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PEDRO SCHERMA DE CARVALHO

Journey for Circular Transformation: A Theoretical Step-by-Step to Implement Circular Economy into Organizations

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Journey for Circular Transformation: A Theoretical Step-by-Step to Implement Circular Economy into Organizations

Undergraduate Monography presented to the undergraduate course in Environmental Engineering at the São Carlos School of Engineering from University of São Paulo to obtain the title of Environmental Engineer

Advisor: Prof. Aldo Roberto Ometto

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I dedicate this monography for the best people in my life: Pedro, Luciana, Gabriel and Caroline. I could not achieve this if I didn't have you by my side. I hope this work can bring a great trajectory for all of us.

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Progress is impossible without change, and those who cannot change their minds cannot change anything

George Bernard Shaw

ABSTRACT

CARVALHO, P. S. **Journey for Circular Transformation: A Theoretical Step-by-Step to Implement Circular Economy into Organizations.** 2020. 153 p. Monography (Undergraduate Thesis) – Program of Environmental Engineering, São Carlos School of Engineering, University of São Paulo, São Carlos, 2020.

The circular economy rises in a scenario of natural resources exhaustion as a new paradigm to redesign nations and businesses for a smarter and cyclical use of resources and energy with holistic system thinking. Key players in this transition are organizations that, while in the position of value creators and proposers, have the capacity to drive the required changes. However, there is a challenge for organizations that are looking to ways to move to a circular economy, as the actions to lead this transition and the ways to perform it are still unclear. Thus, in the light of this gap, this main objective of this research is to develop a theoretical and detailed step-by-step with a toolkit to implement circular economy into organizations by means of circular practices and circular business model, covering all the value chain components. The methodology used to achieve this goal was the Design Research Methodology that aims to drive all the stages of a research life cycle. Three systematic literature reviews were performed about step-by-steps to implement circular economy, circular economy practices, and indicators. An exploratory literature review was conducted to identify the methods and tools to compose the toolkit. As a result, 13 publications regarding methods to implement circular economy, 9 about circular economy practices and 9 about indicators were selected. 4 checklists with a total amount of 158 circular economy practices, and a repository with 40 indicators were structured to support the step-by-step. The step-by-step, here called Journey for Circular Transformation, is composed by 9 phases that covers the life cycle of a project to full implement circular economy: 1. Understanding the Concept, 2. Defining Current Scenario, 3. Identifying Opportunities, 4. Proposing Solutions, 5. Evaluating solutions, 6. Testing and Prototyping, 7. Planning, 8. Implementing and Monitoring, and 9. Reviewing and Modifying. Each phase is composed by a set of steps and tools that shows what need to be done and how to do it. The journey, enforcing a holistic overview covers the main components of the organization's value chain, including analysis of stakeholders, business model, business environment, business organization and the stages of the product life cycle (design, procurement, production, distribution, marketing and sales, use, end-of-life and reverse logistic). Checklists with circular economy practices and indicators are proposed to guide the proposition of solutions and provide qualitative and quantitative analysis of opportunities, respectively. The comparison with circular economy characteristics and principles shows that this new step-by-step has the potential to achieve a circular and a sustainable development. As a conclusion, this monography contribute for the practice and theory about circular economy implementation with a theoretical method that is capable to drive organizations redesign their business model, product and services, value chain, and business organization.

Keywords: Circular Practices. Circular Business Models. Value Chain. Method. Toolkit.

RESUMO

CARVALHO, P. S. **Jornada para Transformação Circular: Um Passo a Passo Teórico para Implantação de Economia Circular em Organizações.** 2020. 153 p. Monografia (Trabalho de Graduação) – Curso de Engenharia Ambiental, Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2020.

A economia circular surge de um cenário de exaustão dos recursos naturais como um novo paradigma para redesenhar nações e negócios para um uso de recursos e energia mais circular e inteligente com um pensamento holístico sistêmico. Atores-chave nessa transição são organizações que, enquanto criadores e propositores de valor, tem a capacidade para direcionar as mudanças necessárias. Contudo, existe um desafio para organizações que estão buscando maneiras para atingir a circularidade, já que as ações para promover essa transição e as maneiras de fazer isso ainda não são claras. Assim, focando nessa oportunidade, a presente pesquisa tem como objetivo desenvolver um passo a passo teórico e detalhado, composto de um toolkit, para implantar economia circular em organizações por meio de práticas circulares e modelos de negócio circulares, cobrindo todos os componentes da cadeia de valor. A metodologia utilizada para atingir o objetivo foi a *Design Research Methodology* que possibilita abordar todos os estágios do ciclo de vida de uma pesquisa. Três revisões sistemáticas de literatura foram executadas sobre passos para implantação de economia circular, práticas circulares e indicadores. Uma revisão exploratória foi feita para definir os métodos e ferramentas. Como resultado, 13 publicações sobre métodos para implantar economia circular, 9 sobre práticas de economia circular e 9 sobre indicadores foram selecionadas. 4 checklists com 158 práticas de economia circular e um respositório com 40 indicadores foram definidos para dar suporte ao passo a passo. O passo-a-passo, aqui chamado de Jornada para Transformação Circular, é composto de 9 fases que cobrem todo o ciclo de vida de um projeto de implantação de economia circular: 1. Compreensão do Conceito, 2. Definição do Cenário Atual, 3. Identificação de Oportunidades, 4. Proposição de Soluções, 5. Avaliação de soluções, 6. Teste e Prototipagem, 7. Planejamento, 8. Implementação e monitoramento, e 9. Revisão e Modificação. Cada fase do passo-a-passo é composta por ações e ferramentas que mostram o que precisa ser feito e como fazê-lo. A jornada, reforçando uma visão holística cobre os principais componentes da cadeia de valor de uma organização, incluindo análises de *stakeholders*, modelos de negócios, ambiente do negócio, organização do negócio e os estágios do ciclo de vida de um produto (design, aquisição, produção, distribuição, marketing e vendas, uso, fim de vida e logística reversa). *Checklists* com práticas circulares e indicadores são construídos para guiar a proposição de soluções e para prover análises qualitativas e quantitativas, respectivamente. A comparação com destaques e princípios da economia circular mostra que o novo passo-a-passo tem o potencial de atingir um desenvolvimento sustentável e circular. Como conclusão, a presente monografia contribui com a prática e teoria de economia circular com um método teórico que é capaz de direcionar organizações redesenhar seus modelos de negócios, produtos e serviços, cadeia de valor e organização do negócio.

Palavras-chave: Práticas Circulares. Modelos de Negócio Circulares. Cadeia de Valor. Método. Toolkit.

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SUMMARY

1 INTRODUCTION[1]

Since 1970, the use of natural resources by human activities has more than tripled and continues to grow (IRP, 2019a). Data from the International Resource Panel (IRP) show that the global extraction of materials, per year, grew from 27 billion tons to 92 billion tons between 1970 and 2017. This growth represents a big pressure on finite natural resources that tends to keep high, mainly due to intense consumption, but also because of low recycling rates (HUNT, 2013).

A huge part of the population, among 4.9 billion of people living in the middle-class foreseen to 2030 (OECD, 2012), accompanied with patterns of consumption that doesn't fit the earth regeneration capacity, is leading the exhaustion of earth natural resources reserves. Some crucial elements for industry continuation, such manganese, zinc, silver and tungsten, are projected to be exhausted if the current rate of extraction were kept (HUNT, 2013). The known reserves of 22 and 15 elements are expected to be total explored in the next 5-50 years and 50-100 years, respectively (HUNT, 2013). The European Commission has defining a list of critical raw material that have high economic importance for European Union and high supply risk, which, for the last publication (EUROPEAN COMMISSION, 2020a), include 12 elements of the list of exhaustion in 5-50 and five in the 50-100 years.

In the current patterns of natural resources utilization and exploration, the trends show that the consumption of natural resources will grow to 190 billion tons/year and 18 tons/per capita in a year until 2060 (IRP, 2019a). Of this total amount, non-metallic minerals will take the largest fraction, expecting to reach 86 billion tons of extractions in 2060, mainly represented by sand, gravel and crushed rock strongly used to increase the infrastructure in developing countries (OECD, 2018). In Brazil, the extraction and material consumption are projected to increase by about 40% and 30%, respectively (IRP, 2019b).

The extraction of natural resources, including materials, fuel and food, causes several damages on environment and human health, responsible for more than 90% of all biodiversity loss, water stress, and up to 50% of total greenhouse gas emission (IRP, 2019a). In Brazil, particularly, the extraction and processing of natural resources accounted for more than 70% of total climate change impacts (IRP, 2019b).

The over-exploration of natural resources and the consequent environmental impacts are overwhelming the planet and putting in test its resilient capacity. Planetary boundaries,

[1] This document follows the USP guidelines for the presentation of dissertations and theses (UNIVERSIDADE DE SÃO PAULO, 2020)

described as the safe operating space for humanity with respect to the Earth system (ROCKSTRÖM et al., 2009), are being pressured. The current consumption patterns have lead the overcoming of some of these planetary boundaries, including rate of biodiversity loss, interference on nitrogen cycle, climate change (STEFFEN et al., 2015; ROCKSTRÖM et al., 2009), land-system changes and interference on phosphorus cycle (STEFFEN et al., 2015).

In order to ensure availability of resources for the current and future generations and operate in a capacity that respects the earth systems, changes in the economy and the ways that resource are extracted and consumed are needed. Traditional linear consumption patterns come up against the availability of resources (ELLEN MACARTHUR FOUNDATION, 2013b). A linear economy, in which goods are manufactured from raw materials, sold, used and then discarded or incinerated as waste, follow a take-make-dispose pattern (ELLEN MACARTHUR FOUNDATION, 2013a; 2013b; 2014). Companies operating in a linear model increase their exposure to risks, mainly represented by higher resource prices and supply disruptions (ELLEN MACARTHUR FOUNDATION, 2014).

What is needed is a move from linear to a circular material flows through a combination of extended product life cycle and intelligent product design (IRP, 2017). Circular economy, an emerging topic that has attracted research interest in the last years (GEISSDOERFER et al. 2017; KIRCHHERR; REIKE; HEKKERT, 2017), refers to an industrial economy that is restorative by intention and seeks to effective flows of materials and energy to rebuilt natural and social capital, to reduce energy consumption and to accelerate the use of renewable energy (ELLEN MACARTHUR FOUNDATION, 2013a). A circular economy is an alternative to the traditional linear economy (make, use, dispose) in which resources are kept in use for as long as possible, extracting the maximum value from them while in the use cycle, and finally, recovering and regenerating products and materials at the end of each service life (ELLEN MACARTHUR FOUNDATION, 2014). The transition to a circular economy occurs at the same time of already implemented efforts related to sustainable development, including resource efficiency, supply chain management, and critical raw material risk mitigation (PAULIUK, 2018).

This new paradigm is currently being promoted in governments and business organizations from all around the world, especially in China and European Union (EU - KORHONEN; HONKASALO; SEPPÄLÄ, 2018). Studies have shown that this concept is able to bring sustainable benefits in a perspective of more effective extraction and production, smarter consumption and generation of employment opportunities in emerging industries (IRP, 2017; EUROPEAN COMISSION, 2015). To successfully operate in a circular economy, organizations require new forms of thinking and doing business, which means transit to a circular business model (BOCKEN et al., 2016), and also adopt circular economy practices to change their operation to fit the circular principles (ZHU, GENG, TAI, 2010; MASI et al., 2018).

As widely expressed in the literature, the circular economy can be implemented in three major levels: micro, by means of business; meso, an industrial symbiosis and eco-industrial parks application; and macro, i.e. implemented in countries, regions and cities (SU et al., 2013; GENG et al., 2012; YUAN; BI; MORIGUICHI, 2006). The current implementation of circular economy around the world includes policies; a variety of value chain cases, such wood and paper, chemical, agriculture, and plastics; and technologies, distributed along different types of industries sectors (WINANS; KENDALL; DENG, 2017).

The benefits in a company level are manly represented by cost savings, new sources of innovation and revenue, improved customer relationships, and improved resilience for organizations (BSI, 2017). For EU manufacturing firms, the circular economy represents an opportunity of USD 630 billion of material savings costs per year (ELLEN MARCARTHUR FOUNDATION, 2013b) and a global market opportunity of USD 1 trillion (SITRA, 2015).

The implementation of circular economy, however, is still a challenge. Companies without know-how have difficult to understand what circular economy is and how this concept can go to practice into closing material loops and delivering new circular offerings (RITZÉN; SANDSTRÖM, 2017). Some companies are current implementing circular economy actions even don’t know what linear and circular economy means (ORMAZABAL et al., 2018). Thus, efforts are necessary in the line that support organizations implement and capture all the values that circular economy can brings.

Researchers and some institutions, such as Ellen MacArthur Foundation, British Standard Institution, and Joustra, Jong and Engelaer (2013), have discussed methods to support the circular economy implementation. Some resources are current available in the literature about circular economy, including standards, frameworks and step-by-steps. However, none of them focus on all the stages of an organization’s value chain and, at the same time, provides a toolkit to support the implementation of such transformation, focusing only in stages of a product life cycle (e.g. design). Thus, there is a gap in the literature to support the implementation of circular economy by showing the actions that are needed to be taken (“What”) and the ways to implement these actions (“How?”), also having a wider overview to cover the entire value chain.

2 OBJECTIVES

Based on the literature gap presented above, the main objective of this research is to develop a theoretical and detailed step-by-step with a toolkit to implement the circular economy into organizations by means of circular practices and circular business models, covering all the value chain components. The step-by-step aims to have a general approach in order to be applicable in any market segment. Also, the means of circular implementation is focused on circular practices and circular business model to cover both operational and business perspective of the organization. And, lastly, the step-by-step aims to be composed of a toolkit to support the execution of each step.

To achieve this target, the following specific objectives are proposed:

a) Identify in the literature steep-by-steps to implement circular economy into organizations;
b) Identify in the literature circular practices;
c) Identify in the literature indicators of circular economy evaluation in organizations;
d) Identify in the literature methods and tools for carrying out previously identified steps
e) Build the step-by-step with toolkit to implement circular economy into organizations

2.1 Justification

Many authors have discussed aspects that contribute for the circular economy implementation; however, a practical guideline for this end is still vague (PAULIUK, 2018). Methodologies to implement circular economy are composed of a procedural guidance for transforming business models into new circular ones (PERALTA; LUNA; SOLTERO, 2019), started by assessing the performance of an organization in terms of circular economy aiming to identify opportunities for improvement (GUSMEROTTI et al., 2019; CNI, 2018). The stages of a guideline show “what need to be done to implement circular economy”. In addition, a toolkit, including indicators, methods and tools, come as a solution to answer the question “how these stages can be performed”, as an organization may not have all the capabilities to move in this transition. The integration of value chain perspective with circular economy is necessary to achieve a system thinking and a holistic overview to better understand an organization and, consequently, to promote the right solutions. The value chain also has a strong dependence with the organization’s business model, which justify the need to consider the value chain stages in this research. The section 3 of this monography clarifies the concepts introduced here.

3 LITERATURE REVIEW

This section presents a deep discussion about circular economy, addressing the main definitions and principles (3.1) that give the ways to implement the concept. Based on the circular economy concept, a brief discussion about its implementation in a value chain perspective (3.2), followed by the main drivers and barriers (3.3) for organization adopt circular economy.

3.1 Introducing the Circular Economy Concept

The concept of circular economy that has emerged in the last years is not new (GEISSDOERFER et al., 2017). Even with a not precise origin, the literature use to attribute the rise from some researches and schools of thoughts that got popular after 1970's years (ELLEN MACARTHUR FOUNDATION, 2013a). The most accepted schools of thoughts precursor of the circular economy are diverse: Regenerative Design (LYLE, 1994); Performance Economy (STAHEL, 2010); Cradle to Cradle (MCDONOUGH; BRAUNGART, 2002); Industrial Ecology (GRAEDAL; ALLENBY, 1995); and Biomimicry (BENYUS, 2002) (ELLEN MACARTHUR FOUNDATION, 2013a; 2013b).

The term circular economy, however, was only introduced for the first time with the work of Pearce and Turner (1989) in the beginning of the 1990s years, when the concept started to drive some policies regarding waste management and raw materials, becoming an important and significant new school of thought in sustainable development (MURRAY; SKENE; HAYNES, 2015). The first two policies guided by circular economy were published in 1996 in Germany, in its closed waste management policy, and in Japan, in a recycling-related law (2002) (SU et al., 2013; GENG AND DOBERSTEIN, 2008). Only in 2009, in the Chinese Circular Economy Promotion Law, the first policy explicit about circular economy was published (SU et al., 2013).

The European Commission incorporated circular economy concerns in 2015 by publishing the European Union action plan for circular economy (EUROPEAN COMMISSION, 2015) that was updated in 2020 (EUROPEAN COMMISION, 2020b), aiming to build a strong alignment and cooperation between different stakeholders and to promote initiatives for key supply chains.

The accomplishment of the proposed actions required not only engagement of policy makers, but also the business commitment. In this perspective, the European Commission launched, in 2015, a circular economy package aiming to incentive small and medium-sized enterprises to adopt circular economy activities (BONTOUX; BENGTSSON, 2015). The work of Bassi and Dias (2019) gives an idea of the current implementation of circular economy across EU companies. Almost 73% of EU SMEs implemented or are about to implement at least one circular economy initiative between, with minimization of waste, recycle or resell, minimization of energy consumption, and redesign of product to minimize material usage being the most applied initiatives

However, the implementation of circular economy in the micro-level is still limited in a global scale (GHISELLINI; CIALANI; ULGIATI, 2016). The term implementation of circular economy is not clear in the literature and may lead to different approaches and results. In a search for a step-by-step to implement it in micro-level, a conceptualization or at least a hypothesis about it is needed. Thus, for the scope of this study, a definition for implementation of circular economy is created, being understood as the *adoption of business model, practices, strategies and/or initiatives that are directly or indirectly aligned with the circular economy definition, principles, and its interrelated schools of thoughts*. The implementation of circular economy by putting in practice the principles is enforced by the British Standard Institution. When implementing it, the aim for an organization is to create long-term business value by design through the sustainable management of resources in its products and services (BSI, 2017).

Since the rise of circular economy as a multidisciplinary concept that brings together different approaches to move toward a more sustainable society (MENDONZA et al., 2017), many definitions were proposed considering a variety of aspects, like the levels of applications in China, waste management disciplines, resources efficiency and scarcity, sustainable pillars, and R-imperatives. Some bibliographic reviews regarding definitions and applications tried to define the state-of-art in terms of circular economy implementation and conceptualization. Even coming out with different definitions, they tends to converge around some key characteristics (KORHONEN et al., 2018; KORHONEN; HONKASALO; SEPPÄLÄ, 2018; PRIETO-SANDOVAL; JACA; ORMAZABAL, 2018; REIKE; VERMEULEN; WITJES, 2018; KIRCHHERR; REIKE; HEKKERT, 2017; WINANS; KENDALL; DENG, 2017; GHISELLINI; CIALANI; ULGIATI, 2016; MURRAY; SKENE; HAYNES, 2015).

The Table 1 brings some definitions of circular economy. The intention here is to have a sample of definitions to analyze the components of the circular economy concept that may guide its implementation. Because of a broad range of definitions, each author suggests key components to be highlighted in a definition. The definition provided by the Ellen MacArthur

Foundation (2013b) is one of the most accepted. For this reason, the review of Korhonen et al. (2018) grouped their findings in two types of definitions: the ones based on the Ellen MacArthur Foundation, and the ones based on own researches achievement. For the scope of this research, the definition of circular economy provided by Korhonen et al. (2018) is adopted, as the components are most aligned with the scope of this research.

Table 1 – Circular economy definitions from different sources.

Author	Definition
Suarez-Eiroa et al. (2019)	Circular economy is a regenerative production consumption system that aims to maintain extraction rates of resources and generation rates of wastes and emissions under suitable values for planetary boundaries, through closing the system, reducing its size and maintaining the resource's value as long as possible within the system, mainly leaning on design and education, and with capacity to be implemented at any scale.
Korhonen et al. (2018)	Circular Economy is a sustainable development initiative with the objective of reducing the societal production-consumption systems' linear material and energy throughput flows by applying materials cycles, renewable and cascade-type energy flows to the linear system. Circular economy promotes high value material cycles alongside more traditional recycling and develops systems approaches to the cooperation of producers, consumers and other societal actors in sustainable development work.
Korhonen, Honkasalo and Seppälä (2018)	Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development. Circular economy limits the throughput flow to a level that nature tolerates and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates.
Prieto-Sandoval, Jaca and Ormazaba (2018)	An economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels.
Geissdoerfer et al. (2017)	A regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.
Kirchherr, Reike and Hekkert, (2017)	An economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.
Murray; Skene and Haynes (2015)	The Circular Economy is an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being.
Ellen MacArthur Foundation (2013b)	The circular economy refers to an industrial economy that is restorative by intention; aims to rely on renewable energy; minimizes, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design.

Source: Own authorship.

As Kirchherr, Reike and Hekkert (2017) found, there were at least 114 different definitions of circular economy available in the literature at 2017. The authors developed a new definition based on this large amount of contributions, resulting in a compiled of components that includes the 3R framework, the three levels of circular economy implementation, and the link with sustainable development to ensure the prosperity of future generations. Some similarities can be found between circular economy and sustainability, including cooperation between different stakeholders, business model innovation, integration of non-economic aspects into economic development, and a system that requires innovation and design changes (GEISSDOERFER et al., 2017).

According to Prieto-Sandoval, Jaca and Ormazabal (2018), the definition of circular economy should be able to include: 1) recirculation of resources and energy, minimization of resources demand, and recovery of value from waste, 2) multilevel approach, 3) path to achieve sustainable development, and 4) close relationship with the way society innovates. For Korhonen et al. (2018, p. 547), “the concept of circular economy should be aligned with the current academic, policy and industry consensus that economic systems should utilize nature's cycles for preserving materials, energy and nutrients for sustainable use”.

Even with no single definition, Peralta, Luna and Soltero (2019, p. 2) state that circular economy looks “to achieve a self-regenerative system without waste, thanks to strategies such as zero waste (waste equal food), eliminating toxic substances, maximizing reuse, promoting the use of renewable energies or extending the useful life of products, services and resources”. The studies of natural non-linear and living systems capable to be self-regenerative and assimilate non-toxic substances are on the core of the circular economy concept (ELLEN MACARTHUR FOUNDATION, 2013b).

Korhonen, Honkasalo and Seppälä (2018) argue that circular economy should be able to make use of nature's cycles in order to preserve materials, energy and nutrients. The authors highlight two components of the circular economy definition: 1) the importance of high value and high-quality material cycles in a new manner; and 2) the sharing economy for a more sustainable production consumption culture.

Circular economy seems to demand innovations on how industries produce goods, how consumers use these goods, and how policy markers legislate (PRIETO-SANDOVAL; JACA; ORMAZABAL, 2018). This implies in a perspective of multi-stakeholder’s roles and obligations in order to full achieve the circular economy aims, which, from a business perspective, may results in an inter-sectoral and inter-organizational management and governance of physical flows (KORHONEN et al., 2018).

Geissdoerfer et al. (2017) explore in their definition the different schools of thoughts that are seem as the basis for circular economy and highlights the design strategies for resource loops proposed by Bocken et al. (2016), which include close, slow and narrow resource cycles. The main R-strategies for technical cycles, mentioned by Ellen MacArthur Foundation (2013b), which include maintenance, repair, reuse, remanufacturing, refurbishing, and recycling, appears as alternatives for the resource loop strategies of Bocken et al. (2016). Murray, Skene and Haynes (2015) works on the main issues implied by the way resources are currently used and extracted, enforcing to the sustainable issues that threat the human well-being. In the same line of Geissdoerfer et al. (2017), the authors explore the links between circular economy and sustainable development.

The same way as other authors already pointed out, the definition of Suarez-Eiroa et al. (2019) is grounded in three main components: 1) operational principles to cover de diversity of concepts and practical tools; 2) the three implementation levels, and 3) the aims of circular economy in the light of the sustainable development framework. The variety of characteristics that ground the concept of circular economy makes the circular economy a powerful school to drives sustainability (GEISSDOERFER et al., 2017).

From a principle perspective, the most accepted set of circular economy principles are the ones defined by the Ellen MacArthur Foundation (2015) and the British Standards Institution (BSI, 2017) by means of the standard 8001:2017. The principles can be viewed as a pathway to implement the circular economy (PESCE et al., 2020; SUÁREZ-EIROA et al., 2019) and, for this reason, should be considering as a frame to guide the decision making and behaviors (BSI, 2017). Such principles rely on initiatives across all the stages of the value chain (KALMYKOVAA; SADAGOPAN; ROSADO, 2018).

Before the introduction of the Ellen MacArthur Foundation and BSI set of principles, the literature used to attribute them to R-imperatives, with emphasis in the so called 3R framework (reduce, reuse, recycle) that guided the earlier applications circular economy, especially in Chine (PRIETO-SANDOVAL; JACA; ORMAZABAL, 2018; REIKE; VERMEULEN; WITJES, 2018; SU et al. 2013). Therefore, some authors point out that circular economy in China can be viewed as a generic term for activities on reducing, reusing and recycling in production, circulation, and consumption, which remains on the 3R concept (LIU et al., 2017).

Besides the 3R framework, other terminologies were proposed, varying from 4R to 10R and sometimes following an hierarchy of choices that aim to extract as much value as possible from materials (REIKE; VERMEULEN; WITJES, 2018). A known R-framework is the 9R hierarchy proposed by Potting et al. (2017), in which circularity increases from recover strategies to refuse strategies, or, in another point of view, from useful applications of materials to smarter use of product.

Considering the contribution from different sources, the literatures cover a total range of 38 R-imperatives that can guide the strategies to implement circular economy in micro, meso and macro level, including (REIKE; VERMEULEN; WITJES, 2018): re-assembly, recapture, reconditioning, recollect, recover, recreate, rectify, recycle, redesign, redistribute, reduce, re-envision, refit, refurbish, refuse, remarket, remanufacture, renovate, repair, replacement, reprocess, reproduce, repurpose, resale, resell, re-service, restoration, resynthesize, rethink, retrieve, retrofit, retrograde, return, reuse, reutilise, revenue, reverse and revitalize.

With the Ellen MacArthur Foundation earlier publications in 2013, a new core of 5 natural principles aligned with the foundation's definition for circular economy were introduced. According to the foundation, the circular economy should be grounded in: 1) design out waste, in which products are designed to fit the biological or technical materials cycles; 2) build resilience through diversity, which implies in modularity, versatility, and adaptability; 3) rely on energy from renewable sources; 4) think in 'systems', understand as how parts influence one another within a whole; and, finally, 5) waste as food, meaning reintroduce products and materials back into the biosphere through non-toxic, restorative loops (ELLEN MARCARTHUR FOUNDATION, 2013a; 2013b).

The Table 2 comprises six different set of circular economy principles, including the ones proposed by the BSI 8001:2017 and the further simplified principles of the Ellen Macarthur foundation (2015). Even spread in different manners, a core principle of circular economy is the reintroduction of end of their life waste in the industrial food chains, considering both energy and material flows (GHISELLINI; CIALANI; ULGIATI, 2016).

Pesce et al. (2020) argue that, based on the range of principles from Table 2, six of them tend to be convergent in terms of ambitions, which include systems thinking, innovation, value optimization, resource recovery, circular design of processes, products and services, and waste as a resource. Some principles focus on how organizations interact with stakeholders and taking decisions, suggesting that they should take a holistic approach to understand and manage how their decisions and activities interact with the entire systems, focus on continuous innovation, collaborate with different stakeholders, and ensure transparence (BSI, 2017; WEETMAN, 2016).

Table 2 – Circular economy principles from different sources.

Author	Principle
Suárez-Eiroa et al. (2019)	Adjusting inputs to the system to regeneration rates Adjusting outputs from the system to absorption rates Closing the system Maintaining resource value within the system Reducing the system's size Designing for circular economy Educating for circular economy
Tonelli and Cristoni (2019)	Green-tech and responsible use of resources Maximize utilization rate Product and materials at the highest utility Minimize and phase out negative externalities
BSI (2017)	Systems Thinking Innovation Stewardship Collaboration Value optimization Transparency
Weetman (2016)	Waste = food Build resilience through diversity Use renewable energy Think in systems
Ellen MacArthur Foundation (2015)	Preserve and enhance natural capital Optimize resource yields Foster system effectiveness
Circle Economy	Prioritize regenerative resources Preserve and extend what is already made Use waste as a resource Rethink the business model Design for the future Incorporate digital technology Collaborate to create joint value

Source: Adapted from Pesce et al. (2020).

Other groups of principles address the limitations of the current consumption patterns and the resource scarcity, expressing that the circular economy, in the line of the definitions, should lead organizations to optimize the use of resources and increase the capture of value them promote, use of renewable energy sources and materials, preserve the natural resources, and reuse waste as an input in the production system (SUÁREZ-EIROA ET AL., 2019; TONELLI AND CRISTONI, 2019; WEETMAN, 2016; ELLEN MACARTHUR FOUNDATION, 2015).

The exploration the circular economy definitions and principles reveal some insights that guides organizations to take actions and initiatives to transit to a more circular society. The Table 3 brings an adaptation of the circular economy characteristics proposed by the European Environment Agency (2016), complemented with the ones identified by exploring the sample of definitions and principles presented in Tables 1 e 2.

Table 3 – Key characteristics of circular economy.

Key Characteristics	Components
Circular redesign of products and services	- Promote design for close, slow and narrow resource loops - Increase recirculation of technical an biological materials - Adopt reuse, maintenance, repairing, remanufacturing, refurbishment, recycling strategies
Usage of renewable materials/Elimination of toxic substances	- Non-renewable resources replaced with renewable ones within sustainable levels of supply - Increased share of recyclable and recycled materials that can replace the use of virgin materials - Eliminate the use of toxic substances - Sustainably sourced raw materials
Usage of renewable energy sources	- Foster the use of renewable energy sources instead of fossil combustive
Reuse of waste/Reduce waste generation	- Reduced emissions throughout the full material cycle through the use of less raw material and sustainable sourcing - Promote reuse of waste when emissions occurs
Correlation with sustainable pillars	- Less pollution through clean material cycles - Regenerative economy by intention - Improve positive social impacts, at the same time that make economic viable products
Collaboration with partners and consumers	- Extend collaboration with partners to promote circular economy - Understand customers' needs to better design products and services
System Thinking	- Understand how parts influence one another within a whole system;
Efficient use of resources/Reduce input of natural resources	- Minimized and optimized exploitation of raw Materials, while delivering more value from fewer materials - Reduced import dependence on natural resources - Efficient use of all natural resources - Minimized overall energy and water use

Source: Adapted from European Environment Agency (2016).

Based on those sources, the organizations should study their end-of-life and reverse logistics strategies to promote recirculation of resources, including both biological and technological cycles, that can be performed by designing to close, slow and narrow resource loops, with a practical representation by reuse, maintenance, repairing, remanufacturing, refurbishment, recycling, or any close-the-loop R-strategy (PRIETO-SANDOVAL; JACA; ORMAZABA, 2018; GEISSDOERFER ET AL., 2017; KIRCHHERR; REIKE; HEKKERT, 2017; ELLEN MACARTHUR FOUNDATION, 2013b; 2015).

Secondly, organizations should pay attention in the manners of how products are design and produced, which also implies in the procurement of resources in general. The actions cover a careful design of the product to be able to operates in the recirculation strategies and eliminates waste generation; the elimination of toxic substances in the product; and the usage of renewable energy and renewable materials (ELLEN MACARTHUR FOUNDATION, 2013b; 2015).

Another takeaway, and in concordance of the hierarchy of material use, is that organizations should study their production system to promote the reuse of wastes, but also thinking in strategies to eradicates the emissions on the environment, which results in minimization of environmental impacts (SUÁREZ-EIROA ET AL., 2019; MURRAY; SKENE AND HAYNES, 2015; WEETMAN, 2016 ELLEN MACARTHUR FOUNDATION, 2015; 2013b). A micro level implementation of circular economy comes with an alignment with the three pillars of sustainable development, implying that organizations should have a look on the positive and negative environmental, social and economic interactions with the system as a whole (KORHONEN ET AL., 2018; KORHONEN; HONKASALO; SEPPÄLÄ, 2018; KIRCHHERR; REIKE; HEKKERT, 2017). The implementation of circular economy practices and business models can help the achievement of some sustainable development goals, in especial the goals 6, 7, 8, 12 and 15 (SCHROEDER; ANGGRAENI; WEBER, 2018).

3.2 Circular Economy Implementation in the Value Chain

The most accepted definition of value chain is the one proposed by Porter (1985), stating that value chain is a set of activities that a firm, operating in a specific industry, performs in order to deliver a valuable product or service for the market. For the scope of this study, the value chain in the context of circular economy, following the definition of Porter (1985), cover the activities that are related to the capability of deliver a circular product or service for the market, i.e. activities that drives circular economy product development and delivery. The circular economy value chain cover stages to close the loop of material flow and is driven by renewable energy (KALMYKOVA; SADAGOPAN; ROSADO, 2018).

The most common activities mentioned in the literature relevant for the value chain are the ones that compose a product life cycle. Organizations should adopt a life cycle thinking to effectively integrate circularity with market competitiveness (GUSMEROTTI et al. (2019). In general, the product life cycle is composed by: design, procurement, production, distribution, marketing and sales, use, end-of-life and reverse logistic (ACCENTURE, 2014). The transition to a circular economy in a micro level can be addressed by integrating its principles into business functions, i.e. involving procurement, logistics, operations, marketing and other life cycle activities (GUSMEROTTI et al., 2019).

Besides the product life cycle stages, other activities are relevant in the context of delivery a circular valuable product. Circular business model activities, i.e. the ones to create, deliver and capture from customers (OSTERWALDER; PIGNEUR, 2010) are intrinsic related to the capacity of an organization design a circular product and deliver it to the market (BOCKEN et al., 2016). Circular business models contribute to reduce the use of resources, generation of waste and emissions, and to close the technical and biological cycles (BOCKEN et al., 2016). This alternative of traditional business model can also be less costly to design and to produce goods for the market (LINDER; WILLIANDER, 2015).

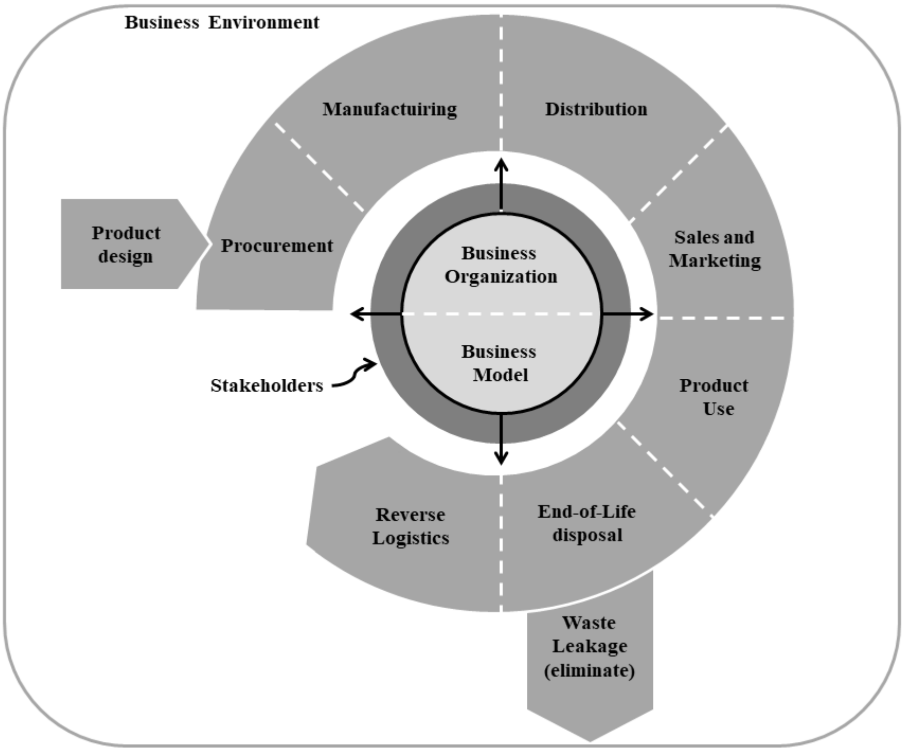
The business environment, i.e. the market, geography location and other external relevant factor, also influences how companies design their circular business model (URBINATI et al., 2020). Present in the organization environment, stakeholders are key players that can add value and quality for product and, for this reason, have important information for circular products design (CNI, 2018). The collaboration and stakeholder's involvement in the circular economy solutions is an aspect mentioned in principles and needs to fully implement this concept (BSI, 2017). The engagement stakeholders, including consumers, with life cycle stages, drive the implementation of circularity across the value chain (GUSMEROTTI et al., 2019).

A last component that is relevant for a circular value chain is the internal organization of a business that supports all the other activities performed to deliver a circular product to the market. Circularity should look up to the entire business functions, i.e. from raw material purchasing to product design, operational activities and market communication (GUSMEROTTI et al., 2019). The authors also suggest that a limited assessment of internal operations may reduce the discovery of opportunities that connected circular economy and market opportunities. A circular value chain for the context of this work can be, then, composed by product life cycle stages and activities related to business model, stakeholder's involvement, business environment and business organization, as presented in Figure 1.

Lieder and Rashid (2016) mention 3 inter-related perspectives that lead to success of circular economy implementation. The first perspective is the avoidance and minimization of environmental impact by means of reduction of solid waste, landfill, and emissions, manly related to government and society bodies. The second, related to businesses, is the economic benefits through the business model, product redesign, supply chain, and choices of materials. The last perspective is the resource scarcity through circularity of resources and materials, and volatility of resources, that is also related to nations and government bodies.

The implementation of circular economy through the life cycle can be made by considering take, make distribute, use and recover stages (DEY et al., 2020; PRIETO-SANDOVAL et al., 2019). The first field is represented by the way companies take resources and energy from the environment. Make is descripting as the ways the resources becomes goods and products, while Distribute represents how the products and goods are delivered for customers.

Figure 1 – Circular economy value chain.



Source: Adapted from Accenture (2014).

The last two fields are the ways of use and how the product, wastes and energy are recovered in the end of product life cycle. In the last decade, the companies are implementing circular models tagging the life cycle of products, components, and useful waste output (ALBUQUERQUE et al., 2019). However, publications across the life cycle are not homogeneous, i.e. some stages are still recent, while others have received more attention. The following sections discuss factors related to circular economy implementation in the life cycle (3.2.1) and in the other activities that compose the suggested circular value chain (3.2.2).

