Practical Considerations for Assessing Product-Related Circularity and Product Social Considerations within LCSA: Insights from Industry

Responsible Authors: Lilian Sanchez Moreno and Martin Charter

Contributors: Till Bachman, Sue E. Taelman, Natalia A. Cano Londono, Thomas Sonderegger & Marina Isasa Sarralde

The Centre for Sustainable Design®, Business School for the Creative Industries, University for the Creative Arts

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Acronyms

Acronym	Meaning
CE	Circular Economy
CEAP	Circular Economy Action Plan
CEIA	Circular Economy Indicator Alliance
CFF	Circular Footprint Formula
D&D	Design and Development
EC	European Commission
EU	European Union
EMF	Ellen MacArthur Foundation
EoL	End of Life
LCA	Life Cycle Assessment
LCSA	Life Cycle Sustainability Assessment
LCT	Life Cycle Thinking
PACE	Platform for Acceleration of Circular Economy
MSME	Micro, Small and Medium Sized Enterprise
ME	Materials Efficiency
PC	Product Circularity
PCA	Product Circularity Assessment
PEF	Product Environmental Footprint
PS	Product Social
PSIA	Product Social Impact Assessment
RISE	Research Institutes of Sweden
SIA	Social Impact Assessments
SPI	Sustainable Products Initiatives
UCA	University for the Creative Arts
WBCSD	World Business Council for Sustainable Development
WG	Working Group

Glossary of Working Definitions

Circular Economy: "Economic system that systemically maintains a circular flow of resources, by regenerating, retaining, or adding to their value, while contributing to sustainable development".[1]

Circularity: "A state of a specified system, organization, product or process where resource flows and values are maintained whilst benefiting sustainable development and approach to promote the responsible and cyclical use of resources."[2]

Eco-design: "Eco-design is the systematic approach which considers environmental aspects in the design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product".[3]

Product Circularity: product circularity can be defined as "*a state of a product where value is retained, regenerated, or added within a technical or a biological system whilst benefiting sustainable development.*[4].

Product Circularity Assessment: A Product Circularity Assessment is an entry-level circularity assessment that aims to help companies undertake a preliminary identification of product circularity (PC) considerations across a product's life cycle.[5]

Product Social Performance: Impact products and services have on individuals and/or communities during the production, use phase and endo-of-life of products and services. Examples of social impacts are impact on health, safety, and rights. However, impact can also be positive, such as the creation of jobs, education, training and fostering community well-being.[6]

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[1]Note: as the terms in the definition and the definition are meant to be broad, definition of technical cycle and biological cycle are included in subsidiary terms that relate back to the definition of circular flow of resources that are embedded in the definition: Source: ISO TC 323/WG 1 as at April 2024.

[2] Working draft of ISO 59020:2024 (ISO TC 323/WG 3).

[3] Identical definitions in IEC 62430:2019 and ISO 14006:2020

[4] Source: Martin Charter-tentative definition for product circularity that is aligned to the current definition of Circular Economy within ISO TC323 WG1, where products are not explicitly highlighted in this definition or other definitions.

[5] Authors' working definition as of April 2024

[6] Authors' working definition as of April 2024

Executive Summary

This report was developed between 2021 and 2022 as part of the European Commission's Horizon 2020 funded project ORIENTING which aims to develop an operational methodology for product Life cycle Sustainability Assessment (LCSA) to support decisions towards the circular economy.[7] Between August 2021 and March 2022, twenty-one in-depth qualitative interviews were conducted by University for the Creative Arts. Participating companies were selected by the researchers based on identification of companies that had circular economy (CE) as a core business strategy or an intention to shift towards a CE business model. The interviews were conducted and transcribed, returned to participants for approval and then analysed using thematic coding analysis. The objective of the interviews was to gain insight into how product-related circularity strategies are currently being considered and assessed by industry. In doing so, the aim was to ensure industry practice is considered in the development of the product circularity aspect of ORIENTING's LCSA methodology. As part of UCA's dissemination activities, a previous draft of the findings outlined in this report was presented to ORIENTING partners within WP2 via Teams on 6th October 2021. Preliminary findings were adapted for WP2's D2.1, D2.2 and D2.3. Furthermore, feedback was provided to participating companies via two webinars that took place in November 2021 and April 2022 respectively. The final findings of the research (elaborated in this report) were presented in two open webinars that took place in May 2022.[8]

The interviewees included the following business functions: CSR manager, Waste manager, CEO/Founder, Design Engineer, Head of Sustainability and Product Designers (front-end and strategy product designers), Product Stewardship and Sustainability Manager and Product Design and Portfolio Management. Based on ORIENTING's product categorisation, the product categories pertaining to the selected companies ranged from final products to intermediate goods and services within the textile, apparel, infrastructure, electrical and electronic equipment (EEE), footwear, software and hardware, toy, and automotive industry. The size of participating companies ranged from start-ups to SMEs, and multinationals. The interviewed companies were primarily headquartered within Europe and North America, while the larger companies' supply chains are global.

With the objective of mapping potential users' needs for ORIENTING's LCSA methodology, each interviewee was assigned an awareness level vis-à-vis LCA, PC and PS considerations according to the ZBIA model[9] and the WBCSD's 'circularity strategy stages[10]. In other words, awareness levels were defined at an individual level rather than an organisational level (see

[7] https://orienting.eu

[8] For more information on these events, see: https://orienting.eu/events/

[9] The ZBIA model is based on a levels of awareness approach within an organisation, which can be classified as being zero, basic, intermediate, and advanced. Source: Charter, M., & Tischner, U. (2001). Sustainable Solutions: Developing Products and Services for the Future. Greenleaf

[10] https://www.wbcsd.org/Programs/Circular-Economy/Factor-10/Metrics- Measurement/Resources/Circular-Transition-Indicators-v2.0-Metrics-for-business-by-business

ANNEX 1 for company classification). The criteria for defining the levels of awareness were based on responses provided by the interviewees and judgement by the interviewer (see Table 1 for the awareness level descriptor). However, while the level of awareness was assigned at an individual level, a 'circularity strategy' level was also assessed at a company level based on the companies' website and response to questions regarding the company's sustainability goals and implementation of circularity strategies. The findings from the interviews suggested that interviewee awareness levels ranged from basic to medium, and advanced (expert). The research with companies showed that in industry, multiple interpretations of CE and PC exist and appear to be intrinsically linked to industry specific needs and levels of awareness. For those that had a more basic awareness of PC, the topic was viewed as being related to recycling primarily. Moreover, the research provides insight into how companies are currently attempting to measure PC and, in this context, the role that LCA's play in conducting PC assessments.

Report Structure

- The first part of the report introduces the background to the aims and objectives of ORIENTING's LCSA methodology. Additionally, it offers a systematic literature review of the following key issues: 1) theoretical developments of the circular economy; 2) product-related circularity and eco-design strategies; 3) the relationship between circularity and materials efficiency; 4) existing circular economy metrics and indicators, and 5) the contextualisation of CE metrics and indicators within an LCSA.

- The interview findings start from Chapter 3, which has been divided into key themes for PC and PS as they emerged during the interviews. The first theme highlights how PC is understood and interpreted differently by individual respondents and at an industry level, which in turn raises the need for a harmonised definition for PC and derived concepts. The second theme offers an overview of current industry practices for assessing PC and the key indicators and metrics being used. The final topic related to PC identifies the main barriers for implementing PC within industry, which includes costs, user acceptability and scalability. The final section within Chapter 3 focuses on the findings related to PS considerations, which appear to be primarily dealt with outside of design and development and primarily related to health and safety issues.

- The fourth and final Chapter offers recommendations for industry and academia to begin to address some of the issues highlighted within the findings.

For readers that consider themselves as having zero to basic knowledge of PC and related topics, it is recommended to start reading from the first chapter to familiarise themselves with the concepts and ideas that underpin the interview findings presented throughout the report. Conversely, for readers with a CE background, it is recommended to start from Chapter 2, which outlines the methodology employed for conducting and analysing the interviews, followed by the interview findings and recommendations.

1. Project Background

The aim of this section is twofold. The first is to provide the reader with a background to ORIENTING project; and the second, to offer a theoretical background of Circular Economy, product related circularity, materials efficiency, and CE standards and initiatives that underpin the aims, objectives and interview findings presented in this report. The background presented in this section was informed by the literature review conducted as part of the Concept and specification stage of the ORIENTING project (WP1 between 2020 and 2021), which resulted in development of document D1.4, 'Critical Evaluation of Material Criticality and Product-Related Circularity Approaches' and which can be accessed here.[11]

As mentioned in the summary, the aim of ORIENTING is to develop a robust and operational methodology for life cycle sustainability assessment (LCSA) of products (goods and services). The LCSA methodology aims to adopt a holistic life cycle approach that addresses environmental, social, and economic topics in a consistent and integrated way and considers circular economy and material criticality issues as important sub-topics. At a macro level, CE is about a shift from the current linear economy based on "take-make-waste" to an economy that is based on retaining value in economic and social systems; in circular economy, waste does not exist. The focus of CE is therefore, on a systemic shift at an economic and societal level rather than purely on incremental improvements and efficiency (BSI, 2017). A circular economy exists at a macro level and at present is a concept. Businesses exist within a CE and therefore at present, discussions are about how to make organisations, operations, and product/services more circular.

The European Commission (EC) has taken global leadership on Circular Economy (CEAP 1.0) with its 1st Circular Economy Action Plan (CEAP 1.0) launched in December 2015 (European Commission, 2015) and a 2nd Circular Economy Action Plan (CEAP 2.0) published in March 2020 (European Commission, 2020a). The CEAP 2.0 has broadened the scope to cover a wider number of supply and value chains, where: "Priority will be given to addressing product groups identified in the context of the supply and value chains featuring in this Action Plan, such as electronics, ICT, and textiles but also furniture and high impact intermediary products such as steel, cement, and chemicals. Further product groups will be identified based on their environmental impact and circularity potential." As a follow-up to CEAP 2.0, the EC published the Sustainable Products Initiative (SPI) - focused on circular economy product policy development – in March 2022.[12]

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11 Authors: Till M. Bachmann (EIF), Isadora Corrêa Hackenhaar (GHE), Rafael Horn (FhG), Martin Charter (UCA), Florian Gehring (FhG), Roberta Graf (FhG), Sophie Huysveld (GHE), Rodrigo A. F. Alvarenga (GHE). Contributions: Mauro Cordella (TEC), Federico Riva (EIF), Jonathan van der Kamp (EIF)

