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Circular economy — Performance-based approach — Analysis of case studies

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Foreword

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This document was prepared by Technical Committee ISO/TC 323, *Circular economy*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

0.1 Background

The global economy is “linear” as it is mainly based on extraction, production, use and disposal. This linear economy leads to resource depletion, biodiversity loss, waste and harmful losses and releases, all of which collectively are causing serious damage to the capacity of the planet to continue to provide for the needs of future generations.[8] Moreover, several planetary boundaries have already been reached or exceeded.

There is an increased understanding that a transition towards an economy that is more circular, based on a circular use of resources, can contribute to meeting current and future human needs (welfare, housing, nutrition, healthcare, mobility, etc.). Transitioning towards a circular economy can also contribute to the creation and sharing of more value within society and interested parties, while natural resources are managed to be replenished and renewed and in a sustainable way, securing the quality and resilience of ecosystems.

Organizations recognize many potential reasons to engage in a circular economy (e.g. delivering more ambitious and sustainable solutions; improved relationships with interested parties; more effective and efficient ways to fulfil voluntary commitments or legal requirements; engaging in climate change mitigation or adaptation; managing resource scarcity risks, increasing resilience in the environmental, social and economic systems), while contributing to satisfying human needs.

The ISO 59000 family of standards (see Figure 1) is designed to harmonize the understanding of the circular economy and to support its implementation and measurement. It also considers organizations, such as government, industry and non-profit, in contributing to the achievement of the United Nations (UN) Agenda 2030 for Sustainable Development.[9]

ISO 59004, *Circular economy — Vocabulary, principles and guidance for implementation*

ISO 59010	**ISO 59020**	**ISO 59040**	**ISO 59014**
Circular economy — Guidance on the transition of business models and value networks	*Circular economy — Measuring and assessing circularity performance*	*Circular economy — Product circularity data sheet*	*Environmental management and circular economy — Sustainability and traceability of the recovery of secondary materials — Principles and requirements*

ISO/TR 59031, *Circular economy — Performance-based approach — Analysis of case studies*
ISO/TR 59032, *Circular economy — Review of existing value networks*

Figure 1 — ISO 59000 family of standards

0.2 Relationship between ISO 59004, ISO 59010 and ISO 59020

ISO 59004, ISO 59010 and ISO 59020 are interconnected, as shown in Figure 2, and support organizations in implementing a transition towards a circular economy.

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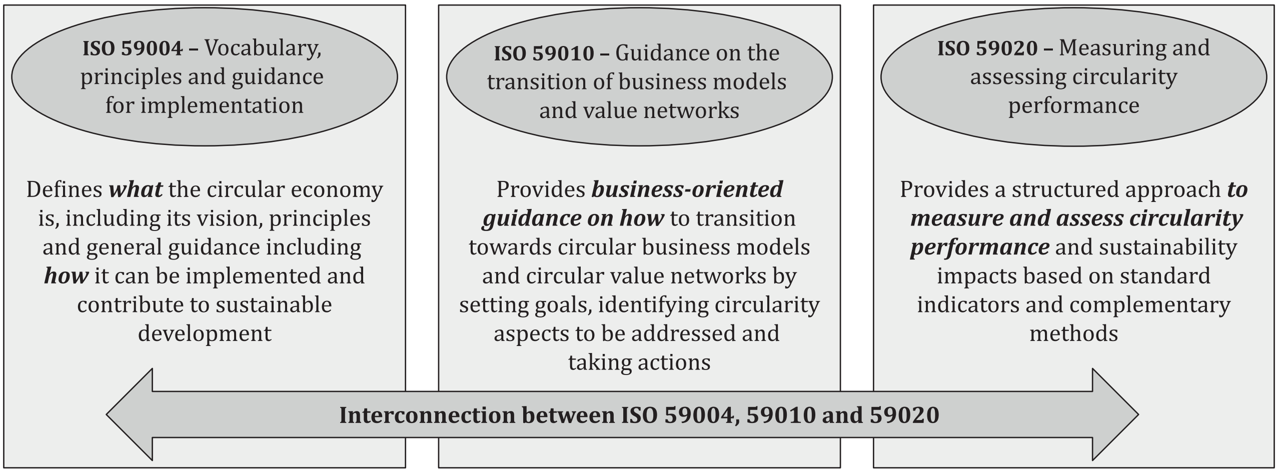

Figure 2 — Relationship between ISO 59004, ISO 59010 and ISO 59020

0.3 Introduction to performance-based approaches

Performance-based approaches, such as functional economy, service economy and product-as-a-service (PaaS) system, are currently acknowledged as being relevant for helping organizations to face the challenges in developing circular-economy-related approaches. Such business models can enable and strengthen their economic viability while simultaneously improving their environmental and societal impacts.

Indeed, in a performance-based approach, the revenue stream of an organization or group of organizations is less dependent on the amount of product or “service unit” delivered and more related to the real impact or outcome of their activities on the customers or beneficiaries. These impacts can be economic and/or social and/or environmental. The performance-based approach has the potential to contribute to the decoupling of economic development with the negative impacts of resource use.

EXAMPLE A car provides one solution among others to meet a need for mobility from a point A to a point B, which is the desired outcome.

Performance-based approaches within a circular economy are currently well documented from a theoretical point of view; however, there seems to be a lack of operational reference for their implementation. Many organizations therefore state that while such approaches are interesting, they are not applicable to their business model and they would require a dramatic transition in their business model, which would threaten their existence in the short term (even if their situation in the long term can be improved). Providing examples of transitions to a performance-based economic model across a range of businesses and companies can bring valuable insight and aid new organizations and economic players to transition to a circular economy (regardless of their size or status). To ensure that this document is a useful tool for promoting changes in business models, the barriers that impede the adoption of a performance-based approach are detailed.

For consistency with the scope of ISO 59010, which covers specific issues of circular economy, this document does not aim to illustrate the many actions, measures and strategies for the implementation of a circular economy within an organization. Instead, it addresses a key question involving the decoupling of revenues from the use of material resources. Decoupling is critical as it reduces the impact of the “rebound-effect” in which reducing the environmental impact of a product has limited effect because one way or another the organization needs to sell more products to grow or survive, which can negate the benefits of circular economy initiatives on resource preservation.

This question of growth is central in this document: it shows how some organizations have managed (at least partially) to make PaaS consistent with sustainable financial results and the preservation of material or intangible resources. In these examples, there are no environmental or social constraints to abide to for mutual development of these three aspects of sustainable development. Of course, achieving synergy from these three aspects demands significant redesigning of all the aspects of an economic model (how to produce value in new ways, ensuring these are valued by customers and, hence, financially rewarding, how the new business models affect work within the organizations, and the relationships between the various stakeholders and the significant time investment needed prior to implementation). This document

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complements ISO 59010, which provides a guidance on circular-economy-compliant business models, in particular the service economy cited in this document.

When the sale of performance is considered, the question of assessment is essential. The assessment covers, for instance, not only environmental impacts such as carbon dioxide (CO_2) emissions, but also other aspects of resource conservation, wellness and intangible resource or value development (e.g. attractiveness of a territory for upcoming investment, reinforcement of relationship between partners for new projects). While a product–service system business model has the potential to improve environmental performance or decrease the environmental impact, the superiority is not always guaranteed (e.g. user mis-behaviour). There is no accepted approach for quantifying this superiority at present. The outputs of using ISO 59014, which centres on the issue of metrics and assessment of circular economy, are essential. This document highlights to what extent they are or can be relevant for the assessment of the contracted performance in each case.

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Circular economy — Performance-based approach — Analysis of case studies

1 Scope

This document provides an analysis of various case studies for the implementation of specific aspects of the circular economy in organizations, regardless of their status. This document specifically focuses on performance-based approaches such as functional economy, service economy, product-as-a-service (PaaS) and other performance-based approaches.

This document mainly describes a selection of use cases of operational implementation of such performance-based approaches as observed in different organizations. It stresses the challenging context faced by concerned organizations in changing their economic and business models. This document depicts cultural, organizational and industrial changes induced by the move of business models toward a performance-based approach. It emphasizes to what extent the total economic value can increase and how this is converted into revenue streams for the concerned organizations.

This document does not apply to the implementation of any circular economy domain of actions (circular design, recycling; responsible purchase policy, etc.), but focuses on the systemic level of development of economic models based on the commercialization of various performance aspects.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
performance-based approach
economic models relying on the sales of solutions with the aim to ensure usage intensity, useful effects or results to be achieved

Note 1 to entry: Solutions are a combination of services and products that cannot be separated.

3.2
reuse,verb
use a product or its component parts after their initial use, for the same purpose for which they were originally designed

Note 1 to entry: Utilization intended by the original design can involve either single-use or multiple-uses by the initial user or customer over time.

Note 2 to entry: Minor treatment (e.g. cleaning) of the product can be needed by the user to allow for reuse.

Note 3 to entry: In some cases, resources, such as water, are considered as a product, in which case, the purpose of "original design" is not applicable.

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[SOURCE: ISO 59004:2024, 3.5.17]

3.3
economic system
system by which a society organizes and allocates resources

Note 1 to entry: The economic system can vary depending upon the geographic region or governmental jurisdiction.

Note 2 to entry: This can include the regulation of resources and the production, use and disposal of these resources.

[SOURCE: ISO 59004:2024, 3.1.2]

3.4
business model
organization's chosen system of interconnected and interdependent decisions and activities that determines how it creates, delivers and captures value over the short, medium and long term

Note 1 to entry: A business model is more than the organization's processes and the solutions it provides.

Note 2 to entry: A business model is a subset of value-creation models wherein the chosen system determines how the organization creates, delivers and captures economic value.

[SOURCE: BSI 8001:2017, 2.8, modified — "solutions" replaces "products or the services" in Note 1 to entry.]

3.5
functional economy
economic model that optimizes the use of solutions and, thus, the management of existing wealth (products, knowledge and nature)

Note 1 to entry: This model fosters usage rather than ownership.

Note 2 to entry: The economic objective of the functional economy is to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible.

Note 3 to entry: The functional economy is therefore considerably more sustainable, or dematerialized, than the present economy, which is focused on production as its principal means to create wealth and material flow.

3.6
product-as-a-service
PaaS
business model (3.4) that allows customers to purchase the performance of a product rather than the product

Note 1 to entry: This model can offer environmental and economic benefits to all the parties along the value chain by reducing manufacturing and intensifying use.

Note 2 to entry: At the end of the life of the product, the service provider has the responsibility for the *reuse* (3.2), recycle, regeneration or disposal of the product.

4 General information

4.1 Objective

This document shares examples of various globally distributed organizations that have developed circular economy practices involving a performance-based approach.

This document can be a resource for an organization:

— from the same sector as that of the case study depicted in this document (sectorial analogy);

— facing a similar barrier in moving from a traditional linear economy approach as seen in the example case study (problems of analogy);

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— considering a business model similar to a case study in this document (business model analogy, e.g. PaaS, sharing platform).

This document provides relevant examples for consideration when shifting from a sales-based or ownership-based business model to a circular performance-based one.

4.2 Selection of cases

Many cases were submitted for investigation. The selection of the use cases for further consideration for use in this document was based on several factors that allowed selection of examples to illustrate performance-based approaches:

— the extent to which the considered solution relies on the sale of a delivered performance or set of outputs and outcomes;

— the scope and the documentation of the economic, environmental and social impacts (whether direct or as external effects) that were taken into account;

— the extent to which intangible effects (including customer satisfaction) of the deployment of the considered solution are taken into account and documented;

— the consideration of one or several aspects of a performance-based approach that contribute to a circular economy (e.g. a sharing economy, remanufacturing strategies, product extension life strategies);

— the demonstration of mechanical and/or service cycles that are compliant with the principles of a circular economy;

— the ability to scale-up or replicate the considered solution in the same sector or in another field;

— the accuracy of the environmental analysis underlying the deployment of the considered solution. e.g. use of life cycle analysis, accounting for greenhouse gas (GHG) emissions balance in a relevant scope (with a preference for analysis in Scope 2 or Scope 3 rather than Scope 1).

From these considerations, cases selected for more extensive investigation and selection for reporting were chosen as detailed in 6.1.2.