3.2.1 Circular Economy in Product Life Cycle Stages

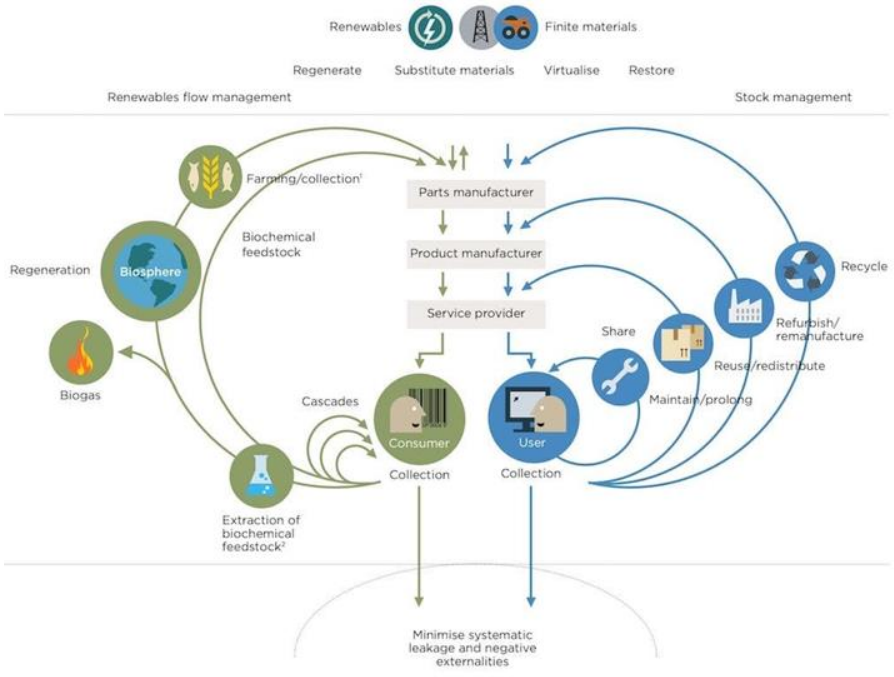
Design

The first step in the life cycle of a product, according to Accenture (2014), is the design phase. The product design is a key stage in the product life cycle (ELLEN MACARTHUR FOUNDATION, 2013a 2013b). The aim of design for a circular economy is to maintain product integrity across multiple cycles and to focus on loop strategies, also ensuring an economically viable product. Bocken et al. (2016) proposed three strategies to transition from a liner economy to a circular economy in a design perspective: slowing resource loop, by means of product life cycle extension and design for long life that is achieved by strategies such repair and remanufacture; closing resource loop, represented by recycling products and parts; and narrowing resource flow, i.e. reducing the usage of resources to build products. Urbinati, Latilla and Chiaroni (2018), with a focus on business value, classify the design practices in two groups. The design for value network, which represents how companies interact with suppliers and internal activities (e.g. Design for remanufacture, disassembly, recycle, repair), and the design for custom value proposition, in which the implementation of circular economy aim to propose value to customers (e.g. design for durability, quality, reliability).

Design for long life means ensure a long period of utilization for products, while design for product-life extension is more related to extend the use period of goods by promoting service loops to extend product life (BOCKEN et al., 2016). The product-life extension strategies in circular economy has a strong emphasis on create multiple use cycles to use materials with as much value as possible (SUMTER et al., 2020). Also, products need to be designed enabling materials, components or waste to be re-integrated into use cycle (BOVEA; PÉREZ-BELIS, 2018).

The Ellen MacArthur Foundation (2013b) proposed the well-known butterfly diagram (Figure 2) that also provides some insights for circular economy across product cycles.

Figure 2 – Circular economy butterfly diagram.



Source: Ellen MacArthur Foundation (2013b).

The diagram has two major flows: the technological and biological flow. The biological flows remits to bio nutrients, designed to re-enter the biosphere safely and build natural capital, while the technical flow is made by nutrients which are designed to circulate at high quality without entering the biosphere (MCDONOUGH; BRAUNGART, 2002) that has the power to drive the different R-strategies for close, slow and narrow resource loops (BOCKEN et al., 2016). By the diagram, the organizations should consider both cycles in order to better allocate the product's parts along several loops targeting different actors and processes.

The literature of design for circular economy is one of the most discussed in terms of life cycle stages, covering several frameworks, concepts and key factors for a successful implementation. Sumter et al. (2020) highlights five key competences for design for circular economy that organizations need to have in mind: systems thinking, anticipatory, normative, strategic, and interpersonal competencies.

Parallelly, Moreno et al. (2016) proposed some recommendations for business designers when moving from a linear to a circular design, including:

a) Design for systems change, when considering any circular design strategy;
b) Design by identifying the circular business model for what the product/service is being designed for;
c) Design by thinking out of the box (circular design goes beyond doing less bad);
d) Design for multiple cycles, disconsidering only the end-of-life;
e) Design by thinking in living and adaptive systems;
f) Co-design with all participants in the value chain, including end users;
g) Design by considering value in a broader view;
h) Design considering failures and a test phase;
i) Design knowing where each material and part comes from and where each material and part goes to in the end-of-life;
j) Design with "hands on" experiences that foster a call for action.

On the other hand, Bovea and Pérez-Belis (2018) developed a methodology that supports designers to identify which circular design guidelines needs to be incorporated into a product design in order to meet the circular economy principles. The same approach is followed by van den Berg and Bakker (2015) that suggested a circular economy framework for product design with a toolkit to be used during the circular design. The authors argue that five characteristics should be considered during such design including future proof, i.e. reducing the need for new products by making more lasting products that are used for a longer period; disassembly; maintenance; remake; and recycle. The authors present a useful sider graphic in which organizations can assess the current state and the desired circular state of a product on these five characteristics.

The design strategies in circular economy can be called Design for X strategies, in which “X” remits to a specific targeted end. Moreno et al. (2016, p. 3) define Design for X as

> “a combination of eco-design strategies including Design for Environment and Design for Remanufacture, which leads to other design strategies such as Design for Upgrade, Design for Assembly, Design for Disassembly, Design for Modularity, Design for Maintainability and Design for Reliability”.

Even the raise of DfX guidelines, there is still a gap on the competencies required for and organization in order to fully apply them in practice (BROWN; BOCKEN; BALKENENDE, 2019).

Procurement

For the procurement stage of the life cycle, the literature still doesn’t have a considerable sample of contributions that explore the link between circular economy this topic. The theme seems to be most commented in the context of circular supply chain. The relations between circular economy and supply chain still need to be more detailed, with a especial attention on the supply chain management contributes to transit to a more circular economy (DE ANGELIS; HOWARD, MIEMCZYK, 2018). According to Geissdoerfer et al. (2018, p. 714) circular supply chain management is defined as

> “the configuration and coordination of the organizational functions marketing, sales, R&D, production, logistics, IT, finance, and customer service within and across business units and organizations to close, slow, intensify, narrow, and dematerialize material and energy loops to minimize resource input into and waste and emission leakage out of the system, improve its operative effectiveness and efficiency and generate competitive advantages”

A circular supply chain needs to take into account the responsibility of the development of resources and the health of the ecosystem, balancing the natural resources availability with the requirements and demands from the industries sectors (VEGTER; HILLEGERSBERG; OLTHAAR, 2020).

To complete implement circular economy into organization is necessary redesign their supply chain (ZHU; GENG; TAI, 2010) in order to achieve a new circular one, which requires an analysis about the relationship between circular economy and the traditional supply chain (ELIA; GNONI; TORNESE, 2020). When transiting to a circular supply chain, De Angelis, Howard and Miemczyk (2018) defined five propositions that may support organizations in this journey. Among the highlights, the authors argue that the product ownership tends to move to a leasing and a service model, a flexible structure, the consideration of technical and biological closed and non-closed material flows, collaboration among partners.

Kannan et al. (2020) developed a checklist that consists in identify and select criteria for supplier selection, considering different economic, social and circular criteria to rank the alternatives. Other key considerations for companies implement a circular supply chain found in the literature are (VEGTER; HILLEGERSBERG; OLTHAAR, 2020): focus on resource efficiency by reducing, maintaining and recovering resources; strives for economic, environmental and social benefits; be planned considering Plan (plan supply chain requirements), Source (schedule delivers, transferences, payments), Make (production-related activities), Deliver (logistics of delivery), Use (consumption phase), Return (the tack back systems), Recover (R-strategies) and Enable (processes management in the supply chain) stages.

Production

The implementation of circular economy in the production stage seems to be manly attributed to resource efficiency strategies and cleaner production (GHISELLINI; CIALANI; ULGIATI, 2016; SU et al., 2013). Farooque et al. (2019) also consider the green manufacturing as a relevant term when discussing the application of circular economy in the manufacturing context. The adoption of cleaner production patterns should be planned in such a way as to balance its isolated process nature by means of better integration into other environmental strategies of a company, an industrial system or the entire society (GHISELLINI; CIALANI; ULGIATI, 2016). Cleaner production practices are valuable for circular economy implementation by increasing the value durability of products and the share of renewable and recyclable resources, and reduction of valuable materials losses and emissions level (SOUSA-ZOMER et al., 2018).

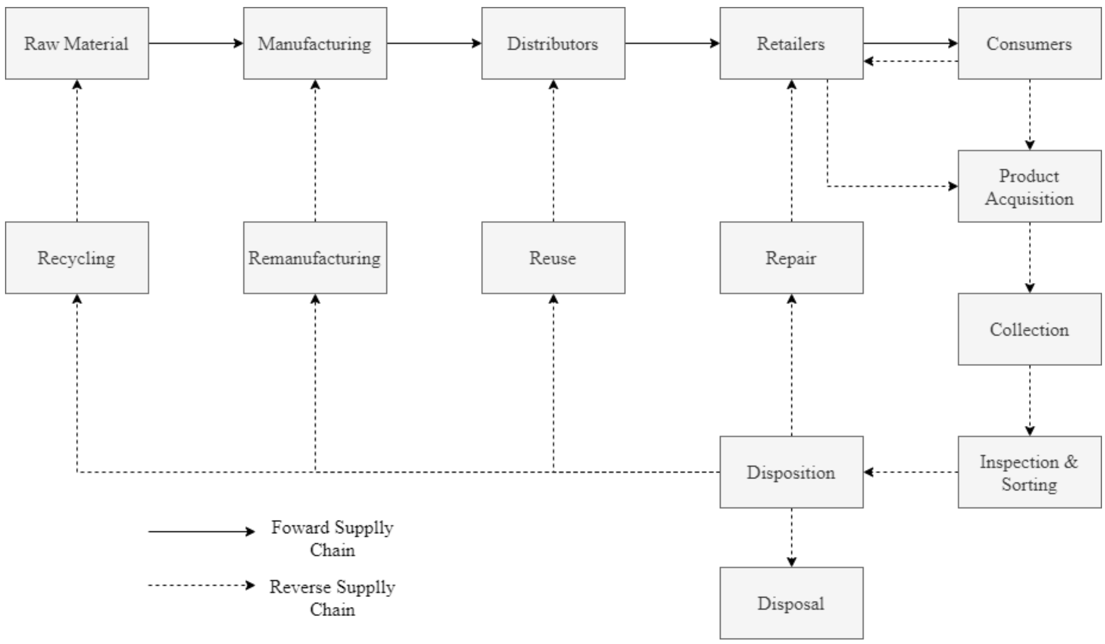
The organizations need to analyze their production system in terms of waste generation, and material, energy, water consumption. A material flow analysis can be a useful tool to support the implementation and monitoring of circular economy strategies (KALMYKOVAA; SADAGOPAN; ROSADO, 2018; GOULD; COLWILL, 2015). The circular economy implementation enable economic model operates in the line of materials, water and energy cycling principles that respect the limits of natural systems (ZHU; GENG; TAI, 2010).

Distribution and Reverse Logistics

The life cycle considers two stages that involve logistics and transportation: distribution and reverse logistic. The links between logistics and circular economy, sometimes called circular logistics, is still unclear. Some researchers use to make the correlation of circular logistics with the term green logistics (SEROKA-STOLKA; OCIEPA-KUBICKA, 2019), which activities involves measure environmental impact of different forms of distribution, reduce energy consumption, and reduce and manage waste treatment (SBIHI; EGLESE, 2009). Some other related activities of green logistics fit the implementation of circular economy, such green packing and green transportation (SEROKA-STOLKA; OCIEPA-KUBICKA, 2019).

When planning the reverse logistic system, exemplified in Figure 3, organizations needs to take into account the viability of this process and how to optimize it. Some key factors that affect the financial performance of a take-back system in the product end-of-life include: type of resource loop, supply chain capabilities, business model, legislation, salary level, and homogeneity of returned products (BOCKHOLT et al., 2020). Factors that influence the performance of a reverse logistic, in especial, are several, such consumer behavior, business environment, existing practices, environmental conditions, supply chain integration, product value, reverse logistic costs, quantity and quality of returned product, and recapturing value (AGRAWAL; SINGH, 2019).

Figure 3 – Reverse logistics in a circular economy.



Source: Agrawal and Singh (2019).

Marketing and Sales

The studies of marketing for circular economy and how marketing contribute to achieve a circular economy is also unexplored (CHAMBERLIN; BOKS, 2018). One of the few works is the study of Chamberlin and Boks (2018) that investigate concerns and factors that affects consumer acceptance of circular value proposition, analyzing the online communication of retail companies that have circular product. The Table 4 presents the results of this study that correlated the main factors that influences consumer behavior with communication design strategies for circular products. Sometimes, consumers do not perceive the environmental gains of products; as a consequence, they do not attribute environmental factors as relevant to consume the product, which makes organizations do not explore the full potential of its circular business model and marketing strategies (ELZINGA et al., 2020).

Table 4 – Communication of design strategies based on consumer behavior.

Consumer Factor	Communication of the design strategy
Contamination/disgust/newness	Importance, playfulness, rephrasing and renaming, emotional engagement, empathy, personality, framing, choice editing
Convenience/availability	Encouragement, direction, simplicity, assuaging guilt, worry resolution
Ownership	Meaning, anchoring
Cost/financial incentive/tangible value	Encouragement, rewards, importance, first one free, scarcity, framing
Environmental impact	Transparency, simplicity, empathy, obtrusiveness, meaning, framing, emotional engagement, importance, assuaging guilt, direction
Brand image/design/intangible valu	Meaning, storytelling, empathy, mood, color associations, importance, emotional engagement, scarcity, prominence, obtrusiveness, expert choice, social proof
Quality/performance	provoke empathy, meaning, storytelling, personality, importance, scarcity, expert choice, direction, emotional engagement, worry resolution
Customer service/supportive relationships	Encouragement, tailoring, transparency, emotional engagement, metaphors, provoke empathy, assuage guilt, reciprocation, importance
Warranty	reciprocation, assuaging guilt, worry resolution, obtrusiveness, metaphor, importance
Peer testimonials/reviews	social proof, storytelling, provoke empathy, expert choice, importance, worry resolution

Source: Chamberlin and Boks (2018).

Use

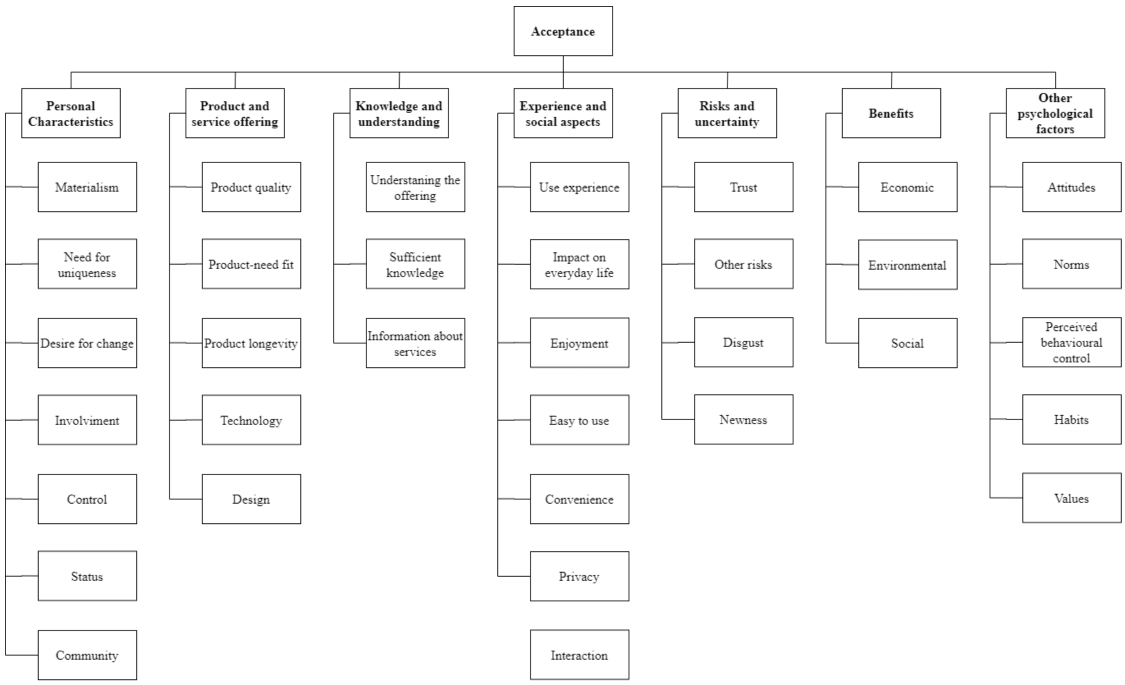
The implementation of circular economy in the use phase of a product life cycle takes into account the needs of users and their behaviors. The consideration of consumers' behaviors and their needs is essential for a correct design of products and business model, and to explore all the potentials of circular economy (KIRCHHERR et al., 2018, 2017; LEWANDOWSKI, 2016).

The acceptance of circular economy solutions has a directly dependence on consumer's personal characteristics that influence their perception, such personality traits, values, and ideologies (CAMACHO-OTERO, BOKS; PETTERSEN, 2018). For this reason, it's important to understand the customers for who the circular solutions are being proposed, also consider the involvement of potential consumers in the solution design. Design thinking can be a powerful tool to support this task and identify customer's needs (HANKAMMER et al., 2019) and need to be more explored as a pathway for circular economy. Geissdoerfer, Bocken and Hultink (2016) developed on of the first works linking design thinking with this topic, exploring the design of sustainable business model innovation.

The level of knowledge and understanding of the offering that is being proposed, and also the psychological factors like attitudes, affects the intention to purchase the product or service (CAMACHO-OTERO, BOKS; PETTERSEN, 2018). The resistance of customers in change their behaviors lead organizations to avoid incentives to implement circular economy (LIU; BAI, 2014). The manner of how consumers pay for a product is intrinsically linked with the habits and behavior and, for this reason, has an important role to determine the success interaction with the organization's circular business models (ELZINGA et al., 2020).

To clarify the acceptance of circular products, Camacho-Otero, Boks and Pettersen (2018) studied the main themes and factors that influence the consumption and acceptance of such products, which is presents in Figure 4.

Figure 4 – Main factors that influence the acceptance of circular products.



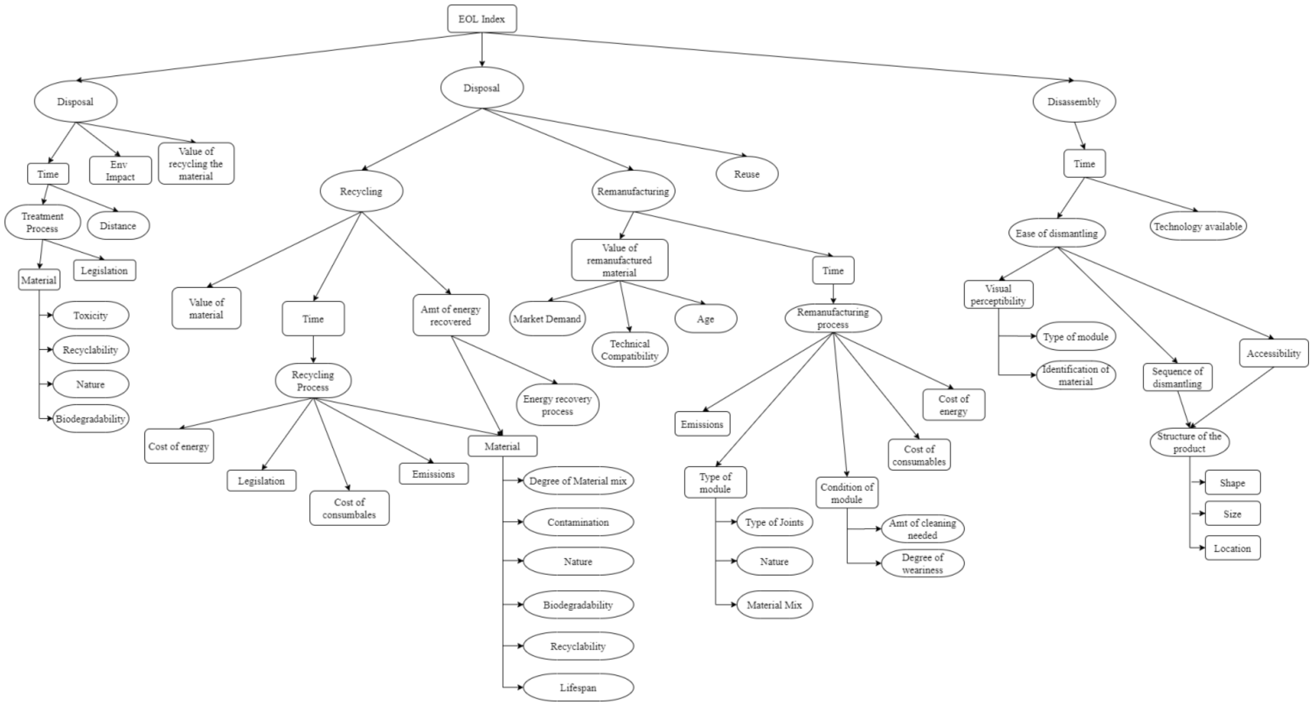
Source: Camacho-Otero, Boks and Pettersen (2018).

From a practical perspective, Wastling, Charnley and Moreno (2018) developed a framework to support the Design for Customer Behavior, which help designer build the right product or service that fits customers' needs and behaviors. The framework is composed by three stages: User research, which goal is to understand the users and how they interact with the product; Design, aiming to develop the product intervention strategies and the aspects of the business models that contribute to encourage the behavior; and Test, focusing in analyzes how effective the product is in changing the behavior.

End-of-Life

The end-of-life is other crucial stage in the product life cycle. The phase involves the loop strategies already pointed out, such maintenance,, repair, reuse, remanufacturing and recycle (ELLEN MACARTHUR FOUNDATION, 2013b) Lee, Lu and Song (2014) developed an end-of-life index to support designers identify weak points, risks and feasibilities when the product get in this stage, as presented in Figure 5.

Figure 5 – Main factors that affects the EoL strategies.



Source: Lee, Lu and Song (2014).

3.2.2 Circular business models, stakeholders and business organization

Circular economy requires collaboration among different stakeholders (BROWN; BOCKEN; BALKENENDE, 2019) that play important roles in the adoption of circular economy principles by organizations (LIEDER; RASHID, 2016; PRIETO-SANDOVAL et al., 2019). Gather new generic business skills and knowledge from external stakeholders is important to the successful implementation of circular initiatives (RUSSELL; GIANOLI; GRAFAKOS, 2019).

A wide range of stakeholders, such consumers and users, designers, academics, investors, policy makers, and manufacturers, are directly and indirectly interact with a product during its life cycle and should be engaged during the pathway to circular economy (RSA, 2013). The involvement of customers can help organizations better design their circular business model and more effectively deliver the value proposition and capture value from customers (URBINATI et al., 2020).

A key action is, by means of business model, create value for all stakeholders (CNI, 2018). The business model describes the rationale of how an organization creates, delivers and captures value (OSTERWALDER; PIGNEUR, 2010, p. 14). Circular business models are ground on the circular economy concept (OGHAZI; MOSTHAGEL, 2018) and focus on the preservation of resources and the circulation of products and materials in closed loop supply chains (KIRCHHERR; REIKE; HEKKERT, 2017). This variance of business model aims to create value for different stakeholder while maintain environmental and social-effective business activities (HOFMANN et al., 2017).

In the same way as for circular economy concept, there are a variety of definitions mentioned in the literature, as shown in Table 5. Some authors defined circular business models according to the specific scope of a thematic, such the case of Nussholz (2017) that explore the link with resource efficiency.

Table 5 – Circular business model definitions.

Consumer Factor	Communication of the design strategy
Frishammar and Parida (2019)	A circular business model is one in which a focal company, together with partners, uses innovation to create, capture, and deliver value to improve resource efficiency by extending the lifespan of products and parts, thereby realizing environmental, social, and economic benefits
Oghazi and Mosthagel (2018)	The rationale of how an organization creates, delivers, and captures value with slowing, closing, or narrowing flows of the resource loops
Hofmann et al. (2017)	A Circular business model describes the rationale of how an organization creates, offers, and delivers value through the structured linkage of various elements while minimizing ecological and social costs in order to achieve the goals of strong sustainability. Only the integration in a circular business network enables organizations to contribute to closing material and product loops
Nussholz (2017)	A circular business model is how a company creates, captures, and delivers value with the value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts (e.g., through long-life design, repair and remanufacturing) and closing material loops
Linder and Williander (2015)	A business model in which the conceptual logic for value creation is based on utilizing the economic value retained in products after use in the production of new offerings
Mentink (2014)	A circular business model is the rationale of how an organization creates, delivers and captures value with and within closed material loops

Source: Own authorship.

Oghazi and Mosthagel (2018) simplify the definition by combining the resource loop strategies (BOCKEN et al., 2016) with the concept provided by Osterwalder and Pigneur (2010). For Hofmann et al. (2017) and Frishammar and Parida (2019), the concept of circular business model is directly linked with achievement of a sustainable development.

The ways to implement circular business model into companies are still unclear, but some authors have made some efforts to clarify this pathway (URBINATI; CHIARONI; CHIESA, 2017). One of the first steps to transit from a linear to circular is to assess opportunities for innovation in business models (CNI, 2018). The transit to a circular business models needs also to start for the understanding of how much the business model is already circular and how level of circularity the organization aim to achieve (MENTINK, 2014).

The core component of a circular business model is the value proposition (LEWANDOWSKI, 2016). There are four simple principles of circular value creation for product, components and materials (ELLEN MACARTHUR FOUNDATION, 2013b): inner cycle; keep in tighter cycles, circling longer, which means keep them in longer cycles of use; cascaded use and inbound material/product substitution, cascading across different product categories; and pure, non-toxic, or easier-to-separate inputs and designs.

Numerous frameworks in the literature focused in design circular business models. Bocken et al. (2019) reviewed the circular business model innovation tools to support organizations in this transition and also proposes a checklist with criteria to development of those tools to guide researches design new ones. According to Urbinati, Chiaroni and Chiesa (2017), there are two major dimensions that need to be considered in a circular business model: the value network; and the customer value proposition and interface. The first-dimension remits how organizations interact with suppliers and organize internal activities. The second is related how organizations use circular economy to propose value for customers.

Lewandowski (2016) states that a circular business model should include the description of the take-back system used by the organization to close the loop, and internal and external factors that interferes in the success of the implementation, such organizational capabilities, technological, political, sociocultural and economic factors. The authors presented some considerations that guide organizations during the design of circular business model, as presented in Figure 6.

From an organization perspective, circular economy implementation requires changes management and system transformation (PERALTA; LUNA; SOLTERO, 2019), and a leadership engagement to starts a behavior change in a circular economy vision (LIU; BAI, 2014). The initiatives need a management that is integrates both bottom-up and top-down

(LIEDER; RASHID, 2016; WINANS; KENDALL; DENG, 2017). Organizations should also consider the alignment between circular economy principles and business strategy to effectively perform the business model (GUSMEROTTI et al., 2019).

Figure 6 – Components to be considered in circular business model development.

<table>
<tr>
<td rowspan="3">Partners
• Cooperative network
• Types of collaboration</td>
<td>Activities
• Optimizing performance
• Product Design
• Lobbying
• Remanufacturing, Recycling
• Technology Exchange</td>
<td rowspan="3">Value Proposition
• PSS
• Circular Product
• Virtual service
• Incentives for customers in Take-Back System</td>
<td>Customer Relations
• Produce on order
• Customer vote (design)
• Social-marketing strategies and relationships with community partners in Recycling 2.0</td>
<td rowspan="3">Customer Segments
• Customers types</td>
</tr>
<tr>
<td rowspan="2">Key Resources
• Better-performing materials
• Regeneration and restoring of natural capital
• Virtualizaion of materials
• Retrieved Resources (product, components, materials)</td>
<td>Channels
• Virtualization</td>
</tr>
<tr>
<td>Take-Back System
• Take-Back management
• Channels
• Customer relations</td>
</tr>
<tr>
<td colspan="2">Cost Structure
• Evaluation Criteria
• Value of incentives for customers
• Guidelines to account the costs of material flow</td>
<td colspan="3">Revenue Streams
• Input-based
• Availability-based
• Usage-based
• Performance-based
• Value of retrieved resources</td>
</tr>
<tr>
<td colspan="5">Adoption Factors
• Organizational capabilites
• PEST factors</td>
</tr>
</table>

Source: Lewandowski (2016).

The structure of an organization has directly influence in its behavior in implementing circular economy (LIU; BAI, 2014). The authors suggest that the structure needs to be aligned and promote the ways to move in the transformation; otherwise, this can be hampered by inefficient bureaucracy that bars the implementation of circular economy. In terms of financial activities, the organizations needs to destine enough resources for circular economy project, as the level of investment and quantity of available resources is directly related to the achievement of the circular economy, considering both internal and external sources (ARANDA-USÓN et al., 2019). The organizational structure of an organization and the manner of how resources are distributed and allocated may hamper the implementation of circular economy due to low incentives in the budgetary system that do not provide sufficient financial or human resources to perform it (LIU; BAI, 2014).

Also, from a social perspective, Fortunati, Martiniello and Morea (2020) state that the integration of circular economy with corporate social responsibility brings benefits for organizations, such enhance company’s image, improve investors’ interest, improve employee’s loyalty, and attract new investors.

Circular economy practices are an alternative to put in practice all the solutions across the value chain. Some authors call circular economy practices (MASI et al., 2018; GENG; TAI, 2010; SU et al., 2010; ZHU), while others prefer the term strategies (KALMYKOVA; SADAGOPAN; ROSADO, 2018; BOCKEN et al., 2016). Despite the term, circular economy has several ways to be implemented across the value chain, as can be seen in Table 6.

Table 6 – Circular economy toolbox with strategies for value chain implementation.

Value Chain Component	Circular Economy Strategy
Materials Sourcing	Diversity and cross-sector linkages Energy production/Energy autonomy Green procurement Material substitution Taxation Tax credits and subsidies Extraction of bio-chemicals Functional recycling High quality recycling Industrial symbiosis Restoration Upcycling
Design	Customization/made to order Design for disassembly/recycling Design for modularity Eco design Reduction
Manufacturing	Energy efficiency Material productivity Reproducible & adaptable manufacturing
Distribution and Sales	Optimized packaging design Redistribute and Resell
Consumption and Use	Community involvement Eco-labelling Product as a service or Product Service System Product labelling Reuse Sharing Socially responsible consumption Stewardship Virtualize
Collection and Disposal	Extended Producer Responsibility (E.P.R) Incentivized recycling Logistics/Infrastructure building Separation Take-back and trade-in systems
Recycling and Recovery	By-products use Cascading Downcycling Element/substance recovery Energy recovery
Remanufacture	Refurbishment/Remanufacture Upgrading, Maintenance and Repair
Circular Inputs	Bio-based materials

Source: Adapted from Kalmykova, Sadagopan and Rosado (2018).

Kalmykova, Sadagopan and Rosado (2018) has a pioneer work in this line by defining a toolbox with strategy to implement circular economy across the value chain, stablishing correspondence between the strategies and the value chain stage. The toolbox covers strategies for material sourcing, design, manufacturing, distribution and sales, consumption and use, collection and disposal, recycling and recovery, remanufacture and circular inputs, as presented in Table 6.

Circular economy implies the implementation of cleaner production and eco-design practices (GHISELLINI; CIALANI; ULGIATI, 2016; SU et al., 2013). For Mura, Longo and Zanni (2020), circular practices are related to waste management, packaging, supply chain, and product design strong contribute for closing-the-loop of material flows. Masi et al. (2018) state that such practices are more commonly driven by economic concerns rather than environmental one, which implies in the preference for the ones that bring a short Return on Investment. Selling of sub-products, reduction of water, energy and raw material consumption are some practices that are ground on cost savings and, consequently, driven by economic factors (ORMAZABAL et al., 2018). The managerial practices apply by an organization affects the degree of circularity achieved by them (URBINATI et al., 2020) and are crucial for the design of circular business models (CENTOBELLI et al., 2020).

3.3 Barriers and Drivers for Circular Economy Implementation

The exploration of barriers and drivers helps organizations to design strategies to overcome these factors and move to a circular economy (KUMAR et al., 2019). The barriers and drivers vary from organization to organization, which requires a study of their own internal and external business environments to identify the most relevant ones to take into consideration when designing a circular business model (TURA et al., 2019). Different sources classified circular economy barriers and drivers into environmental, economic, social, institutional, infrastructural, technological, informational, supply chain, organizational, and market factors (KUMAR et al., 2019; TURA et al., 2019; VERMUNT et al., 2019; MASI et al., 2018).

The Table 7 presents a sample of barriers reported by organizations that tried to implement circular economy strategies, classified in the major categories suggested by the Tura et al. (2019). Integration is a problem for circular economy implementation, being mainly represented by the links between sustainability and business development; products, services and systems; functional domains and departments; hierarchical levels; relevant actors along the value chain (RITZÉN; SANDSTRÖM, 2017).

Table 7 – Barriers for circular economy in micro level of implementation.

Category	Barrier
Economic	- High initial investment costs - Scarcity of raw material, assets or infrastructure - Dominance of economic indicators in decision making
Social	- Region-specific and (local) cultures hamper the implementation of new solutions - Conservativeness in business practices - Lacking or uncertain customer needs
Institutional	- Region-specific laws and regulations against circular economy solutions - Conflicts of interest and fluctuations in taxes and governmental subsidies - high future uncertainty
Technological and informational	- Increased technical difficulty in handling circular economy material flows - Lack of compatible technologies and high technological uncertainty - Lack of practices and systems for collecting, sharing and utilizing circular economy information
Supply Chain	- Conflict of interest, values and modes of operation between different stakeholders - No clear responsibilities and ownerships in circular economy projects - Validating and verifying all environmental effects is a challenge for transparency and analytics
Organizational	- Incompatibility with existing (linear) operations and development targets - Conflicts with existing business culture - Silo thinking and fear of risks

Source: Tura et al. (2019).

Especially for the SMEs context, Rizos et al. (2016) found that administrative burden, in consequence of the transit to a circular model, lack of supply chain support due to limited capacity of negotiation, technical know-how and limited resources and time to acquire new skills, and lack of capital are the main barriers for these companies.

Kumar et al. (2019) reported that company's culture, cost of investment in technologies, lack of willingness of management and personnel expertise on circular economy are some factors. Gusmerotti et al. (2019) suggest that economic and financial factors are one of the most important that increase the probability of a company adopts circular economy; thus, the implementation across the value chain requires external financial support throughout each stage (RUSSELL; GIANOLI; GRAFAKOS, 2019).

Firms have difficult in all the value stream of circular business model (OGHAZI, MOSTAGHEL, 2018). In value capture, organizations seem to have difficult to set new revenue model, even concerning the need for new one. In terms of value creation, a difficult is to build concrete relationships with partners; while in value proposition firms have difficult to set new sustainable offerings. Vermunt et al. (2019) explored barriers for different types of circular business models. Their results show that: PSS model faces the most organizational and financial barriers; resource recovery and circular supplies models have the most technological barriers, especially in consequence of recycling and changes in production processes to fit the input of circular materials. It was also reported that institutional barriers is highly important for resource recovery business model due to waste legislation.

Govindan and Hasanagic (2018) reviewed the main barriers, drivers and practices for companies in the context of supply chain. Their results show that the main drivers are potential job creation, climate change and population growth, while the main limitations are technologies for a durable design, lack of enthusiasm along the supply chain and difficult to manage product in the life cycle. Increasing the value of products by increasing quality and improve efficiency of materials and energy use in supply chain are also drivers for circular economy in the supply chain context. Financial and technological challenges are present in supply chain when actors are depended for discarded products or materials (VERMUNT et al., 2019).

Considering the drivers for circular economy, the Table 8 presents the drivers proposed by Tura et al. (2019). Rizos et al. (2016) explored the drivers in the context of SMEs, founding that company environmental culture, networking, support from demand network, recognition, personal knowledge and government support are factors that enable the implementation of circular economy.

Table 8 – Drivers for circular economy in micro level of implementation.

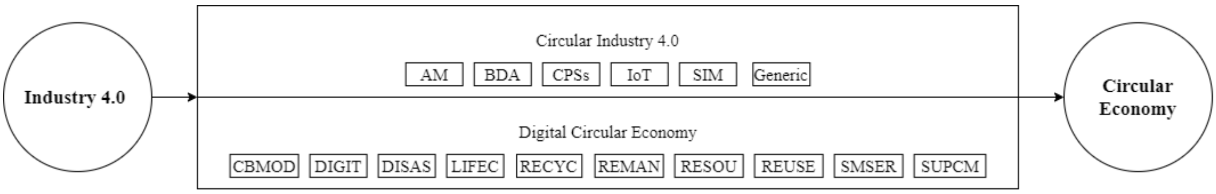
Category	Driver
Environmental	- Global trend to minimize negative environmental impacts Resource scarcity
Economic	- Cost savings - Potential to create value from waste and production side streams - Potential for new service business development
Social	- Increasing awareness of sustainability needs - Increased external demand for sustainability - Societal development projects e.g. industry roadmaps supporting sustainable development
Institutional	- Directing laws and EU regulations create a demand for new solutions - ISO-standard development for solid recovered fuels
Technological and informational	- Emerging process technologies support circular economy business - Enhanced information sharing and management technologies support the creation of new services, increase transparency and enable more efficient processes
Supply Chain	- Increasing the transparency of the supply chain - Increased availability of knowledge and technological resources through collaboration
Organizational	- Circular economy innovations foster a sustainable company brand - Changed organizational structure, strategy and culture to support circular economy - Development of skills and capabilities for circular economy - Flexible decision making and product/service development models

Source: Tura et al. (2019).

A driver that has gained attention is the technological ones. Information Technology has a core role in the circular economy transformation (TURA et al., 2019), especially the industry 4.0 technologies that drive the lifecycle management of products (ROSA et al., 2020). Organizations can make use of Big Data collected by IoT and processed by Analytics technologies to better understand their customer and delivery a product that fits their expectations (BRESSANELLI et al., 2018), playing an important role in the value capture and value creation for circular business models (URBINATI et al., 2020; CENTOBELLI et al. (2020).