12 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en

Circular Economy is also becoming an area of growing policy interest in G20 countries. This resulted in the launch of several global initiatives focused on Circular Economy e.g., Platform for Acceleration of Circular Economy (Charter & Cheng, 2021; PACE, 2021c). The Circular Economy (CE) concept builds on multiple schools of thought, some of which date back to the 1960s, including: industrial ecology, industrial symbiosis, performance economy, biomimicry, cradle to cradle, blue economy, regenerative design, and natural capitalism (BSI, 2017). However, the concept became mainstream as a result of the policy attention given to it by the CEAP 1.0 in 2015. The Ellen MacArthur Foundation (EMF) has played an important role in raising awareness and in engaging business (EMF, 2021). At present there is no internally agreed definition of the CE concept, Kirchherr et al. (2017) identified 114 circular economy definitions in different sources of literature. The findings indicated that CE is primarily highlighted in these definitions as a combination of reduce, reuse, and recycle activities. The systemic shift associated with CE is often not acknowledged in the definitions as well as the explicit linkages of CE to sustainable development (i.e., "benefiting" or "contributing to sustainable development", "maximise ecosystem functioning and human well-being", "accomplish sustainable development", thus simultaneously creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations" and "designed to benefit businesses, society, and the environment"). However, in the definitions relating to sustainability, it appears to be acknowledged that only those measures that contribute to sustainable development should be denoted as belonging to a circular economy, i.e., the final objective is sustainable development and CE measures should contribute to that. The research indicated that CE meant many different things to different people. Kirchherr et al. (2017) highlighted an illustration of this through a reviewer's comment which noted that 'some of the authors [...] seem to have no idea about what [CE] is about' with some equating CE to recycling. The research found that there were a proliferation of CE conceptualizations and that this 'circular economy babble', constitutes a serious challenge to policy makers, business and researchers working on this topic. There is a clear need for a universally agreed definition of Circular Economy and the associated terminology (Charter & Cheng, 2021). ISO is working on a consensus-based definition of CE within ISO TC323 which will be an important step towards increased understanding.[13] Confirming the findings by Kirchherr et al. (2017), the definitions vary in many respects, where only a few definitions mention specific actions that are aimed at changing processes: these range from "minimising the generation of waste" and "wastes are recycled into resources" to a range of production processes ("planning, resourcing, procurement, production and reprocessing" and related to sourcing "consumption of finite resources"), up to including consumption ("production/distribution and consumption processes"). While the flows to be established are described as "restorative and regenerative" (including "regenerative by design"), "maintaining resource flows", "maintaining circular flows", "cyclical use", "reducing, alternatively reusing, recycling, and

[13] As of April 2024, CE has been defined within the work of ISO TC323 as: "A state of a specified system, organization, product or process where resource flows and values are maintained whilst benefiting sustainable development and approach to promote the responsible and cyclical use of resources."

recovering materials", "returning [products, materials, and resources] into the product cycle". It can be noted that only the definition proposed by Kirchherr et al. (2017) and adopted by Saidani et al. (2019) explicitly refers to reducing material use.

In contrast to Material Efficiency, CE is not primarily concerned with reducing the number of materials used in products but also "materials" or "products", complemented with "components" or "resources". Some view resources as materials, but others broaden the definition to include water, land or even labour. While reuse of water is promoted by the CEAP 2.0 (European Commission, 2020a), land and noticeably labour are not defined as "resources" in this context. In an early definition, CEAP indicate that "wastes" are the main focus in relation to the definition of resources; quality aspects are also mentioned frequently (i.e., "keep at highest utility and value", "maintaining values", "regenerating, retaining or adding to their value", "maintain the value of products, materials and resources" and "conserve both the quantity and the quality"), although only two definitions also mention temporal aspects explicitly, i.e., "at all times" or "for as long as possible". Several studies have shown that "more circular" does not necessarily always mean "more sustainable" (e.g., de Oliveira et al., 2021; Dieterle et al., 2018; Helander et al., 2019; Iraldo et al., 2017). So, measures towards CE are not an end in itself but need to be evaluated against the overall goal of sustainable development. A key point here is that CE is understood as an integral component of sustainable development and is therefore not perceived as an equivalent or a more advanced concept. This also means that maintaining the value of materials "as long as possible" or "at all times" might be changed into "as long as justifiable from a sustainable development perspective" if reference were to be made to temporal aspects. While the BSI (2017) definition notes that CE is a state (i.e., not an approach), circularity can be considered a concept or approach. Ultimately, it is a product's materials (or sub-assemblies and/or components thereof), along with the materials used in their production processes whose use shall become more circular. However, it is important to highlight here that while the term "product-related circularity" or short "circularity" has been adopted for the development of ORIENTING's LCSA, as highlighted in the WBCSD's 2018 report. "Circular Metrics: Landscape Analysis" and ORIENTING's D1.4 report, it appears that to date, CE activities within industry have focused on a company or process level rather than a product level.[14] Therefore in practice, PC is a relatively new and evolving area within industry.

In view of these considerations the following definition of "circularity" was proposed by ORIENTING: "approach to promote the extended and/or cyclical use of materials", modified from Moraga et al. (2019). "Use" in this definition, includes technosphere hibernation beyond abandoned parts (i.e., materials in landfills, even though these could be sourced through urban mining), noting that distinguishing between technosphere hibernation and

[14] See findings in Orienting report, 'Critical Evaluation of Material Criticality and Product-Related Circularity Approaches', which can be found here: https://orienting.eu/publications/d1-4-critical-evaluation-of-material-criticality-and-product-related-circularity-approaches/

technosphere dissipation is arbitrary (van Oers et al., 2020). Materials can be recycled and reused through biological and technical cycles as depicted in the butterfly diagram by EMF (see Annex 6). An additional consideration is that products designed for or operating in biological systems also need to consider compostability and biodegradability. The lack of clarity over a universally agreed definition and confusion over terminology is being worked on in the new standard in ISO TC323/WG1 that covers the definition, terminology, and framework for implementation.

1.1Product Circularity and Eco-Design Strategies

From a practical perspective in companies, exploring PC strategies do not happen in a vacuum. At a pragmatic level, it could be argued that PC is one aspect of eco-design.[15] One of the challenges of implementing eco-design in product design and development, is balancing the trade-offs between environmental aspects (i.e., energy vs. materials issues), economic costs, technical feasibility, amongst others. For example, for energy-using products, reducing energy consumption (aspects) relates to reducing carbon emissions (impacts) that also need to be balanced against materials and/or circularity considerations.

Prior to conducting the interviews, based on the author's considerable experience of applied eco-design, it was speculated that at a business level, several companies would be practicing eco-design and eco-design strategies might consider PC and PC strategies (see Annex 3). However, contrary to this, the interviews revealed that eco-design appears to be less practised or understood by companies, compared to a decade ago. This lack of practice appears to also be prevalent within companies with a longstanding history of eco-design, despite IS014006 and IEC62430 being published in 2019 and 2020. To understand the lack of eco-design practice within industry, the authors conducted a non-exhaustive literature review on eco-design vis a vis industry, which indicated a gap in the literature. Moreover, as part of the research process, the authors engaged in conversation with experts in the field, from which the following conclusions were drawn a) it appears that knowledge of eco-design may have been lost in firms due to restructuring; b) previous focus on eco-design has now shifted towards the Circular Economy and c) eco-design considerations and CE issues appear to be disconnected. There are a range of terms being used that broadly relate to PC that are now being used in academia and industry including circular design, circular ready design, design for circularity, among others. Further discussion on the relationship between eco-design and PC issues is raised within the findings and recommendations in this report. This is an area where further research is needed.

[15] "Eco-design is the systematic approach which considers environmental aspects in the design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product" Source: IEC 62430:2019 and ISO 14006:2020.

Europe is leading the way on CE policy development (Charter & Cheng 2021) and ISO, IEC and CEN/CENELEC have initiated standardisation activities related to CE. For example, a key standard that aims to address circularity at a product level is the "Circular Ready Design" standard that is now being developed by industry and other stakeholders within CEN/CENELEC JCT10. The existing product-related Implementing Measures within the EC Ecodesign Directive (European Parliament & Council, 2009) have focused on reducing energy consumption and CO_2 emissions. However, with the aim of promoting a more systematic implementation of material efficiency aspects (i.e., durability, repairability, recyclability), the CEAP 1.0 (European Commission, 2015) delivered a mandate to CEN/CENELEC to publish a series of Materials Efficiency standards which have now been published). Materials efficiency aspects are likely to be added to requirements related to the Implementing Measures for specific products. The Sustainable Products Initiative (SPI) published in March 2021 is further strengthening the EC interest in CE and product policy, signalling a potential expansion of the scope of EC Eco-design Directive to cover new product categories e.g., textiles and to bring in materials efficiency. [16]

Essentially, CE thinking at a product level focuses on maximising the *value* in products, components, and materials for as long as justifiably from a sustainable development perspective. The focus is therefore not on waste but about reframing the discussion over the systemic change. When considering CE within a life cycle thinking context, "End of Life" should be considered practically as much further into the future than compared to traditional "take-make-waste" linear thinking. Industry is responding to the development of the area by creating roles to manage and coordinate the issues. Job titles include but are not limited to the following: "product circularity SME[17]", "Project & Solutions Manager – Circular Products", "Circular product design manager".

1.2 Relationship Between Circular Economy and Materials Efficiency

Circular Economy (CE) is a systems level approach whereas Materials Efficiency (ME) is part of the broader concept of Resource Efficiency or even more broadly Eco-efficiency (DeSimone & Popoff, 1997). Resource efficiency is a broad umbrella term that describes efforts to reduce the total environmental impact of the consumption and production of products and services, from raw material extraction to final use and disposal. Whilst CE and the ME are sometimes referred to interchangeably, there are some distinct differences. Fundamentally, ME does not holistically re-address the linear model of consumption and production; however, it can support the development of more material efficient products/business models and the transition towards a CE. In fact, a CE approach takes a whole systems perspective, where materials are systematically retained, restored, or regenerated. It means being more effective and optimizing how materials are managed across their life cycle to reduce environmental

[16] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en

[17] Subject matter expert (SME)

impact. Implementing its principles in an organization might require a paradigm shift in how an organization operates. ME is concerned with the efficient use of materials, waste prevention and reduction, and causing minimal damage to the environment and depletion of natural resources. It means doing more with less and delivering greater value with less. Organizations might become more materials efficient through relatively simple, incremental actions. ME strategies align to the hierarchical approach set out by the EC Waste Framework Directive (Allwood et al., 2011; Bakker et al., 2014; European Commission, 2008c, 2018a). The Directive presents a waste hierarchy for reducing the waste output and its disposal in landfill. Implicit in the Directive is the acceptance of waste rather than thinking of the retaining or regenerating value in products, components and materials that is implicit in many Circular Economy definitions. The waste hierarchy details a priority order for managing waste, moving from prevention of waste (the preferred option), to reuse, recycling, other forms of recovery (e.g., energy recovery), and disposal (the least preferred option). The goal is to strive for prevention over reuse, and for reuse over recovery, etc. Waste is defined in the Waste Framework Directive as “any substance or object which the holder discards or intends or is required to discard.” The current definitions of prevention, reuse, recovery, and recycling all hinge on the assumption that a product at a certain point in time inevitably will become waste.

1.3 Circular Economy Strategies

As stated above, CE can be defined at various levels. Circularity strategies in this context can be applied at product level, acknowledging that CE is a broader concept than material efficiency. Circularity at a product level is fundamentally based on materials related to the products, components, and the materials themselves. The concept of thinking about products from the perspective of biological nutrients (materials) and technical nutrients (materials) has gained increased recognition through the Ellen McArthur Foundation Butterfly diagram (see Annex 6) that built on original thinking from McDonough and Braungart (Braungart and McDonough 2002). This is now being considered in the development of the ISO definition of Circular Economy. However, in practice, the Butterfly diagram (see Annex 6) is a simplification of the reality of the materials mix of many products, i.e., many products include a mix of biological nutrients and technical nutrients. Another key aspect that needs to be considered in relation to PC is whether products are energy-using (i.e., consumer electronics, vehicles), energy-related (i.e., taps and showers, windows), or non-energy-using products (i.e., furniture, bed mattresses). This is because material and energy related issues will have a primary or secondary role in relation to the environmental impact of products depending on the type of product e.g. energy in use is more important for a toaster, wood in production is more important in furniture, etc.