4.3 How to use this document

This document provides relevant examples of performance-based approaches developed by different types of organizations: companies, business associations and start-ups. Each example shows the main barriers determined by the transition from a traditional linear approach and how these can be overcome. Each example presents the concept of the proposed solution before describing the progress of its delivery. Each description of the case study emphasizes the change in the use of products to enable economic revenue generation and articulates the service element contribution towards effective performance provision. As a conclusion, the case study description underlines the extent to which the initial shortcomings of a linear approach are overcome through the change in business towards a performance-approach.

The case study description also shows how the described approach can be adapted to other situations and the conditions under which this can be considered.

This document can be used to provide the means to identify critical issues when an organization moves towards a performance-based approach. This includes consideration of:

— technical and service cycles;

— quantitative assessments, especially environmental and social impacts (external effects) and cost-benefit analysis, focusing on life cycle simulation (LCS) approaches (when they exist) and GHG emission assessment through life cycle assessment (LCA);

— qualitative assessment and its use, especially regarding consideration of intangible effects;

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— the type of performance-based approach considered (product–service system, remanufacturing and life-extension strategies, sharing economy platforms, etc.);

— replicability, and scale-up opportunities and conditions.

Moreover, each case study provides an overall overview on why a performance-based approach is relevant from a global point of view and what is important to implement a performance-based approach of a circular model, beyond a list of criteria to abide by.

Some of the cases do not focus on or provide for end-of-life treatment (largely because of a lack of information provided). These aspects can be considered in a performance-based approach and in a circular economy.

5 Analysis of cases

5.1 Process to collect and analyse cases

Following a widely distributed invitation from ISO/TC 323 during 2020, and a second call with a special focus on developing countries launched in early 2021, a total of 121 cases were submitted for analysis (see Table 1).

In order to have an impartial analysis, two experts from countries different than the submitted case studies analysed each case. The main criterion was the existence of a performance-based approach. The selected cases were those that provided the clearest evidence of a performance-based approach. In total, seven cases were selected to be reported in this document, based on information given and the expert analysis.

Table 1 — Cases received

Country	Cases received
Benin	1
Bolivia	3
Brazil	2
Cameroon	1
Chile	4
Columbia	1
France	6
Germany	1
Indonesia	1
Iran	1
Italy	24
Japan	46
Kenya	2
Mauritius	1
Serbia	1
Spain	18
Sweden	2
Switzerland	1
Uganda	1
Uruguay	4
Total	**121**

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5.2 Approaches taken in the use cases

5.2.1 General

The selection of cases represents the different aspects of the performance-based circular economy approach. Some cases come from small companies, and others from large companies, but all have based all or part of their business model on an approach that focuses on the sale of the performance of the products rather than on the products themselves. In this way, the link between the manufacture of products and the profitability of the company is broken.

Firstly, it is a question of selling a subscription to the performance of use (mobility, light, industrial stripping, protection of transported and stored products, etc.). The cases presented by these companies never talk about selling products.

Secondly, these companies have recurring income that strengthens their financial stability and strengthens their resilience in the event of economic accidents.

Finally, these companies participate in the fight against global warming and in achieving the Sustainable Development Goals by reducing their demand for materials and energy through the reuse, reparability and controlled recycling of products used for the realization of a performance-based business model.

Some of the companies started directly with a performance-based approach business model and others created or transformed a business unit into a performance-based approach business model (see the information for each use case).

All the data stated for each use case are considered true at the time of collecting the information from the respective institutions and represent a picture of the moment when the data were collected.

5.2.2 Related aspects of the performance-based approach in the cases

Each case is an example of a business model that is based on selling the performance of the product rather than selling the product itself. In all business models, products are at the heart of the service.

This means that the company will first conduct a circular design of the service it wants to provide, then it will use the service's circular design to conduct a good circular design and finally it will provide the specification of the products in relation to the service's circular design.

NOTE The cases are consistent with the principles and definition of circular economy as defined in ISO 59004. Several of the cases received were not included in this document because they were not consistent with these principles. In particular, some examples of recycling without any systemic thought were excluded for this reason.

5.2.3 Circular design

Each of these cases have their own challenges. Some of them have used circular design, while others (regarding the cost and the size of the company) try to do their best to provide what comes closest to a circular design.

Circular design is used to deliver the best performance while minimizing negative impacts during the whole life cycle, in accordance with the best available technology (BAT) and best available methodology (BAM).

The focus of circular design is on curtailing a loss of value that is embedded in raw materials and products, by keeping them circulating in closed loops. These loops, such as reuse, repair, remanufacture, return, refurbishment and recycling, extend the product's life cycle and improve the resource productivity.

In accordance with extended producer responsibility (EPR), circular design methodology is performed by each one of the economic subjects that is introducing a raw material into the market.

The key lies in how a product or material is designed and how different requirements are balanced. The product design phase affects both product life and product performance along the entire supply chain/value chain.

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This does not rest solely on the designer's shoulders since economic entities are required to implement all available methodologies to guarantee the entire supply chain up to the reuse of the product itself and the materials that compose it.

5.2.4 Extended producer responsibility

EPR is a policy approach under which producers are given a significant responsibility (financial and/or physical) for the treatment or disposal of post-consumer products.

Part of the cases presented here are from EPR regulations. Companies often state that it was the arrival of these EPR regulations that triggered the reflections on the change of business model.

EPR is not a mandatory element in the implementation of a circular economy business model, but some of the cases shown here infer that each time this proposal has been implemented, it has accelerated the transition from industrialized business models to the circular economy.

A representation of different types of performance-based approaches for addressing EPR challenges is given in Figure 3.

In business models that rely on a mix of products and services, step one (on the left in Figure 3) is just selling products with some services linked to it (maintenance, consultancy, etc.). The second step is to rent or lease the products and the last step is to sell the use of products; the result provided by products and service is closely linked.

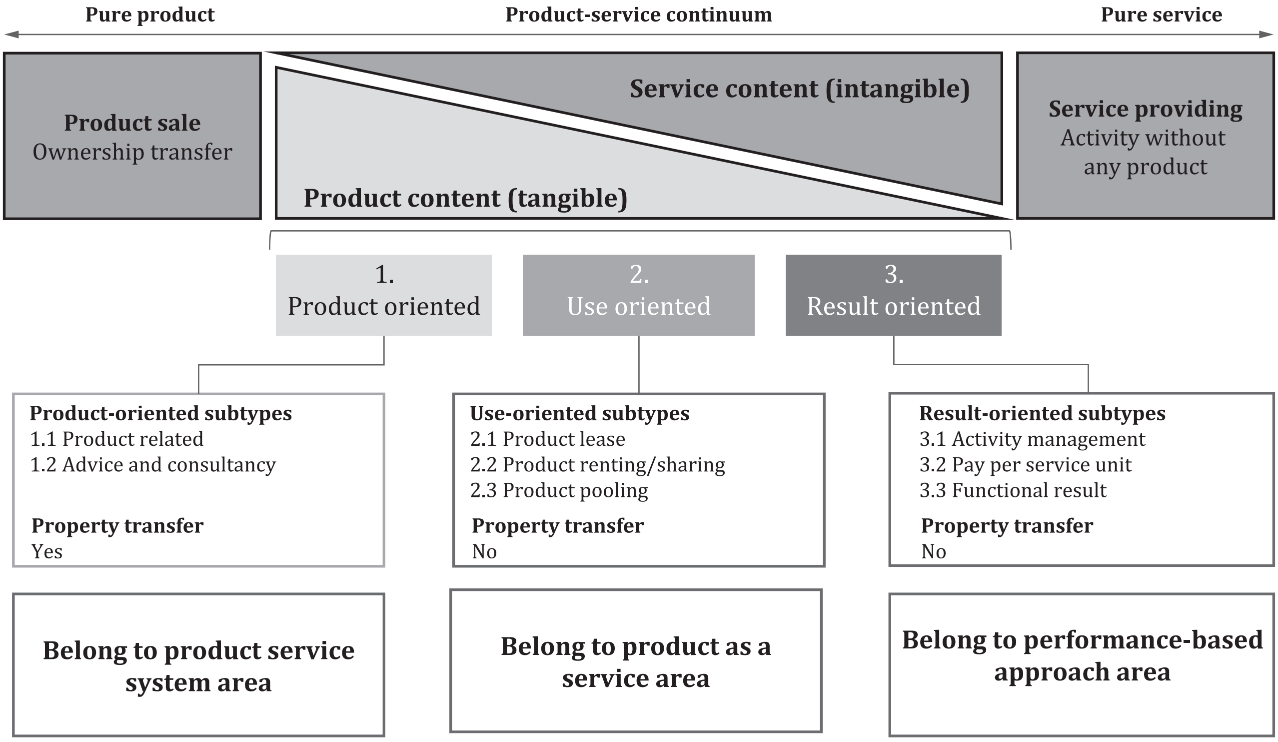

Figure 3 — Different types of performance-based approach for addressing EPR challenges

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6 Case studies

6.1 Overview of cases

6.1.1 Items for describing each case

The template for the presentation of the case studies was composed of the following information:

- Proponent of the case.
- Basic information: Location, industry and size of the organization.
- Agreement to share the necessary information for analysing the case.
- Proposed documents: List of the documents presented.
- Reasons to include the case in this document.
- A short description about the organization and actions in circular economy areas.
- Linear economy:
  - Current problem to be solved: The challenge raised by the environmental sustainability of the initial linear economic model of the considered organizations along the supply chain and eventually up to the final customer. The linear problem was identified with the following dimensions: local, regional (where) or global/international.
- Circular economy:
  - Proposed solution: Describing how the initial "linear value offer" has been, is going to be or can be shifted towards a more "circular and performance-oriented" solution with respect to the problem to be solved. It can be justified through an LCA and a five-year plan, as the proposed solution will demonstrate the environmental advantages with particular references to CO_2 equivalent energy consumption, packaging waste reduction, economic advantages, social positive impacts, etc. With respect to the organizations that are involved with the problem to be solved, the proposed solution:
    - showed the economical comparison between linear and circular solutions;
    - showed the financial parameters of the circular business model that are relevant to the proposed solution.
  - How the solution works: Explains how the proposed circular performance-oriented service has been conceptualized and implemented, how it is achieved, how economic, social and environmental impacts are considered and dealt with, and what are the advantages for final customers and third parties.
- Conclusion: Explaining to what extent the initial sustainability challenge has been overcome and in which other business sectors the solution can be implemented. It also underlined to what extent the business model of the organization has become more economically sustainable: it is the opportunity to prove that there can be no trade-off between "handling social and environmental challenges" and "ensuring the economic viability of the organization and/or supply chain". On the contrary, doing one can reinforce the second. It is also important to underscore the crucial role of intangible aspects (competences and skills, relevance of work organization and planning, of players, and of mutual trust) in the increase in value (as a complement to the unavoidable use of material resources) of the organizations' offer.

NOTE To some cases, some information was not given by companies or not identified by experts in the data collection process in time to have published in this document.

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6.1.2 Criteria for selecting cases as exemplars and reporting

For reporting an example case in this document (after the pre-selection described in 4.2), a more detailed set of selection criteria (similar to those reported in 4.2, but more rigorously examined) were defined and these are grouped and presented as follows:

— Quantitative criteria: Quantitative measures to demonstrate impact; environmental impact; social impact (e.g. social bonding, social cohesion, community sharing, support); quantifying and measuring costs and benefits; description of external/knock-on effects on other parties (e.g. trade partners, customers, suppliers).

— Qualitative criteria: Qualitative measures to demonstrate impact; other intangible effects (e.g. health); measurement of the consumer perception (e.g. brand image perception research).

— Criteria for replicability: Explanation about how the case can be scaled up and applied in other contexts.

— Criteria to assess the performance-based approach: explanations about the way that the product is used for the service (mechanical cycle) and about the way that the performance is delivered to the client (service cycle).

— LCA-related criteria: Whether an LCA is (or is not) carried out and how the company performs the LCA.

— GHG-reduction-related criteria: Providing evidence of GHGs as a result of implementing the solution in a circular model.

The companies provided figures according to the following scopes:

— Scope 1 covers direct emissions from owned or controlled sources.

— Scope 2: Scope 1 + covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the company supplying the report.

— Scope 3: Scope 1 + Scope 2 + includes all other indirect emissions that occur in a company's value chain.

This document includes the seven cases that were finally chosen.

NOTE The companies mentioned in this document have formally approved the publication of their company names. In cases where companies have not given formal approval, the names of the companies and products have been concealed. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the companies and products named.