The industry 4.0 technologies allow organizations enhance the performance monitoring, predictive maintenance and service recovery (RAJPUT; SINGH, 2019). The Figure 7 presents a diagram exploring the main technologies and the circular economy characteristics that is most affected by those technologies.

Figure 7 – Connections between circular economy and industry 4.0.



AM: *Additive Manufacturing*; BDA: *Big Data and Analytics*; CPSs: *Cyber-Physical Systems*; IoT: *Internet of Things*; SIM: *Simulation*; Generic: *Any 14.0 technology*; CBMOD: *Circular Business Models*; DIGIT: *Digital Transformation*; DISAS: *Disassembly*; LIFEC: *Lifecycle Management*; RECYC: *Recycling*; REMAN: *Remanufacturing*; RESOU: *Resource Efficiency*; REUSE: *Reuse*; SMSER: *Smart Services*; SUPCM: *Supply chain Management*. Source: Rosa et al. (2020).

The IoT sensors also drive the implementation of reverse logistics system and monitoring of end-of-life products (BRESSANELLI et al., 2018). This technology is helping organizations improving data collection and sharing resource consumption and materials wastage. Bressanelli et al. (2018) pointed out eight functionalities of digital technologies that contribute to the moving for a circular economy:

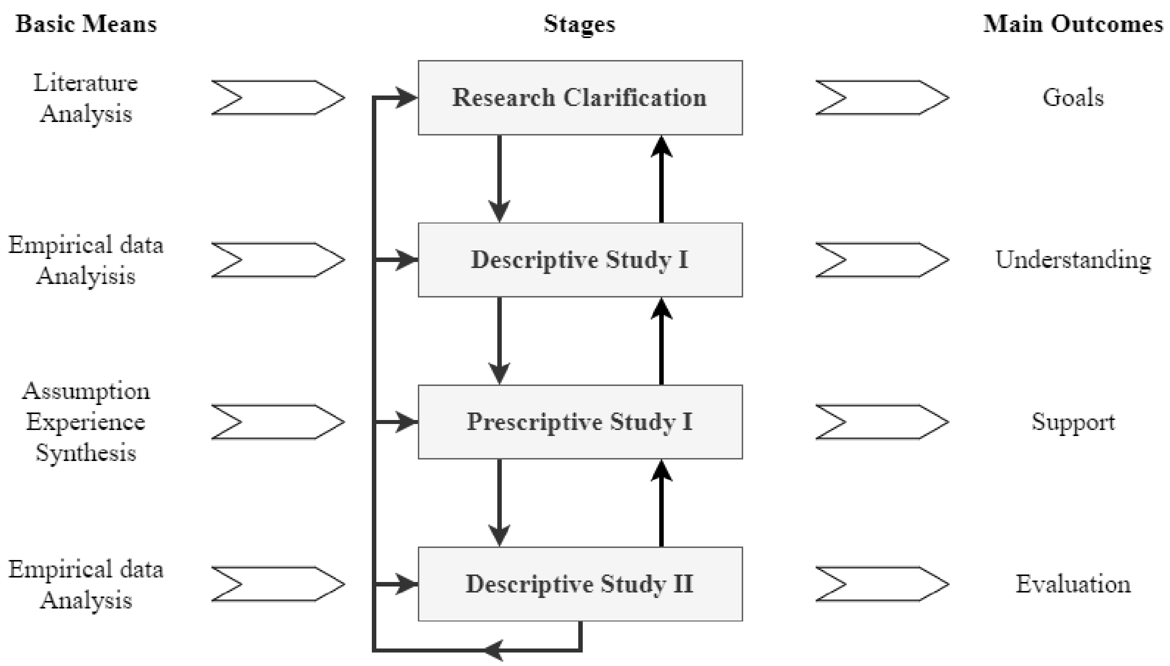
a) Improving product design by prolonging product life cycle and closing the loop;
b) Enhancing marketing activities by attracting target customer segments;
c) Allowing the monitoring and tracking of product activity;
d) Facilitating the provision of technical support;
e) Allowing the provision of preventive and predictive maintenance;
f) Optimizing the product usage;
g) Enhancing product upgrading;
h) Improving the execution of renovation and end-of-life activities.

4 METHODOLOGY

This section aims to describe the methodology used to conduct the research presented in this document. The development of a theoretical step-by-step to implement circular economy into organizations based on circular practices and circular business models require an extensive literature review to cover the maximum of information current available, starting by a validation of the gap in the literature. To achieve this goal, the approach called Design Research Methodology (DRM), proposed by Blessing and Chakrabarti (2009), was adopted.

The DRM, illustrated in Figure 8, consists in 4 iterative stages that cover the entire life cycle of a design research: Research Clarification, Descriptive Study I, Prescriptive Study I, and Descriptive Study II. The dark-grey arrows from stage to stage represent the main flow of the methodology, while the bold ones represent the reverse flow, i.e. iteration possibilities that reinforcing the cyclical and iterative nature of this methodology. Other components of the framework are the left and right columns that describe, respectively, the basic means used to execute the stages and the main outputs from a specific stage.

Figure 8 - Design Research Methodology flow.



Source: Adapted from Blessing and Chakrabarti (2009).

According to Blessing and Chakrabarti (2009), the Research Clarification stage is the moment in which the researcher searches for evidences and indicators that give support for its assumptions in order to formulate a realistic and justifiable research goal. These findings allow the researcher stablishes a reference model composed by a clear description of the current situation related to the task and the desired future scenario. As outputs, the researcher defines the research focus and goals, the main research problem, questions and hypothesis, and the relevant areas to be covered in the descriptive study I (CONFORTO; AMARAL; SILVA, 2011; BLESSING; CHAKRABARTI, 2009)

In the second stage, Descriptive study I, the researcher conduct a literature review to have a better description of the current situation in order to understand which are the main factors that should be addressed in the prescriptive stage and then improve the current situation. The literature review can also be accompanied with empirical studies when few contributions are found in literature. At the end of this stage, the researcher has a complete reference model.

During the Prescriptive Study I, the researcher starts the development of the desired situation description, translated it into a vision of how addressing the key factors of the current situation would result in the improved situation. Several scenarios may be developed and evaluated to select the most feasible to improve the current situation. As an output, the researcher defines the proposition description to achieve the desired situation.

In the last stage, Descriptive Study II, the researcher investigates the impact of the proposition and its ability to achieve the desired situation. According to Blessing and Chakrabarti (2009), the researcher should perform two investigative studies: one to evaluate the applicability of the proposition, and other to evaluate the proposition usefulness to solve the problem and achieve the expected impact and the desired situation. At the end, the researcher has the results of the proposition evaluation and improvement implications to better achieve the desired situation.

Applying the DRM for this study, in the research clarification stage, a literature review was conducted in order to validate the gap in the literature in terms of a circular economy implementation step-by-step with toolkit that covers all the components of a value chain. Facing a situation in which none current methods cover all these fields at the same time, this research gap (problem) was validated. Based on the gap, 4 research questions were defined:

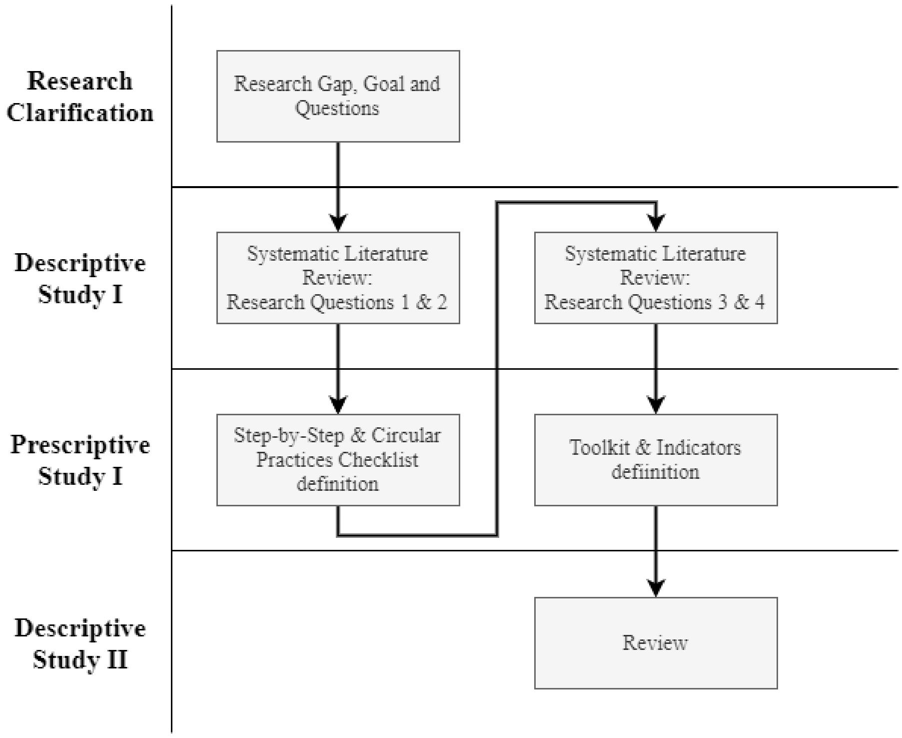
a) **Research Question 1:** What are the actions to be taken in order to implement circular economy in organizations considering its entire value chain?
b) **Research Question 2**: What are the practices adopted by organizations to support the implementation of circular economy in the value chain?
c) **Research Question 3:** What are the indicators to assess the organization’s current state to support the implementation of circular economy?

d) **Research Question 4:** Which methods and tools support the execution of actions to implement circular economy in organizations considering its value chain?

To accomplish the goal in its entirety, the research was separated in two stages: the first one to define the steps to implement circular economy and the circular economy practices; and the second one to define the methods and tools (the toolkit) to implement the steps previously stablished and the circular indicators to provide quantitative and qualitative data to support the identification of opportunities for circular economy. Following this approach, the Research Questions 1 and 2 were covered in the first stage, while the Research Questions 3 and 4 in the second stage.

This approach is justified as the indicators and methods and tools are entirely depended on the steps found in the literature, i.e. to provide quantitative and qualitative analysis about the steps (indicators) and to show and execution option (methods and tools). The circular practices, in turn, are not dependent as they are used to define the new circular initiatives to be taken by the organization. The Figure 9 illustrates the research flow in the DRM context, reinforcing the iterative nature of the DRM.

Figure 9 – Research flow according to DRM approach.



Source: Own authorship.

In the Descriptive Study II, a systematic literature review (SLR) was used to come up with a better description of the current situation of circular economy implementation step-by-step. However, this systematic review was limited only for the Research Questions 1, 2 and 3. The reasons for this approach remits from unviability to systematically review all methods and tools for all the stage of the step-by-step. On the other hand, the indicators to be identified are restricted only to scope of the organization's current state assessment in order to provide quantitative and qualitative analysis, i.e. in a restrict number of steps.

To conduct the SRL, the roadmap proposed by Conforto, Amaral and Silva (2011) was followed. In a first moment, the authors suggest the definition of the primary sources of publications, strings for searches and criteria of inclusion. In terms of primary sources, the Web of Science and Scopus platforms were selected as the means to perform the review due to their wide database. Also, to complement these data sources, a review on the grey literature was also made to increase the range of publications covered by this study. Based on the Research Questions 1, 2 and 3, the strings presented in Table 9 were defined, filtering the search by title, abstract and keywords to select the most relevant publications in the light of the research questions.

Table 9 - Strings used to perform the searches.

Research Question	String
1 - Implementation	("circular economy" OR "circular business model") AND ("Framework" OR "method" OR "methodology" OR "step-by-step") AND ("implementation" OR "application" OR "adoption")
2 - Practices	("circular economy" OR "circular business model") AND ("practices")
3 - Indicators	("circular economy" OR "circular business model") AND ("indicator" OR "measures")

Source: Own authorship.

The searches and reading were separated in three stages (filters) as recommended by Conforto, Amaral and Silva (2011). In the first stage, the reading focused on title, abstract and keywords. In the second stage, the reading focused on these three parts plus introduction and conclusion. Finally, the remaining publication was entirely read to define the ones to carry on. This approach aim to save time focusing in the publications that are most related to the scope of the research questions (CONFORTO; AMARAL; SILVA, 2011).

To select the final findings during the last stage (filters) of the SLR, the inclusion criteria described in Table 10 were defined to standardize the publications selection and to keep focus on the research questions. For the filters one and two, none of the inclusion criteria described on the Table 10 were applied in order to avoid loss of publications that may fulfill the scope of this study. The criteria were applied during the three reading stages. At the end of the publication selection, the findings of all three searches were extracted and organized in a spreadsheet including: name of authors and year of publication; title; and description of main finding. For the indicators, the formulas and variables were also considered.

Table 10 - Inclusion criteria to select the publications.

Research Question	Criteria
1 - Implementation	1. Include an end-to-end sequence of steps to implement circular economy; 2. Specify the actions to be taken to execute the step.
2 - Practices	1. Include practices that are described as circular economy related.
3 - Indicators	1. Include indicators related to circular economy; 2. Include all the equations and resources to apply the indicator; 3. Present indicators related to the scope of the assessment stage of the step-by-step.

Source: Own authorship.

For the Research Question 4, an exploratory literature review was made. Several searches were conducted to cover specifically each step of the step-by-step previously defined, which means a wide range of different strings. The searches had as inclusion criteria methods and tools that have: full capacity to implement the step to which the method/tool is related; a clear explanation about how to complete the execution; and all the resources required to execute the method/tool being available.

In the first Prescriptive Study, the step-by-step and the circular practices checklists (Appendix 1 to 4) were defined based on the findings. The findings were summarized in the spreadsheet to define the last disposition, which included merging of steps or practices and re-organization to achieve the expected result. All the information present on the findings were considered in the final step-by-step. Thus, none criteria were defined to choose which information include in the final version. In the second Prescriptive Study, the toolkit and indicators (Appendix 6) were organized and placed into the step-by-step to come up with the final method. The same process of data curation was applied to achieve the expectations.

In order to validate if the step-by-step has a direct relationship with circular economy, the core components were paired with the main highlights of the circular economy definitions and principles identified from the literature. This approach aims to identify if the step-by-step is really aligned with circularity and understand which components may be missing. The last phase of the DRM, i.e. empirical studies to investigate the applicability and usability to solve the research problem, is represented by a case study with a company to validate the proposed step-by-step. However, this application is not covered by this study due to limitation of available time to conduct this research. Future works will focus specifically on this task.

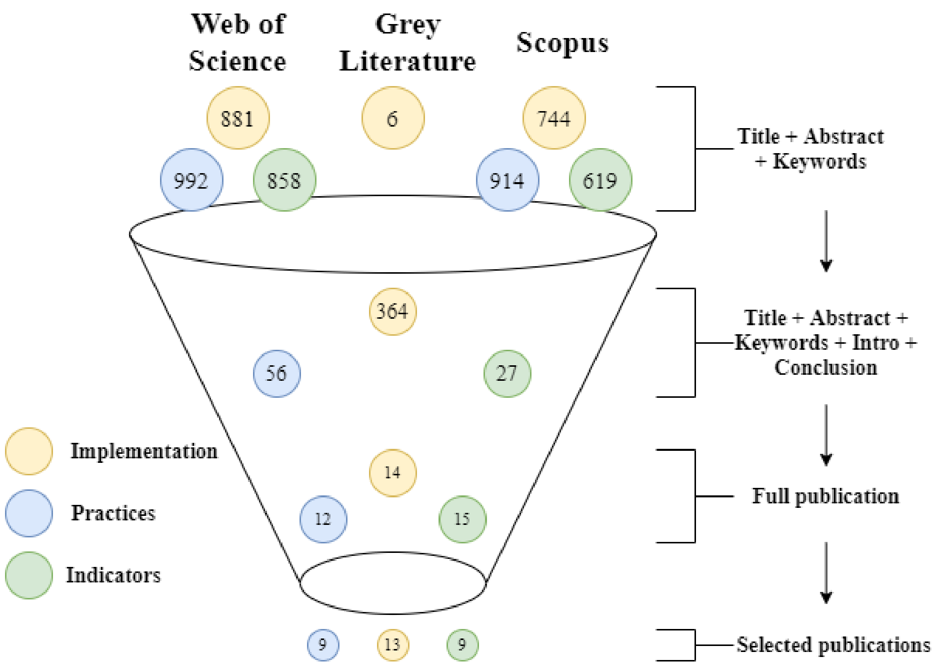
5 RESULTS

This section describes the results of this research, first presenting the outputs of the SLR (5.1), followed by the introduction of the step-by-step to implement circular economy and correlation with circular economy main highlights (5.2), and ended with an in-depth description of the step-by-step including the toolkit and indicators (5.3).

5.1 Systematic Literature Review Results

The Figure 10 describes the results from the SLR including the number of publications and the progressive selection until the final definition of the ones to carry on.

Figure 10 - Results of the systematic literature reviews.



Source: Own authorship.

Based on the Research Question 1 and the findings from the literature review, 13 publications (four from grey literature), among articles, standards and platforms, were selected to build the step-by-step to implement circular economy in organizations, here called as Journey for Circular Transformation. This name brings the idea that a transformation in an organization is needed to move from linear to circular. This transformation involves not only the product or service sphere, but the entire organization and its value chain, including mindset, culture, business model, etc. The idea of this transformation is better illustrated in the section 5.3 of this monography.

The Table 11 summarizes these sources. Among the 13 findings, three of them focus specifically into higher education institutes and universities, two in SMEs and the other 8 in general businesses applications. The work of Jørgensen and Remmen (2018) focus on introducing the concept of circular economy journey as a process to map material relations, environmental life cycle, value chain and business relations to redesign a business in three different levels: product and services, value chain, and internal organization. The article of Dey et al. (2020), focusing on the implementation of circular economy in SMEs, counts with a framework in which circular economy life cycle stages (collect, make, distribute, use, recover) are linked with the three dimensions of sustainable development (environmental, social and economic). The authors included a checklist to assess the current state of a company in terms of circularity. The work of Peralta, Luna and Soltero (2019) focuses specifically in industrial products and services assessment for circular redesign, presenting a range of tools and indicators to support the identification of opportunities along the life cycle.

Table 11 - Findings about circular economy implementation.

Author	Title	Focus
Dey et al. (2020)	Circular economy to enhance sustainability of small and medium-sized enterprises	SMEs
Frishammar and Parida (2019)	Circular Business Model Transformation: A Roadmap for Incumbent Firms	Incumbent Companies
Mendoza, Gallego-Schmid and Azapagic (2019a)	A methodological framework for the implementation of circular economy thinking in higher education institutions: Towards sustainable campus management	Universities and Campus
Mendoza, Gallego-Schmid and Azapagic (2019b)	Building a business case for implementation of circular economy in higher education institutions	High Education Institutions
Peralta, Luna and Soltero (2019)	Towards standards-based of circular economy: knowledge available and sufficient for transition?	Industrial Business
Jørgensen and Remmen (2018)	A methodological approach to development of circular economy options in businesses	Business (general)
Antikainen et al. (2017)	Circular Economy business model innovation process – case study	Business (general)
BSI (2017)	Framework for implementing the principles of the circular economy in organizations – Guide	Business (general)
Mendonza et al. (2017)	Integrating Backcasting and Eco-Design for the Circular Economy The BECE Framework	Business (general)
WBCSD (2016)	Unlocking More Value with Fewer Resources A practical guide to the circular economy	Business (general)
Mentink (2014)	Circular business model innovation a process framework and a tool for business model innovation in a circular economy	Business (general)
Joustra, Jong and Engelaer (2013)	Guided Choices towards a Circular Business model	SMEs
Ellen MacArthur Foundation and IDEO	The Circular Design Guide	Business (general)

Source: Own authorship.

The article of Mendoza, Gallego-Schmid and Azapagic (2019a) focuses on university and campus applications and contains a framework composed by a background analysis and a Plan-Do-Check-Act approach to implement new strategies for circular economy in a university. Mendonza et al. (2017) developed the BECE framework for circular economy implementation exploring the link between Backcasting and Eco-Design as strategies to promote the transformations. Adapting the BECE framework, Mendoza, Gallego-Schmid and Azapagic (2019b) developed a simple guide to implement circular economy thinking into higher education institutions, different of the one present in Mendoza, Gallego-Schmid and Azapagic (2019a).

Despite the other articles works with circular economy in general, the articles of Frishammar and Parida (2019), Antikainen et al. (2017) and Mentink (2014) focused on develop a framework for circular business model transformation. Both articles have similar approaches for business model redesign; however, the framework of the first authors has a strong link between circular economy and sustainability. Mentink (2014), in especial, also organized the framework considering the Plan-Do-Check-Act actions.

The other findings differ from these first ones by the nature of the publication. BSI (2017) is the standard 8001:2017 developed by the British Standardization Institute, being the first standard for circular economy implementation into business already published. The standard also presents a new set of circular principles that differs the ones proposed by Ellen MacArthur Foundation (2015). The Joustra, Jong and Engelaer (2013) guide follows a more instructive approach to support SMEs understand the circular economy concept and how it comes into practice. The World Business Council for Sustainable Development (WBCSD, 2016) reinforce the connection between sustainable development and circular economy implementation, also presenting business cases to clarify each step of the framework. Finally, the Circular Design Guide developed by Ellen MacArthur Foundation and IDEO is a website that presents methods and tools to support organizations design new circular economy initiatives with a strong focus on innovation. The framework is composed by four stages (understand, define, make and release), each one composed by six different methods.

For the SRL about the Research Question 2, nine articles that present circular economy practices were found, being eight original findings and one literature review, as presented in Table 12. In total, 158 circular economy practices were compiled into four checklists (Appendix 1 to 4) grouped into business model practices, product redesign practices, value chain redesign practices and internal organization redesign practices. This approach was adapted from the work of Jørgensen and Remmen (2018), adding the group of practices to redesign a business model into a circular one.

Masi et al. (2018), Urbinati et al. (2020) and Urbinati, Chiaroni and Toletti (2019) developed case studies with several organizations to empirically identify circular practices implemented by them. Zhu, Geng and Lai (2010) and Mura, Longo and Zanni (2020) first performed a literature review to build a questionnaire and, then, realize case studies with different organizations to measure the implementation of the identified circular practices.

Urbinati, Ünal and Chiaroni (2018), Sousa-Zomer et al. (2018) and Suáres-Eiroa et al. (2019) developed a literature review to build a framework/list with circular practices, without case studies. In other hand, the work of Govidan and Hasanagic (2018) covers a review about circular practices implemented by organizations.

Table 12 - Findings about circular economy practices.

Authors	Titles
Mura, Longo and Zanni (2020)	Circular economy in Italian SMEs: A multi-method study
Urbinati et al. (2020)	Circular business models in the European manufacturing industry: A multiple case study analysis
Suárez-Eiroa et al. (2019)	Operational principles of circular economy for sustainable development: Linking theory and practice
Urbinati, Chiaroni and Toletti (2019)	Managing the Introduction of Circular Products: Evidence from the Beverage Industry
Govidan and Hasanagic (2018)	A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective
Masi et al. (2018)	Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective
Sousa-Zomer et al. (2018)	Cleaner production as an antecedent for circular economy paradigm shift at the micro-level: Evidence from a home appliance manufacturer
Urbinati, Ünal and Chiaroni (2018)	Framing the Managerial Practices for Circular Economy Business Models: A Case Study Analysis
Zhu, Geng and Lai (2010)	Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications

Source: Own authorship.

The results from SLR about the Research Question 3 (Table 13) were nine articles composed by different circular indicators to provide qualitative and quantitative analyses to support the identification of opportunities in circular economy. A repository with 40 indicators for circular economy is presented in Appendix 6. Rossi et al. (2020) developed a full review of the current available indicators in the literature, pointing out the main advantages and disadvantages of each circular indicator. At the end, the authors proposed a set of indicators easy to implement and that cover material, economic and social aspects.

Table 13 - Findings about circular economy indicators.

Authors	Titles
Bracquené, Dewulf and Duflou (2020)	Measuring the performance of more circular complex product supply chains
Rossi et al. (2020)	Circular economy indicators for organizations considering sustainability and business models: Plastic, textile and electro-electronic cases
Bradley et al. (2018)	A total life cycle cost model (TLCCM) for the circular economy and its application to post-recovery resource allocation
Cullen (2017)	Circular Economy Theoretical Benchmark or Perpetual Motion Machine?
Linder, Sarasini and van Loon (2017)	A Metric for Quantifying Product-Level Circularity
Favi et al. (2016)	A design for EoL approach and metrics to favour closed-loop scenarios for products
Franklin-Johnson, Figge and Canning (2016)	Resource duration as a managerial indicator for Circular Economy performance
Di Maio and Rem (2015)	A robust indicator for promoting circular economy through recycling
Mathieux, Froelich and Moszkowicz (2001)	Development of recovery indicators to be used during product design process: method, potentialities and limits

Source: Own authorship.

Bracquené, Dewulf and Duflou (2020) developed a set of principles to measure the performance of complex product supply chains. Adapting the Material Circularity Indicator (MCI) proposed by Ellen MacArthur Foundation, the authors defined a Product Circularity Indicator (PCI) covering the gaps of the MCI mentioned by them, such as the tightness of material cycles and the relationship with other product systems. The Circularity Index (CI) proposed by Cullen (2017) aims to take into account quality (material degradation when recycled) and quantity (amount of recovered material) losses when reprocessing materials.

Linder, Sarasini and van Loon (2017) published the Product-level Circularity Metric aiming to quantify the total amount of product part that comes from used products.

Mathieux, Froelich and Moszkowicz (2001) proposed an indicator that expresses the fraction of the product that can be extracted to reuse, recycling and energetic recovery. Still in an EoL perspective, Favi et al. (2016) proposed four indicators to compare different EoL scenario, considering reuse, remanufacture, recycle and incineration.

In an economic perspective, Bradley et al. (2018) proposed a total life cycle cost model to estimate the cost of a product during the entire and multiple generation cycles of its life. Di Maio and Rem (2015) proposes an indicator to calculate the recyclability of a product based on the materials value. To support estimative of duration of product life cycle, Franklin-Johnson, Figge and Canning (2016) proposed an indicator to calculate how long a material is retained in a product system.

5.2 Step-by-Step Overview

To start the design the journey for circular transformation, it was necessary to first compile the steps present in each finding in preliminaries flows to have a better view of the step-by-step used/proposed by each author. These preliminary flows were organized in: 1) steps (a major action to be done), 2) description of the step, 3) actions (an micro view of what need to be done to conclude the step, may having one ore multiple actions), and 4) tools used to support the application.

After the first task, it was necessary to converge all the 13 flows created from the findings into a unique step-by-step. This was made by following the order of the steps in each flow and identifying the ones that are mentioned in multiple flows. Also, to increase the accurate of this process, it was considered the similarity of aims of two or more steps and groups them to ensure coherence within the step-by-step as a whole and a correct ordination.

The third action to build the journey for circular transformation was to merge the steps that have a similarity of aims in order to have a shorter step-by-step. By this process, the actions of two or more steps come together into a unique one to ensure none detail were lost. After this task, the final step-by-step was achieved. A full description of the steps and action to implement circular economy were described in the section 4.3.

Phases, here understand as a common characteristic that group a set of step, were introduced in the journey in order to break down the steps into different stages with common characteristics. The phases were an adaptation of the stages of each finding present in the Table 11. Based in the patterns identified in the final step-by-step, 9 phases were defined: 1) Understanding the Concept; 2) Defining Current Scenario, 3) Identifying Opportunities; 4) Proposing Solutions; 5) Evaluating solutions; 6) Testing and Prototyping; 7) Planning; 8) Implementing and Monitoring; and 9) Reviewing and Modifying. To conclude the journey for circular transformation, the toolkit organized with the Research Question 4, the list of indicators (Appendix 6) and the checklists of circular practices (Appendix 1 to 4) were added to the step-by-step.

The Table 11 presents a correlation matrix between the findings and the steps of the journey for circular transformation. The columns are composed by the authors that are selected to be the base of the step-by-step, and the lines are the steps. The interaction between the lines and columns were then filled with an “X” for the cases in which the author covers the step or any action mentioned in the description of the step (better described in section 5.3).

Figure 11 - Correlation matrix between authors and steps.

Phase	Step	Jørgensen and Remmen (2018)	Mendoza, Gallego-Schmid and Azapagic (2019a)	Mendoza, Gallego-Schmid and Azapagic (2019b)	Dey et al. (2020)	Mendonza et al. (2017)	Peralta, Luna and Soltero (2019)	Frishammar and Parida (2019)	Joustra, Jong and Engelaer (2013)	BSI (2017)	WBCSD (2016)	Ellen MacArthur Foundation and IDEO	Antikainen et al. (2017)	Mentink (2014)
1. Understanding the Concept	1.1 Understand circular economy and its relevance								X	X				X
2. Defining Current Scenario	2.1 Define a team		X	X		X			X	X		X		
	2.2 Assess the baseline		X	X	X					X	X			
	2.3 Identify potential barriers and drivers		X			X								
	2.4 Define the baseline and vision		X	X		X				X	X	X		
3. Identifying Opportunities	3.1 Map the stakeholders	X	X					X	X	X		X		
	3.2 Identify stakeholders' needs	X						X		X		X		X
	3.3 Identify customers' needs							X	X			X	X	X
	3.4 Assess competitors	X						X						
	3.5 Map the current business model							X	X				X	
	3.6 Assess the business model sustainability and circularity			X				X						
	3.7 Analyze external trends	X					X	X	X				X	X
	3.8 Explore design loop strategies				X				X		X	X		
	3.9 Explore design for PSS								X		X			
	3.10 Explore design for collaboration and sharing										X			
	3.11 Assess material selection	X			X		X					X		
	3.12 Assess inbound logistic				X						X			
	3.13 Assess material flow	X					X		X	X				
	3.14 Assess waste generation and management				X									
	3.15 Assess energy and water consumption				X									
	3.16 Assess Product Life Cycle					X	X			X	X			
	3.17 Assess the outbound logistic				X									
	3.18 Assess marketing and sales activities											X		
	3.19 Verify product usage and customer support	X										X		
	3.20 Understand the product EoL				X						X	X		

Continue in the next page

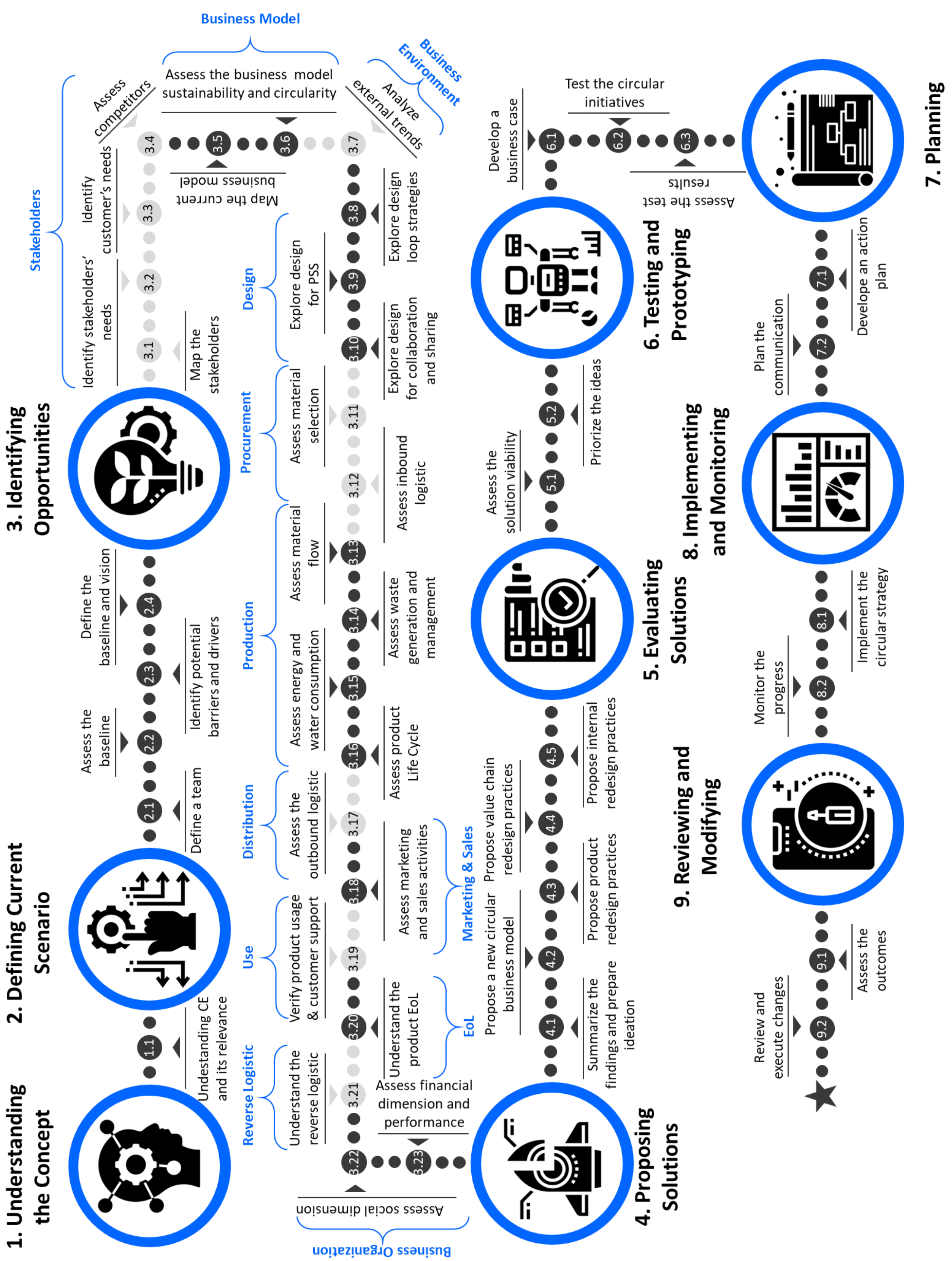
Continuation

Phase	Step	Jørgensen and Remmen (2018)	Mendoza, Gallego-Schmid and Azapagic (2019a)	Mendoza, Gallego-Schmid and Azapagic (2019b)	Dey et al. (2020)	Mendonza et al. (2017)	Peralta, Luna and Soltero (2019)	Frishammar and Parida (2019)	Joustra, Jong and Engelaer (2013)	BSI (2017)	WBCSD (2016)	Ellen MacArthur Foundation and IDEO	Antikainen et al. (2017)	Mentink (2014)
3. Identifying Opportunities	3.21 Understand the reverse logistic				X				X			X		
	3.22 Assess social dimension				X						X	X		
	3.23 Assess financial dimension and performance				X		X				X			
4. Proposing Solutions	4.1 Summarize the findings and prepare ideation	X			X					X				
	4.2 Propose a new circular business model			X				X		X		X	X	X
	4.3 Propose product redesign practices	X				X	X		X	X		X		
	4.4 Propose value chain redesign practices	X				X						X		
	4.5 Propose internal redesign practices	X						X		X		X		
5. Evaluating solutions	5.1 Assess the solutions viability					X				X	X	X		
	5.2 Prioritize the ideas				X					X		X		
6. Testing and Prototyping	6.1 Develop a business case		X							X				
	6.2 Test the circular initiatives		X			X		X		X		X	X	X
	6.3 Assess the test results						X			X				
7. Planning	7.1 Develop an action plan		X	X		X				X		X		
	7.2 Plan the communication											X		
8. Implementing and Monitoring	8.1 Implement the circular strategy		X	X		X		X		X	X			X
	8.2 Monitor the progress		X							X	X			
9. Reviewing and Modifying	9.1 Assess the outcomes	X								X				
	9.2 Review and execute changes		X					X		X		X		

Source: Own authorship.

From the Figure 11, a visual flow of the Journey for Circular Transformation, presented in Figure 12, was built. Based on the value chain presented in Figure 1, the steps of the Phase 3 (Identifying Opportunities) were grouped into those components: stakeholders, business model, business environment, design, procurement, production, distribution, marketing and sales, use, end-of-life, reverse logistic, and business organization.

Figure 12 - Journey for Circular Transformation.



Source: Own authorship.

The stakeholders' steps aim to identify the main actors that are directly and directly involved with the organizations and should be engaged. This include understand their needs and expectations. The business model's steps, in turn, provide an assessment of the organization's current business models, the gaps in terms of circularities and the customer's needs. The business components of the value chains, the business environmental step seeks to come up with the main external trends that affect the business. To conclude of business components that integrate the proposed value chain, the business organization's steps aim to assess organizational characteristics such financial, employees and socials aspects.

In terms of the product life cycle subsets, the design's steps assess different circular strategies to close, slow and narrow resource flow, and PSS feasibility. The procurement, in sequence, assesses the selection of materials and the logistics of raw materials. Next, the production's steps aim to understand the waste management, energy and water consumption, and the environmental impact of a selected product by means of a Life Cycle Assessment (LCA). The distribution step focus on assess the outbound logistic of the products, while the marketing and sales step aim to analyze the marketing strategies used by the organization. The use step of the Journey for Circular Transformation seeks to understand how the product interact with the consumer; while the EoL one focus on assess which strategy fits better for the organization to close the product life cycle. At the end, the reverse logistic steps focus more in understands the journey of different product's components and parts and their destination.

The Figure 13 presents an interaction between the phase 3 and the characteristics of circular economy presented in Table 3. The interactions were marked with "X" in the steps that most contribute for the circular economy highlight, i.e., steps that provide information that support the achievement of circular economy. The exploration of alternatives to redesign product thinking in loop strategy had the major contribution for circular highlights.

The evaluation of feasibility for product-service system, shift for collaboration and sharing, and material flow analysis were also components of the Journey for Circular Transformation that are major linked with circular economy. On the other hand, the inbound and outbound logistic had no direct connections with the selected highlights. Besides those two components, the other ones had, at least, one connection with circular economy highlights.

Figure 13 – Correlation with circular economy characteristics.

Steps of Phase 3	Circular Redesign of Products and Services	Usage of renewable materials/Elimination of toxic substances	Usage of renewable energy sources	Reuse of waste/Reduce waste generation	Correlation with sustainable pillars	Collaboration with partners and Customers	System thinking	Efficient use of resources/Reduce input of natural resources
Map the stakeholders						X	X	
Identify stakeholder's needs						X		
Assess competitors							X	
Map the current business model						X	X	
Assess the business model sustainability and circularity	X				X		X	
Identify customer's needs						X		
Analyze external trends							X	
Explore design to close the loop	X			X				X
Explore design to product-service system	X					X		
Explore design to collaboration and sharing	X					X		
Assess material selection		X						X
Assess inbound logistic								
Assess material flow		X		X				X
Assess waste generation and management				X				X
Assess energy and water consumption			X					X
Assess Product Life Cycle					X		X	
Assess the outbound logistic								
Assess marketing and sales activities							X	
Verify product usage and customer support						X		
Understand the product end of life	X							
Understand the reverse logistic								
Assess social dimension					X		X	
Assess financial dimension and performance					X			

Source: Own authorship.

