input.

Participants in the Circular Business Models working group

Coordination

Industry: Patrick Wiedemann – Reverse Logistics Group, CEO

Sciences: Prof. Dr. Erik Hansen – Johannes Kepler University Linz (JKU), Head of Institute Integrated Quality Design

Current members

Industry

External experts

Manfred Eschenbacher

Sciences

Civil society

Figure 50: Members of Circular Business Models working group (Source: own presentation)

Methodological approach

The presented final report of the Circular Business Models working group within the framework of the *Circular Economy Initiative Deutschland* is the coordinated result of a ten-month multi-stakeholder process with actors from business, science and civil society. In accordance with the general objectives and antitrust regulations of the *Circular Economy Initiative Deutschland*, the cooperation between the participating actors within the working group was limited exclusively to the pre-competitive area. Six working group meetings spread over the period, which were planned and conducted by the *Circular Economy Initiative Deutschland* office together with the working group leaders, constituted the central coordination mechanism. More specifically, the meetings offered the working group members the opportunity to discuss and decide on thematic priorities and positions in terms of content. Intensive preparation for and follow-up of the working group meetings as well as iterative coordination loops between the individual meetings ensured a high degree of stakeholder involvement in the development of the topics and content positioning.

In addition to the consultation process of all working group members in the working group meeting, three taskforces were formed within the working group. These taskforces each wrote a chapter in parallel to the work process of the entire working group (see chapters regarding circular business model typology, barriers, digital enablers and policy enablers). This parallel working process was similarly structured by regular virtual meetings of the taskforce groups, which were organised and conducted by the *Circular Economy Initiative Deutschland* office and the respective leads of the taskforce. The results of the final report are based on the content input of the respective taskforces. In addition, the content and central statements of the individual taskforces were discussed and reviewed in regular consultation loops with the entire working group. Overarching chapters (e.g. chapter on use case and recommendations) were mainly coordinated and written by the leads of the working group and also discussed and validated with the entire working group. Finally, an external review of selected chapters was carried out by distinguished experts from the scientific community.

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