6.2 Business A — Sweden

6.2.1 General information

This case study involves an anonymous company based in Sweden, see Table 2.

Table 2 — Business A's information

Category	Description
Company solution name	Refurbishing flags and tents
Company name (not disclosed)	Business A
Description of the solution	This business case involves refurbishing flags and tents, taking advantage of the remaining useful service time for parts of the products.
Location	Linköping, Sweden
Industry sector	A supplier of physical and digital visibility solutions
Size of the organization	Small
Geographic scope	Sweden

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The company is a supplier of smart visibility through an innovative mix of physical and digital communication solutions. One of their goals is to become carbon neutral by the year 2025. The business case involves refurbishing flags and tents, taking advantage of the remaining useful service time for parts of the products. This is a performance-based approach providing performance (leasing) instead of physical products as such. The results of the LCA and/or the life cycle costing (LCC) demonstrated that prolonging the lifetime of components that have the highest environmental impact significantly influences environmental benefits. Also, extending the lifetime of the durable products in this case generates, without exception, cost reductions for the provider from the life cycle perspective.

NOTE LCA measures environmental performance. LCC measures economic performance.

An example of the tents and flags used in the refurbishing process is shown in Figure 4.

Figure 4 — Example of the tents and flags used in the refurbishing process

6.2.2 Quantitative information

6.2.2.1 What are the quantitative measures that demonstrate impact?

The environmental and economic performances assessed with LCA and LCC, respectively, by an external body with no business interests, are shown in the case. The functional unit for both the LCC and the LCA was set to one item used for one event. The LCC was reduced by 12 % to 18 % in the circular offering. The environmental impact was reduced much more, by 45 % to 88 %, with the largest reduction for the indicator “amount of iron ore” used over the life cycle. The main reasons for the difference in reduction between LCC and LCA are due to:

a) processes increasing only the cost, such as the treatment of returned products;

b) non-reusable items with a higher contribution to the cost than the environmental impact, such as the textile part.

The case is shown to be a win-win solution for the environment and the economy.

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6.2.2.2 How does the case consider environmental impacts?

The LCA was performed with environmental categories of global warming (GHGs), acidification and eutrophication. The results show the advantages of the circular offerings in terms of environment and economy.

6.2.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

No information was given, but on its website the company explains that for a sustainable staff and work environment, it has invested in:

- bright, fresh and inviting rooms;
- listening to and helping each other;
- free access to a gym in the workplace;
- wellness allowance;
- access to fruit in the workplace;
- massage during working hours twice a month at a reduced price.

6.2.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

Answered above.

6.2.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

No information was given.

6.2.3 Qualitative information

6.2.3.1 Does the case measure intangible effects? (e.g. health)

The case does not focus on the intangible aspects such as employees’ skills. However, the company believes that the circular offering will certainly strengthen its relationship with its customers (e.g. perception of environmental performance, shorter time to delivery), and the life cycle perspective.

6.2.3.2 How is the consumer’s perception measured? (e.g. brand image perception research)

Answered above.

6.2.3.3 Does the case use qualitative measures to demonstrate impacts?

No information was given.

6.2.4 Replicability (how the case can be scaled up and applied in other contexts)

The case is easy to understand without any technical knowledge about the products. Moreover, the case is also replicable for other similar products and in other countries, as economic benefits were shown in a country with the highest level of labour cost. A method to choose appropriate circular measures based on LCC has also been published in a peer-reviewed paper and applied to this case. Thereby, a company in similar situation can examine its business case to find out whether a certain circular measure, such as refurbishing, is feasible. This method is based on LCC and makes the replicability of the circular offerings transparent.

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6.2.5 Performance-based approaches

6.2.5.1 General

This subclause explains how the case incorporates one or more of the circular economy business models given in 6.2.5.2 to 6.2.5.4.

6.2.5.2 Remanufacturing strategies

This business case involves refurbishing flags and tents, taking advantage of remaining useful service time for parts of the products. This is an instance of a performance-based approach providing performance instead of physical products as such.

6.2.5.3 Shared economy and platforms

The products can be reused for several customers and thus material consumption is reduced.

6.2.5.4 Product life extension strategies

The company offer rentable products.

6.2.6 Description of the mechanical cycle

The mechanical cycle is related to use parts of the products again and again.

6.2.7 Description of the service cycle

This business case involves refurbishing flags and tents, taking advantage of remaining useful service time for parts of the products. In the circular offering, the ownership of the flag is, instead, retained by the case company, which leases it to the customer for one event and then collects it. The case company then refurbishes the product by reusing the pole and cross-base and replacing the textile, which is customized for each event. The refurbishing process also includes cleaning the pole with water and ensuring that it is in a good condition. The refurbishment of the products takes place in Sweden. Each pole is expected to maintain a good condition for 10 events. The concept is similar for the event tent: the durable aluminium frame and steel weights are reused, while the textile is changed during refurbishment and sent for incineration with energy recovery (if it is printed with a specific company's logo and thus it cannot be reused for another company). The tent frame and weights are also estimated to be used 10 times before end of life.

6.2.8 Life cycle assessment

The functional unit for LCA was set to one item used for one event. The environmental impact was reduced by 45 % to 88 %, with the largest reduction for the indicator "amount of iron ore" used over the life cycle.

6.2.9 Greenhouse gas emissions

The LCA was performed with the environmental categories of global warming (GHGs), acidification and eutrophication. The results show the advantages of the circular offerings in terms of environment and economy.

6.3 Circulô — Brazil

6.3.1 General information

This case study involves Circulô, a company called based in Brazil, see Table 3.

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Table 3 — Circulô's information

Category	Description
Company solution name	Renting clothing/fashion kits for infants and babies
Company name	Circulô[10]
Description of the solution	Circulô proposes the rental of a practical, sustainable and genderless capsule wardrobe, with pieces produced locally and using organic Pima cotton and sustainable cotton with a Better Cotton Initiative (BCI) certificate. In this circular model, the clothes are not used by just one or two babies, but by several, being a much more ecological and economical alternative. By increasing durability, centralizing quality control and hygiene, baby clothes circulate in five families on average before being recycled and giving life to new products.
Location	Belo Horizonte
Industry sector	Fashion/clothing
Size of the organization	Small
Geographic scope	Brazil

This business case of renting clothing/fashion kits for infants and babies covers many aspects of the performance-based economy, including PaaS with renting, lifetime extension, remanufacturing, sharing economy, etc. Besides renting clothes, and refurbishing/remanufacturing models, the case looks further upstream and downstream in the cycle (e.g. sourcing sustainable raw materials for new production and ensuring valuable handling at the end of the extended life cycles).

6.3.2 Quantitative information

6.3.2.1 What are the quantitative measures that demonstrate impact?

There are no quantitative assessments of the impacts generated. The company has only been in the market for a short time, having completed its first year of operation in November 2020. However, each kit is accompanied individually, and each part has already demonstrated a longer or shorter useful life (e.g. in some cases, parts have already reached their sixth cycle of use). In other cases, the piece had lost some of its colour, but went through the dyeing process and was used again in the kits. Such information will collaborate for a future analysis of the impacts generated.

6.3.2.2 How does the case consider environmental impacts?

The partners plan and monitor every detail to deliver quality pieces carefully produced with organic or sustainable cotton (having a BCI certificate), with the commitment to generate the least possible environmental impact. Recently, the waste generated by a bikini company (CILA) has also started to be used as raw material. All the pieces, when returned by the customer, are sanitized with 100 % natural and hypoallergenic soap that is suitable for baby clothes.

The two owners have carried out assessments on the end of life of the clothing kits. The scraps of the pieces produced are reused to pack the kits, and in the production of body extenders and decorative flags. The clothes that are no longer commercialized are donated to socially vulnerable families.

The company aims to contribute to the local economy, to value talent, to slow down consumption patterns and to avoid waste during the entire cycle of products. The models for renting, reselling and renovating clothes extend the product's life cycle.

6.3.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

The clothes are sewn by cooperatives of local seamstresses. In addition, clothing kits are now donated when they reach the end of their useful lives. Circulô has a social project in conjunction with an NGO (Flores da Resistência) to circulate both the Circulô clothes and the clothes of the clients' babies free of charge to families in socially vulnerable situations.

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6.3.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

One example is the end of life of the rented kits, where the owners had evaluated making breastfeeding pillows with these pieces, but this product would not be commercially viable because the delivery costs would be very high, so their choice was to donate these kits to socially vulnerable families after use.

6.3.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

There is a partnership with suppliers of fabrics and suppliers for the supply of environmentally friendly products. They also formed a partnership with a bikini company (CILA) to reuse the scraps as raw materials, and with a non-governmental organization (NGO) (Flores da Resistência), to donate clothes (from their kits and also from their consumers).

6.3.3 Qualitative information

6.3.3.1 Does the case measure intangible effects? (e.g. health)

There are no reviews as yet.

6.3.3.2 How is the consumer's perception measured? (e.g. brand image perception research)

Communication with customers is constant, especially because each kit is directly followed, which also allows the owners to verify the different lifetimes of products.

6.3.3.3 Does the case use qualitative measures to demonstrate impacts?

In qualitative terms, there are assessments such as those carried out by the owners regarding the use of natural or synthetic dyes for fabrics, but a quantitative analysis has not yet been carried out.

6.3.4 Replicability (how the case can be scaled up and applied in other contexts)

The model can be scaled up and multiplied for other segments, promoting an increase in the useful life of other products, a lower consumption of raw materials and less generation of impacts resulting from production, as the volume of products produced will be less since users will not have individual ownership of the products and the demand for them will become less. Furthermore, the model can be replicated in other countries, as the target group (parents and babies) is present in every region around the world.

6.3.5 Performance-based approaches

6.3.5.1 General

This subclause explains how the case incorporates one or more of the circular economy business models given in 6.3.5.2 to 6.3.5.4.

6.3.5.2 Remanufacturing strategies

The owners are looking for alternatives for remanufacturing the kits but have not yet achieved a commercially viable possibility. Using life cycle management, the company can propose remanufacturing strategies.

6.3.5.3 Sharing economy and platforms

The proposal is to use the performance-based economy; Circulô's main focus is the sharing of kits of clothes that are used by up to five users.

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6.3.5.4 Product life extension strategies

The increase in the life cycle of products is also one focus of the company, since the products are required to maintain the best possible quality so that they can be reused by the clients. When the customers contract the service, they receive a manual with instructions on the use and cleaning of clothes in order to return the pieces in the same conditions as when they received them.

6.3.6 Description of the mechanical cycle

The mechanical cycle is related to the use of the products that will meet the necessities of the customer (clothes for babies), and these products will have their maintenance carried out by the service provider. The tendency is that the products have an extended useful life.

6.3.7 Description of the service cycle

The service cycle is the supply of the clothes, as shown in Figure 5.

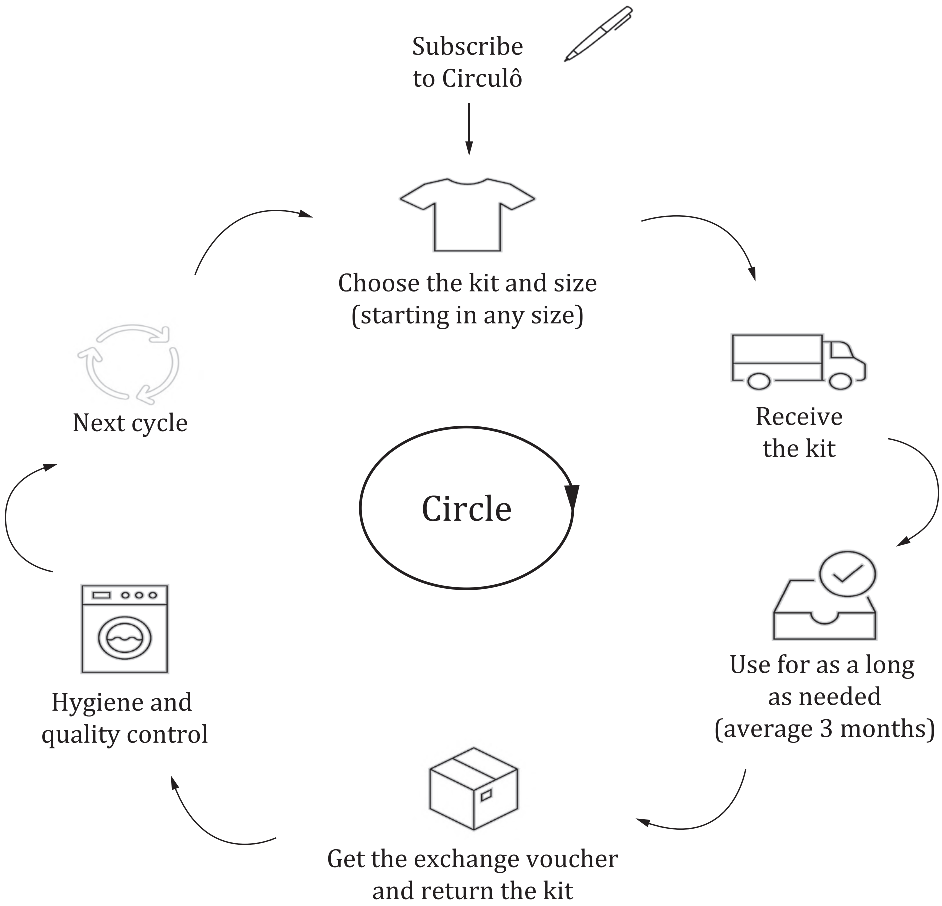

Figure 5 — Service cycle

6.3.8 Life cycle assessment

The company still did not conduct an LCA because the partners did not know about the tool, nor did they feel the need for or perceive the usefulness of having this evaluation.