5.3 Step-by-Step Description

5.3.1 Phase 1 - Understanding the Concept

The main objective of this first phase is providing sufficient knowledge about circular economy for the organization. This is achieved by understanding its concepts and getting a high-level consent about how this could be useful and relevant for the organization

Step 1.1 Understand Circular Economy and its Relevance

What?

a) Understand the concept of circular economy, including definition, principles, and skills and competences required;
b) Develop an initial understanding of how circular economy can be relevant for the organization, including how it can be applied and the benefits

How?

The understanding of circular economy concepts can be done by several ways. A first option is take a look in the literature review (item 3 of this document) that covers definitions, principles, a value chain perspective, and also barriers and drivers. A second possibility is making web searches. In this case, organizations such as Ellen MacArthur Foundation are good start points, which cover high-quality free resources assets that can be accessed. In terms of competences and skills for circular economy implementation, Prieto-Sandoval et al. (2019) recommended the ones presented in Table 14.

Table 14 - Capabilities to implement circular economy in micro level.

Capabilities	
Develop successful, green, and circular products or services	Maintenance services offer
Understand the competitors' strategy	Develop effective green marketing to open new markets
Ability to attract talent with environmental values	Include consumers in product design
Project management	Design circular processes and products
Perform reverse logistics	Create synergies with compatible organizations
Share logistics operations with other organizations	Work in symbiosis in the firm and with stakeholders
Manage traceability	
Dynamic Capabilities	
Access to stakeholders' information	Capability to transform obsolete jobs into new employment
Research and development	Leader's vision and environmental awareness
Improvement of the business models	Capacity to design and reconfigure sustainable business models
Ability to create a “green” culture	Knowledge management and development
Ability to train and increase workers' ability to propose improvements	

Source: Adapted from Prieto-Sandoval et al. (2019).

For the understanding of how the circular economy can be relevant for the organization, the actors involved in this initial phase of the Journey for Circular Transformation can organize a workshop. Each organization has own approaches to facilitate internal workshops, however, the literature covers a range of rules and tips that optimize the execution. During the workshop planning and executing the workshop, consider these follow tips (KUO et al., 2020; PAVELIN; PUNDIR; CHAM, 2014; STEPHENSON; GALLOWAY, 2012; TROPMAN, 1982):

a) Give as much time as needed. Some authors recommend expending 2-3 hours;
b) Prepare a staff team with 2 facilitators at least: one facilitator to conduce the event and other to oversee the presenter and ensure all resources are running and available;
c) Make use of visual artefacts such as power point presentation, sticky notes, etc;
d) Prepare the workshop by taking a look in the resources will be used, defining the attendees will be engaged, and ensuring the room has sufficient space for all attendees and equipped with whiteboards or any surface to take the ideas, and audio-visual equipment;
e) Create a safe and participative environment to allow everybody expose ideas;
f) Send invitations for all the attendees being clear what will be discussed in the workshop, what are the goals and what are the expected outcomes;
g) Define ground rules for the workshop, such as no cellphone usage, no interruptions during a speech, no repression of ideas from other attendees, etc.
h) Start at the scheduled time;
i) Plan the workshop agenda considering the following moments: welcome, brainstorm, discussion, reflection and next steps, and wrap-up.

At first, the welcome moment is when the facilitators greet the attendees, make personal presentations, explain the workshop’s agenda and run warm-up/icebreaker activities. During the warm-up/icebreaker moment, ask the attendees to present themselves (such as name and business function), and prepare an activity to make them interact between each other to stimulate idea generation and have some fun.

The second moment consists in a brainstorm section. The concept was first introduced by Osborn (1957) and represents a strong technique to support idea generation aiming to solve a specific problem. The intention is to come up with as much ideas as possible based in four rules (OSBORN, 1957): 1) quantity over quality, 2) no criticizing any ideas, 3) encourage wild ideas and 4) attempt to explore and improve previously articulated ideas. It’s recommended to make the attendees take notes individually before sharing with the group and make sure everybody is contributing (PAVELIN; PUNDIR; CHAM, 2014). To guide the discussion, focus in answering the two questions based on the circular economy concepts learned before: “How can CE be applied in my organization?” and “What are the benefits from moving from linear to circular?”

After that, all the participants make an in-depth discussion about all the ideas and benefits presented during the brainstorm and agree the relevance of circular economy for the organization. In sequence, review the main topics discussed during the workshop and define the actions to be taken after the event. In this case, the next steps are represented by the Phase 2 of this method and consists in define a team, asses the company’s baseline in terms of circular economy, discuss the main barriers and drivers to adopt circular and, finally, defining where the organization is now in the pathway to a circular economy.

To end the workshop, take the feedback from attendees and write the lessons learned in order to improve the workshop’s quality for the next rounds in later steps. Workshops are widely used in this Journey for Circular Transformation; so, consider use the tips presented in all the cases.

5.3.2 Phase 2 – Defining Current Scenario

The main purpose of this phase is defining the organization’s baseline regarding circular economy. By baseline is understood the current state of the organization in the move from linear to a circular operation model, considering the actions and policies that support the principles of circular economy. Other outcomes of this phase are the definition of a team to execute the next phases of this journey, engagement of relevant internal stakeholders regarding the Journey for Circular Transformation, and the definition of a high-level vision about where the organization wants to be after implementing circular economy.

Step 2.1 – Define a team

What?

a) Create a multidisciplinary and diverse team to execute the steps of this journey. To do so, consider include relevant knowledges and skills for circular economy development;
b) Identify who need to be involved to make the project a success and how to collaborate with the stakeholders. The stakeholders include leadership and actors who might provide information for baseline’s assessment and opportunities’ assessment.

How?

The team to conduce the journey for circular transformation needs to be diverse and multidisciplinary. This includes people with different skills and knowledges, genders, experiences and so on. To do so, visualize the organization chart or staff list to map potential collaborators that can have the competences and skills mentioned in Table 14. This analysis is also useful to identify the relevant leadership and other stakeholders that will provide information to support the baseline assessment (Step 2.2) and opportunities assessment (Phase 3). Consider work together with human resource department to complete this step.

After concluding the investigation, organize a workshop with current involved actors following in the same model as presented in Step 1.1. For this circumstance, the objective of the workshop is review and confirms the stakeholders that will be invited to integrate the team. It's important to highlight the leadership is not considered yet, as the idea is, first, prepare an initial business case (current state, benefits and relevance, and vision) to have a better material to present and engage them. Use this workshop to plan how the current team can gather the data for the baseline assessment.

Step 2.2 – Assess the baseline

What?

a) Identify the sustainability policies implemented by the organization;
b) Identify strategic plans and the level of ambition for circular economy (if existing);
c) Get an overview of the organization's awareness related to circular economy;
d) Gather information related to the effectiveness of sustainability decision-making processes and sustainability management in order to understand the implementation of sustainability strategies;
e) Identify criteria, methods, tools and indicators used by the internal stakeholders to support sustainability management processes;
f) Verify if the company has certifications of environmental management systems or certifications for product or service;
g) Identify existing relevant initiatives for circular economy;
h) Identify the resources that are most importance to the long-term success and resilience of the organization.

How?

The assessment of the baseline can be done in an internal walk-through audit such as the one used by United Nations Environment Programme (UNEP, 2015) to assess the current operational performance. The aim of the audit is to gather documents, data and information that will clarify the organization's current state in terms of circular economy. To guide the audit, the team can use the checklists developed by Garza-Reyes et al. (2018) to assess the current state of the circular economy implementation. In addition, the team can also use the baseline assessment checklist available in the Appendix 5, built based on the fields mentioned by WBCSD (2016) and Dey et al. (2020) to assess the baseline.

The walk-through audit is executed by applying the checklists to verify the circular economy practices and meeting strategic collaborators that can provide the other required information:

a) Sustainable policies;
b) Organization's circular economy awareness;
c) Business strategies;
d) Tools used to support sustainability management;
e) Environmental and product certifications;
f) Internal feedback to check the efficiency of the decision-make process and sustainability management;

In terms of circular initiatives, another tool to support the identification and expand the scope of the analysis is the checklist ReSOLVE developed by Ellen MacArthur Foundation that support generation of circular strategies and growth initiatives (ELLEN MACARTHUR FOUNDATION, 2015). According to the authors, the six components of the checklist are:

a) Regenerate: Shift to renewable energy and materials; reclaim, retain, and regenerate health of ecosystems; return recovered biological resources to the biosphere;
b) Share: Share assets and reuse products (second hand); prolong product life through maintenance, repair, and design for durability;
c) Optimize: Increase product performance/efficiency; remove waste in production and in the supply chain; leverage big data, automation, remote sensing, and steering;
d) Loop: Remanufacture products or components; recycle materials; digest anaerobically; extract biochemical from organic waste;
e) Virtualize: Deliver utility virtually;
f) Exchange: Replace old materials with advanced non-renewable materials; apply new technologies (e.g. 3D printing and electric engines); choose new products and services.

In additional to those practices mentioned in Appendix 5, the assessment team can look for others that has any relationship with the six ReSOLVE dimensions. In terms of identifying resources that are important for long-term success and resilience, besides understand the specific resources used by the organization, Prieto-Sandoval et al. (2019) suggest some that are important for implement circular economy, as presented in Table 15.

Table 15 - Resources to implement circular economy in micro level.

Capabilities	
Procurement department	Market analysts–business intelligence
Materials database	Maintenance services platform
Design and creativity	Communication channels
Human resources department	Reusable and recyclable products and materials
Machinery and equipment	Geographical proximity with the own firm factories, suppliers, customers, and potential partners
Users' designs	Communication channels
Traceability systems	

Source: Adapted from Prieto-Sandoval et al. (2019)

Some barriers can appear during the audit, such as lack of data, staff unavailability and misunderstandings, so, it's important to clear contact who will be met in advance and explain what are being requested.

Step 2.3 – Identify potential Barriers and Drivers

What?

a) Identify both internal and external drivers and barriers to implement circular economy;
b) Identify risks and the root-causes of any problems or issues

How?

Before meet the leadership to present the current findings and get their buy-in to follow with the journey, the team organizes another workshop aiming to come up with main internal and external barriers that prevent the organization to implement circular economy, and the internal and external drivers that support this transition. During the discussion of the main barriers, it's important to identify their root-cause and, to do that, the team can uses the "5 Whys" technique that aim to explore the cause-effect relationship to uncover the root-cause of a problem.

The technique consists in take a problem and asks "why" five times for each problem that results from the previous question. At the end, the team will be able to better understand the root-cause of any problem to fully implement circular economy in the organization.

Step 2.4 – Define the baseline and vision

What?

a) Generate a list of initiatives that support circular economy principles;
b) Determine the current level of circular economy implementation (where the organization is now);

c) Define what challenges and problems, in terms of circular economy, that the organization aims to solve. Also, the team needs to understand if there is a real business case for move from linear to circular;
d) Formulate and agree where the organization wants to be (vision) and a high-level strategy to achieve it. It’s important to map the changes that need to happen;
e) Define roles and responsibilities for all stakeholders and team members;
f) Define a narrative to engage stakeholders by explore the relevance of circular economy and its benefits. This is important to engage and ensure leadership commitment regarding the Journey for Circular Transformation;
g) Meet with the leadership to get their commitment and ensure their enthusiasm;
h) Align the vision and high-level plan with the leadership and make changes, if needed.

How?

Based on the circular practices and other information gathered in Step 2.1, compile all these findings in a list to allows the team to be aware of the whole organization’s circular initiatives. After that, the method developed by Garza-Reyes et al. (2018) named Circularity Measurement Toolkit (CMT) can be used to define the organization’s current level of circular economy implementation. The authors defined nine levels of implementation (GARZA-REYES et al., 2018):

a) 1 - Circular Developer: Leading organizations for circular economy implementation; commitment to participate in the development of new technologies and environmental regulations to improve circularity;
b) 2 - Circular Promoter: Organizations that have successfully integrated circular economy into their business strategy, are satisfying customers and growing the environmentally aware and circular market;
c) 3 – Circular: Organizations that have fully integrated circular economy practices in their business and value chain, including activities related to circular procurement and increase of longevity with customers, suppliers and other companies;
d) 4 – Waved: Organizations that are initiating external awareness and introducing circular economy principles to customers and the supply chain to promote the concept in the entire value chain;
e) 5 – Curved: Organizations that have fully integrated circular economy practices and has adopted circularity as a culture. However, the efforts are only made internally, and no practices are done with the support of customers, suppliers, other companies or competitors

f) 6 - Saw tooth: Organizations that have introduced some important circular practices. The organization recognize the necessity of improvements and are in the process of adopting it as part of their culture
g) 7 - V-shape up: Organizations that not applied any circular practices, however, they are curious about it and are starting to learn the benefits that circular economy can generate. Usually, because a member of the top management is an environmentally aware person;
h) 8 - Λ-shape down: Organizations that without noticing, are already applying some internal circular practices, generally related to the resource consumption, utilization and efficiency. The organization is not aware of circular economy, however, are realized that economic benefits can be obtained with the adoption of certain practices;
i) 9 – Linear: Organizations applying only a linear approach without any knowledge about circular economy. Characterized for being business focused only in the economic benefits that comply with the minimum governmental or legislative requirements to be able to operate.

The CMT consists in answer eight questionnaires, as mentioned in Step 2.2, that aiming to assess the practices adopted by the organization classified based on different factors: Internal practices of resource utility and efficiency percentage (A); internal awareness percentage (B); external awareness percentage (D); value chain support percentage (E); external practices for longevity percentage (F); green market development percentage (G); technological development percentage (H); and legislation development percentage (I). The factor C represents the sum of the factors A and B (GARZA-REYES et al., 2018).

One member of the team is responsible to fill the eight questionnaires by adding the value "1" in one of the three available answers for each question: yes (organization performs 70%-100% of the mentioned practice), partially (organization performs 1%-70% of the mentioned practice) or no (organization does not perform the mentioned practice). The other practices verified by the Appendix 5 can also complement the questionnaires in order to have a more accurate analysis. At the end, the final score for each questionnaire is calculated as below:

a) 0, if the percentage of answers "no" in the questionnaire is 50% or higher;
b) 1, if the percentage of answers "yes" in the questionnaire is 50% or higher;
c) 0,5, if the percentage of both answers "yes" and "no" in the questionnaire is lower than 50%.

The current level of circular economy implementation in the company is then calculated based of the rules mentioned in Table 16, adapted from Garza-Reyes et al. (2018).

Table 16 - Calculation of current level of circular economy implementation.

Circularity Level	Formula	Range	
		Min	**Max**
1. Circular developer	C + D + E + F + G + H + I	6.5	8
2. Circular promoter	C + D + E + F + G	5.5	6
3. Circular	C + D + E + F	3.5	5
4. Waved	C + D	2.5	3
5. Curved	C = A + B (A = 1 and B = 1)	2	2
6. Saw tooth	C = A + B (A = = 0.5–1 and B = 0.5–1)	1	1.5
7. V-shape up	C = A + B (A = 0 and B = 0.5–1)	0.5	1
8. Λ-shape down	C = A + B (A = 0.5–1 and B = 0)	0.5	1
9 – Linear	Linear = 0	0	0

Source: Adapted from Garza-Reyes et al. (2018).

Defined the current level, it's time to prepare the meeting with the relevant leadership defined in the Step 2.1. In this meeting, it will be necessary to obtain the leadership's buy-in and enthusiasm regarding the continuation of the Journey for Circular Transformation. The meeting's agenda need to include all the information collected until this time: circular economy relevance for the organization and the benefits, the team to execute the journey and, finally, where the organization is now on the pathway (level of implementation) and where wants to be (vision). Thus, organize another workshop to:

a) Define which challenges in terms of circular economy the journey aim to solve. At this moment, it's important to clarify if there is a viable business case for circular economy based on the current understanding of concepts, benefits and relevance;
b) Define an initial vision about in what the company aim to achieve in terms of circular economy and a high-level plan. The high-level plan consists in define which areas will be assessed (Phase 3), a chronogram and the roles and responsibilities for each member of the team;
c) Brainstorm how the relevant leadership will be engaged and the message to be transmitted.

Finally, the team meets the leadership. It's possible that some changes in the vision and in the plan occur during the discussion. It's also important to define what their roles in the journey are.

5.3.3 Phase 3 – Identifying Opportunities

The objective of the Phase 3 is to identify opportunities for circular initiatives along the organization's value chain and internal business organization. This is a core phase in the Journey for Circular Transformation as allows the organization to obtain a holistic overview about flow of materials and resources, stakeholders and customers, environmental impacts, business process and much more.

At the end of this phase, the team will be able to purpose ideas to fill the opportunities identified here. All the steps, complementing each specific tools and methods, are executed in an internal walk-through audit similar to the one executed in the Step 2.2, which means contact collaborators from all the areas to be assessed. Also, the Appendix 6 summarizes some indicators found in the literature to support the analysis in some steps. The selected indicators were filtered from the articles to remove the ones which measure is already covered in the step description, aiming to complement the analysis.

And, in addition to the articles used to build this journey, the findings of Prieto-Sandoval et al. (2018) are also considered to compose the opportunities assessment phase, which includes key factors to be assessment when implementing circular economy.

Stakeholders

Step 3.1 – Map the stakeholders

What?

a) Map internals and externals stakeholders involved in the value chain;
b) Understand what type of new stakeholders could help inspire the organization regarding circular economy and make the value chain more effective/efficient;
c) Identify if the organization has partnerships with citizens and non-governmental organizations;
d) Identify threats regarding the mapped stakeholders.

How?

The mapping of internal and external stakeholders can be performed by several tools. In this study, it's suggested use the Actor's Map proposed by Lindahl, Sakao and Carlsson (2014) to identify opportunities for improvement or creation of PSS. The tool consists in identify relevant stakeholders and establish interactions between then in terms of flows of products (tangible objects), flows of services (support, maintenance, etc.) and flows of information. The authors separate the flow of information in 1st level, which is directly related to the ability to provide a PSS, and 2nd level, indirectly related to the product-service system.

The first step is organizing a workshop to identify the stakeholders that will be considered in the map. The idea is organizing a workshop and brainstorm to identify current and new potential stakeholders that could make the value chain more effective/efficient. At this moment, the team clarifies if the organization has partnership with citizens' organization or Non-Governmental Organization. Consider explore the stakeholders presented in Table 17 to support the brainstorm, created adapting the findings of Prieto-Sandoval et al. (2019) and Joustra, Jong and Engelaer (2013).

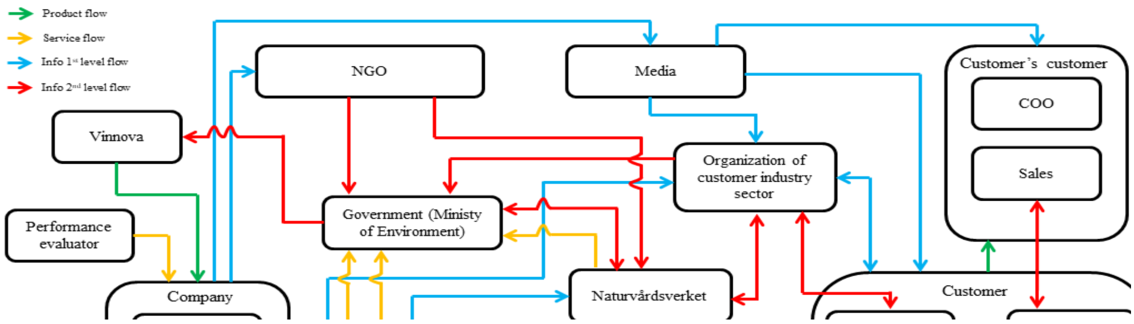
Table 17 - Stakeholders to be considered in the map.

External Stakeholders	Internal Stakeholders
Suppliers	Investors and organizational leaders;
Competitors	Workforce
Governments	Sustainability department
Universities and research centers	Facilities department
Standards organizations	Marketing and Sales department
Design schools	Production department
Shoppers	Research and Development department
Consumers and final users	Finacial department
Second-hand users	IT department
Waste manager	Human resources department
Landfill managers	
Industrial or trade associations	

Source: Adapted from Prieto-Sandoval et al. (2019) and Joustra, Jong and Engelaer (2013).

Defined the stakeholders, the team then identifies the flow of products, services and information that connect the actors. The relationship can be either one-way or mutual (LINDAHL; SAKAO; CARLSSON, 2014). The Figure 14 represents an example of actor's map developed by Carvalho et al. (2020), whose purpose was design circular business models in a Swedish startup. To finish the workshop, the team analyzes and discusses which threats and risks are related to each identified stakeholder.

Figure 14 - A section of an Actor's map.



Source: Carvalho et al. (2020).

Step 3.2 – Identify stakeholder's needs

What?

a) Identify stakeholder's expectations and interests (values demanded);
b) Define stakeholders' role, impact/relation to implement circular economy and their circular economy awareness.

How?

In order to understand the expectations of the stakeholders mapped in the Step 3.1, Allee (2008) developed a Value Network Analysis that aim to map and understand the values exchanged within stakeholders. To build the map, the author proposes 3 steps: 1) roles (stakeholders - already done in Step 3.1); 2) transactions/activities, represented by formal contract exchanges around product and revenue (solid line), and intangible flows of market information and benefits (dashed line); and 3) deliverables, that are actual things that pass from one role to another, including physical deliverable (such as documents) and non-physical (e.g. messages, knowledge, advise, expertise, etc.). The Actor's Map developed in the previous step covers all the components mentioned by Alle (2008) to understand the values exchanged in the network; thus, the team can use that one to perform the analysis. In terms of assess the values, Alle (2008) suggest analyzing the value network under 3 topics:

a) Value exchange analysis: understand the pattern of the value exchange between stakeholders and the health of the network;
b) Impact analysis for value realization: understand if the stakeholders is turning the value input into real gains, benefits or assets;
c) Value creation analysis: understand if the stakeholder is creating value in the network through product or service as an output after receives a value input.

To conclude this step, the team analyzes the awareness of the mapped stakeholders in terms of circular economy. This will support the understanding of effort required to engage them in the Journey for Circular Transformation.

Step 3.3 – Identify customers' needs

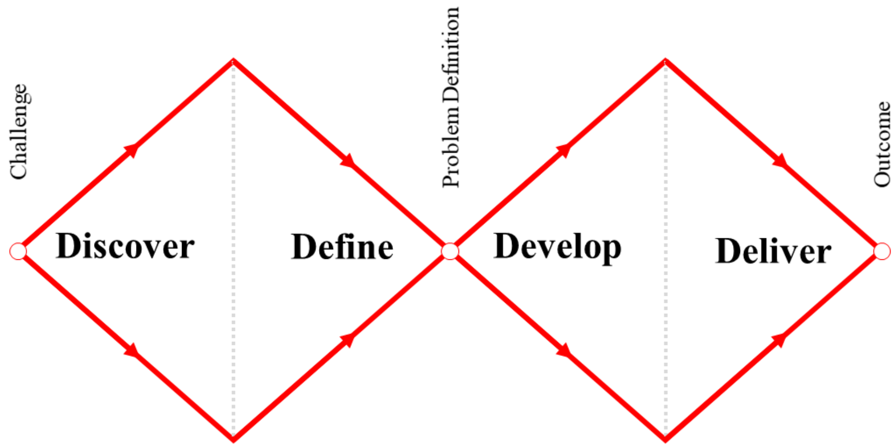
What?

a) Understand for who the organization is creating value and what their needs are. Segment them based on their requirements;
b) Define potential future customers for the new circular offering, their needs and their preferences regarding circular products/services;
c) Define potential customers to prototype the solutions that will be proposed. Try to select the ones that are committed with the company and ease to experiment;
d) Understand what the product/service circularity could offer for customers and pair it with customers' needs.

How?

To understand the customers' needs and identify new potential ones, the company can utilize design thinking techniques that help the organization empathize with customers and understand their point of view. To guide the team in the design thinking journey, the team can use the double diamond technique developed by the Design Council in 2005 and further evolved in 2015 (DESIGN COUNCIL, 2015). The technique, as exemplified in Figure 15, consists in 4 phases: Discover, Define, Develop and Deliver.

Figure 15 - Double Diamond.



Source: Adapted from Design Council (2015).

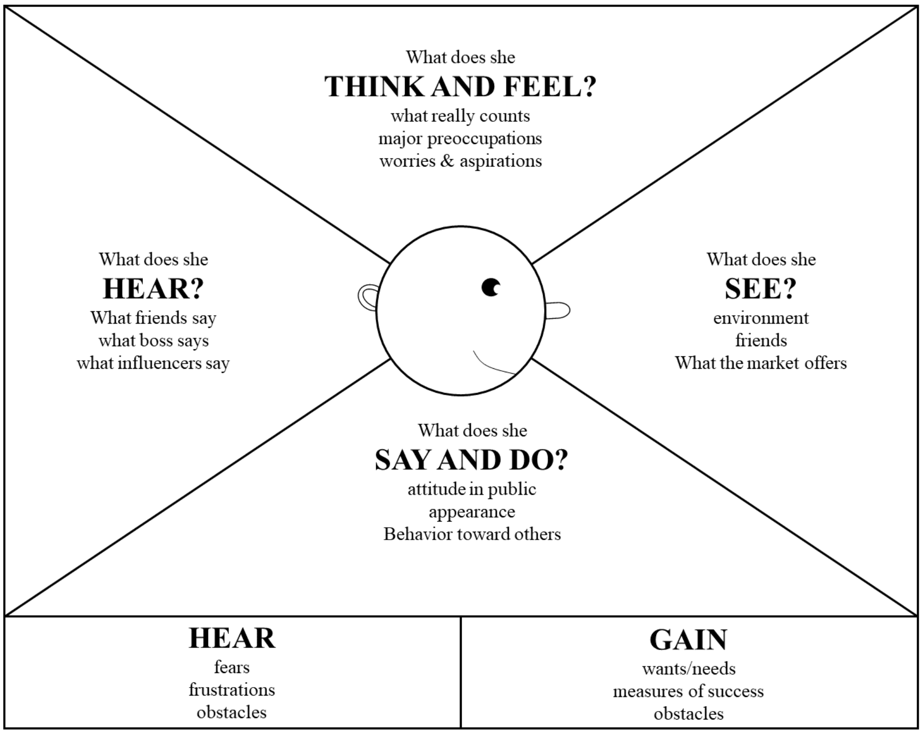
The discovery phase is when the team defines the target niche of users to identify their needs, develop initial ideas, and gather inspiration and insights. In this exploratory phase, the team prepares in-house searches and market researches to gather initial understand about the target users and further performing camp searches and interviews to understand users' pains and point of view. To facilitate the task, the teams should focus on potential customers aware about circular economy.

In the definition phase, the team analyzes the outputs of the discovery phase and identifies opportunities to be explored. To synthetize the information and review the problem to be explored, the team can use a range of design thinking techniques to give support in this task. Thus, the team organizes workshops to apply the following tools, also using brainstorming and visual artifacts, such as sticky notes, to improve the workshop performance.

First, the team creates personas based on the market researches and patterns identified. A persona represents the personification of a target user group by describing detailed information such as name, age, occupation, location, hobbies and interests, likes and des-likes and their needs (DESIGN COUNCIL, 2015). The idea is the team creates more than one persona and explores both current and new potential customers.

A second tool to be used is the empathy map developed by the company XPLANE (OSTERWALDER; PIGNEUR, 2011), in which the team understand what the user think, feel, see, hear, say, do, and what are it pains and gains. The Figure 16 presents an example of an empathy map (OSTERWALDER; PIGNEUR, 2011). The team can use the questions presented in the Figure 18 to guide the discussion and the brainstorm. In the case of pains, the team can use the 5 whys technique conform presented in Step 2.3.

Figure 16 - Empathy Map.



Source: Adapted from Osterwalder and Pigneur (2011).

A third tool to help the team understand the personas is the user's journey in which he team maps how the user interacts with the organization's product/service or with the challenge the team aim to solve (INGLE, 2013). The application consists in identify and map all the relevant interactions between the product/service and the target persona. This helps the team identify the moments that works well for the customer and the ones that might need to be improved (pain points), also helping understand the current experience (DESIGN COUNCIL, 2015).

To finish this exploratory step, based on the customer's needs identified so far, the team pairs them with the potential offerings that the organization could provide in terms of circular economy in order to develop a first understand about how the organization can satisfy customer's needs with circular initiatives.

Step 3.4 – Assess competitors

What?

a) Get knowledge regarding varieties of competitor's products and services entering the market (more environmental friendly products);
b) Get and overview of competitors' environmental strategies;
c) Identify and understand innovative business model from competitors and organizations operating different markets.

How?

In this step, the team needs to understand what the competitors are currently making in terms of sustainability and circular economy. To do so, the team can search in different sources to identify competitor's environmental strategies and products, considering old and new product entering in the market. The search should also include innovative business models in terms of sustainability and circular economy. At the end of the exploratory searches, the team can organize a workshop to discuss the findings and conclude which are the most relevant strategies and products that threaten the organization.

Business Model

Step 3.5 – Map the current business model

What?

a) Design and analyze the current business model, explaining value creation, value delivery, value capture and customer segment;
b) Point out the real core business, what the organization really provides and what are the dependencies with other organizations

How?

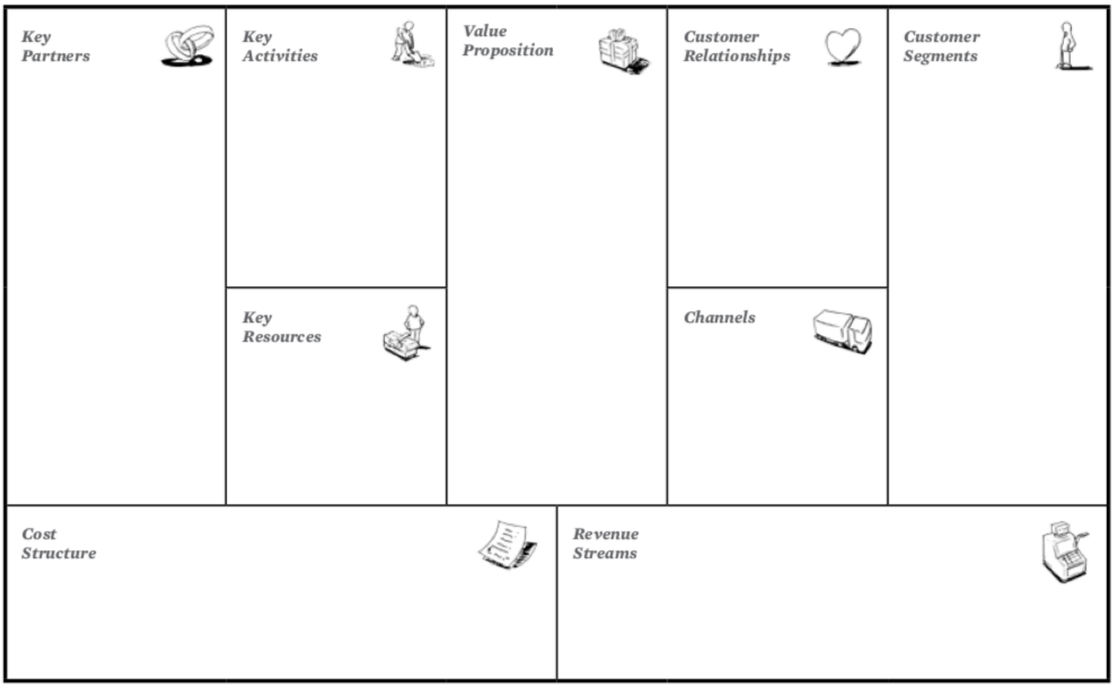
The process to map the current business model can be done by organizing a workshop and applying the business model canvas proposed by Osterwalder and Pigneur (2010). The model consists in nine blocks that describe how an organization propose, create, delivery and capture value from customers.

According to the authors, the blocks, as illustrated in Figure 17, are (OSTERWALDER; PIGNEUR, 2010):

a) Customer segments: represents the target niche for the value proposition;
b) Value proposition: represents the main reason for the customer pay for the product or service, also view as the main pain point that the offering aim to solve;
c) Channels: represents how the organization communicate and delivery value for the customer segment;

d) Customer relationships: represent how the organization conquest and keep a relationship with the customer segment;
e) Revenue stream: represent how the customer segment pays for the value proposition;
f) Key resources: represent the most important resources that are used to build the value proposition and deliver it to the customer segment;
g) Key activities: represent the most important activities performed by the organization to build the value proposition and deliver it to the customer segment;
h) Key partners: represent the key partnerships that helps the organization build the value proposition and deliver it to the customer segment;
i) Cost structure: represent the relevant costs that are needed to operate the business model.

Figure 17 - Business Model Canvas template.



Source: Osterwalder and Pigneur (2010).

Step 3.6 – Assess the business model sustainability and circularity

What?

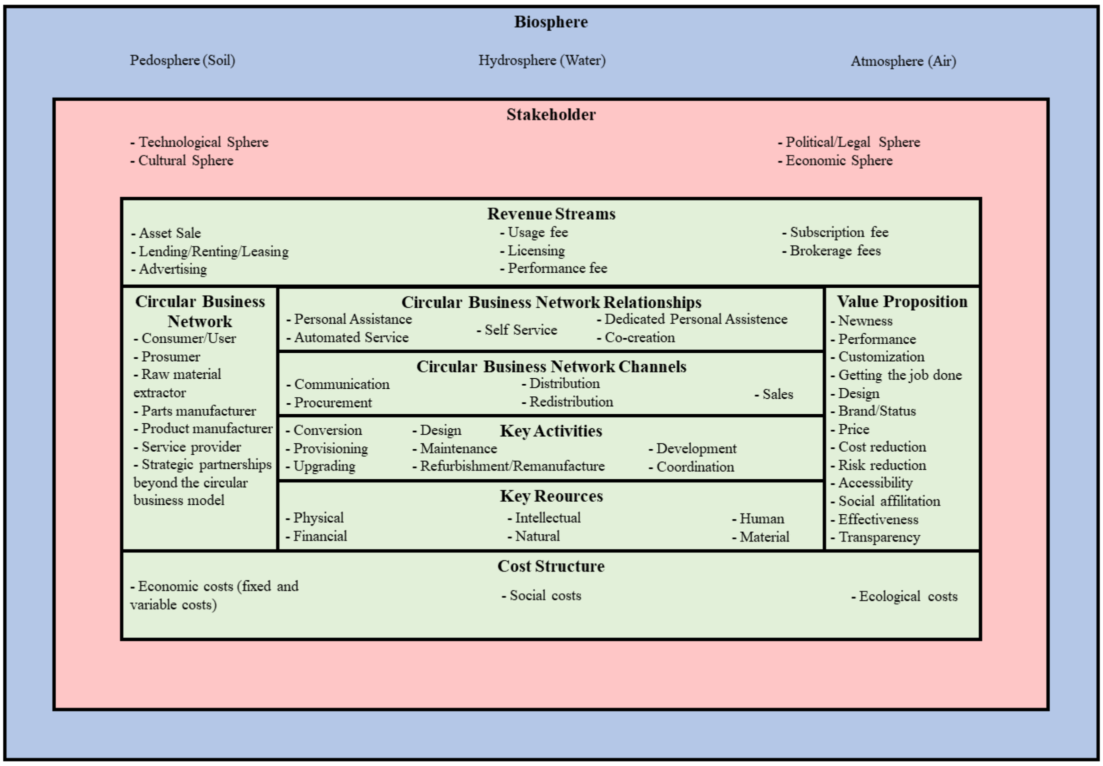
a) Assess how compatible is the current business model with the circular economy principles and the triple bottom line, considering value creation, value delivery and value capture;
b) Identify how the circular economy principles can be the basis for a new business model;

c) Define the business model transformation, including number of dimensions subject to change and the magnitude of this change.

How?

To assess the alignment of the current business model with sustainability dimensions and the circular economy principles, the team can organize a workshop and apply the tool developed by Hofmann et al. (2017) called C3BMC. The tool, as present in Figure 18, is an adaptation of the business model canvas (OSTERWALDER; PIGNEUR, 2010) considering the ecological, social and economic dimensions of the sustainability. In the external block (biosphere), the team takes into account the emissions and impacts in the soil, water and air, translated into pedosphere, hydrosphere and atmosphere. In the stakeholder block (social dimension), the team describes the network who engages in direct and indirect exchange processes with the business model, by considering technological, cultural, political/legal and economic spheres. The other eight elements in the tool represent the value creation, delivery and capture in the light of circular economy.

Figure 18 - C3 Business Model Canvas for sustainability and circularity assessment.



Source: Hofmann et al. (2017).

Defined the C3BMC, the team then organize a workshop and discuss the gaps of the current business model to understand opportunities of improvement in terms of circular economy and sustainability. Also, the team uses the workshop to summarize all the changes that are required to readapt the current business model in a circular and sustainable way, including which dimension is subject to change and the magnitude of each change.

Ecosystem

Step 3.7 – Analyze external trends

What?

a) Analyze the internal and external political, economic, social, technological, environmental and legal trends and determine if it's viable of the implement circular economy in the organization's market;
b) Identify design trends in the product's market.

How?

A very simple and useful tool to support the team analyzes the ecosystem and identify external opportunities and threats is the PESTEL analysis, first introduced by Aguilar (1967) and further detailed by different authors. The application consists in desktop searches for political, economic, social, technological, environmental and legal relevant information that helps understand forces that affect the organization. And, to complement the analysis, the team should gather market trends in terms of sustainability and circular economy. The searches can be made by different sources and platforms. After gathered all the information, the team organizes a workshop to discuss and select the most relevant ones. A template of PESTEL analysis is presented in Figure 19.

Figure 19 - PESTEL analysis template.

	Description	Time	Impact	Likelihood	Significance
POLITICAL					
ECONOMIC					
SOCIAL					
TECHNOLOGICAL					
ENVIRONMENTAL					
LEGAL					

*Time: 0-6 months; 7-24 months; 24+ months / Impact: 1 (very low) – 5 (very high) / Likelihood: 1 (very unlikely) – 5 (certain) / Significace: Impact x Likelihood

Source: Adapted from UNEP (2017).

This model was developed by UNEP (2017) and attributes a measure of time, impact, likelihood and significance for each trend:

a) Time: 0-6 months; 7-24 months; 24+ months;
b) Impact: 1 (very low) to 5 (very high);
c) Likelihood: 1(very unlikely) to 5 (certain);
d) Significance: Impact x Likelihood.

Design

Step 3.8 – Explore design loop strategies

What?

a) Understand which type of circular design for close the loop and extend product lifecycle feels most relevant or achievable. Consider these followings designing alternatives: Maintenance and Repair, Reuse and Redistribution, Refurbish, Remanufacture, Recycle, and Biological Cycles;
b) Define the main functionality of the product (the problem for what it’s designed for) and identify how nature could perform this functionality;
c) Disassembly the product to get an overview about what could be recovered or reused and if it's economically viable to disassembly it

How?