1.4 Circular Economy Measurements, Metrics, and Indicators

There is growing interest in measurement of CE at various levels (e.g., products, organisations, regions), and several metrics and indicators are being developed. New initiatives are being established to explore measurement. For instance, an ISO working group (WG) has been set up to develop a standard related measuring circularity: ISO TC 323/WG3. To date most of the focus of the standard has been at an organisational rather than a product level. In addition, another relevant ISO WG has been established to focus on development of Product Circularity Datasheets: ISO TC 323/WG5. Furthermore, the Circular Economy Indicators Alliance (CEIA) has been recently launched with multi-stakeholder membership including the European Commission and the European Environment Agency with the secretariat provided by PACE (PACE, 2021b). The stated aim of CEIA is to foster collaboration between governments, businesses, entrepreneurs, and experts and to take forward thinking on circularity metrics with a particular focus on different market sectors: food; electronics; textiles; electronics; plastics; and capital equipment. CEIA have published two reports focused on measurement of CE for government and business. In Europe, there is growing interest at government level, i.e., Bellagio Declaration (ISPRA & EEA, 2020) and this is highlighted in a recent CEIA report on Government (PACE, 2021c). A CEIA report on Business provides an overview at a company level, although with little mention of product-related circularity issues.

Business leadership on CE measurement has been taken by the World Business Council for Sustainable Development (WBCSD) and Ellen MacArthur Foundation (EMF), who have developed tools that incorporate product-related circularity metrics and indicators e.g. CTI and Circulytics.[18] As indicated above, the measurement of circularity in business seems to be more focused at the company and business unit level rather than at a product level (WBCSD, 2018). However, details of actual usage of these tools are not in the public domain. As part of ORIENTING, a systematic literature review was conducted to identify the existing circularity indicators in the scientific literature and grey literature, which was then filtered according to the scope of the project. The literature review indicated that there has been a considerable amount of academic research and published papers related to product-related circularity indicators and metrics.[19] In turn, this indicates a gap or "lagged effect" between the research and business communities, i.e., several tools and methodologies have been developed in academia, but few are being used by companies due to a lack of external and internal drivers. Many companies are unlikely to be motivated to measure product-related circularity unless there are external drivers (i.e., customers, legislation, standards) or there is a strong business case (i.e., cost saving, efficiency gains) (WBCSD, 2018).

[18] Experts interviewed in the context of this project suggested two product-related circularity indicator/metric tools are being most used by companies: 1) Circular Transition Indicators (CTI) – Version 2 (WBCSD, 2021),which has been update to CTI 3.0 as of March 2022 and CT 4.0 as of 2023 and 2) Circulytics (EMF, 2019).

[19] https://orienting.eu/publications/d1-4-critical-evaluation-of-material-criticality-and-product-related-circularity-approaches/

1.5 Circular Economy Indicators and Strategies, and LCSA

Based on a survey of 39 global companies and other stakeholder interviews, WBCSD (2018) classified CE indicators (or metrics as they call them) according to scope (i.e., which *environmental aspects* (in ISO language) they address: materials, water and/or energy), level, and supply and value chain or life cycle factors (e.g., internal operations or processes of a business, or the End-of-Life phases of the life cycle). While the WBCSD (2018) (and de Oliveira et al. (2021)) isolate products as a separate nano-level below the micro-level, Kirchherr et al. (2017) and Saidani et al. (2019) distinguish between micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond). Moraga et al. (2019) also distinguish between micro, meso and macro level which they refer to as "scale" but note that the distinction is "neither consistently used nor clearly defined".

CE indicators can be considered quite heterogeneous for several reasons including the lack of a common definition of CE. Nonetheless, a few authors have attempted to cluster the circular economy indicators, using different approaches. In Moraga et al. (2019), two main criteria are used to cluster the indicators, i.e., (A) what to measure and (B) how to measure. Saidani et al. (2019) suggest 10 categories to classify, differentiate and orient the use of CE indicators.

- Categories from #1 to #4 are specific to the CE paradigm (levels, loops, performance, perspective).
- Categories #5 to #6 (usages and transversality) are related to the usages and fields of application of these CE indicators.
- Categories #7 and #8 (dimension and units) are linked to the basic features of indicators.
- Category #9 (format) is dedicated to the assessment framework associated to each CE indicator, facilitating for instance its computation.
- Category #10 (sources) specifies the background in which each CE indicator has been developed.

Saidani et al. (2019), for example, have analysed the coverage of CE strategies by indicators, differentiating them into 3 groups. while Moraga et al (2019) and de Oliveira et al. (2021) proposed grouping the strategies into 6 and 4 groups, respectively, adapted to the life cycle perspective and the elements from life cycle studies. Oliveira et al (2021) have analysed indicators measuring strategies used at a product, component, or material level (58 indicators in total) according to which of the life cycle stages. Their analysis showed that:

· 43% of the indicators evaluated cover strategies in *all the life cycle stages*.

· 3% only address strategies for *reduction of extraction* of natural resources (energy and materials).

· 21% target the *design/manufacturing process* strategies, however, 3% are exclusively dedicated to these strategies.
· 14% evaluate effects of strategies regarding *the acceptance and behavioural shift of consumers* in the use phase, but they are always linked to other strategies.
· 29% of the indicators are *exclusively* dedicated to evaluating the *recovery of waste, materials, and energy* in the EoL phase, but is included in 52% of the indicators.

Moraga et al. (2019) classified CE indicators according to six groups of CE strategies depending on what they seek to maintain (5 groups), or whether they seek to benchmark activities against a reference scenario (1 additional group). Strategies in group 1 aim to preserve the *function* of products or services (i.e., promote product redundancy and multifunctionality); strategies in group 2 aim to preserve the *product* (i.e., promote durability, reuse, restore, refurbish, and remanufacture); strategies in group 3, *components* (i.e., promote reuse, recovery and repurposing); strategies in group 4, *materials* (i.e., promote recycling which may also lead to downcycling); strategies in group 5, the *embodied energy*[20] (i.e., promote energy recovery); strategies in group 6 represent a reference scenario with linear economy and no strategy. In their analysis of micro-level indicators, Moraga et al (2019) found that most indicators address strategies in group 4, i.e., assessing the preservation of materials, and that recycling is the most frequently promoted strategy. Although these studies do not use the same classification and therefore cannot be compared, they are complementary and express a common result.

The reviews show that most of the indicators measure the implementation of strategies at the 'end of life' of the products and are mainly focused on recycling. This finding suggests that to date, recycling has been the focus among companies and that existing literature and/or data for other strategies that should be prioritised is not sufficient. Alejandrino et al. (2021) reviewed the way in which the different sustainability pillars have been implemented in 100 LCSA studies. However, widely known indicators such as the Material Circularity Indicator (EMF & Granta, 2019) was not applied. As a side result, they found that less than 7% of the analysed studies address CE concepts or strategies. Among these, different circularity indicators for disposability, reusability or recyclability are used. It is pertinent to highlight here that despite ORIENTING partners (primarily Ghent University), reviewing over 100 scientific papers to analyse the existing CE indicators and metrics for potential use within Orienting's LCSA, the analysis does not indicate which are the most used in practice. Furthermore, the WBCSD's CTI 2.0 which perhaps is the most used by industry was excluded from the initial analysis, as it was decided within WP1 to focus on the available academic papers rather than

[20] Moraga et al. (2019) speak of "preserving embodied energy ". Note that this is somewhat ill-phrased because energy is always preserved. However, through incineration and capturing gases at landfills one can convert the embodied energy into useful energy.

practice. The research resulting from WP1 concluded that literature on the integration of the circularity indicators analysed in the deliverable and an operational LCSA is currently unavailable. Thus, ORIENTING is a first attempt at integrating CE indicators and metrics into an (operational) LCSA framework. Having set out the theoretical framework that underpins the interviews, the next section aims to summarise the key learnings for the interviews.

1.6 Background Summary

The review of information related to PC measurement was primarily based on the analysis of existing scientific literature focused on academic perspectives and did not provide insights or information on how PC is addressed within industry. As highlighted in the section on eco-design and PC, the literature would suggest practice of eco-design (integration of environmental aspects into product design and development), however, the in-depth qualitative interviews conducted for this research revealed the contrary, with little awareness or practice of eco-design within the companies interviewed.

The key learnings from the literature review and industry experience that were taken into consideration when developing the interview questionaries, and conducting and analysing the interviews were:

- A definition for CE has not yet been established and is understood differently by different people. In this context, a definition of CE was offered at the start of each interview.
- The background literature review indicated that there is growing interest in measurement of CE at various levels (e.g., products, organisations, regions), and several metrics and indicators are being developed. However, the awareness and implementation of these metrics and indicators within industry remains unknown. This in turn, supports the research presented in this report which aimed to explore if and how PC – product level - metrics and indicators are used within industry.
- With many companies unlikely to be motivated to measure PC unless there are external drivers (i.e., customers, legislation, standards) or there is a strong business case (i.e., cost saving, efficiency gains) (WBCSD, 2018), the questionnaire sought to investigate drivers for measuring PC at a product level.
- While section 1.5 of this report's background provides a classification for CE indicators based on the literature, the interviews revealed that very few of these indicators were known or had been used by industry. This included the two selected indicators for Orienting, the EMF's MCI and the WBCSD's CTI.
- To the knowledge of the authors of D1.4, there is no literature on the integration of the circularity indicators analysed in WP1 and an LCSA. Therefore, questions related to the use of LCA's and the integration of PC assessments within industry were included within the interview questionnaire.

2. The Interviews: Methodology

The primary aim of the interviews was to gain insight into PC and product social (PS) issues within industry to inform the development of ORIENTING's LCSA methodology. A further aim was to better understand the practical considerations related to PC and PS issues being faced by industry at a product level. Therefore, interviewees were contacted based on individuals' involvement with the business function of Design and Development (D&D). It is also pertinent to highlight that the interviews focused specifically on increasing understanding of PC and PS issues, rather than on increasing an understanding of the broader product sustainability perspective (i.e., environmental, economic and social). However, for some interviewees, PC may be seen as a specific part of product-related environmental considerations in the D&D process.

Pilot and full interviews were planned for 45 minutes up to 1 hour. Participants were contacted via email in which the aims and objectives of the ORIENTING project, and the interviews were outlined (see ANNEX 2). Information regarding how the data would be used was also provided to the interviewees, with a reassurance provided that names and company details would be anonymised. Upon completion of the interviews, a copy of the interview transcript and/or notes were sent to participants for approval. Some of the benefits offered for participation include a summary report of findings of the interviews and an ongoing connection to feedback and learnings from ORIENTING as well as a range of other ways to engage in the ORIENTING project e.g., through expert workshops.

The research employed semi-structured qualitative interviews with a blend of closed and open-ended questions, accompanied by follow-up 'why' or 'how' questions. Qualitative interviews were used because they facilitate a 'learning approach' with the interviewees, allowing for the recognition of emerging themes and patterns related to the research topic. Therefore, the use of semi-structured interviews facilitated: 1) an in-depth exploration of PC and PS considerations within industry from the perspective of a potential user of ORIENTING's LCSA; 2) insight into the nuances across different industry sectors, in relation to the use of PC, PS and LCA terminology, methodologies, tools, etc and 3) insight into current CE and PC strategies being implemented within companies and other relevant tools and methods that are being used that are not in the public domain.