The size of the organization is too small and, in addition, the practice of carrying out an LCA is not yet widespread in developing countries.

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6.3.9 Greenhouse gas emissions

The company has not yet conducted a GHG emission assessment.

6.4 Business B — France

6.4.1 General information

This case study involves an anonymous company based in France, see Table 4.

Table 4 — Business B's information

Category	Description
Company solution name	Light as a service (LaaS) + circular lighting
Company name	Business B
Description of the solution	Contracting a lighting service at the level agreed with the beneficiary (Lux) with a commitment to energy efficiency and life cycle management of the equipment used.
Location	France and Europe
Industry sector	—
Size of the organization	—
Geographic scope	France and Europe

The practice is already used as an example of a performance-based economy, in which the consumer does not buy the product, but the performance of the service provided. The practice presented in this case, however, claims to be committed to the energy efficiency of the service provided and also to manage the life cycle of the products used to provide the service. In this way, the proposal, in addition to contributing by considering the proposal of performance-based economy, is committed to delivering a service that consumes less energy, and in which the products manufactured to provide this service will have their life cycle evaluated and their environmental impacts will be interpreted and taken into account.

6.4.2 Quantitative information

6.4.2.1 What are the quantitative measures that demonstrate impact?

No information was given.

6.4.2.2 How does the case consider environmental impacts?

Using life cycle management (as well as LCA).

6.4.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

Social impacts such workers' health and safety are claimed, but rather in a qualitative way.

6.4.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

Energy and CO_2 emission savings are part of the preliminary targets that are set before the LaaS/circular economy service deployment.

In the customer case study of a municipal library in Belgium, the LaaS solution aims to contribute to a 40 % decrease in municipal GHG emissions. Energy savings up to 70 % are claimed.

In the customer case study of a storage systems company in the Netherlands, the yearly emission savings are 231 t.

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In the customer case study of a steel and mining producer in Spain, energy savings up to 73 % are claimed.

6.4.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

No information was given.

6.4.3 Qualitative information

6.4.3.1 Does the case measure intangible effects? (e.g. health)

The implementation of the solution builds organizational relationships, trust and skills maintenance systems within the cooperative eco-system to ensure that the various interventions (installation, maintenance, etc.) comply with the planned conditions of use. This means that intangible resources (trust, organizational relevance and competences) are strengthened and developed through this solution.

Moreover, by focusing on lighting needs, the implementation of the solution accurately considers the workers' activities and working conditions, which gives an opportunity to improve worker safety and worker health (testimonies are available on Business B's website).

6.4.3.2 How is the consumer's perception measured? (e.g. brand image perception research)

There are testimonies from three case studies: a municipal library in Belgium, a steel and mining producer in Spain, and a storage systems company in the Netherlands.

6.4.3.3 Does the case use qualitative measures to demonstrate impacts?

Through this solution, there is a greater opportunity to optimize the flow of materials, products and energy because they are the responsibility of Business B (there is an incentive to extend the life of equipment and not to plan obsolescence).

The ex-ante and ex-post assessment of energy consumption (and, therefore, an estimation and assessment of energy savings) are part of the preliminary stage of the contracting. It helps to assess the economic relevance of such a LaaS service.

Testimonies from the use case operator supports the claim for qualitative and intangible impacts of the Business B solution (either LaaS or circular lighting).

In the customer case study of a municipal library in Belgium, energy savings can be up to 70 % compared with the initial situation. A reduction of GHG emissions up to 40 % is claimed, yet no detailed calculation is available.

6.4.4 Replicability (how the case can be scaled up and applied in other contexts)

The proposal incorporates practices from the concept of a performance-based economy, in which the consumer pays for the performance of the product and not for the product. This model can be applied in other segments and in other contexts.

6.4.5 Performance-based approaches

6.4.5.1 General

This subclause explains how the case incorporates one or more of the circular economy business models given in 6.4.5.2 to 6.4.5.4.

6.4.5.2 Remanufacturing strategies

Using life cycle management, the company can propose remanufacturing strategies. This is part of the design work done before the deployment of this solution.

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6.4.5.3 Sharing economy and platforms

The proposal is to use the performance-based economy: the product used for one client can be reused for another one.

6.4.5.4 Product life extension strategies

Usually, in this case, the product life is extended in comparison to the standard product, as the maintenance costs are the responsibility of the owner of the products, which, in this case, is the manufacturer (Business B).

6.4.6 Description of the mechanical cycle

The mechanical cycle is related to the use of the products that will provide the purchased lighting and these products will have their maintenance carried out by the service provider; the tendency is that the products have an extended useful life and that the maintenance is reduced.

6.4.7 Description of the service cycle

The service cycle is the supply of lighting in accordance with the functional specifications of the customer.

The main stages of the implementation of the solution are:

— design of products adapted to long-term use performance and easy end-of-cycle/end-of-life management;

— determination of the usage performance (need for lux per kWh) expected by the beneficiary and long-term contracting with the beneficiary;

— mobilization of a cooperative eco-system integrating installers, maintainers and recyclers;

— redesigning of end-of-life equipment logistics.

6.4.8 Life cycle assessment

No information was given.

6.4.9 Greenhouse gas emissions

6.4.9.1 What evidence is there of GHG reductions as a result of implementing the solution?

GHG emissions (as well as energy savings) are part of the discussion with the customer prior to the LaaS solution agreement (as described above, with significant design stages).

6.4.9.2 What is the scope of GHG emissions taken into account?

The basis for the estimate of the GHG emission reduction seems to be Scope 1 (emissions reduction directly related to lighting energy savings).

NOTE Scope 1 covers direct emissions from owned or controlled sources. Scope 1 + covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company. Scope 1 + Scope 2 + includes all other indirect emissions that occur in a company’s value chain.

6.4.9.3 What are the GHG savings?

See Table 5.

NOTE The GHG savings are expressed in metric tons of CO_2 equivalent.

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Table 5 — GHG emission information

Category	Description
GHG emissions before	
GHG savings	40 % (in the library case study given as an example) 231 t (in the storage building case study given as an example)
GHG emissions after	

6.5 Michelin — France

6.5.1 General information

This case study involves Michelin, a company based in France, see Table 6.

Table 6 — Michelin's information

Category	Description
Company solution name	Tires as a service (TaaS)
Company name	Michelin
Description of the solution	This business case shows a solution in which a vehicle fleet manager does not buy tires for their vehicles but instead subscribes to a service contract for tires which are supplied, maintained, retreaded and, finally, recycled.
Location	France
Industry sector	Michelin is a worldwide group that produces tyres, tracks, conveyor belts and high-tech materials. It proposes enhanced mobility solutions to individual customers as well as services and solutions to corporate customers.
Size of the organization	127 200 employees in 170 countries (data for 2019)
Geographic scope	International

Following a current trend in the market, it seems evident to go from a linear market in which a product is bought, used and discarded to a circular economy in which the product is bought, used, remanufactured and reused before recycling. This is not done everywhere and always, often because of technical and administrative burdens.

The proposal of TaaS facilitates this step since it allows for exploiting the technical capacities and potential of the tire to a maximum, thus reducing material consumption and waste. It also allows the customer or fleet manager to concentrate on their principal business, and optimize resources and budget control.

Beneficial side effects can be noticed for local employment and reinforced social tissues due to tire maintenance operations that can be subcontracted locally.

6.5.2 Quantitative information

6.5.2.1 What are the quantitative measures that demonstrate impact?

The environmental and economic performances have been assessed by using an LCA, carried out by an external body with no business interests shown in the case.

This is documented for the retread market in studies done by Ernst and Young[11] and Score LCA[12], when the tyre is worn to a tread depth of 1,6 mm (corresponding to the height of tread depth indicators on the tyre).

6.5.2.2 How does the case consider environmental impacts?

The functional unit considered in this study is a set of tyres, produced and recycled in Europe for use in regional transport, that is fitted to 400 trucks of a big fleet operating in France, driving 100 000 km per year for five years.

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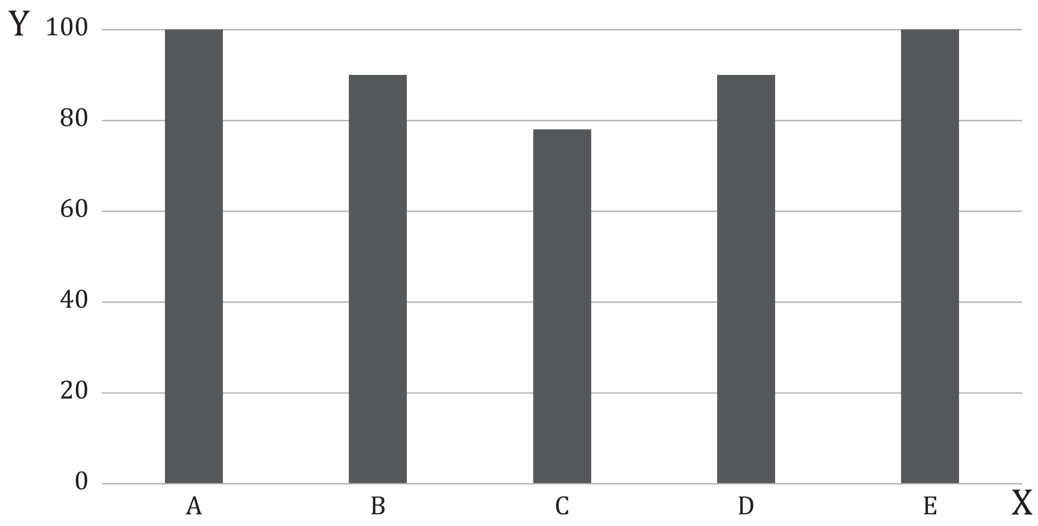
For all considered environmental parameters, important differences can be observed between the conventional system and the system of functional economy, as shown in Table 7.

Table 7 — Comparison between the two systems

Category of impact	Difference
Fossil resources depletion	−6 %
Climate change	−6 %
Ozone layer depletion	−6 %
Human toxicity	−15 %
Freshwater ecotoxicity	−26 %
Marine ecotoxicity	−10 %
Terrestrial ecotoxicity	−26 %
Photochemical ozone formation	−2 %
Acidification	−6 %
Eutrophication	−8 %

Considering the proposed system of functional economy with its management of the tire, in which it is possible to closely monitor tread wear, important gains for raw material consumption (see third column of Figure 6) can be seen when the tire is worn to a tread depth of 1,6 mm instead of the current practice in the market of 4 mm.

Sensitivity analysis regarding consumption of resources in shown in Figure 6.



Key

A conventional system
B functional economy system
C functional economy system, tread depth of 1,6 mm
D functional economy system, regrooving +10 %
E conventional system, with under-inflation
X abiotic depletion potential (ADP) elements
Y percentage, %

Figure 6 — Sensitivity analysis regarding consumption of resources

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6.5.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

Operations, such as inspections, potential repairs, periodic regrooving and, of course, retreading, are organized within the framework of this contract and can be subcontracted locally. This can create beneficial side effects for local employment and reinforced social tissues.