To understand the pros and constraints related to each design type, the team can organize a workshop and brainstorm using the tool developed by the Ellen MacArthur Foundation for the Circular Design Guide. The tool consists in analyze the technical and biological cycles. For each technical cycle (Maintenance and Repair, Reuse and Redistribution, Refurbish, Remanufacture, Recycle), the team answers two questions: 1) “how might this be possible for my product?” and 2) “what would be needed or is standing in my way?”

For the biological cycles, the team answers the two questions for the following alternatives: materials get cascaded through other applications; valuable feedstock gets extracted; and returns to the biosphere. The original tool can be downloaded on the Circular Design Guide website.

To help the team understand the feasibility of some design alternatives, Joustra, Jong and Engelaer (2013) present some criteria for design for refurbishment and remanufacturing:

a) Existence of technology to extract components without damage;
b) Product made or partially made by standardized and interchangeable parts;
c) Cost of upcycling relatively low compared to reuse;

d) Product technology of parts and their performance is stable over more than one product life cycle;
e) Positive cost-benefit for refurbishment or remanufacturing in opposite of dispose or environmental impact of legislation.

To help the team understand how the nature can perform the product functionality, the Circular Design Guide suggest write the challenge the product aim to solve and its functionality, and brainstorm to understand how nature might solve this challenge. Finally, to understand the feasibility of disassembly the product, the team can takes a unit and disassembly all the parts while register the time of all the process. After the task, the team can discuss the viability of consider this design alternative.

Step 3.9 – Explore design for PSS

What?

a) Understand how to change the offering for a product-service model and the benefits of this approach are;
b) Understand the user’s perspectives and point of view (habits, culture, social context and motivation) to design for PSS model.

How?

Morelli (2002) developed a guide to support the development of product-service systems, which is composed of 7 steps: value proposition, market analysis, product-service definition, use-cases analysis, tentative architecture, test and final disposition. The first two steps aim to identify the needs to be filled by the PSS and define the target user. Both activities were already made in the Step 3.3 of this journey. The following step of the PSS guide, product-service definition, aims to define the main functionalities of the PSS based on the needs and target users.

Thus, to support the understanding of how to transform the product into a service model, the team can organize a workshop to discuss how to change the offering for a PSS model, pairing the conclusions with the user’s needs. In this discussion, the team uses the customer characterization developed in the Step 3.3, including habits, needs, characteristics, likes and dis-likes, and others. The next step of the guide proposed by Morelli (2002) are outside the scope of this step and, for this reason, do not need to be executed at this moment.

Step 3.10 – Explore design for collaboration and sharing

What?

a) Understand how the organization can collaborate and share assets with partners;

b) Look at the components of digital systems and imagine how the company can design for characteristics such as agile development, continuous feedback loops, and scalability.

How?

The organization can explore opportunities of sharing and collaboration with other organizations by using their byproducts, providing waste streams as raw materials, sharing production sites, working with consumers to reduce waste, among others (WBCSD, 2016). Thus, to complete this step, the team can organize a workshop and make a brainstorm to identify opportunities in how the organization can collaborate and share assets and resources with other organizations. To guide this analysis, the team can utilize the industrial symbiosis features suggested by Prieto-Sandoval (2018) to implement circular economy in a collaborative and shared way:

a) Belonging to an industrial association, cluster or related organization;
b) Sharing infrastructure or services with industrial neighbors;
c) Valuing the “waste” of some companies as resources for others;
d) Creating joint value between companies;
e) Managing aspects such as trust and transparency among potential partners in the industry;
f) Government and public institution intervention.

To complement the discussion, the team should include a topic to understand how the organization can adopt agile culture, continuous feedback and scalability into digital system.

Procurement

Step 3.11 Assess Material Selection

What?

a) Assess the circularity of the materials used in the company, including the extension of use of recycled and biodegradable resources as raw material;
b) Understand the materials/sources and suppliers’ selection criteria and its issues;
c) Estimate the value of what goes into the product and how smart the material choices are.

How?

To assess the circularity of all materials and substances used within the production boundaries, the team creates a list of materials and substances used to build the product. To complement the analysis, consider apply the selected indicators presented in Appendix 6.

To understand the extension of circular materials usages, the team analyzes which of these are recyclable and biodegradable. Also, gather information regarding the criteria used by the organization to select the materials and suppliers, in order to get opportunities to change the material selection. To finish the material selection analysis, the team identifies the value of each material and substance. All the analyses are helpful to understand how smart the material choices are and identify opportunities for improvement.

Step 3.12 Assess inbound logistic

What?

a) Understand if the company considers environmental factors for inbound transportation and storage;
b) Search for opportunities to optimize the supply chain and procurement.

How?

The assessment of the inbound logistic can be done by using the framework developed by Kazancoglu et al. (2018) to analyze the performance of green supply chain management performance. The framework is composed by six main criteria (Environmental, Economic/Financial, Operational, Logistics, Organizational and Marketing) divided in sub-criteria and measures that aim to assess supply chain with a green holistic overview.

A complete checklist with the sub-criteria and measures to assess the performance of the supply chain, adapted from Kazancoglu et al. (2018), is available at Appendix 7. By using the checklist, the team will be able to identify opportunities to improve the organization's supply chain and procurement. To apply the checklist, the team conducts an internal audit to gather the required information and, after that, organize a workshop to discuss the findings and identify improvement opportunities.

Production

Step 3.13 Assess Material Flow

What?

a) Create a list of the raw materials and components required to manufacture the product;
b) Map speed (time) and size (quantity) of resource flows within the organization;
c) Assess the efficiency of material cycles to reduce resource use.

How?

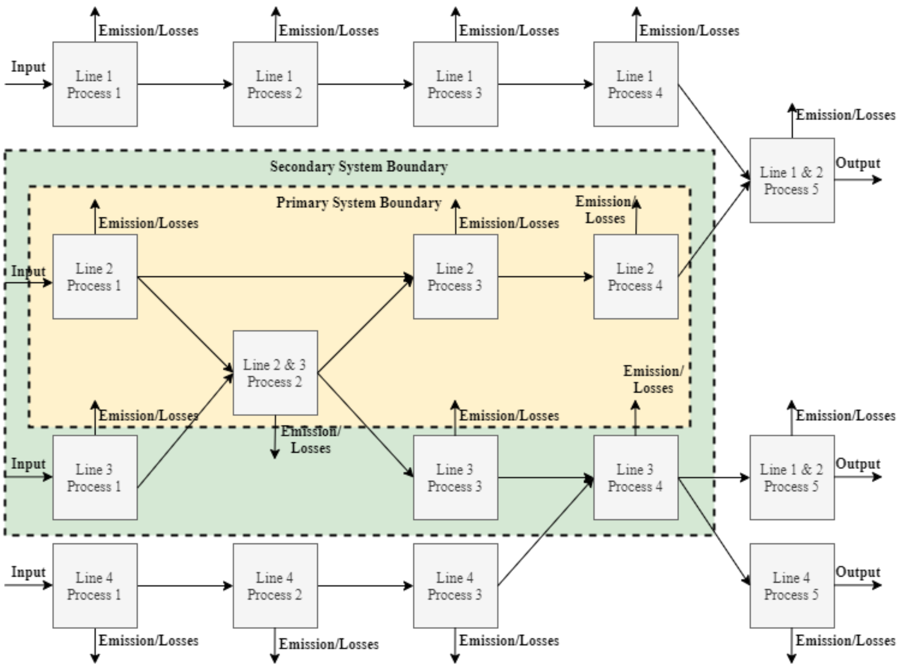
Gould and Colwill (2015) developed an easy-to-use framework for conducting a material flow analysis in manufacturing companies, helping achieve both goals of this step: map material flows and the efficiency of material cycles. The framework is composed of five phases: 1) production system scope, 2) material flow inventory, 3) material flow assessment, 4) improvement scenario modelling and 5) interpretation.

The first phase consists in the team defines the production system, boundaries and processes, and the products being manufactured within the system. As output of this first phase, Gould and Colwill (2015) highlight that it’s necessary to be defined:

a) Production system processes, including manual and automated systems;
b) Spatial and temporal boundaries, including spatial arrangement of each manufacturing element and physical connectivity between the processes (inputs and outputs), and frequency of data acquisition (minute, hours, etc.);
c) Products being manufactured within the boundaries and the required quantities per unit time, classifying in primary the ones that are entire produced within the boundaries and secondary the ones that are partially produced outside the boundaries;
d) The aspects to be focused in the material flow analysis;
e) Information about what is known and measured, and what is unknown and need to be measured;
f) Manufacturing practices and procedures.

An example of system definition is presented in Figure 20. In the next phase, the team needs to establish an characterize all the materials that are required for manufacture the product, define the material flow, represented by inputs and outputs for each process connections, and define the consequences of each process (e.g. transformation, transport, storage) quantitatively and qualitatively.

Figure 20 - Example of production system.



Source: Adapted from Gould and Colwill (2015).

As outputs, the team defines (Gould and Colwill, 2015):

a) Material flow based in mass balance, considering all the inputs and outputs of each process connection;
b) Inventory of all materials and substances used within the boundaries, including materials imbedded in the product and non-imbedded but necessary to the process (this include water quantification). This task is made in Step 3.11;
c) Quantity of each material and substance used per unit of product, also determining the rate of consumption (in unit products per unit time).
d) Qualitative and quantitative information that describe and characterize each material and substance
e) Assess the recyclability of each material and substance;
f) Clarify the function and role of each process unit.

The third phase consists in measure the efficiency of the material flows based on criteria defined by the team to determine how efficient is the organization's material flow (Gould and Colwill, 2015). Some are suggested in Appendix 6. In this moment, the team can discuss and identify if it's possible to reduce consumption of material in any process, focusing in identify opportunities to reduce the consumption of materials, as the identification of opportunities to reduce waste generation and water consumption is outside the scope of this step and will be made during the step 3.14 and 3.15, respectively.

The fourth and fifth phases of the framework are outside the scope of this step. Thus, this activity will be executed in the Phase 4, when the team proposes alternatives and solutions to improve resource efficiency. In the fourth phase, the team discusses the points that are inefficient and determine alternatives to improve resource efficiency, while in the fifth one the team determines the best alternative for improve resource efficiency.

Step 3.14 – Assess waste generation and management

What?

a) Verify where it's possible to reduce waste generations;
b) Verify if the organization recover the raw material and resources in the internal process and where this is reutilized.

How?

During the material flow analysis developed in the step 3.13, the team identified and quantified the waste generated within the production. In this step, the team continues the discussion by organizing a workshop to identify where and how to reduce waste generation and material losses in the production.

To complement the waste generation assessment, the team identifies and quantifies if the organization recover it wastes to be reused in the production. In case of wastewater, the team should also identify if the organization has a treatment plant and the efficiency of this treatment in order to understand the potential to reuse the effluent in internal processes.

Step 3.15 – Assess energy and water consumption

What?

a) Get the energy and water consumption along the organization and where it's possible to improve the efficiency;
b) Verify if and where the organization makes use of renewable energy;

How?

The usage of water within the production process was already mapped during the Step 3.13. This is helpful in this step to support the team identifies where it's possible to reduce water consumption and water losses, as in the Step 3.13 the team only discussed how to improve material efficiency.

In this step, the team complements the material flow diagram by adding the energy low in each process connection, including input and output (losses) quantities. This activity should also map if the company has usage of renewable energy and, if applicable, the participation on this energy source in the entire organization's energetic matrix.

Completed the material and energy flow diagram, the team is able to discuss where it's possible to reduce energy consumption and energy losses in order to identify opportunities to improve energy efficiency within the production. To do so, the team can organize a workshop to discuss both water and energy efficiency, and how the organization can include renewable energy generation in the energetic matrix.

Step 3.16 – Assess product life cycle

What?

a) Classify the portfolio by product or service categories and relevance (e.g., market volume, profits, policy compliance, etc.);
b) Make a life cycle assessment for a target product.

How?

The life cycle assessment can be made by following the standard ISO 14.040 (2006) which is one of the most known guidelines for perform a LCA. The application consists in 4 steps: Scope and Objective definition; Inventory Analysis; Impact Assessment, and Interpretation. Due to previous steps, conduce the LCA will be simplified as the team already mapped the material and energy flow and stablished the product inventory.

In the first phase, the team defines what the objective of the LCA is, which is composed by intended application, target audience (who will be communicated) and motivations for execute the LCA. Also, in the first phase, the scope of the LCA is defined, including product system and boundaries, product function, environmental impacts categories to be considered in the impact assessment and environmental impact assessment tools. Other requirements for complement the scope is mentioned in ISO 14.001 (2009).

In terms of environmental impact assessment, Mendes (2013) reviewed the most established methods for life cycle impact assessment, which presents a range of categories of environmental impacts that can be consulted. The environmental impact assessment can be performed by ad hoc, checklists, interaction matrices, networks and simulation methods. A world known matrix method is the one developed by Leopold et al. (1971), which consists in plot the environmental aspects in the lines and the project's activities in the columns and, later, attributing a score of 1-10 to indicate the magnitude of the action's impact in the environmental aspects (in the upper-left side of the interaction box) and a score of 1-10 for the importance of the action's impact in the environmental aspect (in the lower-right side of the interaction box). The Figure 21 shows an example of the matrix.

Figure 21 - Template of Leopold Matrix.

Project elements / **Environmental Aspect**	**Element 1**	**Element 1**	**Element 1**	**Element 1**	**Element 1**	**....**	**Element N**
Aspect 1							
Aspect 2							
Aspect 3							
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Aspect N							

*Magnitude (Upper-Left): 1-10/ Importance (Lower-right)

Source: Adapted from Leopold et al. (1971).

For the product system, the team can use the material and energy flow diagram that contains a complete overview of the product system and discuss if other processes outside the organization's boundary (e.g. raw material extraction and processing) will be also considered, taking into account the viability of data collection.

The second phase, LCA inventor, consists in map all the inputs and outputs for the product system and the environmental aspects. The ISO 14.001 (2015) defines environmental aspects as elements of the activity, products or services of an organization that interact or may interact with the environment, while environment impacts are modifications in the environment resultant from the organization's environmental aspects.

This activity is supported by the material and energy flow made in the Step 3.13 and Step 3.15, respectively. For process without the organization's boundary considered in the product system (e.g. raw material extraction and processing), the team can gather this information with relevant stakeholders and by desktop searches.

The next phase of the LCA consists in assess the significance of the potential environmental impacts generated by the product system in the light of the categories of environmental impact defined in the scope. To complete the task, the team uses the environmental impact assessment tool defined in the Objective and Scope definition.

The last moment of the LCA consists in discuss and understand the results of the environmental impact assessment. To do so, the team can organize a workshop to understand where the most significant environmental impacts are and how the company can reduce or avoid the impacts.

This step of the Journey for Circular Transformation only presented a high-level overview about a LCA. For more details, the team should consult the ISO 14.040 (2006) or other authors that presents methods to conduce a LCA.

Distribution

Step 3.17 – Assess the outbound logistic

What?

a) Understand if the company considers environmental factors for outbound transportation and storage;
b) Assess if the company develop a sustainable logistics system.

How?

Aiming to assess the performance of a sustainable outbound logistic system, and have a further complementary analysis of the organization's supply chain, the team can use the checklist organized by Wichaisri and Sopadang (2013), which summarize some criteria and sub-criteria to be assessed. The Table 18, adapted from the author, contains the assessment requirements. After collecting the data in an internal audit, the team can organize a workshop to discuss the results and also understand whether the organization considers environmental factors for outbound and warehousing logistics.

Table 18 - Criteria to assess the performance of outbound logistic system.

Criteria	Sub-criteria
Quality	Quality of Product Lead Time
Responsiveness	Demand Responsiveness
Cost	Manufacturing Cost Logistics Cost
Profit	Return on Investment (ROI) Market Share Profit Margin on Sale
Mobility	Intensity of Good Transport
Resource Usage	Energy Usage Water Usage Land Use Raw Material Use
Pollution	Air Pollution Water Pollution
Emission	CO_2 Emission
Waste	Waste Disposal
Eco-Efficiency	Product/Service Value Environment Influence
Health and Safety	Employee Safety Health Care Benefits
Quality of Life	Accident Education and Training Working Condition

Source: Adapted from Wichaisri and Sopadang (2013).

Step 3.18 – Assess marketing and sales activities

What?

a) Review the marketing brand promise and how the company engages customers emotionally.

How?

This step can be performed by organizing a workshop to understand the organization's market strategy and brand promise and how the organization attracts customers emotionally. For complete this task, the team can use the template developed by the Circular Design Guide to review the brand promises, available in the website.

After the application, the Circular Design Guide suggests point out the customers' needs (identified in Step 3.3) and answers two questions: "how should this initiative make the customers feel?" and "what are the emotional qualities that the product brings when the customers buy or use it?" To conclude the discussion, the Circular Design Guide suggests understanding how to make the organization circular initiative feel relevant in a way that relates to the customers' values.

Use

Step 3.19 – Verify product usage and customer support

What?

a) Identify how long the use phase is;
b) Verify how the organization informs users about the right use of the product;
c) Verify if the organization get knowledge about the real use of the products and if this use corresponds to the designed use;
d) Verify how the organization provides information regarding maintenance and repair services.
e) Understand de main issues regarding after-sale services;

How?

This step can easily be performed during the internal audit. To complete this step, the team evaluates:

a) The longevity of the product's use phase, identifying it with relevant stakeholders that can provide this information. An indicator to measure the product longevity is suggested in Appendix 6;
b) How the organization informs users about the right use of the product;
c) How product is real used in practice and compare to understand if correspond to the expected use. If the organization does not have this information, the team can perform an exploratory research to understand this real use;
d) How the support services are transmitted and informed for users;
e) The effectiveness of the post-sales and support services provided for the users. This can be done by identifying how this occur in the practice and compare to the expected scenario

At the end of the data collection, the team discusses the findings and brainstorm to identify opportunities of improvement in product usage and instructions, and how the services can be more effectively informed for users.

End of Life

Step 3.20 – Understand the product EoL

What?

a) Understand what happens with the product after the end of use and what model feels more relevant and achievable for the organization;

b) Assess the recyclability of the discarded product and verify how pure and cleaned the resources are. It’s important to clarify if the discarded product contains hazardous materials.

How?

The assessment of the end-of-life alternatives can be done by using the guide proposed by Alamerew and Brissaud (2018). The guide consists in 6 steps. In the first one, the team selects the potential end-of-life strategies to be considered. Aligning with the step 3.8, consider the following strategies: repair, reutilization, refurbishment, remanufacturing, recycling and incineration (with energy recovery). In the second step, the team reviews the feasibility of the selected strategies in order to eliminate strategies that are not viable and refine the analysis of the end-of-life alternatives. Alamerew and Brissaud (2018) present a list of criteria to be considered during this moment, which can be viewed in Table 19.

Table 19 - Criteria to pre-assess the End-of-Life alternatives.

Category	List of key factors
Ecological (Environmental)	Human health Ecosystem Quality Resources
Legislation	Compliance with legislation
Market	Customer demand (market demand) Competitive pressure
Social	Additional job creation Level of customer satisfaction Consumer perception Safe working environment Customer relations
Business	Return core volume Consumption model Degree of damage Return rate (Timing of product return)
Economic	Financial cost of operating product recovery business Quality of requirement of recovered product Resell price Possible obsolescence of an assembly
Technical	Technical state (EoL condition of returned products) Advancement in technology Availability of recovery facilities Presence/Removability of Hazardous content Processibility Separability of materials

Source: Adapted from Alamerew and Brissaud (2018).

After that, the team selects the indicators to be used to assess the alternatives. Consider use the indicators presented in Appendix 6 and, to complement the analysis, the ones suggested by Alamerew and Brissaud (2018) available in Table 20.

Table 20 - List of criteria to assess EoL alternatives.

Category	List of key factors	Unit
Environmental	EoL impact indicator	Eco-indicator points
	CO_2 emissions	Kg
	SO_2 emissions	Kg
	Energy consumption	KWh
Economic	Net recoverable value	$
	Logistic cost (Collection and transport cost)	$
	Disassembly cost	$
	Product cost (What is paid for incineration, recycle, landfill etc.)	$
Social	Number of employees to perform the scenario	Integer number
	Exposure to hazardous materials (Exposure of employees to hazardous materials in all operations)	Qualitative Scale: 1 (low important) to 5 (very important)

Source: Adapted from Alamerew and Brissaud (2018).

During this assessment, the team takes the moment to assess the product recyclability and understand the situation that the product's parts return by reverse logistic in terms of contents (if there are hazardous substances) and quality (if the components are clear and conserved). The next step consists apply and calculate the selected indicators, followed by the analysis and evaluation of the results, when the team organize a workshop to discuss the outcomes and rank the strategies based on indicators. The last step consists in detail the analysis by identifying the consequences and requirements to implement the selected strategies and the challenges that can appear when performing the new end-of-life strategy. This also can be performs using the Table 19.

Reverse Logistic

Step 3.21 – Understand the reverse logistic

What?

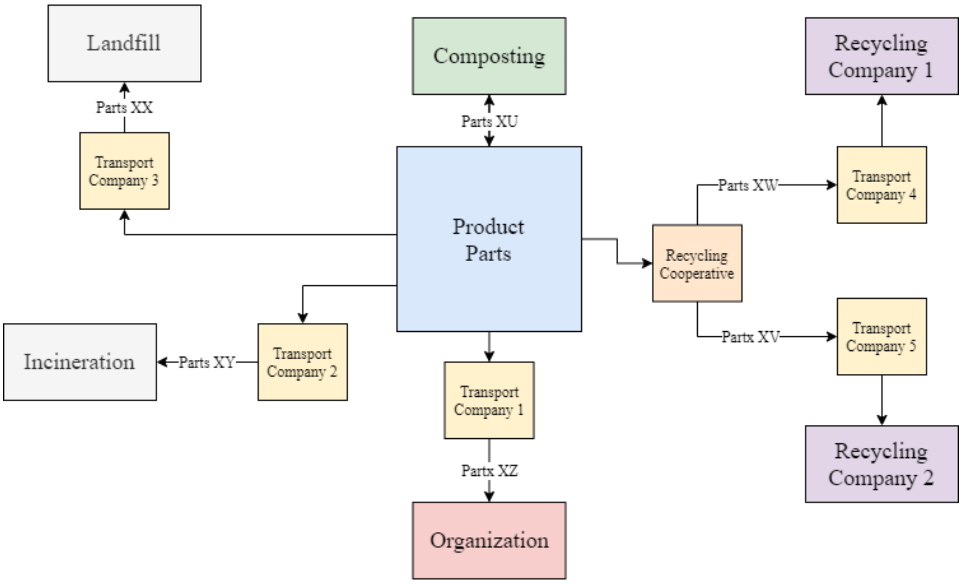
a) Understand the journeys of different product parts after the use phase and if the organization recirculate them;
b) Identify potentials challenges for collection and recovery stage;
c) Verify the efficiency of the company's communication channels to tack-back products from users.

How?

For this step, in order to understand the journey of the product's parts after the end-of-life, the team can take the list of materials (built in step 3.13) and, based on the what happens in end-of-life (mapped in the Step 3.20), identify the destination of each product part. Basically, the map includes the routes and destination of each product part, as exemplified in

Figure 22. Notice that, in this moment, the idea is mapped the destination of each product part, while in the previous step, the idea was to identify what is the end-of-life strategy (dispose, recycle, remanufacture, etc.).

Figure 22 - Example of reverse logistic map.



Source: Own authorship.

Based on the map, the team discusses what are the main challenges for collect and recover the product. Also, to complement the analysis, the team assess the efficiency company’s communication channels to tack-back products from users by understand how it’s works in practice and what are the expected performance.

Business Organization

Step 3.22 – Assess social dimension

What?

a) Verify if and how the organization promote social wellbeing, equality, employee turnover and accident reduction;

b) Understand how to support the circularity by promoting the wellbeing, education or prosperity for users and communities;

c) Conduct a survey with employees and internal stakeholders to understand opportunities to change ways of working;

d) Develop a social life cycle assessment.

How?

To start the assessment of the social aspects of the organization, the team can use the audit to understand:

a) How the organization promote social wellbeing, equality, employee turnover and accident reduction;
b) How the organization promote wellbeing and education for customers and the community.

To understand the collaborators point of view of current ways of work, the team can elaborate a survey to gather data about their perspectives for the work they make and suggestions to change the ways of work. After that, the team can start the social life cycle assessment (S-LCA) by using the guideline developed by the UNEP (2009). Similar to the LCA, the S-LCA consists in 4 phases: goal and scope; inventory analysis, impact assessment and interpretation.

In the first step, the team defines the purposes of the S-LCA (goal), e.g. to assess the social impact of the product life cycle in order to identify opportunities of improvement, and the scope. The scope of the S-LCA, like in a LCA, includes product system and functionality, boundaries, unit processes, product functionality, data collection plan, stakeholders to be considered, scope of social impacts to be considered in the assessment, method of social life cycle impact assessment, among others (UNEP, 2009).

In the case of product system and functionality, boundaries, and unit processes, the team can use the one utilized in the LCA. The team needs to take into account the viability of collecting data from other unit processes outside the organization's boundary; however, they would be very useful to have a wider overview of the social impacts (UNEP, 2009). In addition, the team also needs to define where each process is located and the stakeholders related to these processes, aiming to proceed with data collection.

For the impact assessment, the team correlates the impacts with the stakeholders in consideration. To do so, UNEP (2009) recommend organize the assessment by creating a table with the stakeholder categories, impact categories, subcategories of impacts and, finally, the indicators for each subcategory of social impact. UNEP (2013) presents an in-depth description for each subcategory of impact in each stakeholder category, suggesting the indicators to perform the impact assessment. The Table 21 presents a simplified template with these information. The team can also add new ones to obtain a deeper analysis.

In sequence, the team makes an inventory analysis including collect data for the processes and boundaries, make a hotspot assessment, evaluate each process unit location and characterize the impact assessment. The team already gathered the inputs and outputs of each process during Step 3.13 and later completed in Step 3.16.

Table 21 - Categories and subcategories for social impact assessment.

Stakeholder Category	Impact Category	Subcategory
Workers	Human rights	Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Social Benefits/Social Security
Local Community	Working conditions	Access to material resources Access to immaterial resources Delocalization and Migration Cultural Heritage Safe & healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions
Society	Health and Safety	Public commitments to sustainability issues Contribution to economic development Prevention & mitigation of armed conflicts Technology development Corruption
Consumers	Cultural Heritage	Health & Safety Feedback Mechanism Consumer Privacy Transparency End of Life responsibility
Value chain actors	Governance & Socio-economic repercussions	Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights

Source: Adapted from UNEP (2009).

The guide describes the assessment of hotspots to support the team identify where to focus the impact assessment. The authors define hotspots as unit processes located in a region where a situation occurs that may be considered a problem or opportunity for a social theme of interest, e.g., human rights, work conditions, cultural heritage, poverty, disease, etc. (UNEP, 2009). To do so, the team identifies where these processes are located, and which stakeholders are involved.

In addition to hotspots, the guide suggests identifying which activities are variable in order to help the team understand the importance of different unit processes. These activity variables are set for all unit processes and can be, for example, number of worker-hours located in different processes and value-added by unit process. If enough resources are available, it's possible to conduct visits at the places to collect the required data.

Another task in the inventory analysis consists in desktop searches to get an overview of the social problems in the area where the major input of the product comes from. This can also be allied with in-camp searches. After that, the team reviews which unit process to prioritize in the impact assessment based on the information gathered for each hotspot.

Following the S-LCA, the team defines the data that need to be collecting in the light of the indicators/method selected to assess each subcategories of social impact and how to collect these data. In addition to the indicators suggested by UNEP (2013), the team can use the ones proposed by Siebert et al. (2018) and the ones suggested in Appendix 6. This prepares the team for the main data collection, when the data for each indicator are really collected. UNEP (2009) suggest conduct audits in the places selected for the impact assessment.

If the team decides to utilize the same product system used in the LCA, the flow of resources and energy will be already mapped, and the team could focus on gather the data for the social indicators. To end the inventory assessment, the team should validate the data before starting the social assessment. For more information about this, the team should consult UNEP (2009).

In the impact assessment, the team will aggregate the inventory analysis with the indicators related to each subcategory of social impact assessment. The guideline suggests compares the results with international accepted levels of minimum performance to better understand and analyze the results. In the last phase of the S-LCA, the teams organize a workshop to interpret the results from the previous assessment, identify significant issues in terms of social impacts and conclude the main opportunities for improvement.

Step 3.23 – Assess financial dimension and performance

What?

a) Get information regarding productivity, turnover, cost reduction and business growth;
b) Assess the economic dimension of circularity for materials, components and product;
c) Quantify the investments in Corporate Social Responsibility.

How?

To have an overview of the financial performance, the team collects information regarding the current financial results of the company, including productivity, turnover, business growth, cost reduction initiatives, among others. In addition, the team collects data regarding the organization investments in social and environmental initiatives, such as social corporate responsibility, sustainability, employee's well-being and any other relevant initiative.

To complement the assessment in terms of circular economy, the team uses the indicators presented in the Appendix 6 to assess the economic dimension of the circularity for the product. And, to get an estimation of the total life cycle cost of the product, the team can use the model developed by Bradley et al. (2018). The total life cycle cost can be obtained by summed the costs of manufacturing and customers costs. The equations are shown in Figure 23.

Figure 23 - Equations to calculate the total life cycle cost.

$$TLCC = C_{MFG} + C_{CUST}$$

$$C_{MFG} = (1+Q)\left[(1-x_4)\left(RM + \sum_{i=1}^{N1} PMi\right) + \left(x_4 \sum_{i=1}^{N2} REi + (x_4 - x_3)\sum_{i=1}^{N3} RRRi + \sum_{i=1}^{N4} ESi\right)\right]$$

$$C_{CUST} = (1+Q)(C_{MFG}K - 1) + \sum_{i=1}^{N1} Ui + \sum_{i=1}^{N2} Mi$$

$$Q = \frac{(1+j)^{(G.T)-1} - 1}{j(1+j)^{(G.T)-1}}$$

$$\sum_{i=1}^{N1} PMi = \sum_{i=1}^{N1} Pi + \sum_{i=1}^{N1} RMCi + Zi$$

$$\sum_{i=1}^{N2} REi = EC + LC + TC + LOC + Zi$$

$$\sum_{i=1}^{N3} RRRi = \left(\frac{x_1}{x_1+x_2}\right)\sum_{i=1}^{N1} Pi + \sum_{i=1}^{N1} RMCi + TC + Zi$$

$$\sum_{i=1}^{N4} ESi = LEC + WMC + HSC + Zi$$

$$\sum_{i=1}^{N1} Ui = FC + OCC + Zi$$

$$\sum_{i=1}^{N2} Ui = CM + DR + Zi$$

C_{MFG} = Life cycleN1 cost to manufacturer
C_{CUST} = Life cycle cost to customer
Q = Generational multiplier
RM = Raw material cost
PMi = Processing and manufacturing cost
REi = Recovery cost
RRRi = Recycle, remanufacture, reuse cost
ESi = Environmental and societal cost
Ui = Usage cost
Mi = Maintenance cost
Pi = Material processing cost
RMCi = Remanufacturing cost
Zi = Case-specific costs (any other cost applicable for the case)
K = Profit margin factor
G = number of generations
T = Time length of generations (years)
I = Incentivization fator (cost or reimbursement for returning the previous generation component)
EC = Energy cost
LC = Labor cost
TC = Transportation cost
FC = Fuel costs
CM = Common maintenance
DR = Damage repair cost
LOC = Logistical cost
LEC = Legal costs
WMC = Waste management costs
HSC = Health and safety costs
OCC = Consumable costs
x1 = % of material recycled
x2 = % of material remanufactured
x3 = % of material reused
x4 = % of material recoverable
j = Discount rate
N1, N2, N3, N4 = sub-category index

Source: Adapted from Bradley et al. (2018).

5.3.4 Phase 4 – Proposing Solutions

The objective of the Phase 4 is, based on the organization's vision for circular economy and the opportunities identified in Phase 3, define circular initiatives to guide the organization in the Journey for Circular Transformation, including both circular practices and circular business model. The phase is performed in a series of ideation workshops to redesign the entire organization based on the circular economy principles.

Step 4.1 – Summarize the findings and prepare ideation

What?

a) Summarize all the opportunities, threats, strengths and weakness identified during the assessment phase;
b) Identify the key internal and external stakeholders to integrate the team during the sections to propose solutions. Consider include potential customers to get their point of view;
c) Have in mind for what and why the ideas are being proposed. Consider the organization's value proposition and how it could change to transitioning to a more circular and sustainable model;
d) Identify risks, assumptions and barriers for adopting circular economy practices and circular business models within the organization;
e) Understand how all the initiatives to be proposed are related to circular economy.

How?

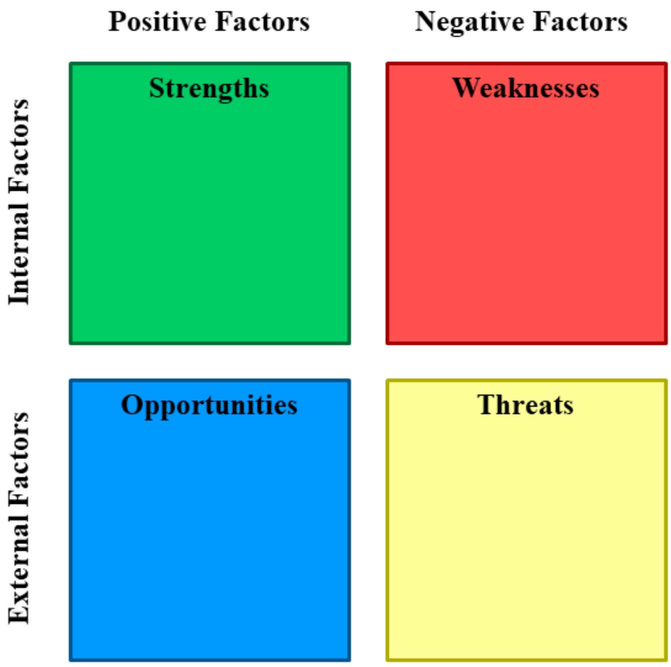
The first step in the ideation phase is summarizing the assessment outcomes (Phase 3) in a SWOT matrix. According to Hill and Westbrook (1997), the origins of SWOT matrix remits from 1960s at Harvard Business School and other American Business School. This technique consists in a matrix 2x2 in which internal factors (strengths and weaknesses) and external factors (opportunities and threats) are organized to support teams taking decisions, as exemplified on Figure 24.

In the scope of this phase, it's recommended to build one SWOT matrix for each ideation workshop, in a total of 4 matrixes:

a) SWOT 1 - Circular Business model matrix for opportunities identified in business model;
b) SWOT 2 - Product and Services redesign matrix for opportunities identified in design;

c) SWOT 3 - Value chain redesign matrix for opportunities identified in supply chain, production, distribution, use, EoL, reverse logistic, stakeholders and business environment;
d) SWOT 4 - Internal redesign matrix for opportunities identified in business organization.

Figure 24 - SWOT matrix template.



Source: Own authorship.

The team can organize a workshop to build the matrixes, also including in the discussion:

a) Potentials stakeholders to integrate each ideation workshop. Consider include relevant leadership and collaborators that might have the background required for propose solutions. For the business mode redesign, in specific, considers include potentials customers to gather their feedback;
b) Identification of assumptions, and potential risks and barriers to implement circular economy practices and circular business models.

Step 4.2– Propose a new circular business model

What?

a) Design alternative circular business models by idea generation, evaluation and prioritization;
b) Achieve sufficient internal alignment for the new circular business model, considering alignment of culture, logic and incentives among internal departments;

c) Review value creation, value delivery, value capture, and customer segment for the new circular business model;
d) Ensure that the business model dimensions fit together as a coherent whole.

How?

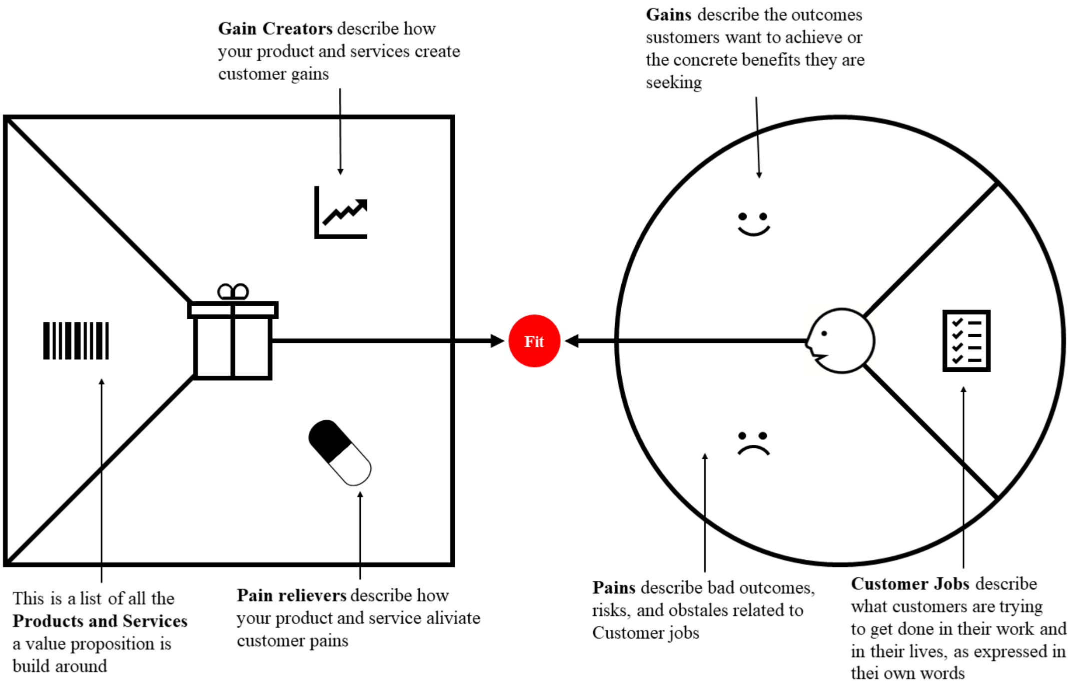
The ideation workshop for circular business model design is carried out by following the third step of the double diamond diagram developed by the Design Council (2005). The development step aims to create, prototype and test solutions, however, the scope of this workshop is limited to creation, as the prototyping and test are performed in Phase 6. Three techniques are used in this step to complete the task: brainstorming, value proposition canvas and business model canvas. Besides that, to support and guide the idea generation, a checklist of circular practices for business model is available in Appendix 1.