The interview process and development of the questionnaire was informed by expert knowledge on behalf of Professor Martin Charter and Dr Lilian Sanchez Moreno of The Centre for Sustainable Design ® at UCA (CfSD) (see ANNEX 2 for interview questionnaire). Further input to help scope, frame and check the content of questionnaire and interview process was obtained during four CE expert interviews completed before and during the main interview process. The CE expert interviews, which also acted as pilot interviews were held between July and August 2021 with the following participants:

Expert Interview 1: Director of Eco-design and Sustainability at a European multinational.
Expert Interview 2: Sustainability consultancy and LCA expert
Expert Interview 3: Expert involved in ISO-TC323-WG3 (Measuring and Assessing Circularity).
Expert Interview 4: Circular Economy PhD/consultant.

The following section presents a summary of the key lessons learnt for the development of the interview questionnaire and process from the four CE expert interviews.

2.1 CE Expert Interviews

Expert interview #1was with a European-based multinational and was a 45-minute open-ended interview held via Teams on the 20th July 2021 with the company's Director of Eco-design and Sustainability. The interview was conducted by Professor Martin Charter (MC) of The Centre for Sustainable Design ® at UCA. A key factor in securing the meeting was prior vetting by a former employee that knew MC and one of that also one of the interviewees knew MC. This interview was not recorded with notes taken. A key learning from this interview is that interviews with people that know MC or Lilian Sanchez Moreno (LSM) allowed for more details to be disclosed, which might not occur during a more formal interview. A further lesson learnt was the importance of tailoring interviews according to the type of company, seniority, and role within company, as it was recognised that a structured interview would not have worked due to time constraints (45 minutes). The expert interview was helpful to gain an initial insight into PC and PS issues to inform the preliminary questionnaire design for the main interviews. It was recognised that MC had some understanding of the company from previous experience but undertaking research before each interview was important for follow up questions (i.e., reading Corporate Sustainability reports). Lessons were also learned from the pilot interview in terms of developing the strategy for further interviews. For example, targeting the Head of Sustainability within larger companies first, assisted in further identifying stakeholders responsible for PC issues such as designers, with PS issues perhaps falling under Supply Chain and Corporate Social Responsibility (CSR) – however it was recognised that this may well be company specific. It was also recognised in both instances that consultants may be sub-contracted to complete PC and PS related tasks in some SMEs.

Within this European multinational, (PC) was seen as part of Eco-design, where Eco-design Strategies were developed at a corporate level first, and then designers were briefed. The company has started to its own approach to circular design and appeared to have an internal definition. However, as disclosed during the interview, *'they are still learning'*. This was particularly relevant as the main interviews also revealed, that most participating companies also considered themselves to be in a learning stage and thought that other companies were much more advanced than themselves. Furthermore, expert interview #1 revealed that the company has developed internal design tools based on adaptation of existing methods. LCA's lifecycle thinking (LCT) and internal LCA's feed into expert interview #1's Eco-design programme – however, what these LCAs cover is unclear. Moreover, the company does not require LCA's to be conducted by their suppliers. Instead, they use external data to assess the environmental impact of their supply chain. Finally, product social issues appeared to be beyond the scope of the interviewee's awareness, and they appeared to be 'fuzzy' about these issues.

The expert interview #2 was held via Zoom on the 28th of July 2021 with sustainability consultant, LCA and CE expert. The interview was conducted by MC at The Centre for Sustainable Design ® at UCA. Key learnings from the expert interview indicated that designers generally don't use LCA's as part of the product Design and Development process. It was also highlighted that completing an environmental analysis and a circularity analysis will give very different answers. However, it was reinforced that *PC cannot be explored in isolation.* The interviewee pointed out that in practice, Social LCA is very different from Environmental LCA, as many companies are still not ready to disclose the data required to quantify product social issues. For example, any mention of child labour will be viewed negatively externally and there is not a 'good' metric that can be externally reported upon. Based on the above, it is possible to speculate that knowledge of PS issues is likely to be embedded in firms and not in the public domain. In turn, this highlighted the need to include questions related to how S-LCA is understood and used within industry within the questionnaire developed for this research.

The expert interview #3 was held via Zoom on the 28th July 2021 with CE expert to ISO-TC323-WG3 and LSM of The Centre for Sustainable Design ® at UCA. The informal discussion focused mainly on the projects the interviewee is currently working on as part of a national European research institute and their participation in the development of the ISO TC323 WG3. The interviewee highlighted that as part of the initiatives for the development of a global ISO standard for the circular economy, the interviewee has tested 'C metric'[21] within industry, which 'quantifies the economic value of circulated materials or components regarding how much virgin materials you put into a product.' In this context, C metric appears to be favoured by companies as it is 'easy to use'. However, this methodology was not mentioned by any other interviewee in the latter interviews. The weakness of C metric, like many other assessment methodologies (as highlighted by the interview participants), is that it combines so much information as a 'value', that you end up not knowing what it represents or how to improve the business, or products e.g., it is just a 'number'. In addition, it was understood that for 'complex products, it was very difficult to apply this tool. This expert interview highlighted that companies want something that is practical for design, but *"…. feel very insecure if it's not the right one [tool], the one that customers really want'. So, they are very keen for some sort of standardisation: 'so a standard value is important".* This point was raised by some of the main interview participants e.g., 'official' guidance on how to select the most the most relevant product-specific tools would be welcomed by industry.

[21] Product Level Circularity Metric (Linder et al, 2017)

The expert #4 interview was held via Zoom on the 28th of July 2021 with a consultant with a CE related PhD, which was conducted by LSM. Key learnings from the expert interview indicated that the decision to implement CE strategies is primarily developed at a management and higher-level leadership team, rather than at a D&D level. However, there are exceptions and within some organisations, initiatives do happen from a bottom-up perspective with the leadership team being receptive to ideas from designers. The interviewee also indicated that barriers to CE implementation within D&D appear to be the lack of autonomy granted to designers and the compartmentalisation of tasks within industry, which often means that there is a lack of communication across business functions. Within larger companies, CE efforts focus on flagship products, which are used for marketing and promotion strategies. In other words, by focusing efforts on "flagship products", an organisation can appear to be more sustainable, whilst other products retain a high environmental or social impact. Nonetheless, this strategy has also been used by companies to drive sustainable innovation. For example, Philips' Green Flagship products aim to offer consumers products with better environmental performance than their predecessors and competitors in the following areas: weight, energy consumption, hazardous substances, packaging and recycling and disposal. These products can be identified by the consumer by a "green tick" logo (Marketing Week, 2007). The interviewee also provided insight into the differences between businesses that are set up to be 'more circular' and those attempting to change/transition an already established company, process, supply chain or product portfolio. The latter takes a long time and for a while will continue to navigate in a linear mode- as it is harder to 'undo' linear models.

2.2 Main Interviews

Based on the learnings from four expert interviews summarised above, the main interviews considered the following points:

- Most companies that are tackling CE and/or PC are likely to consider themselves to be still in the 'learning' phase with regards to the implementation of CE, despite often be more advanced than others.
- LCA's appeared to be used by a number of larger organisations. However, it is unclear how the results from LCA's are used to support decisions at a D&D level.
- Designers normally don't use LCA's as part of the design process.
- The four expert interviews indicated that most companies are not aware of or ready for S-LCA as they are not ready to disclose the data required to conduct this assessment.
- The number of circularity assessment tools available to companies is a challenge, as companies are finding it difficult to know which one is best for their product, or their customer.
- Decisions related to the implementation of PC strategies to be implemented are generally made at a senior level and outside the D&D business function.

The participants for the main interviews were selected based on MC and LSM's 's experience and/or connections of companies that had externally communicated having a core circular economy (CE) business strategy or an intention to shift towards a CE business model. Building on the learnings from the 4 CE expert interviews the following research strategy was developed to gain insight into the different stages and decision-making processes that affect (PC) and (PS) within industry:

For large companies that have various Business Units and corporate functions ('line and branch'), the aim was to initially interview corporate Sustainability Directors who could provide an overview of PC and PS issues across the Business Units. These interviews aimed to identify those with responsibility for PC and PS issues for potential follow-up interviews.
For start-ups and MSMEs the aim was to interview the Founder/Managing Director (MD). As responsibility for sustainability, PC and PS related issues within MSMEs are likely to be carried out by these functions.

Prior to each interview, background research was conducted by reviewing the company's sustainability reports and website. This was essential to contextualise and inform the strategy for the interview and adapt the pre-prepared questionnaire for each participant. As mentioned previously, interviews were either recorded and transcribed or handwritten notes were taken to enable the coding and categorisation of patterns and themes that emerged within each interview.

Twenty-one company interviews were completed in 2 phases. In Phase One, 10 companies were interviewed between August and November 2021, after which a webinar was organised to present initial findings to ORIENTING partners and participating companies. In Phase Two, a further 11 companies were interviewed between November and February 2022 to expand on the initial findings, and to reflect and adapt the interview questionnaire based on the process and content lessons learnt from Phase One. The initial draft of the interview questionnaire was developed by MC and LSM based on experience and knowledge of PC and PS considerations at a D&D level and supported by the findings from the 4 CE expert interviews highlighted previously. The initial questionnaire was divided into three main topics: 1) General questions to assess the interviewee's level of decision making related to (PC) and (PS); 2) PC specific questions, to probe into more detailed aspects related to measurements, metrics, indicators and the use of eco-design strategies and tools, and 3) questions related to PS considerations to probe into more detailed aspects related to measurements, metrics, indicators to define the scope of product-related social topics to be included within the LCSA. All interviews commenced with a brief description of ORIENTING project, followed by the aims and objectives of the interview and a working definition of circular economy, product circularity and product social issues, provided in the glossary of this report.

2.2.1 Process Learnings for Phase One

Phase One outlines the themes and topics that emerged from the first ten interviews, which were used to inform and adapt questions for Phase Two to prompt a more detailed response regarding PC and PS considerations within D&D. Furthermore, the lessons learnt from Phase One helped to identify areas that required additional information from the interviews which resulted in adding further questions to the original questionnaire and/or reengaging with some of the participants via email for further clarification on specific topics. For example, adding more specific questions related to the use of eco-design within design and development.

The majority of interviewee's demonstrated a genuine interest in learning about ORIENTING and contributing to the development of the project. Moreover, participants were open to participating in workshops, webinars, and feedback from ORIENTING, as it was recognised from the first ten companies interviewed, that they are still in the process of 'figuring out' a CE strategy and more specifically, a PC strategy within a CE strategy. A further learning from the interview process was that some of the multinationals would have preprepared presentations as a response to some of the questions related to their sustainability strategy, which in turn, affected the spontaneity of the answers provided. Likewise, some of the larger companies/multinationals were more reluctant to comment on areas outside of their expertise and raised concerns regarding confidentiality issues. Similarly, some of these companies also requested the interview questionnaire in advance to assess whether to take part in the interview, prepare answers or to suggest colleagues that they felt were more aligned to the aims and objective of the interview. In contrast, start-ups and MSMEs appeared to not have a prepared script while responding to the questions, which allowed for an in-depth insight into further PC and PS considerations at a D&D level.

As highlighted in Annex 1, the interviews covered several sectors including automotive, textile, white goods, footwear and hardware and software among others. While the sample size per sector was small (and therefore not representative), nuances were identified with regards to how PC and PS considerations, LCA's, PC measurements, metrics, and methodologies were understood per sector. The nuances identified within each sector, helped shape the questionnaire for the additional interviews conducted with these sectors. As a surprising lack of awareness on eco-design within D&D amongst participants emerged, this resulted in providing a definition for eco-design at the start of the interviews, as well as, specifically asking participants about their awareness of IEC 62430:2019 and ISO 14006:2020. In parallel, a non-exhaustive literature review on eco-design within industry was conducted as well as engagement with experts in the field who confirmed the current lack of awareness and implementation of eco-design.