The fleet manager is able to concentrate on their business priorities and principal operations. Existing skills and competencies are used for logistic and supply chain operations, as well as for the technical operations linked to regrooving and retreading.

6.5.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

The fleet manager subscribes to a contract-based service that provides them with precise economic conditions depending on the distance covered by their vehicles. These conditions are not given in a general way as they depend on each case. All operations, such as inspections, potential repairs, periodic regrooving and, of course, retreading, are organized within the framework of this contract.

6.5.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

No information was given.

6.5.3 Qualitative information

6.5.3.1 Does the case measure intangible effects? (e.g. health)

The proposed solution is based on the idea of facilitating operations for the fleet manager and maximizing the exploitation of the technical and economic potential of a tire. The time-consuming operations of inspection, regrooving, retreading and regrooving again are already organized and carried out for a certain number of tyres on the market, but not for all of them.

The fact that tires are regularly checked and maintained in a professional way within the framework of the service contract reduces the risk of damaged tyres and downtime, and improves the confidence of drivers in the vehicle they are using (truck, tractor, trailer). This can also strengthen the bond they have with their employer as they see that the company is investing in the safety of the driver’s working conditions.

Administrative burdens, and perhaps psychological hurdles, can exist, hindering fleet managers to put into practice the operations represented in Figure 7.

All operations, such as inspections, potential repairs, periodic regrooving and, of course, retreading, are organized within the framework of this contract. The fleet manager is enabled to concentrate on their business priorities and principal operations.

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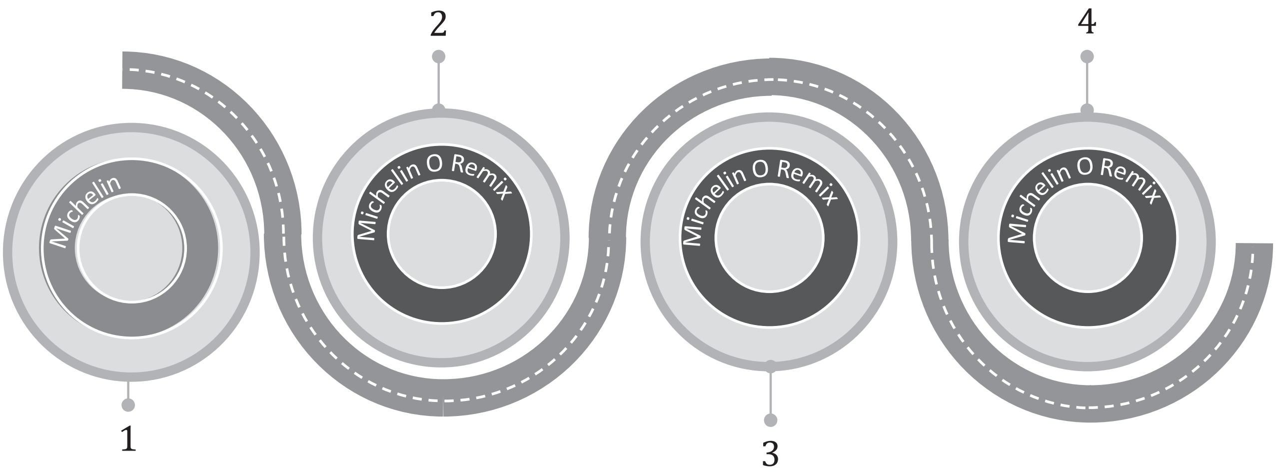

Key

1 new tyre
2 first regrooving
3 first retreading
4 second regrooving

Figure 7 — The four lives of a tire

6.5.3.2 How is the consumer's perception measured? (e.g. brand image perception research)

Michelin measures net promoter score (NPS) and customer effort score (CES) in most of the European countries in which the offer is deployed.

6.5.3.3 Does the case use qualitative measures to demonstrate impacts?

Michelin measures environmental impact through the retread rate, which is obtained in the operations.

6.5.4 Replicability (how the case can be scaled up and applied in other contexts)

The case is easy to understand without any technical knowledge about the products. Moreover, the case is replicable and already carried out in other countries. Operations have been started in France, Spain, Italy, Belgium, the Netherlands, Luxembourg, the United Kingdom, Sweden, Germany, Austria, Switzerland, Romania, Poland, Türkiye, Hungary, Czechia and the United States.

A company with a similar situation can examine their business case to decide whether a comparable circular measure is feasible.

6.5.5 Performance-based approaches

6.5.5.1 General

This subclause explains how the case incorporates one or more of the circular economy business models given in 6.5.5.2 to 6.5.5.4.

6.5.5.2 Remanufacturing strategies

This business case shows how to use the whole mileage potential of a tire by organizing and optimizing the operations of regrooving and especially retreading, before recycling the worn-out product.

Retreading is a remanufacturing operation that consists of replacing the outer part of the tire, the crown or tread layer that is in contact with the road, once the tyre is worn to the legal limit of tread depth, see Figure 8.

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Residual parts of the tread are taken away and a new tread bandage is put on and vulcanized on the casing. The casing or carcass is the inner and most valuable part of the tyre. It contains the steel cords that keep the tyre beads on the rim, and which give the tyre its form and solidity. This operation is done in qualified workshops and specialized companies, and it is regulated via United Nations Economic Commission for Europe (UNECE) regulations.

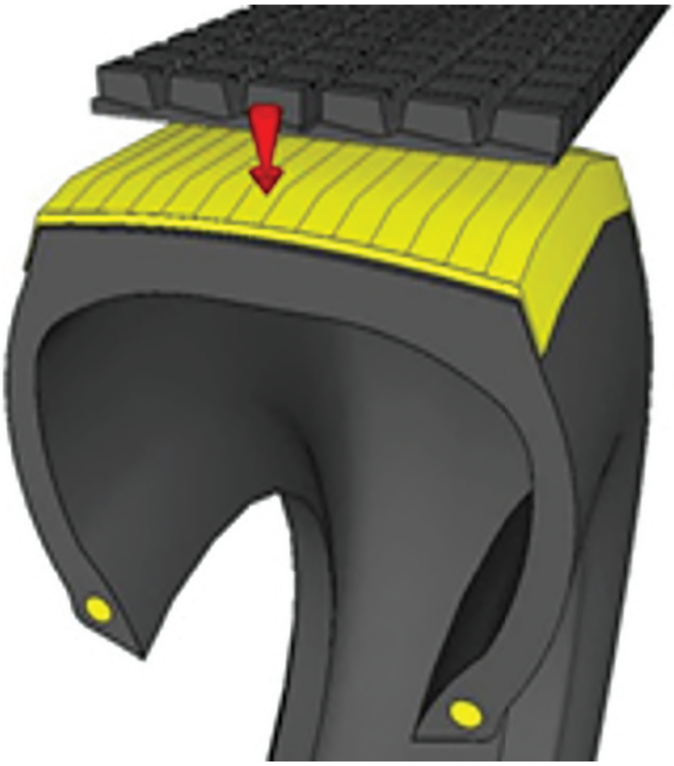

Figure 8 — Retreading operation with a new tread layer

6.5.5.3 Shared economy and platforms

The described operations can be organized on common platforms for several customers and, thus, reduce logistic constraints and costs.

6.5.5.4 Product life extension strategies

The operations of regrooving and remanufacturing by retreading extend the product life and allow for exploiting the technical capabilities and potential of the tyre to a maximum, thus reducing material consumption and waste.

6.5.6 Description of the mechanical cycle

The solution is based on the idea of maximizing the exploitation of the technical and economic potential of a tire. The operations of inspection, regrooving, retreading and regrooving again are organized and carried out within the framework of a service contract, see Figure 9.

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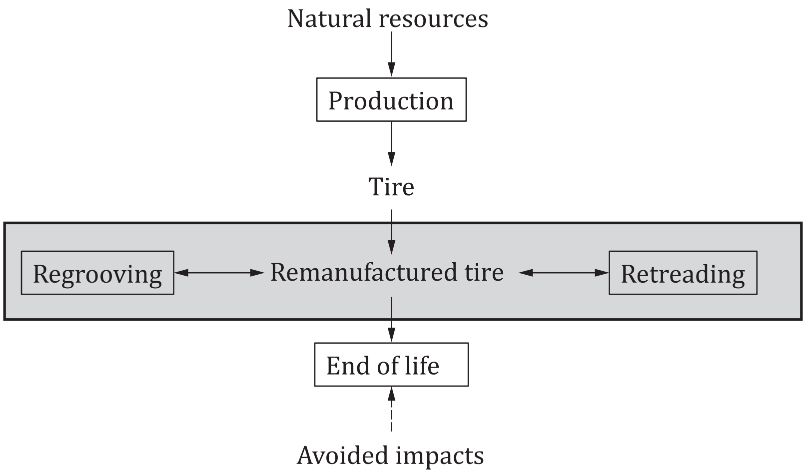

Figure 9 — Product life cycle including remanufacturing

6.5.7 Description of the service cycle

The proposed tire management system, which allows tire mileage to be used as a service and no longer as a product, covers the following points:

— choice of tire type and category adapted to intended usage;

— logistics and supply-chain operations, including stock management;

— consistent pricing for the service, with high transparency for the budget and in monthly invoices;

— availability of a local or regional service provider network.

Another part of the offer is frequent fleet inspections, which allow more efficient operations with higher uptime, guaranteed compliance to regulations and preventive controls to ensure the safety of drivers, vehicles and merchandise.

The service cycle is shown in Figure 10.

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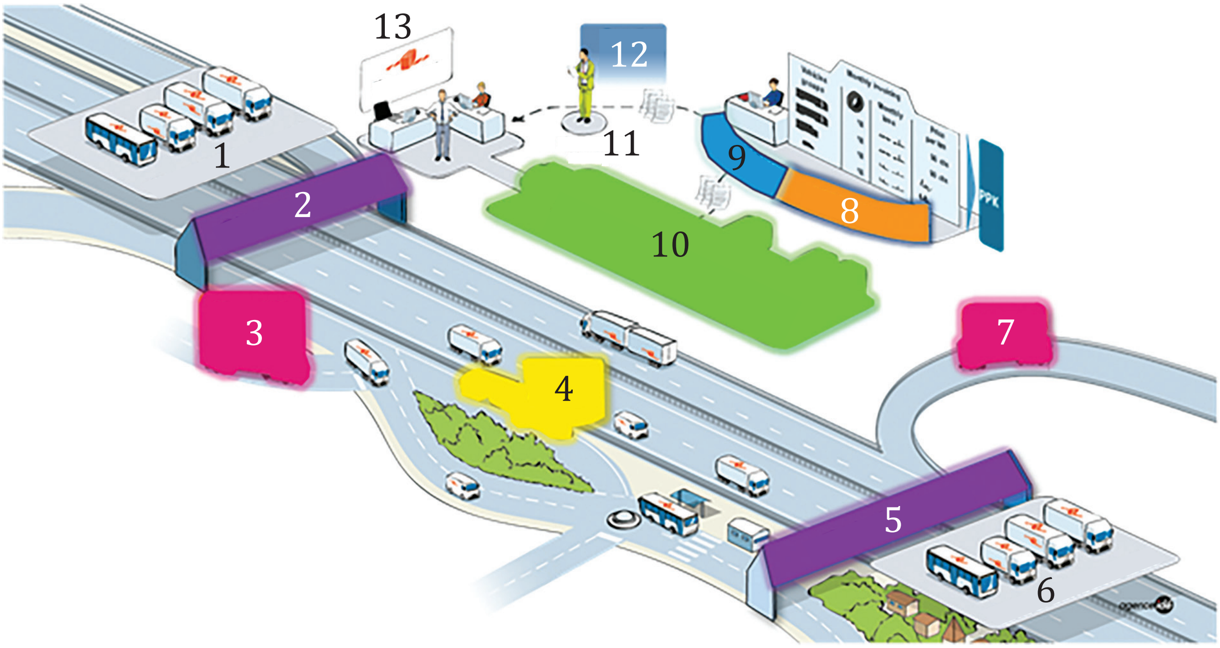

Key

1	fleet initial audit
2	start of contract
3	new vehicle entering the contract
4	road assistance
5	end of contract
6	end of contract audit
7	vehicle exits the contract
8	reporting
9	invoicing
10	full outsourcing of tires management
11	key account manager
12	reporting advice consulting
13	transport

Figure 10 — Service cycle

6.5.8 Life cycle assessment

The analysis done by an external organization showed important differences for a conventional, linear system and the proposed system of TaaS.