In first, the team needs to align which challenges or opportunities will be the drive for design the new circular business model. The opportunities are those summarized in the SWOT 1. Considering an alignment with the vision defined in Phase 2, the team discusses and come out with the selected opportunities, don't being limited to select only one, as the idea is assessing different options to conclude which one is the best option.

Defined the opportunities to carry on, and taking into account the potential customers identified in Step 3.3, the team uses the value proposition canvas, developed by Osterwalder et al. (2014), in order to build the value proposition to be used in each business model canvas alternative. The tool, as presented in Figure 25, consists in two different blocks (Value Map and Customer Profile) composed by three different dimensions that describe the value proposition in an in-depth approach:

a) Customer Jobs: Describe what customers are trying to get done in their work and in their lives;
b) Pains: Describe bad outcomes, risks, and obstacles related to customer jobs;
c) Gains: Describe the outcomes that customers want to achieve or the concrete benefits they are seeking;
d) Gain creators: Describe how organization's product and services create customer gain;
e) Pain relievers: Describe how organization's products and services alleviate customer pains;
f) Products and Services: Describe the product and services in which the value proposition is built.

Figure 25 – Template of Value Proposition Map.



Source: Adapted from Osterwalder et al. (2015).

After that, the value proposition block of the business model canvas will be filled. The next step is finishing the other canvas blocks by using brainstorming. It's important to always keep in mind that the outcome is a circular business model, which means that circular economy principles need to be consider during the design. Another point to be consider is the alignment with the company culture (or new desired culture) and harmony among internal departments.

The next step is reviewing all the canvas and clarifies the value creation, value delivery and value capture, and the target customer segment. To finish the workshop, the team should point out the changes that will be required in order to implement each option.

Step 4.3 – Propose product redesign practices

What?

a) Propose circular practices to re-design the provided products and services based on the opportunities;
b) Consider all the changes required to apply these new solutions;
c) In case of product-service redesign, consider propose tangible services.

How?

The workshop for product and service redesign aim to purpose new circular design practices. It's important to ensure these practices are aligned with the proposed circular business models options built in the Step 4.2. Thus, consider generate circular practices for each option, as they will be assessed in the next phase.

The execution is performed in a workshop using brainstorming to generate ideas and considering the opportunities present in the SOWT 2 as the base for ideation process. A checklist with circular practices for design of products and services is available in Appendix 2 to support the ideation. Finally, points out all the changes necessary to implement the proposed practices.

Step 4.4 – Propose value chain redesign practices

What?

a) Propose circular practices to redesign the entire value chain based on the opportunities. This include propose alternatives for supply-chain;
b) Consider all the changes required to apply these new solutions.

How?

The third ideation workshop is to redesign the entire value chain with circular design, which includes opportunities found in supply chain, production, distribution, use, EoL, reverse logistic, stakeholders and business environment. It's important to keep in mind the previous practices and the business models' alternatives in order to ensure an alignment.

To do so, use the SWOT 3 in a workshop and apply brainstorming to generate ideas. A checklist with circular practices for redesigning the value chain is available in Appendix 3. To conclude the workshop, the team should take notes of all changes required to implement the proposed practices.

Step 4.5 – Propose internal redesign practices

What?

a) Propose circular practices to redesign the internal organization based on the related opportunities found, including process, incentives, talent, culture and infrastructure;
b) Propose new ways of working based on the found opportunities;
c) Configure the ecosystem of stakeholders, considering alignment of processes, activities, contributions, roles, incentives and perception of business model dimensions

How?

The last ideation section aims to redesign the internal business organization, proposing circular practices for process, incentives, talent, culture and infrastructure. Also, based in the interviews with collaborators, new ways of working can also be proposed. The new internal organization needs to support the practices proposed in the last 3 ideation workshops.

In the same model, organize a workshop with the team to discuss the ideas based on the opportunities pointed out in the SWOT 4. A checklist with circular practices for internal business organization redesign is available in Appendix 4. To end the workshop, the team should take notes about all the changes required to implement the practices and the new configuration of stakeholders' ecosystem, including their roles.

5.3.5 Phase 5 – Evaluating solutions

The Phase 5 of the Journey for Circular Transformation aim to assess the viability, feasibility, desirability and circular economy principles alignment of all practices and business models proposed in the Phase 4. As a result, the organization will have a list of the most promising ones to start the test phase.

Step 5.1 – Assess the solutions viability

What?

a) Evaluate qualitatively the proposed practices in terms of viability (economic, social and environmental criteria), feasibility (technical criteria), desirability (attendance customer's needs) and circular principles to select the most promising solutions to achieve the circular economy vision. Consider use quantitative data from life cycle assessment, if needed;
b) Assess the circular business model considering the linkage with the strategy, customer and market needs, value proposition, activities, processes, resources, etc.

How?

The assessment of the proposed practices is performed based on 4 dimensions:

a) Desirability, which means fits the expectations of the customers and stakeholders;
b) Feasibility, which means the availability of technological and infrastructure required for the implementation, as well as the organization's readiness to execute them;
c) Viability, which means fits the economic, environmental and social dimensions of the triple bottom line;
d) Circular economy principles alignment. For this case, the organization can use the ReSOLVE checklist components;

The four dimensions provide a full understand of the practice's requirement and impacts, which help the organization select the most promising ones. In a qualitative approach, the assessment of the practices can be executed following the template presented in Figure 26. For this task, the team can use score system (1-3; 1-5; 1-10).

Figure 26 - Template for circular initiative evaluation.

Initiative	Viability			Feasibility (Technical)	Desirability	Circularity					
	Economic	Environme.	Social			Re	S	O	L	V	E

Source: Own authorship.

If the organization prefers a quantitative analysis to support the decision making, the life cycle assessment tools used during the assessment (LCA, TLCC and SLCA) can be used. The Figure 26 can also be used to assess the business models, however, for this case, is important to consider alignment with organization's main value proposition and strategy.

Step 5.2 Prioritize the ideas

What?

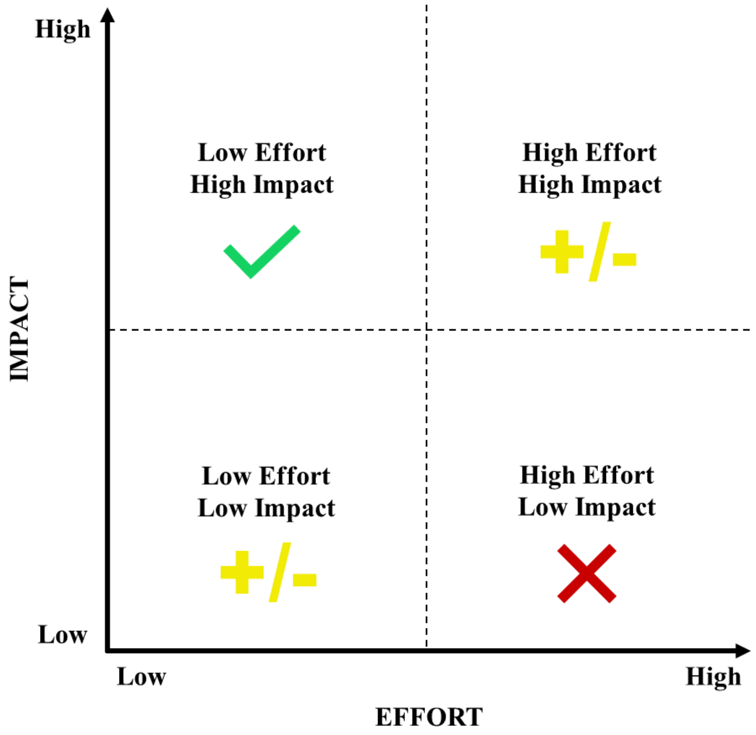
a) Plot the results of the assessment in a matrix impact vs effort and hierarchize the practices in terms of priority;
b) Review and confirm the practices and aligned with circular economy vision;
c) Understand how the related solutions could improve user experience;
d) Evaluate capability and readiness of the organization and what the solutions require that doesn't exist.

How?

The first step to decide which practices and business model to carry on is plotting them in the Impact vs Efforts matrix. This technique makes easy to visualize the solutions in terms of impacts that they'll bring and the efforts that is required to implement them. A template is presented on Figure 27. The first quadrant to be considered as priority is the one that provide high impact with low effort. They are priority for execution as they provide quick wins for the organization, just needing few resources to be expended.

The practices belonging to the quadrant that provides high impact with high effort need to be more detailed. These practices can generate valuable outcomes for the organization; however, they need high effort, which means that the organization needs to expend more time to carefully study these practices before apply them.

Figure 27 - Impact vs Effort matrix.



Source: Own authorship.

The practices in the quadrant with low impact and low effort are not totally useless, even the impact being low. Thus, consider apply these practices according to resources and time availability. The quadrant with low impact and high effort should not be consider as they will require high resources and bring only few outcomes for the organization.

After defined the practices to carry on, consider rank them based on their score generated in the Step 5.2. The result is the list of practices that the company should leverage to achieve a circular operation model. To finish this step, the team should organize all the changes requirements to apply the practices and the business model.

5.3.6 Phase 6 - Testing and Prototyping

The idea of the Phase 6 is to first develop a business case that helps the team gather the buy in of the executives in order to keep moving with the journey. Is in this phase that team put in practice the solutions defined in previous phases in a small scale by means of tests and prototypes. By these actions, the team will be able to identify which solution may not be viable in a real application and other parameters to guide the implementation in large scale

Step 6.1 – Develop a business case

What?

a) Translate the solutions into a business case considering: Market analysis, customer journey, operations, IT requirements, logistics and supply chain requirements, financial information, metrics, regulatory requirements and license to operate, hurdle rates (required or target internal rate of return), and other business specific financial expectations;
b) List out all of the hypotheses, goals and touchpoints (people, places, and things) for the prototype. Also, consider when the pilot can be enough or suspended;
c) Identify issues to piloting step;
d) Plan how to get the data required for the test and prototyping step;
e) Identify and agree performance metrics/outcomes, such as KPIs;
f) Agree frequency of business case review and update face feedback from key internal or external stakeholders;
g) Secure the necessary top-level commitment and ownership.

How?

The business case aims to register all the actions necessary to get start in a project. In this case, the project is to test the circular practices and the new circular business model. In this document, is important to consider the actions that will be performed and the resources to implement the business case. Thus, summarize in the business case:

a) The practices to be tested;
b) The analysis that underpin the project;
c) The resources required to perform the test, including: Operation, IT services, logistic and supply chain, financial, team, and regulatory requirements and license to operate;
d) The metrics will be used to monitor the test, such as Key Performance Indicators (KPIs), including the metrics to determine when the pilot can be enough or suspended;
e) The goals outcomes that are expected;
f) The chronogram;

Also, the team needs to discuss and understand the risks and problems that might appear during the executing. To finish the step, the team organizes a meeting with the relevant leadership to present them the business case and obtain their commitment and ownership to start the prototyping.

Step 6.2 – Test the circular initiatives

What?

a) Explore different approaches of testing and confirm the most appropriate ones;
b) Create and implement the prototype. Try to simulate the test in a real-like environment;
c) Implement the new business model in a pilot version. Try to understand the triple bottom line and circular principles effects;
d) Validate the viability, feasibility, desirability and consistency by simulation, trial tests, and/or prototyping;
e) Iterate until get all the required information and data.

How?

The test and prototype of the circular practices, business model and new products (if applicable) can be done by a range of alternatives, including organization's own ways and third-party platforms that provide infrastructure and support to do it. Thus, the organization needs to identify which option is more feasible with its interests.

A important aspect to be consider is apply the prototype in a real-like environment, which means execute the practices in the places that they would be applied in large scale implementation. For example, if the practices include new ways of work, the organization can apply it for a short period of time within the target department.

For the business model, the test can be done with a group of potential customers and then monitor the acceptance, performance and effects in terms of sustainability and circular economy. The team needs to validate the business model, verifying if the 9 blocks were well defined and fits together with coherence.

The prototype needs to be monitored until get the expected results, which means validate the viability, feasibility and desirability. If the results are far from the expected ones, the team can pivot and iterate until achieve them.

Step 6.3 – Assess the test results

What?

a) Review the results from the pilot and summarize the changes required before implement in large scale. Make sure to continually capture lessons learned;
b) Reassess the circularity of the tested practices and circular business model;
c) Inform the insights and results to relevant internal and external stakeholders.

How?

After concluding the performance of the test, the team organize a workshop to discuss and review the results, ensuring the results were achieve, and pointing out the main challenges and barriers faced during the execution (lessons learning). Based on the feedback, the team then makes all the needed changes before applying the practices and the business model in large scale.

The workshop should also include a discussion about if the circular economy expectations were achieved. The idea is to make sure the organization is running in the right way in the journey for circular transformation. Finally, the team wrap-up all the results and transmit them for the stakeholders in a simple message to understand.

5.3.7 Phase 7 – Planning

The objective of the Phase 7 is defining a strategic plan to guide the execution of the Journey for Circular Transformation in large scale. The plan consists in define the goals, the staff that will be involved in the project, the activities and other relevant information that comes into a plan.

Step 7.1 – Develop an action plan

What?

a) Build a detailed actin plan to execute the vision, practices and business models proposed and tested before in order to transit to a more circular and sustainable mode of operation. Include: strategic objectives, goals and milestones, roadmap, metrics and performance indicators to measure the progress, roles, responsibilities and governance arrangements;
b) Ensure the circular strategy is aligned corporate core goals and interests;
c) Identify resources and competences required to implement the strategy and allocate them;
d) Make use of existing management systems, processes and tools, if possible, in order to optimize the implementation;
e) Establish a change management system to implement and sustain the planned change, and ensure the prevailing culture is supportive of a move towards a more circular and sustainable model.

How?

In the light of the circular initiatives and their requirements, the organization develops a strategic plan to start the journey for circular transformation. The methodology suggested here is the Balanced Scorecard developed by Kaplan and Norton (1996), which helps organizations manage and achieve their strategic objectives, classified in 4 perspectives and organized in a strategic map. According to the authors, the organization break down their strategic objectives in 4 major perspectives that helps them obtains a holistic overview of all strategy:

a) Financial: Reflect the financial results that the organization aims to achieve;
b) Clients: Reflect the clients' satisfaction and needs that need to attend in order to be able to achieve the financial results;
c) Internal Process: Reflect the high quality and excellence internal process that the organization needs to have in order to achieve financial and clients' satisfaction results;
d) Organizational Capacity: Reflect the human capital, innovation, infrastructure, culture and general resources the organization needs to have in order to achieve the other 3 perspectives.

After understanding the perspective, the first step is organize a workshop to review the vision for circular economy, as it's possible to be desired any change based in the previous phases. After that, the team defines the strategic objectives the organization aim to achieve in the scope of the 4 perspectives. These strategic objectives reflect the major aims in terms of circular economy based in the vision and the initiatives proposed. Besides that, it's important to ensure the strategic objectives are aligned with corporate core goals and interests.

Defined the objectives, the team establishes performance metrics to measure the progress against the time for each strategic objective. One set of indicators very known is the key performance indicators, which are the ones that focus on aspects of organizational performance that are most critical for current and future success (PARMENTER, 2016).

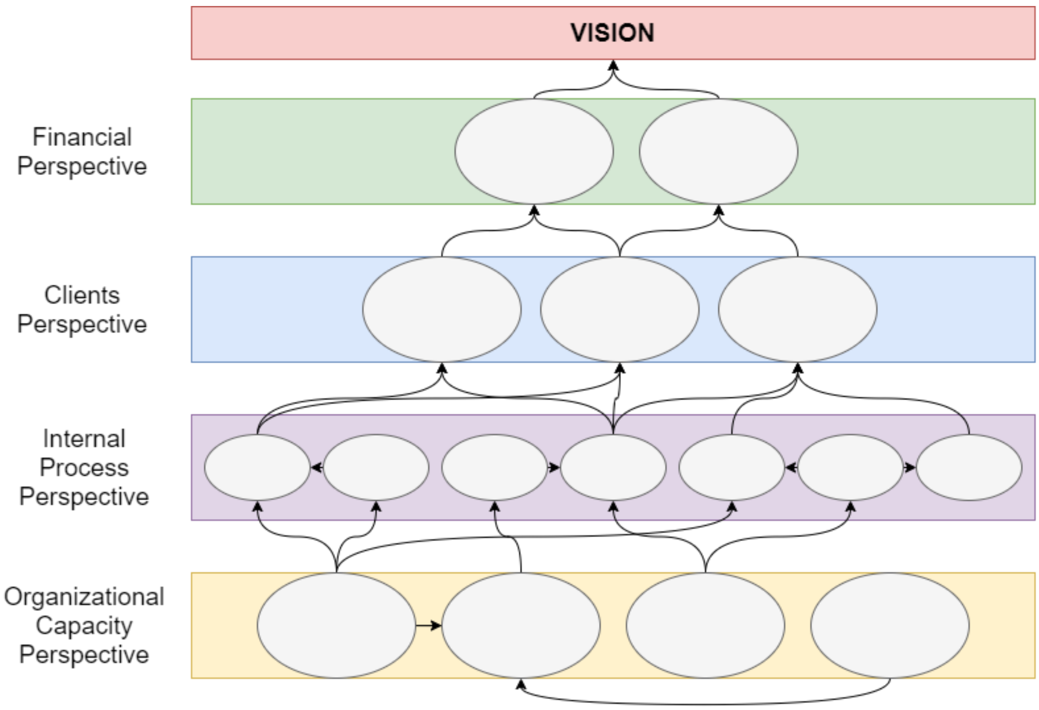
Also, the team defines the goals for each indicator, which represent the target result expected for each indicator. The team can use the SMART goals technique to help the development. This technique was first established by Doran (1981) and suggests the goals need to consider 5 aspects:

a) Specific: the goals need to be clear and specific for one target;
b) Measurable: the goal needs to be possible to measure against the time;
c) Achievable: the goal needs to be realistic and possible to achieve;
d) Relevant: the goal needs to be relevant for the target;
e) Time-related: the goal needs to consider a deadline.

The next step is to define strategic projects that reflect the actions to be taken in order to achieve goals. These strategic projects are organized in an action plan which also includes responsibilities and roles, capabilities and resources required for each strategic project, and deadlines. A roadmap can be designed in order to improve the visualization of the action plan.

The last part of the methodology is designing the strategic maps, a visual tool that presents the strategic objectives organized in the 4 perspectives and in which is established a cause-dependence relationship. In other words, the objectives are linked by arrows that express the cause-dependence relationship. An example of strategic map is presented on Figure 28.

Figure 28 - Example of strategic map.



Source: Kaplan and Norton (1996).

Step 7.2 - Plan the communication

What?

a) Define the circular message and brand promise base on the circular economy to engage customers emotionally. It's important to ensure the message makes the customer feel involved in the new circular model, and connected with the organization's values;
b) Rethink the emotional qualities wanted for the brand;
c) Create empathize with internal audiences and a storyboard to transmit the message for them.

How?

Before starting the implementation, the team needs to consider how they will communicate the results and progress with relevant stakeholders. To do so, organize a workshop to brainstorm and define how the organization will:

a) Involve and engage customers emotionally, making them fell involved in the organization's circular initiative;
b) How the new circular initiative is related with organization's values;
c) Empathize with internal stakeholders to engage them in the circular initiatives.

To define the message, the team cans use the process described in the Step 3.23.

5.3.8 Phase 8 – Implementing and Monitoring

The Phase 8 aims to implement the strategic plan to conduce the Journey for Circular Transformation. The progress against the time is monitored to ensure the results are within the scope of the expected goals. The previous phases showed the considerations that the team needs to take into account in a real application and the plan to put the solutions in practice.

Step 8.1 – Implement the circular strategy

What?

a) Large-scale implementation of the strategy (practices and business model), performing all the required changes;
b) Integrate the metrics with the organization's sustainability reporting systems;
c) Facilitate continual and transformational improvement;
d) Use already established processes and structures to make easier the implementation;
e) Ensure the employees engagement and buy-in regarding circular economy;
f) Execute the external and internal communication's plan;
g) Ensure the execution is being performed with support from the top-level leadership;
h) Ensure all mechanisms and structures are in place to continuously capture key data and other insights to enable future strategic and operational performance evaluation.

How?

This step is executed by following the strategic plan defined in Phase 7 and using the resources and infrastructures foreseen in the plan and available in the organization. It's important to ensure the mechanisms and structures are in place and the collaborators are being engaged to improve the performance of the strategic projects.

Step 8.2 – Monitor the progress

What?

a) Establish a continuous monitoring and positive learning culture to check the business model and practices in terms of financial, social and environmental performance;
b) Adapting simpler circular economy messaging to consumers;
c) Take notes to compose the lessons learned;

d) Build a resilient culture to manage and apply required changes keeping focus on the vision and strategy;
e) Communicate the outcomes with storytelling, educational messages and statistics to the defined audience;
f) Ensure collaboration and transparency with external stakeholders;
g) Ensure the existence of mechanisms to get and respond stakeholder feedback regarding organization's circular economy vision and strategy.

How?

The organization should consider use already available infrastructure and resources to monitor the projects and any other defined in the strategic plan. Make sure the organization establish a continuous monitoring and resilient culture, take notes and feedback about the performance, and communicate the stakeholders with transparency

5.3.9 Phase 9 – Reviewing and Modifying

The last phase of the Journey for Circular Transformation consists in, after executed the strategic plan until the first scheduled review, assess the results and make the changes that are required to ensure continuous improvement.

Step 9.1 – Assess the outcomes

What?

a) Run internal audits and management review processes to analyze the changes in the organization's environmental impacts and aspects and evaluate the performance and effectiveness of the strategy to transit to a more circular and sustainable model.

How?

The first step of the assessment consists in run internal audits to verify how the strategy for circular economy changed the organization's environmental impacts. This helps the organization understand their environmental quality and performance.

To do so, the team can make use of one of the environmental impact assessment tools already discussed in step 3.16. In terms of understand if the strategy was effective in terms of transit to a more circular model, the organization can use the ReSOLVE checklist and circular principles defined by Ellen MacArthur Foundation (2015) in the same way as used in Phase 5 to assess the ideas.

Step 9.2 Review and execute changes

What?

a) Review the progress against the feedback and assessment and summarize to uncover patterns and insights;
b) Identify if the goals and strategic objectives were achieved and, if not, what is the current progress;
c) Review and reformulate the strategic plan for scaling the strategy;
d) Make necessary corrective actions for continuous improvement and continuous learning;
e) Implement the selected improvements and corrective changes to approaches where evidence indicates that these are necessary and/or desirable;
f) Ensure that the success is celebrated and communicated to intern audience and relevant external stakeholders.

How?

To conclude the journey for circular transformation, the organization executes a workshop to:

a) Review the progress of the goals against the indicators to understand if the expected results were achieved;
b) Review the feedback and lessons learning collected during the execution;
c) Define which changes are require and brainstorm to define what will be the changes;
d) Review and reform the strategic plan based on the changes.

After reviewing the strategic plan, the organization can continue with the implementation of the journey. The last part of this step-by-step is celebrating the results with all the stakeholders involved in the project to engage and create enthusiasm to keep on the journey.

6 DISCUSSION

The current available frameworks and models in the literature have difficult to successfully illustrate the steps needed for an organization to be able to implement circular economy (LIAKOS et al., 2019). Only few contributions have the capacity to transmit these steps; however, they do not cover all the stages of a value chain that is necessary to holistically redesign an organization in the scope of circular economy. In a framework to implement circular economy, the idea is to ensure that the actions taken by an organization are in line with circular economy principles and the circular economy vision of its stakeholders (PAULIUK, 2018).

When visualize individually, the findings cover different project management-related steps, but not all together at the same time, except the BSI 8001:2017 standard. Some examples of such steps are team definition, business case elaboration, leadership engagement, prototyping, monitoring, and review. When all the pieces are put together, like in the Journey for Circular Transformation proposed here, a full and more complete project is achieved, i.e., all the stages of a project life cycle. Some disciplines such innovation, entrepreneurship and technological development also play an important role in the transformation of industrial value chains (KORHONEN et al., 2018).

In the framework proposed by the BSI, there is no defined an entry point or order that needs to be followed, allowing the organizations adapt the steps to their level of circularity maturity (BSI, 2017). The step-by-step here is also thought to provide flexibility to users. Organizations do not need to execute all the steps present in Phase 3; the idea is performing the steps that will bring information that are aligns with their vision for circular economy. Also, the Phase 4, where solutions are proposed, the idea is also considering only the steps that are aligned with the organization’s vision.

The BSI standard is most composed by business processes of a project aligns with circular economy expectations. As Pauliuk (2018) stated, the BSI 8001:2017 has a link between established business procedures and the ambitions of the circular economy approach. The main gap in the standard, however, is the absence of components in an assessment stage that support organizations identify where the opportunities of improvement can be found.

Even being a process that focus on circular economy implementation, the step-by-step built from literature findings is still essentially related to business procedures disciplines. In this line, the ways to apply circular economy into organizations may be mainly differentiated from other business projects by the assessment and proposition of solutions that are proposed following the definitions and principles of circular economy.

In the line of this hypothesis, the Phase 3 of the Journey for Circular Transformation comes as a key component of the proposed step-by-step. From a literature perspective, the authors included in their processes a variety of fields to be assessed in order to identify circular opportunities, but again, when considered individually, the findings have a limited assessment. The work of Dey et al. (2020) seems to be the most completed one in terms of fields to be assessed, contemplating fields from the entire life cycle of a product. The Journey for Circular Transformation considers the value chain of an organization, including not only the product life cycle, but also the assessment of stakeholders, business environment/ecosystem, and organizational characteristics. This process of map the business's organizational is essential to develop the circular practices (JØRGENSEN; REMMEN, 2018).

The analysis with main circular economy characteristics showed that the Phase 3 is aligned with circular economy principles definitions. First because provides a full understand of the materials, water and energy used by an organization. This help to map the types of resources that are consumed and understand if they are toxic dangerous, recyclable, biodegradable, or any other characteristic that, when known, makes possible design loops or changes for more sustainable and circular inputs. Close resource loop and usage of circular inputs are being stated as core principles of circular economy (SUÁREZ-EIROA et al., 2019; TONELLI; CRISTONI, 2019; ELLEN MACARTHUR FOUNDATION, 2015).

A second reason is the process of mapping wastes, its quantities, and the moment in the production line that they are generated. In a circular perspective, waste is seem as an issue in the design and needs to be reintroduced in the system as a valuable input. Thus, this understanding is important in order to propose alternatives of processes and reintroduction to mitigate environmental impacts and resource losses. Waste prevention seems to be strong connected with circular principles (SUÁREZ-EIROA et al., 2019; TONELLI; CRISTONI, 2019; ELLEN MACARTHUR FOUNDATION, 2015; WEETMAN, 2016).

A third factor that aligns the step-by-step with the circular economy is the assessment of product's design. Different authors pay attention on the product design in circular economy principles (SUÁREZ-EIROA et al., 2019; ELLEN MACARTHUR FOUNDATION, 2013b). The design of a product has a key role to close the loop of resources, as this determines the quantity of materials required to produce a product, and how easy is to reuse, remanufacture, disassembly, and recycle the different parts. The assessment of the product end-of-life also contributes for the creation and design of resource loops. The Journey for Circular

Transformation considers a shift for product-service system approach, which is widely mentioned in the literature as a pathway for circular economy.

A fourth reason is the procedure to map the stakeholders and customers and identify their needs. Collaboration is being mentioned as a key factor and principle to move to a circular economy model (BSI, 2017; WEETMAN, 2016; ELLEN MACARTHUR FOUNDATION, 2013b). Understand the actors that affect the organization directly and indirectly, and their needs, makes possible design products and services to fit their expectations, but also have support in the new projects defined to transit from linear to circular. The minimization of waste and replanning of energy use are linked to improve efficiency within organizations and may lead to greater profitability, and also providing capabilities to drive for sustainable development (KATZ-GERRO; SINTAS, 2018).

A fifth reason is the steps that focus on the environmental impact assessment, social impact assessment, and total life cycle cost quantification. In possession of such information, the organization is able to identify the negative impacts that are current being caused and propose alternatives to mitigate it. Together with financial viability identification, the journey cover all the dimensions of the triple-bottom-line that enable organizations contribute for a sustainable development. Circular Economy can be viewed as a condition for sustainability, having a beneficial interrelationship (GEISSDOERFER et al. 2017). The study of Dey et al. (2020) suggests that the most relevant phases of a life cycle are the production and usage stages, which mainly contribute for the sustainable dimensions' performance (DEY et al., 2020). The authors state that the environmental performance is mainly affected, thinking in circular economy, by energy efficiency, waste reduction and resource efficiency.

Not all the steps, however, seems to have the same weight in terms of contribution for circular transition. In the Phase 3, the most recommended step from the findings is the mapping of stakeholders, which may enforce the importance of consider all the parts when working on circular economy. In other side, the assessment of the outbound logistics and marketing activities are only mentioned by one finding.

Considering the link between the steps and circular economy highlights, the exploration of product redesign to fit loop-strategies and analysis of material flow may be key components in the assessment. On the other side, the logistics analysis seems to be the assessments less related to circular economy. However, more studies are needed to conclude such hypothesis. Looking at the highlights perspectives, the system thinking and collaboration with partners seems to be the most aspects that are intrinsic on the assessment.

About the other phases of the journey, components such definition of a team to execute the project, definition of the baseline and the vision for circular economy, redesign the product, and test the solutions are the steps that are most considered in the other publications. The process of test a solution before implementing it a in a large scale is a powerful resource to support organizations concentrate resources and effort in the ones that is really relevant for the stakeholders, including customers.

The leadership engagement seems to be especially important to have success in the transformation (MENDOZA, GALLEGO-SCHMID AND AZAPAGIC, 2019a; 2019b; BSI, 2017; MENDONZA et al., 2017; WBCSD, 2016; ELLEN MACARTHUR FOUNDATION; IDEO), as investments are necessary to put in practice the solutions proposed for the circular economy transformation. This means that organizations need to designate financial resources that sometimes can be scarce or highly controlled. For this reason, the alignment of the vision for circular economy with the business vision, enforced in step 2.4 and 7.1, come as a key factor to have success in the transition.

It is noted that each finding has some strong components that, when put together, contribute for a more complete step-by-step. The highlight of process of Jørgensen and Remmen (2018) is the approach for solutions proposition. The authors consider a redesign of the entire company, including product redesign, value chain redesign and business organization redesign. The gap here is the consideration of business model redesign for a circular economy approach, which is compensated when merged with other findings (MENDOZA, GALLEGO-SCHMID AND AZAPAGIC, 2019b; FRISHAMMAR AND PARIDA, 2019; ANTIKAINEN et al., 2017; BSI, 2017; ELLEN MACARTHUR FOUNDATION AND IDEO).

Mendoza, Gallego-Schmid and Azapagic (2019a; 2019b) and Dey et al. (2020) most contribute with the assessment of the baseline (current state of the organization in terms of circular economy). To full implement circular economy into organizations, it’s necessary to first know the current state of circular economy to better drive the transition (DEY et al., 2020). For this reason, the Phase 2 of the Journey for Circular Transformation focus on built a team, engage leadership and analyze the current state to develop an accurate vision for circular economy aligns with the business vision. By knowing the current state, the organizations can optimize the implementation by using current assets and skills, and also focus on the weak components in terms of circularity.

About the circular business models, it is noted that the current available procedures to design it are not aligned with the various types and taxonomies of circular business model proposed in the literature. Thus, there is not a clear understanding of the ways to identify which type may be most relevant for an organization.

The toolkit is composed of some well-known methods, such Design Thinking, LCA and MFA, which may facilitate it application. Material Flow Analysis is a powerful tool for measure the input of natural resources, the loss of materials and the emissions of pollutants (ELIA; GNONI; TORNESE, 2017). By combining different tools, the identification, assessment and prioritization of circular economy solutions is facilitated (MENDOZA; GALLEGO-SCHMID; AZAPAGIC, 2019b). Also, the combination of tools makes possible to overcome the barrier of lack of knowledge to implement circular economy.

The various workshops proposed along the journey aim to facilitate the communication and ensure co-design between different parts. Co-design sessions between different actors, such researchers and business, are crucial to develop the outcomes for circular economy (JØRGENSEN; REMMEN, 2018). Jørgensen and Remmen (2018) also highlight the importance of dialog with customers and final users to understand the current practices and design the desired ones.

The term circular practice, or circular economy related practices, is still unclear in the literature as stated in the literature review. The checklists organized for the Phase 4 aim to provide some insights for the team that are designing the solutions. A conclusion of the reviewed practices is that they seem to be related to a variety concepts (such cleaner production, eco-design) and topics (water-related practices; energy-related practices and material efficiency). The classification of the practices in this study may bring a new alternative group them and makes easier to support organizations identify the most relevant based on their needs.

In general, the practices of resource efficiency and energy efficiency are the most common ones implemented by organizations (MASI et al., 2018). Such practices ae driven mainly by costs savings. Organizations also have preference of firm level circular practices instead of practices in supply chain level (MASI et al., 2018), as interaction and establishment of partnerships with suppliers are sometimes a blocker and more costly.

Based on the review about this topic, more studies are need in the scope of circular practices. First, it’s needed a clear definition and the factors that classify a business practice in a circular one. Second, it’s needed an understanding of the correlation between the proposed practices and the circular economy principles in order to understand how they contribute to circular economy.

The Journey for Circular transformations may face some challenges when coming into practical applications. The major barrier of the proposed toolkit is the lack of data and information to input in the methods, tools and indicators. Social life cycle assessment, for example, is still a recent method and has not been widely implement around the world, which implies in lack of databases (UNEP 2009). The same problem can be found during the application of LCA. The organizations may not have a complete description of the data required for the MFA, stakeholders mapping, and all the suggested indicators. Regarding the indicators, as Rossi et al. (2020) stated, the current available indicators for circular economy have some difficult to be applied due to lack of data and, sometimes, lack of more clear description and resources to calculate it.

Another barrier for the journey is the quantity of financial and human resources available to implement the solutions (LIU; BAI, 2014). Redesign of products and replan water and energy usage, for example, requires a higher monetary investment, which sometimes lead to a low profitability in a first moment (KATZ-GERRO; SINTAS, 2018). Changes in raw material for more circular ones sometimes can imply in increase of costs for the organization and changes in the supply chain.

Most existing methods and frameworks are generic and don’t focuses on a specific industry sector (PERALTA; LUNA; SOLTERO, 2019). This is also true for the Journey for Circular Transformation, as non-specific segments (e.g. retail, chemical, etc.) are mentioned. Thus, future researches can focus on specify the step-by-step for industry sectors as they have differentiations and specifications on supply chain, policies, business structure, production system, customers and so on.

A second opportunity of future researches on this journey is the validation by a case study. The scope of this study is proposing a theoretical step-by-step, but do not consider a practical validation. During a case study, feedbacks can be collected to understand the main strengths and limitations of the step-by-step, such the order of the steps and the harmony between them. Industrial symbiosis, for example, is still a challenge for companies and, for this reason, it’s not widely considered in circular economy assessment for company implementation. (PRIETO-SANDOVAL et al., 2019). Also, the step-by-steps for circular economy implementation current available in the literature do not considered the analysis of business cooperation in terms of industrial symbiosis. Consequently, the Journey for Circular Transformation do not cover this type of assessment and can be an opportunity for future researches identify the steps and actions needed to have this assessment.

Considering the Phase 3, a third opportunity of further researches is to complement the assessment with other fields that, when analyzed, may bring useful information to support organizations transit to a circular model. This can include more literature inputs but also the considerations of specialists in circular economy and business procedures, which can be executed by a Delphi study. The Journey for Circular Transformation includes only two types of circular business model described in the literature (PSS and collaboration/sharing), as the findings only mentioned these two. Accenture (2014) defined five types of circular business models: circular supplies, resource recovery, product life extension, sharing platform and product as a service. The other types not mentioned in this research can be addressed in a future opportunity.

The study of drivers and barriers for circular economy may provide some insights about new analysis. Company culture (KUMAR et al., 2019; RIZOS et al., 2016), as suggested by some authors, has the potential to drive the implementation of circular economy, and also be an impediment when the organization's culture do not enable this transition. Capabilities and internal skills (RIZOS et al., 2016) is another driver that may enable the Journey for Circular Transformation.

Technological drivers (TURA et al., 2019), by means of informational technologies and new emerging ones from industry 4.0 (cloud computing, analytics, IoT, big data and artificial intelligence), enable organizations deliver and implement life cycle strategies, such end-of-life and reverse logistic, and deliver value for market (DEV; SHANKAR; QAISER; 2020; RAJPUT; SINGH 2019; BRESSANELLI et al., 2018). The journey still does not convers an assessment of the technologies used by an organization and the internal IT capabilities. Other contributions and internal analysis that may improve the assessment and understanding of the organization's opportunities are: human resources department and activities in the line of supporting and giving the ways for internal employees drive the transition (PRIETO-SANDOVAL e al., 2019); financial department and its processes to support the implementation of circular solutions

Thus, futures researches can focus on understand how to conduct and assessment to identify opportunities of improvement to redesign: the internal organization in terms of culture; how the staff is trained and how the already present internal capabilities are; the IT department and technologies employed to support the solutions; and the other departments activities, such human resources and financial, to support the organization promote and fully implement circular economy.

7 CONCLUSION

The shift of current patterns of consumption and extraction of natural resources, and the breakage of the linear logic of take-make-dispose, is crucial to ensure a sustainable development. The literature has shown that this transition faces several challenges, especially in the micro level in which organizations do not have the know-how to promote this shift. This research contributes with the theory and practice of circular economy implementation at the micro level by providing a new descriptive and theoretical step-by-step that has a holistic overview of the value chain. The toolkit, suggested here, which include some well-known methods and four checklists with circular economy practices, complement the application by showing the ways to do so. With both pieces together, the Journey for Circular Transformation becomes able to support organization move from linear to a circular.

The main conclusions from the extensive literature review are two. The ways to implement circular economy, here understood as the adoption of business model, practices, strategies and/or initiatives that are directly or indirectly aligned to the circular economy definition, principles, and its interrelated schools of thought, is driven by established business procedures in which the identification of opportunities and solutions propositions are the core stages that need to be aligned with circular economy. The current methods to implement circular economy in micro level in the literature do not explicit ways to achieve all the ambitions of circular economy and also limitations in terms of opportunities identification for circular economy improvement.

The steps of the Journey for Circular Transformation cover a wide range of analysis that provides useful information and data that are relevant to redesign the business model, product and service, value chain, and business organization into a circular model. In especial, the phase 3 seems to be directly aligned with some circular economy goals, such redesign of product, close, slow and narrow resource loops, foster efficient usage of renewable resources and collaboration with stakeholders. The assessment also provides useful information for the understanding of sustainable impacts and ways to improve/avoid it.