2.2.2 Process Learnings for Phase Two

Once the first ten interviews from Phase One were completed, a webinar covering the learnings was organised with the participating companies. The objective was twofold: the first was to keep participants engaged with the process, present a more detailed overview of ORIENTING project, and introduce the preliminary interview findings. An additional goal was to gain feedback from participants regarding the preliminary interview findings. Participants were contacted via email, in early November 2021 with the aim to schedule the webinar for the end of the month. Response rate to the webinar invite was approximately 50% due to other commitments. The webinar was held with four participants from two organisations (one multinational, one start-up). The overall aims and objectives of ORIENTING were well received by the participants, as one participant expressed the need within the market for a harmonised LCSA methodology that includes circularity and criticality perspectives, as well as the need for a streamlined, multilevel approach that can facilitate a quick assessment for internal decision making. From the preliminary interview findings presented at the webinar, participants were surprised to hear that most companies, including multinationals with a longstanding history of eco-design, were still within the 'learning' phase with regards to the development of circularity indicators and metrics. In other words, most companies perceived themselves as being in the early stages of CE implementation, while thinking others were much more advanced. This was further evidenced in the following 10 interviews as part of Phase Two of this research, where apart from two/three companies, it was identified that most of the companies interviewed, remain in the 'learning' phase of their circularity journey. Based on the thematic coding analysis framework employed to analyse the in-depth interviews, once new PC strategies, indicators, or metrics stopped emerging for 3 consecutive interviews, it was concluded that data saturation had been achieved. In other words, collecting additional data would not produce further insights. Therefore, it was agreed by UCA and ORIENTING partners that interviews would be capped at 20/21. Equally, as ORIENTING project's environmental assessment is based on the European Commission's Product Environmental Footprint (PEF)[22] framework, as the project progressed, the relevance to identify if and how both PEF and the Circular Footprint Formula (CFF)[23] is being used by industry, was highlighted. Therefore, questions regarding the use of PEF and CFF were raised during the last 2 interviews. (2) participants had provided information regarding the use of PEF and CFF in the context of the initial interview questionnaire, while specific questions regarding the use of PEF and CFF were included for the remaining (4) interviews, as well as contacting the (14) participants that had not mentioned either PEF or CFF.

2.2.3 Conclusion

Twenty-one interviews were conducted in two phases. Feedback collected from ORIENTING partners at the end of the first 10 interviews, enabled in-depth investigation into PC, PS and

[22] https://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf

[23]https://ec.europa.eu/environment/eussd/smgp/pdf/TrainingCFF%20Circular%20Footprint%20Formula10Nov2020_final_corr.pdf

LCA related topics that were aligned to the overall development of ORIENTING's LCSA methodology. Examples of how the interview findings have served as input to ORIENTING methodology (see Section 3) included: identifying various levels of awareness with regards to PC, PS and LCAs at a sectorial, organisational, and individual level; nuances in interpretation of PC across different sectors, and insights into industry related to how PC is currently being measured. The development of a two-tier approach proved to be the most effective interviewee strategy in relation to the aims and objectives of this research, whereby for large companies that have various Business Units and corporate functions, corporate Sustainability Directors were contacted first, while for start-ups and MSMEs, contact was established with Founders/Managing Directors. For example, Sustainability Directors either reached out to further relevant colleagues to establish 1:1 interviews or invited colleagues from other relevant business units for a joint interview. From the 21 interviews conducted, one multinational mentioned that their responses would be less open, due to the interview being recorded. Additionally, 3 participants requested a copy of the interview questionnaire prior to the interview: 2 to assess their suitability and willingness to participate and 1 participant for the purpose of preparing their responses. While these details have been accounted for in the analysis of the corresponding data, they appear to not have affected the overall outcome of the findings.

2.3 Analysis of Data: Thematic Coding

The data from the twenty-one interviews was analysed using thematic coding, which consists of categorising and assigning different values to the key themes and topics that emerge from each interview. Thematic analyses or thematic coding is a method for analysing qualitative data that entails labelling and organizing data to identify, analyse and report different themes and patterns (Braun and Clarke, 2006). A distinguishing feature of this method is its flexibility to be used within a wide range of theoretical frameworks such as grounded theory and discourse analysis, and to be applied to a wide range of study questions, designs, and sample sizes (Kiger and Varpio, 2020). Thematic analysis can be used as a stand-alone analytical methodology or as a foundation for other qualitative research methods. Labels were assigned to words or phrases that represented important and recurring themes related to PC and PS issues within each response from the sample pool. Themes were identified by analysing patterns in words used during the interview and sentence structure. While the interview questionnaire was adapted and improved after each interview, the core questions were maintained for comparability. Regarding the process for extracting and organising the data, the interviews were initially transcribed by one of the authors of this report, whilst simultaneously adding notes related to the themes and topics that were repeated or emphasised throughout the interview. Subsequently the key themes were categorised and arranged to produce a summary that highlighted key findings related to the following topics: eco-design, product circularity strategies, indicators and metrics, barriers to implementation of PC strategies, LCA as well as the use and development of other impact assessment methodologies and frameworks, and product social considerations at a design and development level. The summaries were then discussed between the two authors (MC and LSM) to identify further areas of enquiry that needed to be addressed by follow-up questions via email and/or in subsequent interviews. At fifteen interviews, saturation point for some of the sectors was near completion, as very few new themes and topics were emerging. However, completing twenty-one interviews served to support the preliminary findings and expand the sampling of companies/product category. In turn, this resulted in targeting intermediate products for the remaining six interviews, with the aim of gaining broader perspective of PC issues and assess further themes or topics that could potentially emerge from the sector. As mentioned previously, companies were also categorized by sector, size, and relevant PC related data, as well as assigning awareness levels according to the ZBIA model.[24] The WBCSD's 2018 report, 'Circular Metrics Landscape Analysis' was also used to support the identification of various awareness levels related to an organization's 'circularity stage'.[25] The following section provides a more detailed description of each awareness level.

2.4 Multilevel PC Awareness and Use of CE Metrics

As part of the process for analysing the interviews, each participant was assigned a PC awareness level. The evaluation was based on the review of the interviewed companies' annual sustainability reports and the responses provided in relation to the companies' sustainability strategy and the implementation of CE strategies, the use of CE indicators and metrics, as well LCA practices. Further to the use of companies' sustainability reports and responses to the interview questionaries to assign PC awareness levels, the ZBIA model which describes levels of awareness that range from zero to basic, intermediate, and advanced and the WBCSD's 2018 report, 'Circular Metrics Landscape Analysis'[26] was used to develop the table below (see Table 1). It is pertinent to highlight that from the ZBIA model, level "zero" was removed as companies interviewed were already identified as being on a CE journey. Subsequent research following the interviewees has indicated that in larger companies, Sustainability Directors might have reflectively advanced knowledge of PC and CE topics, but the organisation overall might be at much lower levels of awareness and understanding (zero to basic).

[24] Charter, M., & Tischner, U. (2001). *Sustainable Solutions: Developing Products and Services for the Future*. Greenleaf.

[25] https://www.wbcsd.org/Programs/Circular-Economy/Factor-10/Metrics- Measurement/Resources/Circular-Transition-Indicators-v2.0-Metrics-for-business-by-business

[26] The WBCSD's report is based on 38 company interviews and the assessment of 140 sustainability reports, which highlights three CE strategy levels.

Table 1. Multilevel CE Awareness Descriptor

Circularity Strategy Stage	**Description**
Level 1/ *Basic*	Company has started to research, explore CE strategies but has not yet defined a product and/or company strategy. 1-2 years' experience within the remit of circularity.
Level 2/ *Intermediate*	Company has started to research, explore CE strategies but has not yet defined a product and/or company strategy. 2-3 years' experience within the remit of circularity.
Level 3/ *Advanced*	CE trailblazers or 'advanced' CE companies with 4+ years' experience in developing company and product level CE strategy.

Based on the levels descriptor in Table 1 and aligned to the findings by the WBCSD - where companies identified as level 1 begin their CE journey by 'weaving a CE narrative into their current operations' - only 3 interviewed companies were classified at a basic level. At this early stage, CE is not formally recognised, and any circular metrics used are at an 'operational efficiency' level. This means that any associated metrics at this early stage are often 'standard performance metrics' that measure for example, resource efficiency, energy consumption, water, and waste, which can be measured before a corporate sustainability programme is adopted.[27] A further 8 companies were classified as level two or *intermediat*e, as they appear to integrate 'circular thinking into the [company's] sustainability strategy', by measuring 'sustainability performance' which addresses some of the environmental and social impacts of the company's activities and products. Finally, 10 companies were identified as being within a level three or *advanced* on the circularity journey where circularity appears to be integrated within the company's corporate strategy to track business improvement through circularity initiatives.[28] However, a caveat to the advanced level is that companies might be advanced at a corporate level or business function level, but not necessarily at PC level.

[27] Ibid.
[28] Ibid.

As a result of assigning awareness levels to each participant, needs and requirements related to implementation were identified per level. This in addition to identifying circularity measurements and indicators at a company, department, or individual level. An example of this, which is discussed in more detail within the findings of this report, is that for companies classified as level 3, requirements for conducting PC assessments include the need for frameworks that address a 'cradle to grave' perspective. It is thus suggested that companies could be offered a multilevel self-assessment matrix to identify their circularity stage, which in turn could potentially serve as a starting point for defining the goal and scope of a proposed circularity assessment. Furthermore, a self-assessment matrix to define a company's circularity readiness stage can also serve as a benchmark to help companies advance their circularity goals and ultimately, complete a full LCSA as per the objective of ORIENTING.

3. Findings

The findings from the interviews show how different industry sectors are thinking through and/or measuring PC. Based on the themes that emerged during the interviews, the findings have been divided into the following sections: **3.1) Defining Circularity:** which highlights the multiple meanings identified for circularity amongst interviewees - at a product level – and how PC is being considered and implemented within industry; **3.2) Measuring Circularity:** highlights how companies are currently measuring PC or considering PC measurements, indicators, and metrics vis a vis available product circularity tools and methods. This section also highlights the use and adaptation of standard LCA's to conduct sustainability assessments that include circularity indicators and metrics; **3.3) Barriers Identified for the Implementation of PC**: highlighting the existing PC barriers across sectors and exploring potential solutions to overcome the barriers identified and **3.4) Product-related Social Considerations.**

3.1 Defining Circularity

CE is seen as part of sustainable development across all companies interviewed that include start-ups, SMEs, and multinationals within the apparel, textile, footwear, white goods, toy, hardware and software, furniture, infrastructure, and automotive industry. The companies interviewed were found to be either in the early stages of defining a circularity strategy vis a vis their sustainability goals (e.g., Participant 5 and 9); had been founded on CE principles (e.g., Participant 1, 8 and 19) or have historically been associated with developing and implementing eco-design strategies (e.g., Participant 4, 10, 11, 14). Based on the answers provided by the twenty-one interviewees with regards to their sustainability goals, 'circular economy' or 'circularity' was highlighted as 1 of 3 sustainability focus areas by the participants. While the other two sustainability focus areas were 'climate action' which was ubiquitously associated to 'decarbonization' and 'social' and/or 'ethical' business practices which encompassed: health and safety, equality, diversity, inclusivity, working conditions, among others. The interview findings suggest that an understanding of how to implement circularity and what this entails is fragmented. As the interviews conducted show that the concept of CE and how circularity is implemented at a product level varies depending on the type of product and industry.