The results of this external study show that the PaaS has a lower environmental impact than the conventional system. The benefits are minimal for some impact categories but can reach a 9 % impact reduction for the categories with a preponderant contribution of raw materials for tire production (e.g. ADP elements, see Figure 11). The implemented system has the potential to be improved by reducing the height at which tires are removed. Currently, tires are removed at an average height of 4,5 mm compared to 4 mm for the conventional system. Any effort to reduce this removal height would significantly increase the benefits of the system implemented by Michelin.

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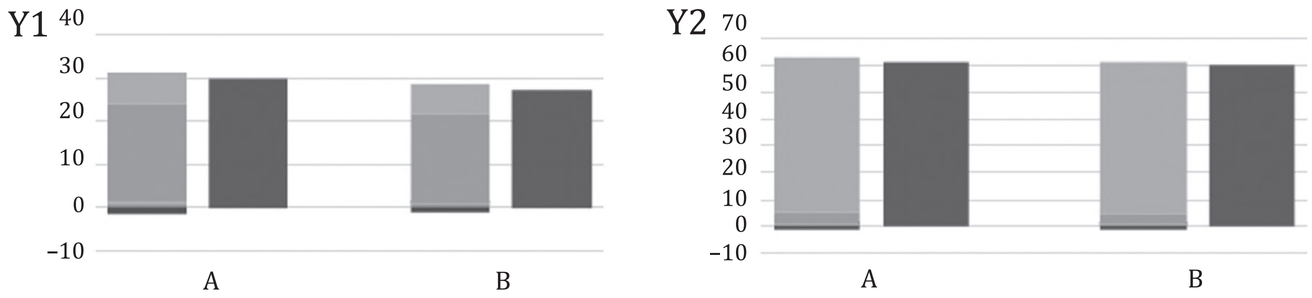

a) ADP elements **b) Climate change**

Key

Y1	kilograms equivalent to antimony per functional unit (kg eq. Sb/FU)
Y2	kilotonnes equivalent to CO_2 per functional unit (kT eq. CO_2/FU)
A	conventional system
B	product–service system
■	distribution of new tires
■	retreading
■	raw materials for tires
■	use (tire particulate emissions)
■	total
■	production of new tires
■	regrooving
■	use (fuel consumption)
■	end of life

Figure 11 — Impact on resources and climate change

6.5.9 Greenhouse gas emissions

6.5.9.1 What evidence is there of GHG reductions as a result of implementing the solution?

The four-step approach from the diagram in Figure 9, in which a new tyre is retreaded once and regrooved twice, makes it evident that GHG emissions can be avoided for tire production and for raw material production.

6.5.9.2 What is the scope of GHG emissions taken into account?

In the external study, the following process steps were taken into account:

— production of raw materials for the production of tires and retreading (natural rubber, carbon black, steel, organic and inorganic additives);

— production of new tires with consumption of energy, water, chemical substances and emissions;

— regrooving process, including the energy demand;

— retreading process, including energy consumption and emissions;

— usage phase with the fuel consumption due to tire rolling-resistance and the emission of tire wear particles due to the friction with the road surface (during braking, acceleration and during cornering);

— end-of-life processes, taking different ways of tire valorization into account.

NOTE Scope 1 covers direct emissions from owned or controlled sources. Scope 1 + covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company. Scope 1 + Scope 2 + includes all other indirect emissions that occur in a company’s value chain.

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6.5.9.3 What are the GHG savings?

The external study showed that GHG savings can reach 6 % when tires are removed and replaced at a tread depth of 1,6 mm.

NOTE The GHG savings are expressed in metric tons of CO_2 equivalent.

6.6 Business C — Germany

6.6.1 General information

This case study involves an anonymous company based in Germany, see Table 8.

Table 8 — Business C's information

Category	Description
Company solution name	Metal cleaning/textile cleaning
Company name (not disclosed)	Business C
Description of the solution	Service solution for cleaning metals and textiles
Location	Germany
Industry sector	Chemical
Size of the organization	—
Geographic scope	—

Business C is a provider of services and solutions related to the use of solvents in industrial surface cleaning and professional textile cleaning. This case provides an example of a performance-based approach where the company is selling cleanliness rather than solvent products.

6.6.2 Quantitative information

6.6.2.1 What are the quantitative measures that demonstrate impact?

Up to 98 % reduction in solvent consumption for clients in combination with closed cleaning equipment technology.

6.6.2.2 How does the case consider environmental impacts?

The closed-loop system is a double-walled safety steel container system for the safe handling of fresh solvents and the return of used solvents for recycling. It was designed jointly with clients and the machine manufacturer. The benefits are:

— up to 98 % reduction of solvent consumption for clients in combination with closed-cleaning equipment technology;

— using the closed-loop system, virtually no chemicals are spilled or gases emitted.

6.6.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

Parts cleaning, if not handled properly, can easily put a company's sustainability strategy at risk. The more a company produces, the more solvent it needs. With Product A, the company benefits from existing know-how and increases safety, optimizes solvent consumption and its entire cleaning process. Thus, Product A contributes to more sustainability in the company.

This is also a way to enhance the safety and the health of all workers.

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6.6.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

See the benefits given in 6.6.2.2.

6.6.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

Driven by customer demand and guided by product stewardship principles, Business C has developed an innovative closed-loop service system to help its clients meet their needs regarding:

— cleaning performance through the use of recyclable solvents;

— workplace safety;

— regulatory compliance;

— environmental protection;

— reduced solvent consumption and, therefore, waste.

Through its closed-loop service system, Business C enables its clients to manage the product-specific risks of chlorinated and non-chlorinated solvents. Its product and service offering is suited to small and medium-sized enterprises (SMEs).

By being 15 years ahead of European regulations, the company benefited from an untapped market demand for the safe and sustainable use of solvents in cleaning applications.

6.6.3 Qualitative information

6.6.3.1 Does the case measure intangible effects? (e.g. health)

No information was given.

6.6.3.2 How is the consumer's perception measured? (e.g. brand image perception research)

See 6.6.2.5.

6.6.3.3 Does the case use qualitative measures to demonstrate impacts?

See 6.6.2.5.

6.6.4 Replicability (how the case can be scaled up and applied in other contexts)

The idea of containing dangerous chemical products in a closed loop with a dedicated service for the use of the product is replicable in other economic areas.

For example, it can be replicated in agriculture for fertilizers and other dangerous products used by farmers.

6.6.5 Performance-based approaches

Business C offers chemical product–service systems, such as chemical leasing in which clients pay for the performance of cleaning rather than the volume of chemicals consumed. Thus, it is clearly a performance-based approach. In this way, it is compliant with:

— remanufacturing processes;

— product life extension strategies.

The Product A chemical leasing model applies the principles of a circular economy. This regenerative system helps to close the resource loop by reducing chemical consumption, reusing solvents and extending solvent

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lifetime, as well as recycling solvents. Product A thus helps to optimize resource usage and reduce waste, which gives customers an additional economic benefit.

The mechanical and service cycles are shown in Figure 12.

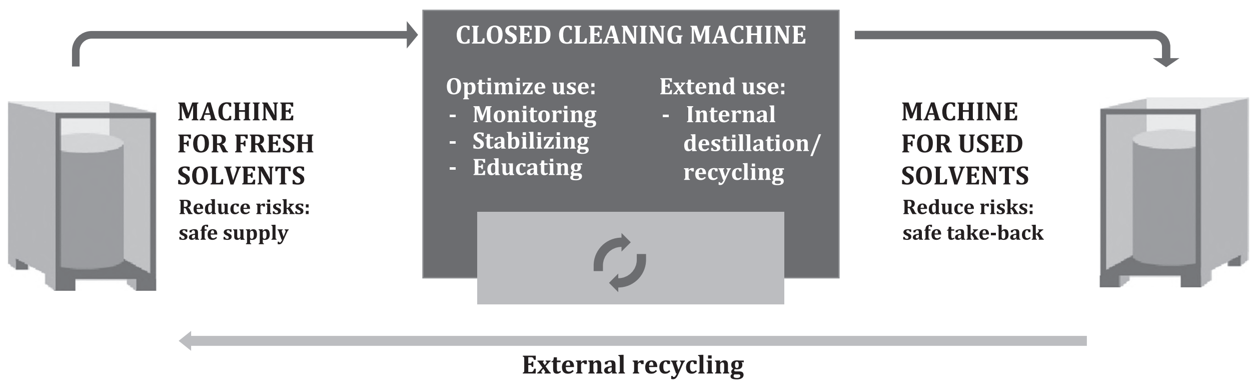

Figure 12 — Mechanical and service cycles

6.6.6 Description of the service cycle

Fresh solvent is supplied in the Product B system and used solvent is collected and sent for professional recycling, thus closing the loop. This solution not only enables a safer supply of fresh material, it also allows the users of solvent to safely return used solvents to be recovered in an accredited professional recycling facility.

Furthermore, other chemical product services provided by Business C expand the lifespan of the solvents in the cleaning machines, thus conserving resources and also further contributing to a circular economy.

6.6.7 Life cycle assessment

The LCA is not available for public release.

6.6.8 Greenhouse gas emissions

The calculation of GHG emissions has not yet been done. By saving 98 % of chemical product use and extending the lifespan of chemical products to four years, it is predicted that there will be a huge reduction in GHG emissions.

6.7 Free Pack Net — Switzerland

6.7.1 General information

This case study involves Free Pack Net, a company based in Switzerland, see Table 9.

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Table 9 — Free Pack Net's information

Category	Description
Company solution name	Circular and returnable packaging system for white goods
Company name	Free Pack Net Holding SAGL
Description of the solution	Free Pack Net is a platform company integrated with suppliers and customers and specializes in returnable protective packaging (RPP), reverse logistics, tracking systems and methodologies united with circular design. Through service agreements based on a PaaS business methodology, Free Pack Net provides the rent per cycle of low carbon RPP solutions (reusable 20 times and 100 % recyclable at end of life) to protect the appliances on their journey from the factory to the end user. The RPP solution allows for: — eliminating current disposable one-way packaging in expanded polystyrene, cardboard, thermo-shrinking film and wood; — eliminating product damage along the supply chain; — reducing CO_2 emissions by 76 %; — reducing the total cost of ownership (TCO); — increasing saturation in warehouses and in the major means of transport; — changing product technology (e.g. the packed appliance does not to have resist to stacking and clamping forces anymore and, therefore, it can be redesigned with important savings in material, or it can be redesigned using different technologies: "the dishwasher must be able to wash dishes and not to resist to 1,200 kg").
Location	Switzerland
Industry sector	Returnable protective packaging for finished goods
Size of the organization	SME
Geographic scope	Europe, North American Region, Latin American Region, China

Free Pack Net's strategic vision for plastic in a circular economy leads to RPP and reverse logistics.

The starting sector is white goods for the following reasons:

— It is global, and after building and construction, it is the second largest market sector worldwide.

— Over the past 40 years, there has been no technological innovation in packaging and this has prevented the technological change of the products.

— Disposable packaging does not adequately protect products and enormous economic losses are generated due to damage to products.

— Disposable packaging is mainly composed of expanded polystyrene, and this waste/problematic material of more than 1 200 000 tons per year is creating serious environmental damage at a global level.

Offering a full service, Free Pack Net replaces disposable packaging with reusable packaging. These are basically rented per cycle to manufacturers and/or retailers to protect the appliances on their journey from the factories to the end users.

With the support of its reverse logistics organization and the integration with retailers and third-party logistics (3PL), Free Pack Net collects the RPP and delivers it back to the factories.

After 20 cycles, the reusable packaging is ground down and the recycled material is reused to produce new packaging.

This case allows the achievements of the following six points:

a) PaaS induces circularity between manufacturers, retailers and third-party logistics.