Considering circular economy practices, the literature jargon still does not have a consensus of definition and criteria that classifies practices into a circular one. More studies are needed regarding this topic to clarify these gaps. The practices have the potential to guide organizations in the transition towards a circular economy. The same can be speculated about indicators that brings quantitative and qualitative data. The literature about this topic covers different measures that can be useful; but at the same time, some authors have pointed out limitations of their application mainly due to lack of data and lack of equations and resources to quantify the indicators.

This study has some limitations that need to be considered. The first limitation is regarding the theoretical scope of this study, which does not consider an application to validate the components of the Journey for Circular Transformation. A practical test is crucial to understand the applicability of this step-by-step, the main challenges and the successful transformation of the studies organization across the circular economy.

A second limitation is the applicability of the proposed toolkit and indicators. As some authors stated, the lack of available information may limit the assessment of opportunities and, as a consequence, reduce the scope of possibilities for circular economy improvements. The lack of capital, high investments needed to propose solutions and difficult to establish partnership with stakeholders are some internal barriers that also challenge the circular transformation.

Some opportunities for future researches were also identified. Seeking to complement the Journey for Circular Transformation and better cover circular economy aspects, a Delphi study with experts in this topic can be conducted to understand new steps that can bring more information regarding improvements that an organization needs to adopt to successfully transit to a circular economy. The scope of such study can be expanded for experts in project management and business procedures to optimize the application and improve the chances to complete the journey. The analysis of drivers for circular economy can also clarify these improvements.

A second opportunity is adaptation of the journey for specific industry segments. The proposed step-by-step is idealized to be applicable in any type of business. However, different industry sectors may have some specifications in terms of supply chain, required policies and production system. The understanding of these nuances might optimize the application and also come up with better results to efficiently move towards a circular economy.

8 REFERÊNCIAS

ACCEMTURE. **Circular Advantage**. Accenture Strategy. 2014. Available in: https://www.accenture.com/t20150523t053139__w__/us-en/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/strategy_6/accenture-circular-advantage-innovative-business-models-technologies-value-growth.pdf. Accessed in 13 Jul. 2020.

AGUILAR, F. J. **Scanning the business environment**. New York: Macmillian, 1967.

AGRAWAL, S.; SINGH, R. K. Analyzing disposition decisions for sustainable reverse logistics: Triple Bottom Line approach. **Resources, Conservation & Recycling**, v. 150, p. 104448, 2019.

ALAMEREW, Y.; BRISSAUD, D. Circular economy assessment tool for end of life product recovery strategies. **Journal of Remanufacturing**, v. 9, p. 169–185, 2019.

ALBUQUERQUE, T. L. M.; MATTOS, C. A.; SCUR, G.; KISSIMOTO, K. Life cycle costing and externalities to analyze circular economy strategy: Comparison between aluminum packaging and tinplate. **Journal of Cleaner Production**, v. 234, p. 477–486, 2019.

ALLE, A. Value network analysis and value conversion of tangible and intangible assets. **Journal of Intellectual Capital**, v. 9, n. 1, p. 5–24, 2008.

ANTIKAINEN, M.; AMINOFF, A.; KETTUNEN, O.; SUNDQVIST-ANDBERG, H.; PLOHEIMO, H. Circular Economy Business Model Innovation Process - Case Study. In: International Conference on Sustainable Design and Manufacturing, 2017. **Proceedings**: Sustainable Design and Manufacturing 2017, Bologna, Springer, 2017. p. 546-555.

ARANDA-USÓN, A.; PORTILLO-TARRAGONA, P.; MARÍN-VINUESA, L. M.; SCARPELLI, S. Financial Resources for the Circular Economy: A Perspective from Businesses. **Sustainability**, v. 11, p. 888, 2019.

BASSI, F.; DIAS, J. G. The use of circular economy practices in SMEs across the EU. **Resources, Conservation & Recycling**, v. 146, p. 523–533, 2019.

BATISTA, L.; BOURLAKIS, M.; SMART, P.; MAULL, R. In search of a circular supply chain archetype – a content-analysis-based literature review. **Production Planning & Control**, v. 29, n. 6, p. 1–14, 2018.

BENYUS, **Biomimicry: Innovation Inspired by Nature**. 1 ed. New York: HarperCollins Publishers, 1997, 308 p.

BLESSING, L. T. M.; CHAKRABARTI, A. DRM, **A Design Research Methodology**. London: Springer, 2009, 397 p.

BOCKHOLT, M. T.; KRISTENSEN, J. H.; COLLI, M.; JENSEN, P. M.; WAEHRENS, B. V. Exploring factors affecting the financial performance of end-of-life take-back program in a discrete manufacturing context. **Journal of Cleaner Production**, v. 258, p. 120916, 2020.

BOCKEN, N. M. P.; PAUW, I.; BAKKER, C.; VAN DER GRINTEN, B. Product design and business model strategies for a circular economy. **Journal of Industrial and Production Engineering**, v. 33, n. 5, p. 308–320, 2016.

BOCKEN, N.; STRUPEIT, L; WHALEN, K.; NUSSHOLZ, J. A Review and Evaluation of Circular Business Model Innovation Tools. **Sustainability**, v. 1, p. 2210, 2019.

BONTOUX, L.; BENGTSSON, D. 2035 Paths towards a sustainable EU economy Sustainable transitions and the potential of eco-innovation for jobs and economic development in EU eco-industries 2035. 2015.

BOVEA, M. D.; PÉREZ-BELIS, V. Identifying design guidelines to meet the circular economy principles: A case study on electric and electronic equipment. **Journal of Environmental Management**, v. 228, p. 483-494, 2018

BRACQUENÉ, E.; DEWULF, W.; DUFLOU, J. Measuring the performance of more circular complex product supply chains. **Resources, Conservation & Recycling**, v. 154, p. 104608, 2020.

BRADLEY, R.; JAWAHIR, I. S.; BADURDEEN, F.; ROUCH, K. A total life cycle cost model (TLCCM) for the circular economy and its application to post-recovery resource allocation. **Resources, Conservation & Recycling**, v. 135, p. 141–149, 2018.

BRESSANELLI, G.; ADRODEGARI, F.; PERONA, M.; SACCANI, N. Exploring how usage-focused business models enable circular economy through digital technologies. **Sustainability**, v. 10, p. 639, 2018.

BROWN, P.; BOCKEN, N.; BALKENENDE, R. Why Do Companies Pursue Collaborative Circular Oriented Innovation? **Sustainability**, v. 11, p. 635, 2019.

BSI. **Framework for implementing the principles of the circular economy in organizations – Guide**. London: BSI Standards, 2017.

CAMACHO-OTERO, J.; BOKS, C.; PETTERSEN, I. N. Consumption in the Circular Economy: A Literature Review. **Sustainability**, v. 10, n. 2758, p. 1-25, 2018

CARVALHO, P. S.; LINDAHL, M.; HJELM, O.; OMETTO, A. R. How to Design Circular Business Models for Startups: A Case Study with a Swedish Company. In: IS4CE2020 Conference of the International Society for the Circular Economy, **Proceedings**, Exeter, 2020.

CENTOBELLI, P.; CERCHIONE, R.; CHIARONI, D.; VECCHIO, P. D.; URBINATI, A. Designing business models in circular economy: A systematic literature review and research agenda. **Business Strategy and the Environment**, p. 1-16, 2020.

CHAMBERLIN, L.; BOKS, C. Marketing Approaches for a Circular Economy: Using Design Frameworks to Interpret Online Communications. **Sustainability**, v. 10, p. 2070, 2018.

CIRCLE ECONOMY. Making sense of the circular economy: the 7 key elements. Available in: https://www.circle-economy.com/circular-economy/7-key-elements. Accessed on 16 Oct. 2020

CNI. **Circular economy: opportunities and challenges for the brazilian industry**. Brasília:CNI, 2018, 68 p.

CONFORTO, E. C.; AMARAL, D. C.; SILVA, S. L. Roteiro para revisão bibliográfica sistemática: aplicação no desenvolvimento de produtos e gerenciamento de projetos. In: 8° Congresso Brasileiro de Gestão de Desenvolvimento de Produto – CBGDP 2011, Porto Alegre, p. 1–12, 2011.

CULLEN, J. M. Circular Economy: Theoretical Benchmark or Perceptual Motion Machine? Journal of Industrial Ecology, v. 00, n. 0, p. 1-4, 2017.

DE ANGELIS, R., HOWARD, M.; MIEMCZYK, J. Supply chain management and the circular economy: Towards the circular supply chain. **Production Planning and Control**, v. 29, n. 6, p. 425-437, 2018.

DESIGN COUNCIL. Design methods for developing services: An introduction to service design and a selection of service design tools. 2015. Available in: https://www.designcouncil.org.uk/sites/default/files/asset/document/DesignCouncil_Design%20methods%20for%20developing%20services.pdf. Accessed in 15 Jul. 2020.

DEV, N. K.; SHANKAR, R.; QAISER, F. H. Industry 4.0 and circular economy: Operational excellence for sustainable reverse supply chain performance. **Resources, Conservation & Recycling**, v. 153, p. 104583, 2020.

DEY, P. K.; MALESIOS, C.; DE, D.; BUDHWAR, P.; CHOWDHURY, S.; CHEFFI, W. Circular economy to enhance sustainability of small and medium-sized enterprises. **Business Strategy and the Environment**, p. 1-25, 2020.

DI MARIO, F.; REM, P. C. A Robust Indicator for Promoting Circular Economy through Recycling. **Journal of Environmental Protection**, v. 6, p. 1095-1104, 2015.

DORAN, G. T. There's a S.M.A.R.T. Way to Write Management's Goals and Objectives, **Management Review**, v. 70, n. 11, pp. 35-36, 1981.

EUROPEAN ENVIRONMENT AGENCY. Circular economy in Europe: Developing the knowledge base. Luxemburg, 2016.

ELLEN MACARTHUR FOUNDATION. **Towards the Circular Economy: Opportunities for the consumer goods sector**. Ellen MacArthur Foundation, 2013a. 111 p.

ELLEN MACARTHUR FOUNDATION. **Towards the Circular Economy: Economic and business rational for an accelerated transition**. Ellen MacArthur Foundation, 2013b. 96 p.

ELLEN MACARTHUR FOUNDATION. **Towards the Circular Economy: Accelerating the scale-up across global supply chains**. Ellen MacArthur Foundation, 2014. 76 p.

ELLEN MACARTHUR FOUNDATION. **Growth Within: A Circular Economy Vision for a Competitive Europe**. Ellen MacArthur Foundation, 2015. 97 p.

ELLEN MACARTHUR FOUNDATION; IDEO. Circular Design Guide. Available in: https://www.circulardesignguide.com/. Accessed in 29 Jun. 2020

ELIA, V.; GNONI, M. G.; TORNESE, F. Evaluating the adoption of circular economy practices in industrial supply chains: An empirical analysis. **Journal of Cleaner Production**, v. 273, p. 122966, 2020.

ELIA, V.; GNONI, M. G.; TORNESE, F. Measuring circular economy strategies through index methods: A critical analysis. **Journal of Cleaner Production**, v. 142, p. 2741–2751, 2017.

ELZINGA, R.; REIKE, D.; NEGRO, S. O.; BOON, W. P. C.. Consumer acceptance of circular business models. **Journal of Cleaner Production**, v. 254, p. 119988, 2020.

EUROPEAN COMMISION. **Study on the EU’s list of Critical Raw Materials (2020). Luxemburg: European Commission**, 2020a. 153 p.

EUROPEAN COMMISION. **Circular Economy Action Plan: For a cleaner and more competitive Europe**. European Commission, 2020b. 27 p.

EUROPEAN COMMISION. **Closing the loop - An EU action plan for the Circular Economy**. Brussels: European Commission, 2015. 21 p.

FAROOQUE, M.; ZHANG, A.; THÜRER, M.; QU, T. HUISINGH, D. Circular supply chain management: A definition and structured literature review. **Journal of Cleaner Production**, v. 228, p. 882–900, 2019.

FAVI, C.; GERMANI, M.; LUZI, A.; MANDOLINI, M.; MARCONI, M. A design for EoL approach and metrics to favour closed-loop scenarios for products. **International Journal of Sustainable Engineering**, p. 1-11, 2016.

FORTUNATI, S.; MARTINIELLO, L.; MOREA, D. The Strategic Role of the Corporate Social Responsibility and Circular Economy in the Cosmetic Industry. **Sustainability**, v. 12, p. 5120, 2020.

FRANKLIN-JOHNSON, E.; FIGGE, F.; CANNING, L. Resource duration as a managerial indicator for Circular Economy performance. **Journal of Cleaner Production**, v. 133, p. 589-598, 2016.

FRISHAMMAR, J.; PARIDA, V. Circular Business Model Transformation: A Roadmap for Incumbent Firms. **California Management Review**, v. 61, n.2, p. 5-29, 2019.

GARZA-REYES, J. A.; VALLS, A. S.; NADEEM, S. P.; ANOSIKE, A.; KUMAR, V. A circularity measurement toolkit for manufacturing SMEs: A circularity measurement toolkit for manufacturing SMEs. **International Journal of Production Research**, v. 57, n. 23, p. 7319-7343, 2019.

GEISSDOERFER, M.; BOCKEN, N. M. P.; HULTINK, E. J. Design thinking to enhance the sustainable business modelling process e A workshop based on a value mapping process. **Journal of Cleaner Production**, v. 135, p. 1218–1232, 2016.

GEISSDOERFER, M.; NAOMI, S. N.; CARVALHO, M. M.; EVANS, S. Business models and supply chains for the circular economy. **Journal of Cleaner Production**, v. 190, p. 712–721, 2018.

GEISSDOERFER, M.; SAVAGET, P.; BOCKEN, N. M. P.; HULTIN, E. J. The Circular Economy - A new sustainability paradigm? **Journal of Cleaner Production**, v. 143, p. 757–768, 2017.

GENG, Y.; FU, J.; SARKIS, J.; XUE, B.; Towards a national circular economy indicator system in China: an evaluation and critical analysis. **Journal of Cleaner Production**, v. 23, p. 216-224, 2012.

GENG, Y.; DOBERSTEIN, B. Developing the circular economy in China: Challenges and opportunities for achieving 'leapfrog development'. **International Journal of Sustainable Development & World Ecology**, v. 15, n. 3, p 231-239, 2008.

GHISELLINI, .a; CIALANI, C.; ULGIATI, S. A review on circular economy : the expected transition to a balanced interplay of environmental and economic systems. **Journal of Cleaner Production**, v. 114, p. 11–32, 2016.

GOULD, O.; COLWILL, J. A framework for material flow assessment in manufacturing systems**. Journal of Industrial and Production Engineering**, v. 32, n. 1, p. 55–66, 2015.

GOVINDAN, K.; BOUZON, M. From a literature review to a multi-perspective framework for reverse logistics barriers and drivers. **Journal of Cleaner Production**, v. 187, p. 318–337, 2018.

GOVIDAN, K.; HASANAGIC, M.; A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. **International Journal of Production Research**, v. 56, n. 1-2, p. 278-311, 2018.

GRAEDAL, T.; ALLENBY, B. R. **Industrial Ecology**. 1 ed. New Jersey: Prentice Hall, 1995, 363 p.

GUSMEROTTI, N. M.; TESTA, F.; GORSINI, F.; PRETNER, G.; IRALDO, F. Drivers and approaches to the circular economy in manufacturing firms. **Journal of Cleaner Production**, v. 230, p. 314-327, 2019.

HANKAMMER, S.; BRENK, S.; FABRY, H.; NORDEMANN, A.; PILLER, F. T. Towards circular business models : Identifying consumer needs based on the jobs-to-be-done theory. **Journal of Cleaner Production**, v. 231, p. 341–358, 2019.

HILL, T.; WESTBROOK, R. SWOT Analysis : It's Time for a Product Recall. **Long Range Planning**, v. 30, n. 1, p. 46–52, 1997.

HOFMANN, F.; MARWEDE, M.; NISSE, N. F.; LAND, K. D. Circular added value: business model design in the circular economy. In: Product Lifetimes And The Environment 2017, **Proceeding**, Delft 2017.

HUNT, A. **Element Recovery and Sustainability**. 1 ed. Cambridge:Royal Society of Chemistry, 2013, 270 p.

IGLE, B. R. Design **Thinking for Entrepreneurs and Small Businesses: Putting the Power of Design to Work**. New York:Apress, 152 p., 2013.

IRP. **Gloubal Resource Outlook 2019 – Natural Resources for the Future We Want**. Nairobi: United Nations Environment Programme, 2019a. 158 p.

IRP. **Natural Resource Use in the Group of 20: Status, Trends, and Solution**s. Nairobi: United Nations Environment Programme, 2019b. 82 p.

IRP. **Assessing global resource use: A systems approach to resource efficiency and pollution reduction**. Nairobi: United Nations Environment Programme, 2017. 99 p.

ISO**. ISO 14001:2015 - Environmental management systems — Requirements with guidance for use 14001**. 2015, 35 p.

ISO. **ISO 14040:2006 - Environmental management — Life cycle assessment — Principles and framework**. 2006, 20 P.

JØRGENSEN, M. S.; REMMEN, A. A methodological approach to development of circular economy options in businesses. **Procedia CIRP**, v. 69, p. 816–821, 2018.

JOUSTRA, D. J.; JONG, E.; ENGELAER, F. **Guided Choices: Towards a Circular Business Mode**. Venlo: C2C BIZZ, 2013. 50 p.

KALMYKOVA, Y.; SADAGOPAN, M.; ROSADO, L. Circular economy – From review of theories and practices to development of implementation tools. **Resources, Conservation & Recycling**, v. 135, p. 190–201, 2018.

KANNAN, D.; MINA, H.; NOSRATI-ABARGHOOEE, S.; KHOSROJERDI, G. Sustainable circular supplier selection: A novel hybrid approach. **Science of the Total Environment**, v. 722, p. 137936, 2020.

KAPLAN, R. S.; NORTON, D. P.; **The Balanced Scorecard: Translating Strategy into Action**. 1 ed, Boston: Harvard Business Review Press, 1996, 384 p.

KATZ-GERRO, T.; SINTASM J. L. Mapping circular economy activities in the European Union: Patterns of implementation and their correlates in small and medium-sized enterprises. **Business Strategy and the Environment**, p. 1-12, 2018.

KAZANCOGLU, Y.; KAZANCOGLU, I.; SAGNAK, M. A new holistic conceptual framework for green supply chain management performance assessment based on circular economy. **Journal of Cleaner Production**, v. 195, p. 1282–1299, 2018.

KIRCHHERR, J.; PISCICELLI, L.; BOUR, R.; KOSTENSE-SMIT, E.; MULLER, J. HUIBRECHTSE-TRUIJENS, A.; HEKKERT, M.. Barriers to the Circular Economy: Evidence From the European Union (EU). **Ecological Economics**, v. 150, p. 264–272, 2018.

KIRCHHERR, J.; REIKE, D.; HEKKERT, M. Conceptualizing the circular economy: An analysis of 114 definitions. **Resources, Conservation & Recycling**, v. 127, p. 221–232, 2017a.

KORHONEN, J.; HONKASALO, A.; SEPPÄLÄ, J. Circular Economy: The Concept and its Limitations. **Ecological Economics**, v. 143, p. 37–46, 2018.

KORHONEN, J.; NUUR, C.; FELDMANN, A.; BIRKIE, S. E. Circular economy as an essentially contested concept. **Journal of Cleaner Production**, v. 175, p. 544–552, 2018.

KUMAR, V.; SEZERSAN, I.; GARZA-REYES, J. A.; GONZALEZ, E. D. R. S.; AL-SHBOUL, M. A. Circular economy in the manufacturing sector: benefits, opportunities and barriers. **Management Decision**, v. 57, n. 4, p. 1067–1086, 2019.

KUO, A. K.; WILSON, E.; KAWAHARA, S.; HORNING, D.; BELGER, S.; LUCEY, C.. Meeting Optimization Program: A “Workshop in a Box” to Create Meetings That Are Transformational Tools for Institutional Change. **MedEdPORTAL : the journal of teaching and learning resources**, v. 13, p. 10569, 2017.

LEE, H. M.; LU, W. F.; SONG, B. A framework for assessing product End-Of-Life performance: reviewing the state of the art and proposing an innovative approach using an End-of-Life Index. **Journal of Cleaner Production**, v. 66, p. 355-377, 2014.

LEOPOLD, L. B.; CLARKE, F. E.; HANSHAW, B. B.; BALSLEY, J. R. **A Procedure for Evaluating Environmental Impact**. Geological Survey Circular 645, 1971. 13 p.

LEWANDOWSKI, M. Designing the Business Models for Circular Economy - Towards the Conceptual Framework. **Sustainability**, v. 8, p. 43, 2016.

LIAKOS, N., KUMAR, V., PONGSAKORNRUNGSILP, S., GARZA-REYES, J.A., GUPTA, B., PONGSAKORNRUNG-SILP, P. Understanding circular economy awareness and practices in manufacturing firms. **Journal of Enterprise Information Management**, v. 32, n. 4, p. 563–584, 2019.

LIEDER, M.; RASHID, A. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. **Journal of Cleaner Production**, v. 115, p. 36–51, 2016.

LINDAHL, M.; SAKAO, T.; CARLSSON, E. Actor's and system maps for Integrated Product Service Offerings - Practical experience from two companies. **Procedia CIRP**, v. 16, p. 320–325, 2014.

LINDER, M.; SARASINI, S.; VAN LOON, P. A Metric for Quantifying Product-Level Circularity. Journal of Industrial Ecology, v.00, n. 0, 2017

LINDER, M.; WILLIANDER, M. Circular Business Model Innovation: Inherent Uncertainties. **Business Strategy and the Environment**, v. 26, p. 182-196, 2015.

LIU, L.; LIANG, Y.; SONG, Q.; LI, J. A review of waste prevention through 3R under the concept of circular economy in China. **Journal of Material Cycles and Waste Management**, 2017.

LIU, Y.; BAI, Y. An exploration of firms' awareness and behavior of developing circular economy: An empirical research in China. **Resources, Conservation & Recycling**, v. 87, p. 145–152, 2014.

LYLE, J. T. **Regenerative Design for Sustainable Development**. 1 ed. New York: Johns Wiley & Sons, 1994, 338 p.

MASI, D.; KUMAR, V.; GARZA-REYES, J. A.; GODSELL, J. Towards a more circular economy : exploring the awareness, practices, and barriers from a focal firm perspective. **Production Planning & Control**, v. 29, n. 6, p. 539-550, 2018.

MATHIEUX, F.; FROELICH, D.; MOSZKOWICZ, P. Development of recovery indicators to be used during product design process: method, potentialities and limits. **Proceedings** Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing, p. 281-286, 2017.

MCDONOUGH, W.; BRAUNGART, M. Remaking the Way We Make Things. 1 ed. New York:North Point Press, 2002, 208 p.

MENDES, N. C. **Métodos e modelos de caracterização para a Avaliação de Impacto do Ciclo de Vida: análise e subsídios para a aplicação no Brasil**. Dissertação (Mestrado em Engenharia de Produção) - Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, p. 149, 2013.

MENTINK, B. **Circular Business Model Innovation: A process framework and a tool for business model innovation in a circular economy**. Thesis (Master in Industrial Ecology) – Delft University of Technoogy & Leinden University, 2014, 167 p.

MENZONZA, J. M. F.; GALLEGO-SCHMID, A.; AZAPAGIC, A. A methodological framework for the implementation of circular economy thinking in higher education institutions: Towards sustainable campus management. **Journal of Cleaner Production**, v. 226, p. 831-844, 2019a.

MENZONZA, J. M. F.; GALLEGO-SCHMID, A.; AZAPAGIC, A. Building a business case for implementation of a circular economy in higher education institutions. **Journal of Cleaner Production**, v. 220, p. 553-567, 2019b.

MENDOZA, J. M. F.; SHARMINA, M.; CALLEGO-SCHMID, A.; HEYES, G.; AZAPAGIC, A. Integrating Backcasting and Eco-Design for the Circular Economy: The BECE Framework. **Journal of Industrial Ecology**, v. 21, n. 2, p. 526-544, 2017.

MORELLI, N. Product-service systems, a perspective shift for designers: A case study: the design of a telecentre. **Design Studies**, v. 24, n. 1, p. 73–99, 2003.

MORENO, M.; RIOS, C. D. L.; ROWE, Z.; CHARNLEY, F. A Conceptual Framework for Circular Design. **Sustainability**, v. 8, p. 937, 2016.

MURA, M.; LONGO, M.; ZANNI, S. Circular economy in Italian SMEs: A multi-method study. **Journal of Cleaner Production**, v. 245, p. 118821, 2020.

MURRAY, A.; SKENE, K.; HAYNES, K. The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. **Journal of Business Ethics**, 2015.

NUSSHOLZ, J. L. K. Circular Business Models: Defining a Concept and Framing an Emerging Research Field. **Sustainability**, v. 9, p. 1810, 2017.

OECD. **Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences**. OECD Publishing, Paris, 2018.

OECD. **Perspective on Global Development 2012: Social Cohesion in a Shifting World**. OECD Publishing, 2012.

OGHAZI, P.; MOSTAGHEL, R. Circular Business Model Challenges and Lessons Learned - An Industrial Perspective. **Sustainability**, v. 10, p. 739, 2018.

ORMAZABAL, M.; PRIETO-SANDOVAL, V.; PUGA-LEAL, R.; JACA, C. Circular Economy in Spanish SMEs: Challenges and opportunities. **Journal of Cleaner Production**, v. 185, p. 157–167, 2018.

OSBORN, A. F. **Applied imagination**. New York: Scribner's, 1957.

OSTERWALDER, A.; PIGNEUR, Y. **Business Model Generation: A Handbook for Visionaries, Game Changers, and Challenger**. New Jersey: John Wiley & Sons, 2010. 278 p.

OSTERWALDER, A.; PIGNEUR, Y. **Business Model Generation - Inovação em Modelos de Negócios: Um manual para visionários, inovadores e revolucionários**. Rio de Janeiro: Alta Books, 2011, 300 p.

OSTERWALDER, A.; PIGNEUR, Y.; BERNARDA, G.; SMITH, A. **Value Proposition Design: How to Create Products and Services Customers Want**. 1 ed. :Wiley, p. 320, 2014.

PARMENTER, D. **Key Performance Indicators: Developing, Implementing, and Using Winning KPIs**. 3 ed. Hoboken: John Wiley & Sons, 2015, 488 p.

PAULIUK, S. Critical appraisal of the circular economy standard BS 8001: 2017 and a dashboard of quantitative system indicators for its implementation in organizations. **Resources, Conservation & Recycling**, v. 129, p. 81–92, 2018.

PAVELIN, K.; PUNDIR, S.; CHAM, J. A. Ten Simple Rules for Running Interactive Workshops. **PLoS Computational Biology**, v. 10, n. 2, p. 1-5, 2014.

PEACER, D. W.; TURNER, R. K. Economics of Natural Resource and the Environment. Baltimore:Johns Hopkins University Press, 1989, 392 p.

PERALTA, M. E.; LUNA, P.; SOLTERO, V. M. Towards standards-based of circular economy: knowledge available and sufficient for transition? **International Journal of Sustainable Development & World Ecology**, p. 1–18, 2019.

PESCE, M.; TAMAI, I.; GUO, D.; CRITTO, A.; BROMBAL, D.; WANG, X.; CHENG, H.; MARCOMINI, A.. Circular Economy in China: Translating Principles into Practice. **Sustainability**, v. 12, p. 832, 2020.

PORTER, M. E. **Competitive Advantage: Creating and Sustaining Superior Performance**. 1 ed. New York: Macmillian, 1985, 557 p.

POTTING, J.; HEKKERT, M.; WORRELL, E.; HANEMAAIJER, A. **Circular Economy : Measuring Innovation in the Product Chain**. PBL Netherlands Environmental Assessment Agency, The Hague, 2017.

PRIETO-SANDOVAL, V.; JACA, C.; ORMAZABAL, M. Towards a consensus on the circular economy. **Journal of Cleaner Production**, v. 179, p. 605–615, 2018.

PRIETO-SANDOVAL, V. P.; JACA, C.; SANTOS, J.; BAUMGARTNER, R. J.; ORMAZABAL, M. Key strategies, resources, and capabilities for implementing circular economy in industrial small and medium enterprises. **Corporate Social Responsibility and Environmental Management**, v. 26, p. 1473–1484, 2019.

PRIETO-SANDOVAL, V.; ORMAZABAL, M.; JACA, C.; VILES, E. Key elements in assessing circular economy implementation in small and medium-sized enterprises. **Business Strategy and the Environment**, v. 27, p. 1525-1534, 2018.

RAJPUT, S.; SINGH, S. P. Connecting circular economy and industry 4.0. **International Journal of Information Management**, v. 49, p. 98–113, 2019.

REIKE, D.; VERMEULEN, W. J. V.; WITJES, S. The circular economy: New or Refurbished as CE 3.0? - Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. **Resources, Conservation & Recycling**, v. 135, p. 246–264, 2018.

RITZÉN, S.; SANDSTRÖM, G. O. Barriers to the Circular Economy - integration of perspectives and domains. **Procedia CIRP**, v. 64, p. 7–12, 2017.

RIZOS, V.; BEHRENS, A.; VAN DER GAAST, W. ; HOFMAN, E.; IOANNOU, A.; KAFYEKE, T.; FLAMOS, A. RINALDI, R. PAPADELIS, S.; HIRSCHNITZ-GARBERS, M.; TOPI, C. Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers. **Sustainability**, v. 8, n. 1212, p. 1-18, 2016.

ROCKSTRÖM, J.; STEFFEN, W.; NOONE; K.; PERSSON, Å.; CHAPIN, F. S.; LAMBIN, E. F.; LENTON, T. M.; SCHEFFER, M.; FOLKE, C.; SCHELLNHUBER, H. J.; NYKVIST, B.; WIT, C. A.; HUGHES, T.; VAN DER LEEUW, S.; RODHE, H.; SÖRLIN, S.; SNYDER, P. K.; COSTANZA, R.; SVEDIN, U; FALKENMARK, B.; KARLBERG, L.; CORELL, R. W.; FABRY V. J.; HANSEN, J.; WALKER, B.; LIVERMAN, D.; RICHARDSON, K.; CRUTZEN, P.; FOLEY, J. A. A safe operation space for humanity. **Nature**, v. 461, p. 472–475, 2009.

ROSA, P.; SASSANELLI, C.; URBINATI, A.; CHIARONI, D.; TERZI, S. Assessing relations between Circular Economy and Industry 4.0: a systematic literature review. **International Journal of Production Research**, v. 58, n. 6, p. 1662–1687, 2020.

ROSSI, E.; BERTASSINI, A. C.; FERREIRA, C. S.;AMARAL, W. A. N.; OMETTO, A. R. Circular economy indicators for organizations considering sustainability and business models: Plastic, textile and electroelectronic cases**. Journal of Cleaner Production**, v. 247, p. 119137, 2020.

RSA. Investigating the role of design in the circular economy. London: RSA, 2013. 8 p. Available in: https://www.thersa.org/globalassets/pdfs/reports/great-recovery-executive-summary-june-2013.pdf. Accessed in 23 Aug. 2020.

RUSSEL, M.; GIANOLI, A.; GRAFAKOS, S. Getting the ball rolling: an exploration of the drivers and barriers towards the implementation of bottom-up circular economy initiatives in Amsterdam and Rotterdam. **Journal of Environmental Planning & Management**, p. 1-24, 2019.

SBIHI, A..; EGLESE, R. W. Combinatorial optimization and Green Logistics. **Annals of Operations Research**, v. 175, p. 159-175, 2010.

SCHROEDER, P.; ANNGRENI, K.; WEBER, U. The Relevance of Circular Economy Practices to the Sustainable Development Goals. **Journal of Industrial Ecology**, v. 23, n. 1, p. 77–95, 2018.

SEROKA-STOLKA, O.; OCIEPA-KUBICKA, A. Green logistics and circular economy. **Transportation Research Procedia**, v. 39, p. 471–479, 2019.

SIEBERT, A.; BEZAMA, A.; O’KEEFFE, S.; THRÄN, D. Social life cycle assessment indices and indicators to monitor the social implications of wood-based products. **Journal of Cleaner Production**, v. 172, p. 4074–4084, 2018.

SITRA. **The opportunities of a circular economy for Finland**. Helsinki: Sitra, 2015. 68 p.

SOUSA-ZOMER, T. T.; MAGALHÃES, L.; ZANCUL, E.; CAMPOS, L. M. S.; CAUCHICK-MIGUEL, P. A. Cleaner production as an antecedent for circular economy paradigm shift at the micro-level: Evidence from a home appliance manufacturer. **Journal of Cleaner Production**, v. 185, p. 740-748, 2018.

STAHEL, W. R. **The Performance Economy**. 2 ed. Basingstoke: Palgrave Macmillina, 2010, 349 p.

STEFFEN, W.; RICHARDSON, K.; ROCKSTRÖM, J.; CORNELL, S. E.; FETZER, I.; BENNETT, E. M.; BIGGS, R.; CARPENTER, S. R.; DE VRIES, W.; DE WIT, C. A.; FOLKE, C.; GERTEN, D.; HEINKE, J.; MACE, G. M.; PERSSON, L. M.; RAMANATHAN, V.; REYERS, B.; SÖRLIN, S. Planetary boundaries: Guiding human development on a changing planet. **Science**, v. 347, n. 6223, p. 1259855, 2015.

STEPHENSON, J.; GALLOWAY, A. **The Secrets to Workshop Success**. Londres:BookBoon, 31 p., 2012.

SU, B.; HESHMATI, A.; GENG, Y.; YU, X. A review of the circular economy in China: moving from rhetoric to implementation. **Journal of Cleaner Production**, v. 42, p. 215–227, 2013.

SUÁREZ-EIROA, B.; FERNÁNDEZ, E.; MÉNDEZ-MARTÍNEZ, G.; SOTO-OÑATE, D. Operational principles of circular economy for sustainable development: Linking theory and practice. **Journal of Cleaner Production**, v. 214, p. 952-961, 2019.

SUMTER, D.; KONING, J.; BAKKER, C.; BALKENENDE, R. Circular Economy Competencies for Design. **Sustainability**, v. q2, n. 1561, p. 1-16, 2020.

UNEP**. Eco-i Manual: Eco-innovation implementation process**. United Nations Environment Programme, 2017. 377 p.

UNEP. **Guidelines for social life cycle assessment of products**. United Nations Environment Programme, 2009. 103 p.

UNEP. **The Methodological Sheets for Subcategories in Social Life Cycle Assessment (S-LCA)**. United Nations Environment Programme, 2013.

TONELLI, M.; CRISTONI, N. Strategic Management and the Circular Economy. New York:Routledge, 2019, 256 p.

TROPMAN, J. E. The decision group: ways to improve the quality of meetings and decisions. **Human Systems Management**, v. 3, p. 107–118, 1982.

TURA, N.; HANSKI, J.; AHOLA, T.; STÅHLE, M.; PIIPARINEN, S.; VALKOARI, P. Unlocking circular business: A framework of barriers and drivers. **Journal of Cleaner Production**, v. 212, p. 90–98, 2019.

UNIVERSIDADE DE SÃO PAULO. **Agência USP de Gestão da Informação Acadêmica. Diretrizes para apresentação de dissertações e teses da USP**. 5 ed. São Paulo: Aguia, 2020, 76 p.

URBINATI, A.; CHIARONI, D.; CHIESA, V. Towards a new taxonomy of circular economy business models. **Journal of Cleaner Production**, v. 168, p. 487–498, 2017.

URBINATI, A.; ROSA, P.; SASSANELLI, C.; CHIARONI, D.; TERZI, S. Circular business models in the European manufacturing industry: A multiple case study analysis. **Journal of Cleaner Production**, v. 274, p. 122964, 2020.

URBINATI, A.; ÜNAL, E.; CHIARONI, D. Framing the Managerial Practices for Circular Economy Business Models: A Case Study Analysis. **Proceedings** - 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), p. 1-7, 2018.

VAN DEN BERG, M. R.; BAKKER, C. A. A product design framework for a circular economy. Product Lifetime And The Environment Conference 2015, **Proceedings**, Nottingham, p. 365-379, 2015.

VEGTER, D.; HILLEGERSBERG, J. V.; OLTHAAR, M. Supply chains in circular business models: processes and performance objectives. **Resources, Conservation & Recycling**, v. 162, p. 105046, 2020.

VERMUNT, D. A.; NEGRO, S. O.; VERWEIJ, P. A.; KUPPENS, D. V.; HEKKERT, M. P. Exploring barriers to implementing different circular business models. **Journal of Cleaner Production**, v. 222, p. 891–902, 2019.

WASTLING, T.; CHARNLEY, F.; MORENO, M. Design for Circular Behaviour: Considering Users in a Circular Economy. **Sustainability**, v. 10, p. 1743, 2018.

WBCSD. **Unlocking More Value with Fewer Resources A practical guide to the circular economy**. Geneve: World Business Council for Sustainable Development, 2016. 23 p.

WEETMAN, C. **A Circular Economy Handbook for Business and Supply Chains: Repair, Remake, Redesign, Rethink**. 1 ed. New York: Kogan Page, 2016, 432 p.

WICHAISRI, S.; SOPADANG, A. Sustainable Logistics System: A Framework and Case Study. **Proceedings** – 2013 IEEE International Conference on Industrial Engineering and Engineering Management, p. 1017–1021, 2013.

WINANS, K.; KENDALL, A.; DENG, H. The history and current applications of the circular economy concept. **Renewable and Sustainable Energy Reviews**, v. 68, p. 825–833, 2017.

YUAN, Z.; BI, J.; MORIGUICHI, Y. The Circular Economy: A New Development Strategy in China. **Journal of Industrial Ecology**, v. 10, n. 1-2, p. 4-8, 2006.

ZHU, Q.; GENG, Y.; LAI, K. Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. **Journal of Environmental Management**, v. 91, p. 1324–1331, 2010.

APPENDIX 1 - Circular practices for business model redesign.

Author	Circular Practice	Author	Circular Practice
Masi et al. (2018)	Targeting Green segments of the market	Rampton (2015)	Customer involvement in circularity initiatives
Suárez-Eiroa et al. (2019)	Interconnecting stages/Redistributing second-hand goods	Urbinati et al. (2020)	Sale of products by adding complementary services
Suárez-Eiroa et al. (2019)	Designing new business models and strategies	Urbinati et al. (2020)	Exploitation of the company website to promote the value proposition
Urbinati, Ünal and Chiaroni (2018); Urbinati et al. (2020)	Sale of single products	Zhu et al. (2010)	Investment recovery (sale) of excess inventories/materials
Tukker (2004); Tukker (2015); Tukker and Tischner (2006)	Sale of products with additional complementary assets	Mura et al. (2020)	The company develops products or services promoting energy savings
Mont (2002); Urbinati et al. (2020)	Leasing/renting	Mura et al. (2020)	The company develops products or technologies in the renewable energy sector
Stahel (2016); Urbinati et al. (2020)	Pay-per-use	Urbinati, Ünal and Chiaroni (2018)	Communication of circularity through all channels

APPENDIX 2 - Circular practices for product and service redesign.