At a product level, the most common focus areas for addressing circularity within the companies interviewed are the use of recycled content and biobased materials, along with ensuring that product components can be easily recovered and recycled through eco-design strategies such as design for product life extension that includes standardization, compatibility, and design for disassembly[29]; although few companies appeared to use the term eco-design, which was surprising to the authors. The responses from the interviewees also indicated that whilst CE and within it, PC was seen as part of the companies' sustainability

[29] These strategies have also been identified within the eco-design checklist presented in ORIENTING's D1.4 document (Pp. 108-111) that further illustrates PC strategies that companies might consider within the context of eco-design. See Annex 3

strategies, CE activities were somewhat compartmentalized perhaps indicating "newness" in many organisations. In addition, where eco-design was recognized as a practice in companies, PC aspects were considered separately to eco-design, despite being inherently aligned with eco-design strategies. It is important to highlight, that there was a lack of awareness and understanding of eco-design from 15 of the 21 interviewees, and this included participants from companies that have historically been associated with developing and implementing eco-design.

This surprising lack of awareness of eco-design within the interviewed companies led the authors to complete a non-exhaustive literature review of recently published information on the application of eco-design. In addition, the authors discussed these issues with other experts in the field. Based on these discussions and literature review, it is possible to suggest that the lack of awareness was potentially due to companies restructuring over the years where sustainability professionals with eco-design knowledge and understanding have either been moved to other departments or sustainability roles, that included eco-design responsibilities, had been made redundant over the past 5-10 years. There was some speculation that is only in recent years, driven by growing awareness over climate change, media visibility and policy initiatives such as the EC's Circular Economy Action Plan, that companies are starting to rebuild sustainability units often focused primarily on climate change related issues but increasingly starting to build CE awareness and understanding. The interviews also highlighted that for several companies, it appears that CE, while aligned to sustainability departments, is still not fully integrated across the organisation's various business functions. Regarding the interview process, this lack of awareness resulted in the IEC 62430:2019 and ISO 14006:2020's definition for eco-design[30] being read to participants at the start of each interview from phase two, to ensure that the interviewees were clear as to the terminology being used.

As previously discussed, at a product level, most of the interviewees understood PC as separate to eco-design and did not recognise its inherent linkage. Furthermore, for some of the larger companies, PC appeared to be operating outside of design and development process. This is exemplified in the following quote by [participant 1] who employed the term 'circular design' to refer to the use of recycled materials and designing for material recovery as per the eco-design checklist in Annex 5: *'At a product level, the company starts with a 'circular design', meaning 'we work with materials that are either recyclable, or biodegradable. We don't incorporate anything that cannot be recycled' and 'stick to a handful of materials that are all a combination of post-consumer recycled [materials]'or 'Reduce the number of components to ease disassembly.'* The quote also highlights the emergence of new concepts and terminology, where the use of 'circular design', 'circular by design' and 'circular-

[30]'Eco-design is the systematic approach which considers environmental aspects in the design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product'- sources IEC 62430:2019 and ISO 14006:2020

ready design' is increasingly becoming synonymous with specific design strategies and products that are aligned with Design for Material Sourcing, Design for Manufacturing and Design End-of-life (See Annex 5). A potential consequence of organisations' directly associating circularity with the use of recycled material and design for disassembly, is that other PC strategies such as re-use and repair remain excluded from CE discourses. In turn, the exclusion of such strategies from mainstream discourse can potentially lead to some companies, particularly MSMEs, to remain unaware of the existence of PC strategies within the use phase. Furthermore, as current PC assessments focus primarily on measuring the use of recycled or biobased content to define a product's circularity, this could lead to some companies who will not necessarily be aware of strategies beyond the use of recycled material to not explore the implementation of design for disassembly, reuse, repair as a viable PC solution.

However, while the majority of companies interviewed were focusing on the use of recycled materials and components and design for disassembly due to the constraints described above, some of the more 'advanced' companies (as defined within the ZBIA model (See Annex 1)) have started to challenge the direct association between circularity and the previously mentioned strategies (i.e., recycling) by differentiating for example, '*Material sustainability initiatives'*[31], from *'circularity initiatives'*[32] and appear to be assigning a hierarchy to circularity strategies. In this context, 9 of the companies categorized as level 3 or 'advanced' as per Table 1, indicated a shift in their circularity ambitions towards product and part reuse through designing for repair, maintenance, and upgradability as well as exploring product service systems (PSS) such as 'pay-per-use', 'product leasing' and 'take back' schemes.

This hierarchisation also highlights the differing understanding of PC amongst interviewees as it shows that the precise definition of the concept varies from one company and product to another, and this varies perhaps with the level of awareness/understanding/experience of PC/and CE more generally. This is exemplified by a quote from an EEE company: '*There is varying understanding of the scope of circularity. At a basic level there is a large push towards*

[31] 'Sustainable materials initiative' in the context of the interview appears to refer to strategies that focus specifically on reducing the environmental impact of a products materials. As per the eco-design checklist presented in Annex 3, this strategy focuses primarily on 'Design for Material Sourcing' that includes the reduction of weight and volume of a product, increase use of recycled materials to replace virgin materials, the elimination of hazardous substances and the use of materials with for example, lower embodied energy and/or water, which do not necessarily lead to PC.

[32] 'Circularity initiative' on the other hand, appears to focus more on strategies that enable material and product extension at the 'end-use phase' through 'Design for Manufacture and Assembly' and 'Design for Use (including installation, maintenance and repair)' as per Annex 3. These eco-design strategies for example avoid designs that are detrimental to material recycling, reduce the amount of residual waste generated within their D&D process, avoid designs that are detrimental to reuse and enable design for disassembly to ease repair, recycle and reuse.

more 'circular materials'[33] *(recyclable, use of recycled, and partnerships with recyclers). Then there is exploring the concept of 'pay-per-use', product service systems* (PSS) *and repair and refurbishment.'* [participant 4] While this quote highlights that PC is considered in relation to reducing the environmental impact of products by using recycled materials to replace virgin materials and the implementation of (PSS) [34], for other industry sectors such as aerospace and defence, PC is considered from a supply risk perspective. As [participant 11] indicated: *'The way I look at this [circularity] is why we manage materials supply risks. So, we take the mitigation strategy that we use for materials supply risk, which is very context dependent, it depends on the material, how we are using it, why there might be a risk there and what have you, but I would class most of these as circularity aspects.'* For companies classified as intermediate (materials) who do not have control over the end-use of their product, the focus of PC appears to be on recovering and reusing internal waste and process materials, as [participant 20] stated: *'In terms of circularity, we are making use of waste and process materials and looking at the recovery of other residues […] as an intermediate product we have less control over the use of the product or the final application [and] do not own our downstream business.'* Therefore, while the company is fully aware that their product is highly recyclable, they do not have full traceability of where that material ends up at its end-of-life and thus do not include percentage of material recovered for recycling or the use of recycled content as part of their circularity strategy.

This section has highlighted the various concepts and nuances that are emerging within industry when defining circularity. In the context of ORIENTING project, identifying such nuances has assisted in defining the scope for a PC assessment methodology within an LCSA. Regarding the development of PC assessments, this section also highlights the importance of considering how circularity is interpreted from a myriad of perspectives, which will ultimately affect the approach adopted for measuring PC. While for [Participant 16] circularity means to 'create products that are made to last, from, recycled and sustainably sourced materials that can be repaired, reused and remade multiple times.' [Participants 2, 4, 5, 11, 15, 16, 17, 18, 20, 21] indicated that they do not find the tools available in the public domain or commercially to be useful for quantifying and communicating their organisation's PC strategies.

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[33] 'Material Circularity' in this context can be differentiated from 'sustainable materials' as going beyond the reduction to the environmental impact of a product by reducing materials' embodied water or energy, the use of recycled materials to replace virgin materials', towards 'Design for Manufacture and Assembly' that considers for example the 'use of internally recovered or recycled materials from process waste'. See Annex 3.

[34] In the context of sustainability, a 'Product Service System' (PSS) is defined as *'a business innovation strategy offering a marketable mix of products and services jointly capable of fulfilling a client's needs and/or wants - with higher added value and a smaller environmental impact as compared to an existing system or product. Whereby a PSS meets consumer's needs by 'selling' utility instead of providing product ownership. In essence the right of product ownership is shifted from a client to the producer or service provider.'* Source: Ezio Manzini, Carlo Vezzoli, and Garrette Clark (2001), 'Product-service systems: using an existing concept as a new approach to sustainability', *Journal of Design Research*, Vol.1 No.2, p.27 – 40.

Based on the above findings, it is suggested that ORIENTING's methodology could offer guidance for adapting PC measurements and indicators to meet industry specific requirements or at a basic/entry-level, helping companies to define a starting point for their PC journey. A pilot approach is currently being undertaken by UCA to develop an entry-level Product Circularity Assessment (PCA) starter checklist. The results of the pilot aim to contribute to ORIENTING's training material for stakeholders wishing to increase their awareness of PC in the context of an LCSA. The following section aims to offer insight into how companies are currently measuring PC or considering PC measurements and indicators vis a vis available PC tools and methods. The objective for assessing PC indicators and metrics that are being used by industry was to gain insight into potential avenues for the integration of PC industry needs in the context of ORIENTING's LCSA methodology.

3.2 Measuring Circularity

As a result of WP1 and further internal discussions, the Ellen MacArthur Foundation's Circulytics or MCI (2021) and the WBCSD's CTI tools were selected for the development of ORIENTING's LCSA. Therefore, when interviewees were questioned regarding the specific use of the EMF's MCI or the WBCSD's tools, from the 21 companies interviewed only 2 companies claimed to measure circularity at a product or business level using the EMF's MCI and Circulytics, whilst not a single participant mentioned the use of the WBCSD's CTI tool.[35] One of the 2 companies stated that within their sustainability goals, that their aim was to *'reach 75% circularity for products and packaging by 2030'* [Participant 10]. In total 19 companies are not using these tools and as an example one of these companies that currently does not measure circularity, stated that it is within its short-term goals to start measuring PC, and indicated that they would like to *'have an actual value to say, hey, we are 95% circular'* [Participant 1]. For [Participant 10], the circularity percentage refers to the company's '*total annual product and packaging content by weight, that will come from recycled and renewable materials and reused products and parts*. While for [Participant 1], how they will achieve the 95% circularity has not been defined. As both companies are classified as 'advanced' in terms of PC strategies, this highlights that for companies with this level of awareness, the focus of PC measurement remains on quantifying inflows of recycled content or the use of biobased materials within a product and outflows through recovery percentages. This is due to companies perceiving that this is what they can pragmatically control, measure and report; with the use phase often seen as outside their control in current business models. Nonetheless, as [Participant 15] indicated, internally, some companies are seeking to explore the feasibility of measuring PC beyond the use and recovery of recycled content by developing *'KPI's for circularity'* that could potentially include indicators such reuse rates through take-back schemes or repair and refurbishment, as well as methods for *'measuring company*

[35] The numbers presented here are based on the interviewee's awareness of the use of either the EMF's MCI or the WBCSD's CTI 2.0 within their company and background research into company sustainability reports. Since most of the interviewees formed part of D&D units, it is possible that more companies are looking into these PC measurements and indicators, but this information is held elsewhere within the company.

success in circularity', or disassembly times vis a vis economic viability. As one of the more advanced companies indicated: *'[PC] is measured […] an indicator is also time: time for dismantling. How fast can you dismantle and at the moment I am working on new measurement systems of the expression of sustainability'* [Participant 15]

Equally, companies appear to be '*working on how to integrate circularity into design and development, while figuring out where the boundaries are for measuring circularity.'* In this sense, the boundaries for circularity appear to be driven by product type and industry sector. For example, a toy manufacturer that designs for longevity where their products are rarely recycled (as there is significant reuse of the products), would have to assess the trade-offs associated with replacing the current materials used with recycled or bio-based materials, which would then have to be measured during the *use* phase. Aligned to the extension of the system boundaries, [Participant 5] has started to explore ways to incorporate the *use* phase by conducting '*internal investigations to gain insight into what happens to the product once it has left the manufacturer'* and what influence it might bring to the *use* phase through design decisions that 'nudge' or 'educate' the user to make decisions that have a lower environmental impact during the use phase.