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b) Reduction of the TCO along the whole value chain: Average of EUR 22 per appliance or EUR 11 billion on a global production of 500 million pieces per year.

c) Global saving of 1 200 000 tons of packaging waste per year (2,4 kg per unit per year) and 255 000 000 tons of CO_2 per year (510 kg CO_2 per unit per year).

d) Product damages reduced to zero (current global damages: 30 million pieces per year).

e) Allows for changes in product technology (RPP resists up to 1 200 kg in all directions and the appliance can be redesigned).

f) Applicable in other sectors, such as televisions (TVs), water heaters and clothes.

6.7.2 Quantitative information

6.7.2.1 What are the quantitative measures that demonstrate impact?

6.7.2.1.1 Linear economy

Current problems in the white goods sector (the starting sector for Free Pack Net) are as follows:

a) Global packaging waste: 1 200 000 tons per year (mainly expanded polystyrene).

b) Global damages to products: 30 million pieces per year (conservative estimate).

c) Disposable packaging does not protect the appliances from vertical (stacking in the warehouse) and lateral (clamping-handling) forces. Therefore, the appliances are required to be developed and produced to resist these forces (up to 1 200 kg) and this prevents the technological development of products and the application of more sustainable and environmental solutions.

d) High TCO along the value chain. Total costs are added to the selling price and, therefore, all the inefficiencies relevant to the linear economy are paid by the final customers, the end users.

6.7.2.1.2 Circular economy

The impacts of RPP are as follows:

a) RPP (made from polypropylene (PP) and expanded PP) is reusable and, after 20 rent-cycles, it is recycled. With the recycled material, a new RPP is produced. As a consequence, packaging waste is therefore reduced almost to zero, energy consumption is reduced by 85 % and CO_2 emissions are reduced by 76 %.

b) RPP is composed of an external rigid shell (PP) and few inner reusable parts called “spacers” made from expanded polypropylene (EPP) that are coupled to the product shape from the external shell and, at the same time, absorb kinetic energy during drops or improper handling. As a result, with RPP damages to the product have been reduced to zero. The technical performance of RPP is certified by TÜV (reports are delivered to clients).

c) Autonomously, the shell of the RPP is able to resist up to 1 200 kg in all directions. In this way, a dishwasher can be developed and produced only to wash dishes and not to resist to 1 200 kg. The refrigerator can be developed and produced only using vacuum-insulated panels (VIPs) instead of the pollutant polyurethane foams, which are very difficult to dispose of. VIPs are panels used for insulation. They consist of a low-thickness, closed honeycomb in which the air inside is removed and a vacuum is created. The vacuum level (10-6, 10-9, etc.) determines the insulation coefficient. They can fully replace polyurethane foams in the refrigerator but are not able to withstand lateral forces such as clamping with 1 200 kg, since they need an external shell to protect them from these forces. The RPP structure therefore protects the refrigerator that can be built with such panels, while at the same time avoiding the pollutant foams. The cardboard or the expanded polystyrene is not able to give this level of protection. Regarding the refrigerator, the new RPP and the change of product technology will allow the elimination of the compressor and a simple chemical reaction (two components) stimulated by the

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energy from a solar panel can be used to generate low temperatures. This is called "product technology change" (PTC).

d) Reduction of TCO within the linear economy: The additional costs relevant to inefficiencies are very often hidden in the shadows of different tasks that refer to different functions. For example, the cost of pure product damage is almost always hidden in the "after-sales management costs", which in turn corresponds to 5 % of the industrial cost of the household appliance. In the organization of the linear economy, the factory (manufacturing) pays the sales organization the 5 % that, in the company's balance sheets, is listed as "after-sales costs". In many companies, the total protection cost is simply ignored. Very often, retailers do not know the value of the disposable packaging because, as usual, they buy packaged products and the cost of disposable packaging is included. In order to dismantle these perverse logics, Free Pack Net developed a dynamic model called the "Integrated Product Protection Costs (IPPC) comparison model", which includes all the activities and costs along the supply chain from the factory to the final customer. Manufacturers and retailers have been involved and the model has been deployed globally. Such an integrated approach to the protection cost along the appliances value chain undertaken with several manufacturers has helped to assess the savings potential of returnable packaging in a EUR 10 to EUR 44 per unit range, which represents 10 % to 44 % of the industrial cost of the appliance.

6.7.2.2 How does the case consider environmental impacts?

The LCA has been utilized to make the comparison between the standard type of disposable packaging and the reusable one. Technically speaking, the RPP cannot be damaged and that has been confirmed by clients. However, while currently the life of the RPP is 20 cycles and is increasing to 40 cycles, the LCA has been done considering only 15 cycles and the results are still extremely positive.

Within the comparison, the LCA does not consider the impact of damaged products.

6.7.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

The product design phase affects both product life and product performance along the entire supply chain. This does not rest solely on the shoulders of Free Pack Net's designers, but the entire supply chain is involved to achieve the reuse of the RPP.

The social culture of the circular economy has been deployed using integrated methodologies (design for induced circularity, design for durability, design to protect, design for reuse, design for circular supply chain, design for circular logistics and reverse logistics, design for traceability, design for assembly and disassembly, design for modularity, design for upgradability, design for reliability, design for dematerialization, design for PaaS and finally, design for circular agreements), which allows manufacturers, third-party logistics operators, retailers and end users to understand and evaluate different perspectives, collateral solutions and the environmental benefits offered by the use of RPP services.

6.7.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

Free Pack Net's developed a dynamic model called the "Integrated Product Protection Costs (IPPC) comparison model", which includes all the activities and costs along the supply chain from the factory to the final customer. Manufacturers and retailers were involved and the model was deployed globally.

The IPPC comparison model allowed Free Pack Net to identify that, in accordance with different methodologies in use by retailers in the management of damaged products, the RPP allows a saving from EUR 10 to EUR 44 per appliance along the supply chain. With the RPP solution, the average saving is therefore EUR 22 per product.

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6.7.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

Before the signature of service agreements, clients (manufacturers and retailers) gain awareness on effects and benefits during field tests that help to plan ahead of the learning curve. With the signature of service agreements, clients can budget for the achievement of results.

6.7.3 Qualitative information

6.7.3.1 Does the case measure intangible effects? (e.g. health)

The LCA demonstrated that, in comparison with disposable packaging, through the use of RPP, health damage is reduced by 85 %.

6.7.3.2 How is the consumer's perception measured? (e.g. brand image perception research)

Surveys with consumers allowed Free Pack Net to measure the very positive feedback in the fields of environmental protection and technological innovation.

6.7.3.3 Does the case use qualitative measures to demonstrate impacts?

The reduction of TCO was demonstrated with the use of the IPPC comparison model, in which clients can calculate the economic impact of the RPP solution.

The environmental impact was demonstrated through the LCA, which makes the comparison between disposable packaging and reusable packaging.

6.7.4 Replicability (how the case can be scaled up and applied in other contexts)

The model applied to the white goods sector is "copy and paste". It can be applied in different regions as well to different products.

White goods are mainly distributed through the logistic platforms of major retailers, where they receive different kinds of finished products (i.e. flat-screen TVs) with the same problems. Free Pack Net has already become involved in different new projects.

6.7.5 Performance-based approaches

6.7.5.1 General

This subclause explains how the case incorporates one or more of the circular economy business models given in 6.7.5.2 to 6.7.5.4.

6.7.5.2 Remanufacturing strategies

After 20 rent-cycles, the RPP is recycled and the PP material is used to produce new packaging.

6.7.5.3 Sharing economy and platforms

The PaaS model and the logics of service agreements imply collaborative supply chain methodology between the service provider (Free Pack Net), the manufacturer and the retailer. The common platform is based on the RPP tracking system that provides information to the parties involved.

6.7.5.4 Product life extension strategies

With reference to the RPP, the life extension of the product is reached with the optimization of certain plastic parts in the RPP shell. The company expects to reach a life cycle of 40 rent-cycles within two years.

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6.7.6 Description of the mechanical cycle and the service cycle

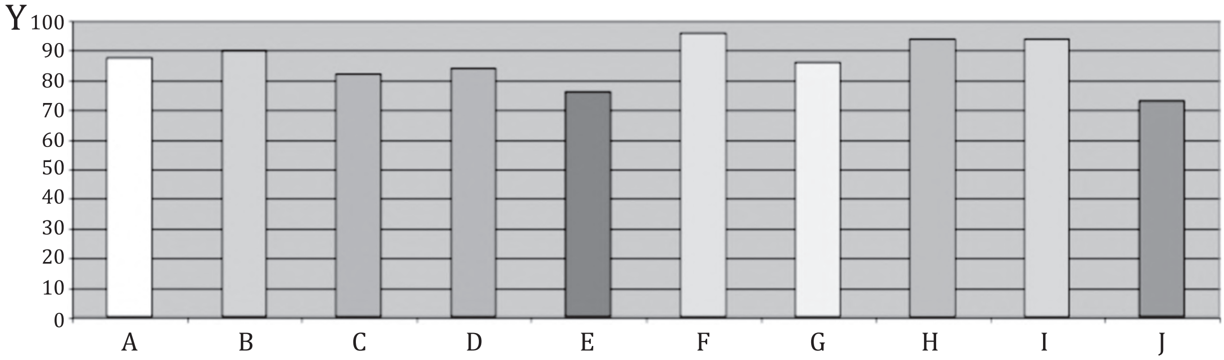
The RPP is produced using plastic injection technology.

The service cycle works via two service agreements for the protection of products on the journey from the factory to the final customer. The service agreement with the manufacturer indicates product models, factories and call off methodologies, and the service agreement with the retailer basically deals with the reverse logistics methodologies and procedures.

Via the service agreements, the RPP is rented to the manufacturers and retailers. The RPP uses radio-frequency identification (RFID) technology for traceability, and Free Pack Net installs antennas and readers at each point of the clients' supply chain. When the product packed with the RPP is delivered to the final customer, the RPP is returned to a collection centre that collects all the RPP from a specific geographical area. In the collection centre, the RPP is prepared in order to be efficiently transported to a sorting centre where it is checked, sanitized and prepared for a new delivery to the factory.

6.7.7 Life cycle assessment

The environmental impact is demonstrated through the LCA, which shows environmental impact mitigation as a result of the reusable packaging (see Figure 13).



Key

Y	saving percentage, %	F	acidification, g(HS)
A	total energy, MJ	G	summer smog/oxidants, g(HS)
B	total waste, kg	H	eco-system damage, g(HS)
C	health damage, g(HS)	I	eutrophication aquatic, g(HS)
D	health/radioactive, KBq	J	ozone degradation, g(HS)
E	greenhouse effect, g(HS)		

Figure 13 — Environmental impact mitigation

6.7.8 Greenhouse gas emissions

6.7.8.1 What evidence is there of GHG reductions as a result of implementing the solution?

In accordance with the conservative LCA, the CO_2 saving is expected to be 225 000 000 tons per year (without considering other savings such as elimination of product damage).

Other elements are indicated in the LCA (see 6.7.7).

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6.7.8.2 What is the scope of GHG emissions taken into account?

See 6.7.7.

NOTE Scope 1 covers direct emissions from owned or controlled sources. Scope 1 + covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company. Scope 1 + Scope 2 + includes all other indirect emissions that occur in a company's value chain.

6.7.8.3 What are the GHG savings?

Only packaging in the white goods sector. See Table 10.

NOTE The GHG savings are expressed in metric tons of CO_2 equivalent.

Table 10 — Free Pack Net GHG emission information

Category	Description
GHG emissions before	296 000 000 tons per year
GHG savings	225 000 000 tons per year
GHG emissions after	71 000 000 tons per year

6.8 Kuradashi — Japan

6.8.1 General information

This case study involves Kuradashi, a company based in Japan, see Table 11.

Table 11 — Kuradashi's information

Category	Description
Company solution name	A social-contribution-based, food sharing shopping site (food loss reduction)
Company name	Kuradashi Co., Ltd.[13]
Description of the solution	Kuradashi significantly reduces the occurrence of waste (including food waste) by using the internet to promptly match products that would otherwise be discarded with consumer needs. Sponsor companies enjoy the benefits of reductions in disposal costs and CO_2, as well as avoiding reputational risk, such as damage to brand image, and market conditions. Consumers can purchase products for very low prices at discounts ranging from 40 % to as much as 99 %.
Location	Japan
Industry sector	Digital
Size of the organization	—
Geographic scope	International, provides services all over the world

This case study provides a good example of a service-based digital solution that can be used to reduce waste in the food and beverage sector. Its model is likely replicable, and avoidance of food waste can be linked to reductions in environmental impact.