Author	Circular Practice	Author	Circular Practice
Masi et al. (2018); Zhu et al. (2010)	Designing of products for reduced consumption of resources and materials	Ghisellini et al. (2016)	More simplified lifestyle by end consumers
Masi et al. (2018); Zhu et al. (2010); Urbinati, Ünal and Chiaroni (2018); Urbinati et al. (2020)	Design of products for reuse the product and/or components	Suárez-Eiroa et al. (2019)	Eco-design
Masi et al. (2018); Zhu et al. (2010)	Design of processes for minimization of waste	Suárez-Eiroa et al. (2019)	Designing transparent, reproducible and scalable products to build the same products in other places based on local resources
Urbinati et al. (2019)	Design for upgradability, flexibility or adaptability	Suárez-Eiroa et al. (2019)	Thinking about practical utilities and consumer preferences (customization/made to order)
Urbinati, Ünal and Chiaroni (2018); Urbinati et al. (2020); Urbinati et al. (2019)	Design for remanufacturing	Sousa-Zomer et al. (2018)	Design according to the consumer profile to increase durability for each consumer type (B2B and B2C)
Urbinati, Ünal and Chiaroni (2018); Urbinati et al. (2020); Urbinati et al. (2019)	Design for disassembly and/or reassembly	Urbinati, Ünal and Chiaroni (2018); Urbinati et al. (2020); Urbinati et al. (2019)	Design for Environment
Urbinati, Ünal and Chiaroni (2018); Urbinati et al. (2020); Urbinati et al. (2019)	Design for upcycling/recycling	Urbinati et al. (2019)	Design Out Waste
Ness (2008); Ghisellini et al. (2016); Lieder and Rashid (2016); Su et al. (2013); Sauvé et al. (2015); Ma et al. (2013); Soo et al. (2016); Jawahir and Bradley (2016); Liu (2016); Zhijun and Nailing (2007); Zhu et al. (2010); Landaburu-Aguirre et al. (2016); Lihong (2011); Amato et al. (2016); Sihvonen and Partanen (2016); Smol et al. (2015)	Appreciable design and durable design to make it possible to implement in supply chain	Sousa-Zomer et al. (2018)	Design to simplify the product installation
Masi et al. (2018); Zhu et al. (2010); Sousa-Zomer et al. (2018)	Design of products for reducing consumption of energy	Sousa-Zomer et al. (2018)	Consideration of recyclability issues in the product design
Zhu et al. (2010)	Design of products to avoid or reduce use of hazardous products	Sousa-Zomer et al. (2018)	Integration of environmental issues during the design enabled by new capabilities developed by the R&D area

APPENDIX 3 - Circular practices for value chain redesign.

Author	Circular Practice	Author	Circular Practice
Supply Chain			
Masi et al. (2018); Suárez-Eiroa et al. (2019)	Using renewable materials as input in the production process	Mura et al. (2020)	Bio/natural raw materials used into the products
Masi et al. (2018); Mura et al. (2020)	Selecting suppliers using environmental criteria	Mura et al. (2020)	Biodegradable materials for packaging
Suárez-Eiroa et al. (2019)	Promoting green procurement	Masi et al., 2018	Reusing energy and/or water across the value chain
Xinan and Yanfu (2011) apud Govidan and Hasanagic (2018)	Increase environmental accounting in supply chain	Su et al. (2013); Zhijun and Nailing (2007); Ghisellini et al. (2016) apud Govidan and Hasanagic (2018)	Pilot projects for circular economy in supply chain
Ghisellini et al. (2016); Ilić and Nikolić (2016); Su et al. (2013); Lieder and Rashid (2016); Sauvé et al. (2015) Govidan and Hasanagic (2018)	Decouple economy in supply chain with environmental impacts	Su et al. (2013); Geng et al. (2012); Franklin-Johnson et al. (2016); Reuter (2016); Pan et al. (2015) apud Govidan and Hasanagic (2018)	Performance indicators on recycling, reuse and remanufacture in supply chain
Su et al. (2013); Ghisellini et al. (2016); Lieder and Rashid (2016); Ying and Li-jun (2012) apud Govidan and Hasanagic (2018)	Cleaner purchases from purchasing	Urbinati et al. (2020); Urbinati, Ünal and Chiaroni (2018)	Usage of friendly materials, which are natural, recyclable, durable, and easy to separate
Reuter (2016) apud Govidan and Hasanagic (2018)	Measurable data to measure the environment performance in regards of the initiatives by implementing circular economy in supply chain	Sousa-Zomer et al. (2018)	Selection of materials that minimize total lifecycle impact
Suárez-Eiroa et al. (2019)	Substituting renewable materials with low regeneration rates for other with faster regeneration rates	Sousa-Zomer et al. (2018)	Supplier integration to establish materials' transparency and eliminate hazardous components
Mura et al. (2020)	Environmental criteria for purchasing electricity, gas or other supplies	Urbinati et al. (2019)	Resource Efficiency Measures (REMs) or practices at supply side, demand side and life cycle to reduc
Production			
Mura et al. (2020)	Reduction of the material content into packaging	Mura et al. (2020)	Closed loop for water reuse
Jawahir and Bradley (2016); Ghisellini et al. (2016); Lieder and Rashid (2016); Ying and Li-jun (2012); Zhu et al. (2010); Su et al. (2013); Zhijun and Nailing (2007); LandaburuAguirre et al. (2016); Franklin-Johnson et al. (2016); Supino et al. (2016); Reuter (2016); Reh (2013)	Increase eco-efficiency in production	Mura et al. (2020)	Captation/reuse of wastewater and/or rainwater
Ghisellini et al. (2016); Bezama (2016)	Introducing reclassification in production	Masi et al. (2018) Sousa-Zomer et al. (2018)	Reducing wastes
Zhu et al. (2010)	Technical equipment and facilities to remanufacturing	Suárez-Eiroa et al. (2019)	Separating biological and technical wastes properly

Weelden et al. (2016)	Standards for refurbishment quality	Mura et al. (2020)	Separated waste collection system
Zhu et al. (2010) Masi et al. (2018) Sousa-Zomer et al. (2018)	Existence of pollution prevention or reducing programs such as cleaner production	Mura et al. (2020)	Environmental impacts monitored in air/earth/water
Suárez-Eiroa et al. (2019)	Substituting materials and processes which produce technical outputs by those which produce biological outputs	Sousa-Zomer et al. (2018)	Key indicator ‘total waste’ set up to measure waste generation to produce each appliance
Suárez-Eiroa et al. (2019)	Substituting processes for those with lower waste generation rates/more eco-efficiency processes	Sousa-Zomer et al. (2018)	Implementation of a waste treatment center to screen and sort out materials used during the production process
Mura et al. (2020)	Substitution of chemicals with safer and environmentally friendly alternatives	Sousa-Zomer et al. (2018)	Facility efficiency by applying technology improvements and renewable use
Mura et al. (2020)	Resource-saving production processes	Sousa-Zomer et al. (2018)	Programs to replace hazardous materials
Urbinati et al. (2019)	Continuous use and improvement of virgin (raw) materials	Sousa-Zomer et al. (2018)	Programs to reduce the consumption of water
Urbinati et al. (2019)	Re-design of processes	Sousa-Zomer et al. (2018)	Programs to reduce the input of natural resources
Urbinati et al. (2019) Mura et al. (2020)	Product Life Cycle Assessment (LCA)	Masi et al. (2018)	Reducing material consumption
Masi et al. (2018) Mura et al. (2020) Suárez-Eiroa et al. (2019) Sousa-Zomer et al. (2018) Urbinati et al. (2020)	Reducing energy consumption/improve energy efficiency	Masi et al. (2018)	Green packaging
Suárez-Eiroa et al. (2019)	Saving materials/improving resource productivity	Mura et al. (2020)	Secondary raw materials as inputs of the production
Suárez-Eiroa et al. (2019)	Promoting energy recovery by converting waste into heat, electricity or fuel	Suárez-Eiroa et al. (2019)	Increasing durability (i.e. practical guides for reparability, preventive and corrective maintenance, repurposing, etc.)
Mura et al. (2020)	Energy supply from renewable sources (100%)	Suárez-Eiroa et al. (2019)	Reducing obsolescence (i.e. updating software)
Logistic			
Supino et al. (2016)	Implement new pathways of logistics systems	Suárez-Eiroa et al. (2019)	Fostering renewable mobility
Su et al. (2013); Ghisellini et al. (2016); Sauvé et al. (2015); Spring and Araujo (2017); Tukker (2015); Velis (2015)	Redesign infrastructure system delivery services		
Consume and Use			
Zhijun and Nailing (2007); Ness (2008); Ghisellini et al. (2016)	Consumers shift from the linear model to Circular Economy	Suárez-Eiroa et al. (2019)	Expanding the Extended Consumer Responsibility
End-of-Life			
Ghisellini et al. (2016)	Recycling of end of life products	Masi et al. (2018) Suárez-Eiroa et al. (2019)	Remanufacturing products and components
Ghisellini et al. (2016)	Recycling of scrap or waste	Masi et al. (2018)	Refurbishing products

Ghisellini et al. (2016)	Recycling of products after usage	Masi et al. (2018)	Cascading use of components and materials
van Weelden et al. (2016)	Reusing products	Mura et al. (2020)	Recovery/reuse of plastic and derivative packaging
Masi et al. (2018)	Recycling Materials	Suárez-Eiroa et al. (2019)	Promoting and improving downcycling, recycling and upcycling of wastes
Business Environment			
Masi et al. (2018)	Cooperating with other firms to establish eco-industrial chains	Suárez-Eiroa et al. (2019)	Promoting industrial symbiosis
Ghisellini et al. (2016)	Cooperate with other companies to make it possible to reuse/recycle/ remanufacture	Suárez-Eiroa et al. (2019)	Promoting functional service economy and sharing economy
Su et al. (2013); Lieder and Rashid (2016)	Easier regional ecoindustry network to make it possible to recycle		
Reverse Logistic			
Masi et al. (2018)	Taking back products from consumers after the end of their functional life	Zhu et al. (2010)	Establish a recycling system for used and defective products
Masi et al. (2018)	Taking back products from customers at the end of their usage	Sousa-Zomer et al. (2018)	Deployment of processes and capabilities for tracking, collecting, and assessing product chemical composition
Su et al. (2013)	Efficient information system to track materials in recycling	Sousa-Zomer et al. (2018)	Adoption of a closed loop model to recover and recycle products through reverse flows at the end of life
Zhu et al. (2010)	Collect and recycle end-of-life products and materials		
Stakeholders			
Urbinati et al. (2018)	Support of all partners to develop awareness and new skills, hence rendering the business model more viable, i.e. circular, for all the actors involved in the supply chain	Sousa-Zomer et al. (2018)	Information sharing between the company and recyclers
Urbinati et al. (2020)	Involvement of supply chain stakeholders in value creation initiatives	Urbinati et al. (2018)	Establishment of effective communication with suppliers, retailers and end-of-life materials managers, such as the waste industry, as well as with all the actors involved in the supply chain
Urbinati et al. (2020)	Practices related to effective communication with the supply chain stakeholders and upstream partners		

APPENDIX 4 - Circular practices for internal organization redesign.

Author	Circular Practice	Author	Circular Practice
Hazen et al. (2017) apud Govidan and Hasanagic (2018)	Setting the right price of the product in regards of how much it costs to reuse/ remanufacture/recycle in supply chain	Zhu et al. (2010)	Generation of environmental reports for internal evaluation
Suárez-Eiroa et al. (2019)	Adjusting taxes and subsidies of technology, products and materials based on their resource regeneration rates	Suárez-Eiroa et al. (2019)	Designing new methodologies to guarantee a continual improvement
Suárez-Eiroa et al. (2019)	Adjusting taxes and subsidies of technology, products and materials based on their waste generation rates	Masi et al. (2018); Mura et al. (2020); Zhu et al. (2010); Sousa-Zomer et al. (2018)	Environmental certifications (e.g. ISO14001/EMAS)
Masi et al. (2018)	Adopting a leasing or service based marketing strategy	Mura et al. (2020)	Incentive policies for the return of old/worn products to the company
Suárez-Eiroa et al. (2019)	Informing consumers properly (eco-labelling/product declarations)	Suárez-Eiroa et al. (2019)	Designing projects to promote sustainable development and circular economy
Ghisellini et al. (2016)	Marketing of remanufactured products in supply chain	Suárez-Eiroa et al. (2019)	Adjusting educational curricula to the current challenges
Su et al. (2013); Zhijun and Nailing (2007); Jawahir and Bradley (2016); Lieder and Rashid (2016); Ghisellini et al. (2016); Sauvé et al. (2015); Liu et al. (2009); Geng et al. (2008); Ilić and Nikolić (2016); Weelden et al. (2016); Reuter (2016); Pan et al. (2015) apud Govidan and Hasanagic (2018)	More awareness on circular economy to make it attractive for suppliers and end consumers to buy remanufactured products	Suárez-Eiroa et al. (2019)	Promoting knowledge, skills, capabilities and values that ensure the proper performance of circular economy
Suárez-Eiroa et al. (2019)	Adjusting selling doses to consumer doses	Suárez-Eiroa et al. (2019)	Promoting habits and individual actions in favor of circular economy
Jumar and Venkatesan (2005) apud Govidan and Hasanagic (2018)	Promotion on company website	Ghisellini et al. (2016); Xinan and Yanfu (2011) apud Govidan and Hasanagic (2018)	New strategies in supply chain
Baxendale et al. (2015) apud Govidan and Hasanagic (2018); Urbinati et al. (2020)	Advertising and sales personnel in store	Masi et al. (2018); Zhu et al. (2010)	Special training for workers on environmental issues and circular economy
Zhu et al. (2010)	Sale of scrap and used materials	Lieder and Rashid (2016)	Increase employment rates in supply chain towards circular economy
Zhu et al. (2010)	Sale of excess capital equipment	Sihvonen and Partanen (2016) apud Govidan and Hasanagic (2018)	Support from top management towards introducing circular economy in supply chain
Masi et al. (2018); Zhu et al. (2010)	Including environmental factors in the internal performance evaluation systems	Urbinati et al. (2020)	Initiatives on sustainability and circular economy themes, which involve customers
Sousa-Zomer et al. (2018)	Establishment of a business unit focused on materials' EoL, to perform recycling and disposal	Zhu et al. (2010); Masi et al. (2018)	Eco-labeling of products

Zhu et al. (2010)	Total quality environmental management	Zhu et al. (2010)	The internal performance evaluation system incorporates environmental factors
Su et al. (2013); Jawahir and Bradley (2016); Lieder and Rashid (2016); Xinan and Yanfu (2011); Sihvonen and Partanen (2016)	Education on recycling, remanufacturing and reuse	Sousa-Zomer et al. (2018)	Connection between the critical materials management program with support processes and areas, such as suppliers' management and purchasing
Jawahir and Bradley (2016)	Visionary Thinking	Sousa-Zomer et al. (2018)	Connection between the implementation of cleaner production practices and the support processes (policies, standards, and laws) from a top-down standpoint
Zhu et al. (2010)	Commitment of environmental management from senior managers	Sousa-Zomer et al. (2018)	Deployment of a new business unit to support reverse logistics and foster recycling, and increasing company's control of the full product lifecycle
Zhu et al. (2010)	Support for environmental management from mid-level managers	Su et al. (2013); Jawahir and Bradley (2016); Lieder and Rashid (2016); Ilić and Nikolić (2016)	Training in regards of circular economy in supply chain
Zhu et al. (2010); Masi et al. (2018)	Cross-functional cooperation for environmental improvement	Suárez-Eiroa et al. (2019)	Promoting Extended Producer Responsibility

APPENDIX 5 - Baseline Assessment Checklist

Practice	Check
Recover waste	☐
Remove waste from production and supply chain	☐
Map resource flows and have reporting and objectives on material/resource consumption	☐
Reuse byproducts for its own processes	☐
Remanufacture products and encourage maintenance and upgradability	☐
Have a program for energy/water consumption reduction	☐
Design products that help customers save energy/water	☐
Optimize and increase the performance and efficiency of products and organization as a whole	☐
Engage circular economy and LCA experts	☐
Ensure sustainable procurement/supplies	☐
Initiate a dematerialization principle	☐
Adopt reverse logistics or share assets	☐
Leverage big data and new emerging technologies	☐
Integrate eco-design, extend product life against obsolescence and design for durability	☐
Implement industrial symbiosis	☐
Adopt strategic partnerships contributing to circular economy development	☐
Develop new offers or business models from ownership to service or to performance-based payment models	☐
Work with public authorities on policies that enable the circular economy (lobbying)	☐
Consider environmental factors when choosing suppliers	☐
Consider environmental factors in the raw material and process used in the production	☐
Consider environmental factors while transportation within production plant	☐
Consider eco-design in production?	☐
Implement lean manufacture practices	☐
Develop conservation and efficiency initiatives to reduce energy consumption	☐
Use renewable source of energy	☐
Has an effective social well-being and equality	☐
Consider environmental factors in the storage outside the production plant	☐
Consider environmental factors in logistics	☐
Has an effective after sales service	☐
Consider repair the product during use phase	☐
Consider reuse of material in process/product/after sales	☐
Has and effective corporate social responsibility	☐
Recycle the product/parts	☐
Has effective reverse logistic actions	☐
Support recycling, reclaim, and/or recovery of material from waste derived from production processes	☐

APPENDIX 6 – Repository of indicators.

Step	Author	Indicator	Description	Formula
3.8	Rossi et al. (2020)	Reduction of raw materials - Manufacturing	Measure the reducing quantities of raw materials in the process of manufacturing	Quantity of raw materials reduced in the manufacturing
3.8	Rossi et al. (2020)	Reduction of raw materials- Product	Measure the reducing quantities of raw materials in the product itself, making it lighter	Quantity of raw materials reduced in the product
3.8	Rossi et al. (2020)	Reduction of toxic substances	Quantify the reduction of the use of toxic substances considering RoHS	Quantity of reduction of toxic substances
3.9	Cullen (2017)	Circularity Index	Material circularity that takes account of losses in both quantity (material recovered) and quality (material degradation when recycled) when reprocessing materials	$CI = \frac{recovered\ EoL\ material}{total\ material\ demand}\left(1 - \frac{energy\ required\ to\ recove\ material}{energy\ required\ for\ primary\ production}\right)$ CI = Circularity Index (material circularity that takes account of losses in both quantity and quality when reprocessing materials)
3.9	Bracquené, Dewulf and Duflou (2020)	Virgin Material	The amount of required virgin material	$V = \frac{(1-Fu)M}{Ecp\ Efp}(1-Fr)$ V = Amount of required virgin material Fu = Fraction of reused components Ecp = Efficiency of the component production Efp = Efficiency of feedstock production Fr = Amount of recycled contents
3.9	Bracquené, Dewulf and Duflou (2020)	Waste from feedstock production	Waste produced from feedstock production	$Wfp = \frac{(1-Fu)M}{Efp\ Ecp}(1-Efp)(1-Cfp)$ Wfp = Waste from feedstock production Cfp = Fractions of losses in feedstock production recovered as useful recycled material
3.9	Bracquené, Dewulf and Duflou (2020)	Waste from component production	Waste produced from component production	$Wcp = \frac{(1-Fu)M}{Ecp}(1-Ecp)(1-Ccp)$ Wcp = Waste from component production Ccp = Fractions of losses in component production recovered as useful recycled material
3.9	Bracquené, Dewulf and Duflou (2020)	Uncollected EoL product	Uncollected waster in prduct EoL, represented by material sent to energy recovery or landfill at end-of-use	$Wu = M(1-Cr-Cu)$ Wu = material sent to energy recovery or landfill at end-of-use Cu = Fraction of collected end-of-use products available for component reuse Cr = fraction that is collected for recycling
3.9	Bracquené, Dewulf and Duflou (2020)	Waste from material separation	Waste generated during material separation	$Wms = M(1-Ems)Cr$ Wms = waste generated during material separation Ems = efficiency of the material separation
3.9	Bracquené, Dewulf and Duflou (2020)	Waste from recycled feedstock production	Waste generated during recycled feedstock production	$Wrfp = M\ Ems\ Cr(1-Erfp)$ Wrfp = waste generated during recycled feedstock production Erfp = efficiency of the recycling process used to produce the recycled feedstock
3.9	Bracquené, Dewulf and Duflou (2020)	Unrecoverable waste	Total amount of unrecoverable waste leaving the product system	$W = Wfp + Wcp + Wu + Wms + Wfrp$ W = total unrecoverable waste
3.9	Bracquené, Dewulf and Duflou (2020)	Recycled material used for feedstock production	Amount of recycled material used as input	$Rin = Fr\frac{(1-Fu)M}{Efp\ Ecp}$ Rin = amount of recycled material used as input
3.9	Bracquené, Dewulf and Duflou (2020)	Recycled material recovered	Sum of amount of scrap generated during feedstock and component production, and amount of end-of-life recycled material recovered	$Rout = (1-Efp)Cfp\frac{(1-Fu)M}{Efp\ Ecp} + (1-Ecp)Ccp\frac{(1-Fu)M}{Ecp} + Erfp\ Ems\ Cr\ M$ Rout = amount of recycled material used as output
3.9	Bracquené, Dewulf and Duflou (2020)	Recycled material (net exchange)	Amount of recycled feedstock exchanged with the outer system	$R = \|Rin - Rout\|$ R= amount of recycled feedstock exchanged with the outer system

3.9	Bracquené, Dewulf and Duflou (2020)	Reuse Components (net exchange)	Amount of material flowing through the system boundary for component reuse	$C = \|M(Fu - Cu)\|$ C= amount of material flowing through the system boundary for component reuse
3.9	Bracquené, Dewulf and Duflou (2020)	Linear Flow Index	Fraction of material flowing through the system boundary in a linear fashion compared to the fully linear systems	$LFI = \frac{V + W + \frac{1}{2}\|R\| + \frac{1}{2}\|C\|}{\frac{2M}{Ecp\,Efp}}$ LFI = fraction of material flowing through the system boundary in a linear fashion compared to the fully linear systems
3.9	Bracquené, Dewulf and Duflou (2020)	Utility factor	Ratio of the available or used functional usage duty cycles versus the expected functional usage duty cycles based on average product design requirements	$X = \left(\frac{L}{Ld}\right)\left(\frac{I}{Id}\right) = \frac{FUDC}{FUDCd}$ X = product utility FUDC = available or used functional usage duty cycles (actual available or used functional unit)
3.9	Bracquené, Dewulf and Duflou (2020)	Product Circularity Indicator	Product Circularity Level	$PCI = 1 - \frac{LFI}{X}$ PCI = Product circularity Indicator
3.9	Rossi et al. (2020)	Renewability - Renewable raw materials	Measure the quantity of renewable raw materials used in the product	Raw material from renewable sources/All the materials used in a product
3.9	Rossi et al. (2020)	Recyclability - Recycled materials	Measure the use of recycled materials in the product	Recycled materials/all materials composing the product
3.9	Rossi et al. (2020)	Reuse - Manufacturing process	Quantify the reused materials in the supply chain	Quantity of material reused in the supply chain
3.9	Rossi et al. (2020)	Reuse - Product	Quantify the reused materials in the product	Quantity of reused material in the product
3.9	Rossi et al. (2020)	Remanufacturing	Quantify the remanufacturing products	Quantity of remanufactured products
3.9	Rossi et al. (2020)	Refurbishment	Specification and quantity of the products and refurbished parts	Quantity of the total recovery or parts (components) of the product, without necessarily going through all stages of the remanufacturing.
3.18	Franklin-Johnson, Figge and Canning (2016)	Longevity Indicator	Represent the length of time for which a material is retained in a product system	$Longevity = A + B + C$ $B = B1 + B2 = w1 \times x1 \times U1 + w1 \times x1 \times w2 \times x2 \times U2$ $C = C1 + C2 = \left(\frac{(A + B1 + B2) \times (w1 \times x1 \times z1))}{(1 - w1 \times y1 \times z1)}\right) + \left(\frac{(A + B1 + B2) \times (w1 \times x1 \times w2 \times x2 \times z2))}{(1 - w1 \times y1 \times w2 \times x2 \times z2)}\right)$ A = Product initial lifetime (total amount of time of new use) B = Additional months gained due to product return, refurbish or reuse C = recycled lifetime contribution C1 = Products used, returned and recycled C2 = Products used, returned, refurbished, returned and recycled wi = percentage of products returned (1: one time, 2or second time) xi = percentage of these products refurbished (1 for one time, 2 for second time) Ui = Lifetime of a newly refurbished product (1 for one time, 2 for second time) y = percentage of recycled products z = percentage of unrecovered materials from the product
3.19	Favi et al. (2017)	End-of-life Indices (Design Methodology)	Reuse index considers the possibility of a given component being reused in the same product or in similar products	$I_{EoL-Ru} = \frac{VRe + VMat + VMan - CRL - CSd - CC}{VRe + VMat + VMan}$ CRL = Reverse Supply Chain Costs CSd = Selective Disassembly operations costs Cc = Cleaning operations costs Vre = Value of the reused part (This is a percentage of the original value of the part under analysis considering mechanical/fatigue deterioration due to use and taking into account the consumers' lower quality perception of used parts and products) Vmat = No virgin material used to produce the part = mass[kg]*Cost of virgin material[R$/kg] Vman = No manufacturing operations to build up the parte (R$) = cost of the manufacture activities + cost of the transport phases

3.19	Favi et al. (2017)	End-of-life Indices (Design Methodology)	Remanufacture index evaluates the possibility of a component being regenerated on the basis of different cost types and revenues involved in the 'remanufacture loop'	$I_{EoL-Ru} = \frac{VRem + VMat + V_{man\_s} - CRL - CSd - CC - CRem}{VRem + VMat + VMan\_s}$ Crem = Additional remanufacturing operations costs Vrem = Value of the remanufactured part (This is a percentage of the original value of the part under analysis considering deterioration, degradation and corrosion due to the use and the overall process to refurbish the part. Furthermore, this item takes into account the consumers' lower quality perception of used parts and products) Vman_s = Value of original manufacturing operations to produce the part not necessary for remanufacture
3.19	Favi et al. (2017)	End-of-life Indices (Design Methodology)	Recycling index compares the difference between the production costs for virgin materials and the revenues coming from the recycling process	$I_{EoL-Ru} = \frac{VRc + VEn - CRL - Cdd - CC}{VRc + VEn}$ Cdd = Destructive disassembly operations costs Vrc = Value of the recycled material = mass[kg]*recycling factor*cost of recycled material[R$/kg] Ven = Energy saved by not producing virgin material = mass[kg]*Energy saved(difference between primary embodied energy and recycling energy[MJ/kg]*energy cost[R$/MJ]
3.19	Favi et al. (2017)	End-of-life Indices (Design Methodology)	Incineration index establishes whether particular combinations of materials can be directly incinerated for energy production	$I_{EoL-Ru} = \frac{VEinc - Crl - Cdd}{Veinc}$ Veinc = Energy gained from combustion = mass*heat value[MJ/kg]*energy cost (industrial)[R$/MJ]
3.19	Mathieux, Froelich and Moszkowicz (2001)	Technical Recovery Indicator	Show the product weight (%) that can be extract for reuse, recycling and energetic recovery	$TRI_{recovry} = \frac{\sum recycable\ materials + \sum energetically\ recoverable\ materials}{product\ mass}$ $TRI_{recycle} = \frac{\sum recycable\ materials}{product\ mass}$ TRI = Technical Recovery Indicator
3.21	Rossi et al. (2020)	Job creation	Quantify the job creation from circular business model, e.g. quantity of job creation from reverse supply chain activities (maintenance, reverse logistics, reuse, remanufacture, refurbishment, etc)	Quantity of job creation from circular business model
3.21	Rossi et al. (2020)	Employee participation in the circular model	Quantify the percentage of jobs of the organization and its hierarchical level related to the circular economy	Jobs in the company related to circular economy/Total amount of jobs
3.22	Rossi et al. (2020)	Financial results - Cost Reduction	Show the cost reduction of the manufacturing due to acquisition of less raw materials and energy	Monetary value from circular business model provided by cost reduction from raw materials, energy, etc
3.22	Rossi et al. (2020)	Financial results - Revenue Generation	Show the billing percentage generated by circular business model	a) Competitive advantage: percentage of market share of the circular business model compared with the competitors. b) Risks: map the risks associated with the circular business models. c) New revenues: new revenues from circular business models/total revenue.
3.22	Rossi et al. (2020)	Financial results - Profitability	Measure the net profit	Net profit of the Return On Assets (ROA) and Return On Equity (ROE)
3.22	Rossi et al. (2020)	Taxation or regulatory milestones	Specify the taxation or regulatory milestones that subsidize the circular business model	Qualitative
3.22	Rossi et al. (2020)	Circular investment - Inovation	Quantify in monetary values the financial resources invested to change the business model, from strategic and management actions to capacity	Quantify investments from the innovation process
3.22	Rossi et al. (2020)	Income generated by jobs	Quantify in monetary values the income from new jobs creation from circular business model	Monetary value the income generated by job creation from circular business model
3.22	Linder, Sarasini and van Loon (2017)	Product-level Circularity Metric	Fraction of a product that comes from used products	$c = \frac{economic\ value\ of\ recirculated\ part}{economic\ value\ of\ all\ parts} = \frac{ri}{ri + ni}$ $c_{1\&2} = c1\frac{v1}{v2 + v2} + c2\frac{v2}{v1 + v2}; vi = ri + ni$ c = product-level circularity metric ri = economic value of recirculated parts of the new product part ni = e economic value of non-recirculated parts (virgin materials for the relevant product part i) = cost of non-circulated parts v = value of product part i

3.22	Di Maio and Rem (2015)	Circular Economy Index (CEI)	Ratio of the material value produced by the recycler (market value) by the material value entering the recycling facility	$CEI = \frac{material\ value\ produced\ by\ the\ recycler}{material\ value\ entering\ the\ recycling\ facility}$ CE = Circular Economy Index

APPENDIX 7 - Green Supply Chain Assessment Checklist. Adapted from Kazancoglu, Kazancoglu, Sagnak (2018).

Subs-criteria	Measure		Subs-criteria	Measure	
Environmental Criteria					
Decreasing Emissions	Green House Gas Emissions	☐	**Decreasing Environmental Cost**	Cost of Scrap	☐
	Air Emissions	☐		Cost of Rework	☐
	Carbon Emissions	☐		Additional Cost for Environmentally-Friendly Products and Materials	☐
Decreasing Energy Consumption	Energy Utilization Ratio	☐		Disposal Costs	☐
	Usage of Green Fuels	☐		Recycling Costs	☐
	Less Consumption	☐		Cost of Waste Treatment	☐
	Usage of Alternative Energy Sources	☐		Waste Discharge Fee	☐
Decreasing Business Waste	Solid Waste	☐		Environmental Accidents Fine	☐
	Liquid/Water Waste	☐		Cost for Energy Consumption	☐
	Total Flow Quantity of Scrap	☐		Frequency of Environmental Accidents	☐
	Waste generated by Suppliers	☐	**Increasing Environmental Revenues**	Revenues from Green Products	☐
	Percent of Materials Recycled or Reused	☐		Sale of Recycled Materials and Products	☐
	Total Amount of Hazardous and Toxic Waste	☐		Sale of Scrap and Used Materials	☐
	Usage of Hazardous/Harmful/Toxic Materials	☐		Sale of Excess Inventories and Materials	☐
	Compliance of effluents with national and local environmental rules and regulations	☐		Sale of Excess Capital Equipment	☐
Economic/Financial Criteria					
Cost-Oriented	Warranty Cost	☐	**Revenue-Oriented**	Average Profit from Green Products	☐
	Transportation Cost	☐		Profit Growth Rate for Green Products	☐
	Labor Cost per Hour	☐		Average Return on Sales from Green Products	☐
	Training and Orientation Cost	☐		Average Return on Investment from Green Products	☐
	Manufacturing Cost	☐		Average Return on Net Assets from Green Products	☐
	Cost of Raw Materials	☐			
	Cost of Procurement	☐			
Operational Criteria					
Increase in Quality	Customer Rejection Rate	☐	**Improving Green Manufacturing**	Redefine Operation and Production Processes	☐
	Finished Product Yield Rate	☐		Use of Non-Toxic and Hazardless Materials in Production	☐
	In Plant Defect Rate	☐		Use of Recyclable Materials in Production	☐
	Total Quality Environmental Management	☐		Use of Recycled Materials in Production	☐
	Employee Satisfaction from Green Processes	☐		Waste Reduction and Pollution Monitoring Equipment	☐
	Poka-Yoke Equipment	☐		Structure for Easy Disassembly	☐
	Continuous Improvement System	☐		Monitoring and Maintenance System	☐
	Scrap Rate	☐		Inventory Levels	☐
	Rework Rate	☐		Reduction in Operation Steps	☐
Increasing Efficiency	Overhead Expense	☐		Reduction in Number of Hazardous Production Processes	☐
	Operating Expense	☐		Reduction in Number of Hazardous Machines	☐
	Capacity Utilization	☐		Reduction of Health and Safety Risks	☐
	Energy Efficiency	☐		Green Technology Adoption	☐
Improving Green/Eco Design	Reduction in Energy Consumption	☐		Structure for Easy Assembly	☐
	Reused Materials in New Designs	☐		Scheduling and Input/Output Control in Production Planning and Control for Waste Reduction	☐

Improving Green/Eco Design	Recycled Materials in New Designs	☐		Process Design for Reducing Energy Consumption	☐
	Reduction of Resource Consumption and Waste Generation during the Use of Product	☐		Process Design for Minimization of Waste	☐
	Reduction of Hazardous Manufacturing Process and materials	☐		Reducing the Noise Pollution	☐
	Less Volume for Storage	☐		Use of Renewable Energy Resources	☐
	Easy Setup for Energy Saving	☐		Acquisition of Green Production Technology/ Equipment	☐
	Longer Service/Product Life	☐		Cooperation with Customers for Green Production	☐
	Reduction of Material Consumption	☐	Improving Green Packaging	Use of Non-Toxic and Hazardless Materials in Packing	☐
	Design for Remanufacturing	☐		Use of Recyclable Materials in Packing	☐
	Concurrent Engineering	☐		Use of Recycled Materials in Packing	☐
	Cooperation with Customers for Eco-Design	☐		Cooperation with Customers for Green Packaging	☐
	Cooperation with Suppliers for Eco-Design	☐		Cooperation with Suppliers for Green Packaging.	☐
	The Number of Patents for Green Products	☐		Use of Eco-Label on Package	☐
	Life Cycle Assessment and Costs	☐		Labeling for Retrieval Purposes	☐

Logistic Criteria

Improving Green Logistics	On time delivery	☐	Improving Reverse Logistics	Remanufacturing of materials	☐
	Eco-driving to decrease fuel consumption	☐		Reusing and recycling of materials	☐
	Just in time for logistics	☐		Reduction of time for recycling	☐
	Order cycle time	☐		Incorporating third party logistics for customer cooperation	☐
	Environmental friendly transportation	☐		The number of customers cooperated for reverse logistics	☐
	Recyclable or reusable packaging/containers in logistics	☐		Design for reverse logistics	☐
	Order fulfillment	☐	Improving Green Purchasing	Eco labeled materials and products	☐
	Delivery dependability	☐		Environmentally friendly materials	☐
	Modal split (weight of goals transported by road)	☐		Supplier education	☐
	Average handling factor (Road tons-lifted)	☐		Supplier support	☐
	Average length of haul (tons-km)	☐		Cooperation with suppliers for green purchasing	☐
	Average load on laden trip (weight/volume)	☐		Understand environmental risk and responsibilities with suppliers	☐
	Average percentage of empty running	☐		Environmentally-audited suppliers	☐
	A recycling system for used and defective products	☐		Certified suppliers other than ISO 1400	☐
	Products with take-back policies	☐		ISO14000 certified suppliers	☐
	Mode of transport	☐		Providing design specifications to suppliers with environmental requirements	☐
	Greener vehicles	☐		Second-tier supplier environmental evaluation	☐
	Route optimization	☐		Requiring certification of testing for green product conformance	☐
	Vehicle utilization	☐		Urging/forcing suppliers to conduct environmental actions	☐
	Fuel efficiency	☐			

Organizational Criteria

Incorporating Environmental Management	Commitment from managers	☐	Improving Green Image	Number of related fairs/ symposiums participated	☐
	Commitment from employees	☐		Reduction of environmental accidents	☐
	Green initiatives and eco-service	☐		Improved employee and community health	☐
	A Clear environmental policy statement.	☐		Sponsoring to environmental events/collaboration with ecological organizations	☐
Incorporating Environmental Management	Cross functional teams for environmental managemen	☐		CSR activities on GSCM	☐

	Environmental auditing	☐	Green Information Systems	Monitoring the environmental information (such as toxicity, energy used water used, air pollution)	☐
	Keeping the website updated on environmental issue	☐		Accurate and prompt information exchange between trading partners	☐
	Activity report on environmental management	☐		Environmental information sharing with customers	☐
	Taking stakeholders' opinions and requirements into consideration	☐		Environmental information sharing with suppliers	☐
	Business ethics and code of conduct	☐		Customer relationship management related with GSCM	☐
	R&D budget on green products	☐		Informing trading partners prior to changing environmental needs	☐
	Compensation/incentive linked to environmental factors	☐			
	Environmental management on accounting practices	☐			
	Training for workers on environmental issues	☐			
	Employee suggestion system on environmental issues	☐			
	Participation in environmental programs and research projects	☐			
	Increase the proportion of employee recommendations and proposes for improvement in quality, social and environment health and safety performance	☐			

Marketing Criteria

Increasing Customer Satisfaction	After sales service performance	☐	**Marketing Measures**	Conservation of energy and resources in marketing mix	☐
	Out of stock for green products	☐		Use of environmental arguments in marketing	☐
	Service response rate	☐		Customer profitability on green products	☐
	Customer returns	☐		Number of green products	☐
	Customer lost rate	☐		Number of new customers on green products	☐
	Number of customers retained	☐		Customer complain rates on green products	☐
	Number of recalls	☐		Average market share growth on green products	☐
Improving Cooperation/Collaboration with Customers	Sharing common goals with customers	☐		Average sales growth (volume and dollar) on green products	☐
	Resolve environmental problems with customers	☐		Increasing customer value on green products	☐
	Understand environmental risk and responsibilities with customers	☐		Budget on green marketing activities	☐
	Cooperation with customers to decrease environmental impact of operations	☐			
	Communicating firm's strategic needs to customers	☐			
	Cooperation with customers to encourage green purchasing behavior	☐			