Other companies appear to also be measuring the recycled content that is reintroduced within their production line as an indicator of a products' circularity. However, measuring the inflow of recycled content within a product is challenging for some companies, due to the nature of their business. As [Participant 11] indicated, *'we have parts moving around all the time, because they go through various stages [and] can get stuck at any point. I don't mean stuck, but they can be there for quite a while, the waste manager will wait until they have a bigger batch of things. So, moving things through can span a couple of years sometimes, or certainly a couple of reporting periods. so, I think the measures that we have, we do have them I just don't think they are well developed to really give a representative of circularity. I mean questions like the recycled content of certain aloeids from that process is difficult to quantify'* [Participant 11]. Considering the current work being undertaken by companies at different circularity readiness stages and/or levels of awareness, it is important to promote the importance of a multilevel approach within sustainability assessment methodologies. As from a circularity perspective, companies classified as zero to basic might start by measuring the inflow of recycled content as an initial step toward implementing PC. While the more 'advanced' companies that have started to explore PC considerations within the use phase, will potentially be interested in measuring beyond the use of recycled material and beyond 'cradle to gate', towards a 'cradle to cradle' perspective.

The next section focuses on the current use of Lifecycle Assessments (LCAs) within industry and how such assessments have been simplified and/or adapted to align circularity indicators and measurements with an LCA methodology. From the companies interviewed 15/21, claimed to conduct LCA's to assess the environmental impact of their products and services.

(8) of the multinationals interviewed indicated that they conduct internal LCA's assisted by consultancies. A further (2) multinationals and (3) SMEs use consultants for an annual LCA. (1) start-up claimed to have started to conduct an internal LCA (but there were indications that perhaps they did not know what an LCA was) and was constrained by resources (economic and other time commitments), while (1) further company revealed confusion over LCA's and 'third party' verification. However, when pressed further on how the LCA's were conducted and used to inform decision making, several interviewees revealed that the LCA's that had been completed were adapted and simplified versions designed to meet internal requirements. [Participants 7, 11, 12] appear to be using a hybrid approach to LCA's to meet specific industry needs e.g., to meet requirements from customers and other external stakeholders. It emerged that there is a need to assess industry's use of in-house tools (i.e., excel based) and methodologies, which while aligned to LCA, appear to be adapted and simplified to meet product/company needs and overcome time and resource constraints. As the following multinational highlighted when questioned about the use of LCA's: *'We don't do a massive amount of them to be honest, and they vary in how granular they are. So …we've certainly done one, and we did it a long time ago, so I am sort of hesitated to say we have done one because it was such a long time ago… but we did a very detailed one […] that took us 2.5 years or so to do… but it was using very typical kind of…[what's the word]… academic LCA capability and I think that is one of the reasons we were driven to develop our own capability because we just didn't think it was working very well. so …we've done that. The rest of the other kind of stuff we don't use a tool, we use parts of the tool that we developed but a lot of it through basic excel modelling if you like. We have a range of models for manufacturing processes that we use to kind of build lifecycles that way, and kind of work things out that way.'* [Participant 11]

It is also relevant to highlight how companies that have been classified as having an advanced level of awareness, appear to be integrating PC and PS considerations within LCA's, alongside attempting to evaluate the impact of PC on a product's aesthetics. As the following participant stated: '*we developed a measurement tool; we have a measurement tool which we developed internally on social impact and carbon footprint but also on where it is put in the design. So how visible is the material on that scale, if its maximum visible it has to be maximum transparent and it has to be the most visible footprint so it's a kind of like a measurement spider, we developed internally. So, we can measure, understand, and make better decisions on the connections: social assessment, LCA, CO2 and also then, expression in design'* [Participant 15].

Equally, companies that indicated that they do not conduct LCA's, offered insight into the use of either confidential internal *'frameworks*' [Participant 12] or the development and use of '*simplified lifecycle-based analyses*. As the following SME stated, when questioned about the use of LCA's: *'I wouldn't call it [an LCA], … I don't know the definition of an LCA, but we are doing simplified lifecycle-based analysis, it's not full LCA's. We are considering the whole* *lifecycle of the products and taking data from the material, and suppliers'* [Participant 7]. A further issue identified was the extensive number of frameworks, assessment tools and methodologies in the public domain that are commercially available, often with limited guidance for users about the benefits of one over the other. As [Participant 1] highlighted: *'The problem now with sustainability and circularity is that there is so much out there and sometimes for a company it's difficult to prioritize on what we are doing, SDG's, circularity, the social thing… what tools we should be using, what's the right approach, how to build strategies, and what is the value for a brand…'* Based on the myriad of internal tools being used by interviewees for assessing sustainability concerns, and within this PC, a key learning from this section is that there is a need for the development of sustainability assessments to be flexible and adaptable to existing industry processes. However, to measure PC, organisations will first need to overcome barriers associated with the implementation of PC strategies, some of which are presented in the following section.

3.3 Identified Barriers for the Implementation of PC

A key barrier identified for the implementation of PC, was the siloed nature of communication across business functions. It was identified that the connections between the various business functions (e.g., environmental, CSR, supply chain, marketing…) that are directly or indirectly involved in the design and development (D&D) process, depend on the culture of the company and individual initiatives. For example, when [Participant 15] was asked how communication was established between the D&D and the environmental teams, it was highlighted that such connections are dependent on individual interests and initiatives, as the following quote shows: *'Every kind of connection is based on the people who do it. There is no natural connection between them, it is something I established because it is within my job and my network that I'm going to bring these people in. I do talks in their department, and they do talks in my department. So, this is something that I enforced a lot, that we do have a lot of exchange and … I really pushed that. And that colleagues talk directly to my people, to the designers'*. Thus, as recognised in the literature, establishing a common language and a shared vision of PC can ultimately assist in communicating PC strategies across an organisation's various business function, which is seen as key for the implementation of eco-design and product circularity.[36]

Assessing the trade-offs associated with the implementation of PC strategies was also perceived as a barrier for the implementation of PC. In this context [Participant 5] highlighted how the sustainability department is currently weighing the trade-offs of material substitution versus product longevity: *'As I mentioned earlier, do we move away from ABS towards using recycled PET or a biobased material? An LCA is going to tell us that's going to have carbon impacts as a trade-off, that's going to have a longevity impact, it might not be as recyclable, so in terms of making bold choices in the future, we are currently working through*

[36] Pigosso, D.C.A., et al., 'Ecodesign maturity model: a management framework to support eco-design implementation into manufacturing companies', *Journal of Cleaner Production* (2013).

this, but it is part of the core plan.' Moreover, the costs associated with material substitution, development of new infrastructure and business models was also mentioned by most interviewees as barrier. As one participant pointed out: '*[…] recycled plastic costs more than virgin, so if we want to implement it in the product, it will cost more. Reusing the product has a huge cost associated with reverse logistics so there are costs related to the closed loop management of the products. On the other hand, it's not so clear that the consumer is willing to pay more, and I… don't want to say that it's a lack of interest, because the consumer today is really interested in sustainability, the point is, are they willing to spend more? And so that is the key point that is still blocking our development.'* For some of the smaller companies, the scalability of PC strategies such as the production of materials utilising byproducts from other industries appears to also be an issue of concern. With regards to material substitution, it is not only that cost represents a barrier, but also maintaining product functionality, performance and consumer expectations whilst using an alternative material such as recycled PET or biobased materials.

Finally, a key area that was also mentioned by the interviewees, is the aesthetics of sustainability and how these need to align to customer/market demands. For example, this includes consumer willingness to accept aesthetic/external product changes associated with sustainability interventions such as the 'feel' or 'look' of recycled materials or plant-based materials e.g., 'vegan leathers'. Some of the companies interviewed are addressing concerns related to the potential impact of PC strategies on a product's aesthetics by, for example, using recycled materials only on non-consumer facing product surfaces as the following quote highlights: *'we have different use for different plastics from different waste streams and we put them back into our products, often like a multi-layer system where the inner layer is recycled materials and then the outer layer, the consumer facing materials of the product is virgin plastic* '[Participant 17]. If the barriers to implementing PC are to be overcome, it is recommended that PC assessment methodologies and tools address how to effectively communicate and present results across business functions. Additionally, strategies should aim to educate/raise awareness around sustainability decisions being made that may potentially have an impact on the product aesthetics and price to increase market acceptability. For example, [Participant 1] organise regular workshops to raise awareness amongst consumers on their product development vis a vis sustainability considerations.

Based on the above, the key PC learnings are the following:

- Increasing the use of recycled material to replace the use of virgin materials is the most advanced PC strategy at implementation and assessment level.
- The implementation and therefore assessment of product circularity is industry specific. In turn this requires for methodologies and or tools to be flexible and adaptable.
- There is a lack of awareness of eco-design within companies, and it appears that PC is viewed as a separate to eco-design.

- While most of the companies interviewed were aware of the EMF's MCI, only 2 from the 21 companies interviewed had used it.
- While some of the respondents understanding of LCA might be questionable, most of the interviewees claimed to be using LCA. However, there also appears to be an extensive use of internal methodologies and tools to assess their product's environmental impacts.
- Barriers identified for the implementation of PC, was the siloed nature of communication across business functions, assessing the trade-offs associated with different PC strategies and user acceptance of PC related aesthetics and costs, which are ultimately passed on to the consumer.

3.4 Product-Related Social Considerations

The prime focus of the interviews was on practical considerations related to implementing and measuring product circularity. However, aligned to ORIENTING's social component of the LCSA methodology, there was secondary goal of trying to understand product social (PS) issues at a D&D level. While most respondents engaged with the questions related to PS issues and provided some answers, they also highlighted that PS issues weren't within their area of responsibility and that they fell within CSR or supply chain. This section presents the key findings related to PS issues. For the authors, Product Social (PS) is defined as 'the potential social impacts that a product may have at any stage of its lifecycle (extraction of raw materials, production, distribution, use and end of life), which are defined at the design and development stage'. From the 21 interviews conducted as part of this research on PC and PS issues, (21/21) participants claimed that their organisations considered PS. The key issues mentioned were primarily from a supply chain and health and safety perspective. When questioned about PS issues, interviewees raised the following topics: working conditions, access to minimum/living wage and responsible sourcing, gender equality, human rights, diversity, and inclusion. The interviews also highlighted that PS is not considered a design requirement and appears to not be expected by the user. Furthermore, it is important to note that none of the social considerations mentioned above are dealt with at a D&D level and that product health and safety considerations were not recognised as being part of D&D; although many *are* actually legal or technical requirements.

Prior to engaging with the interviewees, the authors conducted a non-exhaustive literature review on current practices in industry that design engineers use to consider the social impact of products. Based on the literature review, while designing engineered products and systems from a social perspective appears to be an emerging topic in literature, the extent to which social impact is considered in D&D found in industry, remains a gap in knowledge. The main social topic considered in D&D highlighted by A. T. Pack et al. (2018) appeared to be health and safety, which the interviews confirmed. A. T. Pack et al. (2018) indicated that while social impact assessments (SIA) and social life cycle assessments (SLCA) are two of the most common evaluative processes discussed in the literature, from the interviews conducted as part of their research, *"not a single company used either of these processes despite affirming* *that they do consider social impact in product design."* Less discussed in literature are methods for predicting social impact in early design stages as there are very few tools available to assist in predicting impacts and informing engineers/stakeholders before production.