6.8.2 Quantitative information

6.8.2.1 What are the quantitative measures that demonstrate impact?

The website has been in operation since February 2015. There are more than 390 000 members and approximately 1 100 sponsor companies. The reduced tonnage and reduced CO_2 are calculated using indicators.

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6.8.2.2 How does the case consider environmental impacts?

The website is a mechanism to re-distribute products that were supposed to be discarded and is environmentally friendly.

Sponsoring manufacturers provide products at a special sponsorship price, thus enabling ethical consumption at bargain prices. Personal consumption by the user helps to contribute to society through the reduction of food waste.

In September 2022, food waste was reduced by approximately 500 tons per month.

The company has so far reduced food waste by a total of 12 605 tons.

6.8.2.3 How does the case consider social impacts? (e.g. social bonding, social cohesion, community sharing, support)

Redistribution leads to the solution of social issues (reuse).

Users who purchase products through Kuradashi can see the index because their social contribution is visualized.

In addition, as per the concept of Kuradashi, the company values food sharing, and it has a mechanism for the community to work on reducing food loss and share food.

The website sets an amount to be donated to a social activity organization for each product. The amount set is donated to a designated organization when a product is purchased.

An amount of 3 % of net sales is donated to organizations working to resolve social issues including environmental conservation and enhancement of medical and social welfare services. Total donations have reached JPY 86 million, with the money given to 23 organizations.

6.8.2.4 How does the case quantify and measure costs and benefits? (including high-level measurements)

The normal process results in:

— manufacturer’s food loss (case of disposal);

— product cost loss (the production costs cannot be recovered);

— additional costs required for disposal (increasing economic costs);

— CO_2 generation for disposal amortization (harmful to the environment).

Using the website results in:

— zero food loss (cost recovery because Kuradashi buys the food);

— disposal costs reduction;

— depreciation eliminated and CO_2 emissions suppressed;

— users can purchase at a lower price than the regular product price (financial advantage).

6.8.2.5 How does the case describe external/knock-on effects on other parties? (e.g. trade partners, customers, suppliers)

Kuradashi’s business model is a mutual-benefit business model, as follows:

— Food manufacturer: Cost reduction for disposal, plus cost recovery, plus environmental consideration (suppression of CO_2 generation).

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— User: Option to purchase products at a discount, plus part of the purchase price will be donated to social contribution activities (promotion of ethical consumption).

— Social contribution group: Activation of social contribution activities based on the donated funds (e.g. donation to the World Food Programme).

The financial process is shown in Figure 14.

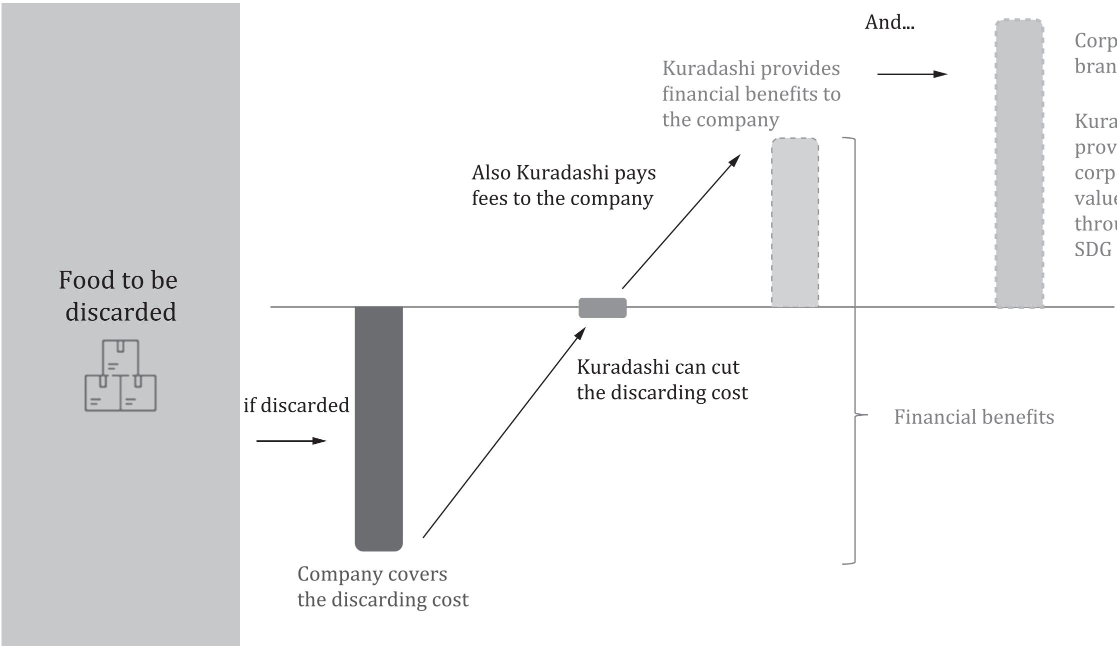

Figure 14 — Financial process

6.8.3 Qualitative information

6.8.3.1 Does the case measure intangible effects? (e.g. health)

The effects are as follows:

— Food manufacturer: As a company that actively works to reduce food loss, it is possible to improve the brand value of a company in a social and environmental sense.

— User: Shopping is good for society. Granting the joy of participating in social contribution activities.

6.8.3.2 How is the consumer's perception measured? (e.g. brand image perception research)

According to a customer satisfaction survey, Kuradashi improved customer satisfaction and led to higher profits.

Following brand image perception research, involving a questionnaire for 390 000 members, Kuradashi improved its service quality.

6.8.3.3 Does the case use qualitative measures to demonstrate impacts?

Qualitative measures include:

— regular measurement of food reductions, whereby food loss reduction volume is measured every quarter and the results provided publicly on the website;

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— measurement of customer contribution score, whereby, based on key performance indicators (KPIs), customer contribution is measured and the score is provided to each customer, which helps customers by granting the joy of participating in social contribution activities.

6.8.4 Replicability (how the case can be scaled up and applied in other contexts)

Since it is an online matching platform, it can be deployed all over Japan.

From the viewpoint of user expandability, it is a scheme with extremely high expandability.

The company is also strengthening cooperation with local governments, and it is possible to acquire users at each base, including each local government.

6.8.5 Performance-based approaches

The circular economy business model is shown in Figure 15.

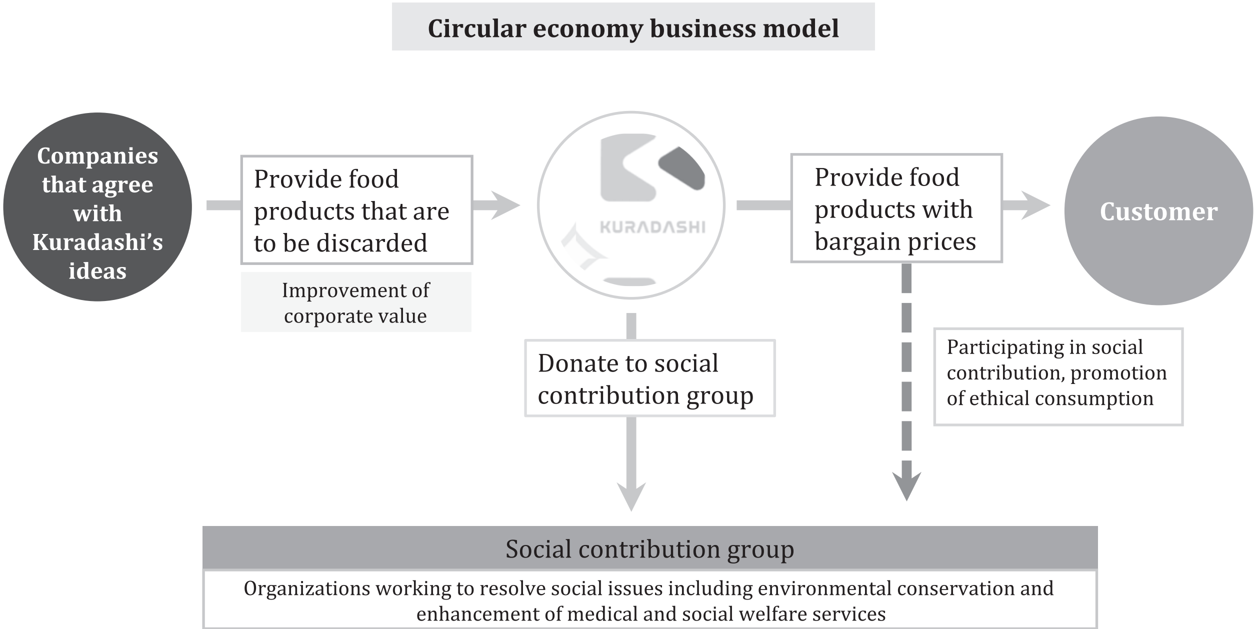

Figure 15 — Circular economy business model

6.8.6 Description of the mechanical cycle

A proper food value chain was created a long time ago. The new normal food value chain is a secondary distribution system built by Kuradashi, such as Mercar, New Market.

6.8.7 Description of the service cycle

The service cycle is as follows (see Figure 15):

— companies that agree with Kuradashi's ideas provide food items (the food to be discarded);

— Kuradashi sells the food items through its website;

— customers buys the food items via the website and contribute to social impacts and ethical activities;

— Kuradashi donates to the social contribution group.

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6.8.8 Life cycle assessment

The LCA is not yet available but one is planned.

6.8.9 Greenhouse gas emissions

6.8.9.1 What evidence is there of greenhouse gas reductions as a result of implementing the solution?

GHG reductions are estimated at 33 417 t-CO_2, due to the reduction of food loss, avoidance of waste and energy efficiency, see Table 12.

Table 12 — Kuradashi GHG reductions

Category	Description
Incineration of industrial waste	2,56 kg-CO_2/kg
Estimated total food waste avoided	10 476 tons
Emissions from waste treatment	2,56 kg-CO_2/kg × 1 000 kg = 2,56 t-CO_2
Cumulative CO_2 reduced	2,56 kg of CO_2/ton of food × 10 476 tons of food = 26 818 56 kg CO_2 = 26,81 t-CO_2

6.8.9.2 What is the scope of GHG emission taken in account?

No information was given.

6.8.9.3 What are the GHG savings?

See Table 13.

NOTE The GHG savings are expressed in metric tons of CO_2 equivalent.

Table 13 — Kuradashi GHG emissions

Category	Description
GHG emissions before	
GHG savings	33 417 tons of CO_2 equivalent (as of Sept 2022)
GHG emissions after	

6.8.9.4 What is the GHG reduction result?

GHG reduction forecasts based on business plans, see Table 14.

Table 14 — Kuradashi GHG emission reductions

Date	Reduced food loss per year	GHG reduction per year
June 2021	2,693 tons	7,138 tons CO_2
June 2022	4,663 tons	12,363 tons CO_2
July 2023 (forecast)	6,900 tons	18,170 tons CO_2

7 Conclusion

In conclusion, the analysis of the case studies presents valuable insights into real-world situations and demonstrates the tangible benefits of adopting a performance-based approach in the context of the circular economy. These case studies demonstrate positive outcomes of adopting circular economy strategies, including significant reductions in waste, GHG emissions and resource consumption. The cases show that

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it is possible to not only minimize environmental impacts, but also create profitable business models by rethinking the approach to production and consumption.

The significance of having standardized indicators to measure performance in the circular economy cannot be overstated. As demonstrated in the case studies, metrics such as waste reduction, CO_2 emission reduction and resource efficiency are critical in quantifying the impact of circular practices. Such indicators not only help in monitoring progress, but also in benchmarking and comparing performance across industries and regions.

Lastly, the success stories presented highlight several key factors that enabled companies to develop performance-based solutions. These include a strong commitment to sustainability, collaboration with stakeholders, the use of digital technology and a focus on user engagement. However, it is important to acknowledge that there can be negative outcomes, such as potential challenges in scaling these models or initial resistance to change from traditional linear business practices.

In summary, the case studies serve as compelling evidence that the circular economy is not just a theoretical concept but a practical approach that can yield both environmental and economic benefits. They underscore the importance of global collaboration, standardized measurement and continued innovation to drive the transition towards a more sustainable and circular future. These valuable lessons pave the way for further exploration and action in the realm of circular economy practices.

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