Regarding the measurements of social impact, the difference between 'audits' and Social LCA (S-LCA) was questioned by (3/21) interviewees. Moreover, S-LCA is not considered or well understood by (19/21) companies interviewed, while (2/21) indicted that *'industry is not ready for S-LCA',* as highlighted by [Participant 18]: *'we see it being applied to supply chains; I would say that's not really LCT, it's about evaluating social impacts in your supply chain… Thinking about social impacts across manufacture, use and end of life of the product, I have not seen that being done anywhere…' 'I would worry about reducing social impact to a single number, there is going to be inherent weighting to different factors and, especially in the social space, I would worry a lot about biases.'* When asked about further PS measurements, (5/21) responded with the use of certified materials, such as GOTS cotton, which ensures the environmental and socially responsible manufacturing of the cotton used within their products. While at a company level, BCorp (3/21) was mentioned to highlight how PS issues are measured within the company and (2/21) the Higg transparency Index. Based on the above, the key learnings on how PS is understood and measured within D&D are the following:

- Design engineers do not equally consider the whole spectrum of social impacts that their product could potentially have, and the tools necessary to quantify social impact a product has are either non-existent or underdeveloped across industries.
- An understanding of S-LCA's within industry is low and is perceived either underdeveloped or not adequate for certain sectors. From the 21 interviews conducted, no company is using S-LCA.
- Moreover, apart from health and safety issues, the social impact of products does not appear to be seem as design requirement by industry and is currently not measured at a product level.
- The interviews highlight a need for increased clarity over the types of PS decisions that are being made by the different internal stakeholders involved in the D&D process to support decision making.
- The research highlights the need for the development of tools that support the inclusion of social considerations during D&D, but perhaps changing the terminology to social, health and safety.

With the aim of addressing the lack of awareness and understanding of PS impacts within industry from a D&D perspective, the following topics are highlighted as a starting point for considering product social issues during the design phase. These are based the responses from the 1-2 companies that appeared to consider the social impact of products during the D&D phase.

Community well-being: At a product level, community well-being focuses on how the product might benefit local communities. For example, by integrating design features that might enable consumers to make sustainable choices or where the use of the product leads to a direct community benefit.

Health and safety: Some companies consider health and safety as a PS topic at the D&D level. In other companies, H&S appears to be considered as a technical issue such as child safety.

Human health: Topics that are considered under human health are material toxicity (e.g., child safety/toys) and the emission of hazardous substances during production affecting workers and local communities.

Design for inclusivity: 'Inclusivity' is considered a social topic at a D&D level by some companies. For example, considering how accessible products are for visual, motor, audio impairments at the early design stages.

Affordability: At a D&D level this topic considers the selection of materials and production processes that meet technical requirements whilst also enabling users/consumers to access the products at affordable prices. Moreover, affordability can also relate to taking into account supply chain costs from the early D&D phases.

4. Conclusion/Recommendations

4.1 Harmonising Product Circularity Concepts

The interviews highlighted that circularity is context specific and is understood differently at an individual, organisational, and sectorial level. Furthermore, the lack of harmonisation of definitions and concepts related to PC has led to the direct association between circularity and recycling to go unchallenged. The research also identified that the multiple understanding of circularity is aligned to various levels of awareness regarding PC at an individual, organisational, and sectorial level. Moreover, at a product-level, circularity is predominately being addressed at present by calculating the percentage of recycled and/or biobased materials used within a product as well as by quantifying a product's recyclability. The interviews also revealed that few companies use the term eco-design when discussing product circularity. While many would consider PC as part of eco-design, in the context of the interviews, PC appears to have evolved as a separate topic, and in some instances, even separately to D&D. In turn, the lack of awareness regarding eco-design – with its alignment to life cycle thinking - and the focus on recycling has the potential to hinder the implementation of other PC strategies that address the use phase, such as design for repair and reuse. For ORIENTING, these findings emphasise the need to harmonise PC related concepts to ensure that the way in which PC in monitored and measured is standardised.

4.2 Circularity Indicators and Metrics: Addressing the Products' full life cycle

The literature review conducted as part of ORIENTING's WP1 (See report D1.4) which assessed over 100 papers to identify the most suitable PC indicators and metrics to be integrated within an LCSA, showed that the indicators and metrics were primarily from a 'cradle to gate' perspective, which excludes the *use* phase.[37] The findings from the interviews reveals that while industry PC indicators are aligned to a 'cradle to gate' perspective, the need to go beyond the 'gate' and include the *use* phase, was expressed by interviewees with advanced level of awareness. The 'advanced' participants highlighted the need for methodologies to integrate measurements that include the *use* phase such as product repair, re-use, and refurbishment. Barriers identified by the interviewees for assessing PC during the *use* phase were challenges related to accessing data, confidentiality concerns and the lack of availability of methodologies that include use phase considerations. However, it is worth mentioning that this may change, since as of March 2022, the WBCSD's CTI 3.0 has included lifetime indicators as well as indicators that assess the use phase such as repair and reuse indicators and more recently, there have been updates with the launch of CTI 4.0.[38]

[37] This review did not include the WBCSD's CTI 2.0 as it was not identified within the literature. It was only until after the completion of WP1 that the CTI tool was considered for the development of ORIENTING. As of March 2022, the WBCSD has updated CTI to 3.0 and in March 2024 to CTI4.0 to include lifetime strategies such as reuse, repair and refurbish within their calculations.

[38] https://www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Resources/Circular-Transition-Indicators-v3.0-Metrics-for-business-by-business

4.3 Addressing Consumer Acceptance of Direct Product Effects Related to the Implementation of PC Strategies

Regarding existing barriers for implementing PC strategies, a further two key issues identified were the cost and a change in product aesthetics. Both issues require consumer/user acceptance as with the former, a percentage of the cost would most likely be passed on to the user. In this sense, there is a need for companies to raise awareness amongst consumers of the costs associated with transitioning towards more circular products, alongside the potential environmental, economic, and social impacts associated with consuming such products. Furthermore, there is a need from industry, academia, and policy to develop strategies that address consumer concerns regarding product aesthetics, quality, and performance related to the impact of sustainability considerations on a product's physical features.

4.4 The Need for Tools to Address Multiple Levels of PC Awareness and Communication Across Organisations.

The findings from the interviews suggest that there are different levels of awareness and understanding of PC at an organisational and sectorial levels. Moreover, levels of awareness varied from business function to business function. From a methodological development perspective, this calls for the need for PC assessments to be flexible and adaptable to needs of business functions, with clear communication of results adapted to multiple audiences that might have zero to advanced PC awareness.

4.5 Further Research

At the time the interviews were being conducted (between August 2021 and March 2022), the EC's Sustainable Product Initiative (SPI) was published in March 2022. Having completed the 21 interviews and undertaken a preliminary analysis of the data, it was agreed by the authors to revisit the interview transcripts to assess the alignment between the feedback received from participating companies regarding their product circularity strategies and the SPI documentation. Based on this, 4 companies, primarily in the textile and/or fashion industry, highlighted the need for digital product passports (DPPs).[39] Further evidence from the interviews suggests that some of the larger players interviewed were potentially anticipating this action by the EC and were therefore already exploring how to implement DPPs, and other related CE strategies aligned to the SPI. However, to assess the extent to which industries' PC strategies are aligned to initiatives such as the SPI and how these initiatives are shaping industry, currently being monitored, and enforced, requires further research.

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39 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en

4.6 Product Social Recommendations

- **Need to include PS standards within policy and legislation**

The interview questions related to PS considerations revealed that most respondents understood social impact from a supply chain perspective. 21/21 interviewees claimed to address social issues related to their products with topics considered including: gender equality, safe working conditions, fair wages, monitoring that there is no child labour used across the supply chain, avoiding conflict minerals, monitoring factory footprint, etc. When questioned further in relation to PS considerations at the D&D phase, the research reveals that very few organisations appear to be addressing the social impact at the D&D level. However, it is important to point that the lack of awareness on PS considerations within D&D could be an issue of terminology. Nevertheless, the interviewees identified the following as the rationale behind the lack of consideration of PS issues within D&D: 1) not being required to consider the social impact of the product by the customer, other stakeholders, or legislation and 2) the lack of available design tools/methodologies that consider social issues within the D&D process and assess a product's potential social impact during the early design stages to support decision making. Therefore, a recommendation to increase the adoption of PS considerations within D&D, is to harmonise terminology and the potential topics that might be addressed at this level. For example, develop product requirements or standards related to health and safety or inclusivity. Also, the findings suggest the need to increase awareness of the relationship between products and social impacts, topics, and issues among consumers/users to incentivise companies to invest in the implementation of PS solutions.

- **Further development of tools and methodologies that assist the evaluation of PS issues during the early stages of design and development level.**

Aligned to the findings presented above, there is a clear need for the development of tools and methodologies that consider PS impact at the D&D phase that can support design decisions. While the Product Social Impact Assessment (PSIA) framework developed by the Roundtable for Product Social Metrics states that the PSIA can be used by 'product development' business functions to 'understand the social impact of a product to support design and application decisions'[40], the integration and alignment of the PSIA with industry D&D processes is unclear. Therefore, further research is required for the development and integration of PS impact assessments with practical D&D processes, as well as raising awareness of social assessments amongst those involved within design and development.

4.7 Concluding Remarks: ORIENTING

This final section aims to contextualise the findings and recommendations from this report to support the development of ORIENTING's LCSA during its early concept and specification

[40] https://www.social-value-initiative.org/wp-content/uploads/2021/04/20-01-Handbook2020.pdf

stage. Due to the small sample size on which the findings are based, these should be viewed as indicative rather than definitive.

The first section of the findings highlighted how ‘circularity’ is understood differently by companies and is influenced by a company’s ‘circularity strategy stage’, size, product, and industry sector and their level of awareness/understanding (e.g., ZBIA). This in turn, resulted in identifying the need for further research into the different interpretations of circularity and more specifically PC used by individuals in D&D. In this context, it was identified that an improved understanding of PC is required within D&D and ORIENTING should provide appropriate guidance in relation to potential LCSA users.

The second section of the findings offered an insight into how the companies interviewed are assessing PC or considering a PC assessment. The result of this highlights how a multilevel approach is needed not only for the overall LCSA methodology, but also for individual domains such as the PC component of the LCSA. As indicated by the interviewed companies, while measuring the inflow and outflow of recycled materials is feasible for some product types, and for reporting purposes, other companies have already started to move beyond this approach as this indicator is incompatible with certain sectors such as the intermediate and infrastructure industries. There are indications that some of the more ‘advanced’ companies have moved from a ‘cradle to gate’ to a ‘cradle to cradle’ perspective. Simultaneously, some of the more ‘advanced’ companies appear to be developing internal methodologies and tools to address the gaps within existing PC measurement, indicators, and metrics, which could potentially be integrated into ORIENTING’s learning material to enable the adaptation of circularity indicators to company-specific needs.

While the overall aim of this report is to offer insight into PC practical considerations from industry with regards to how circularity is understood at a product level, the report also sheds light on the following lessons which are specifically aligned to the development of ORIENTING’s PC measurement, indicators, and metrics:

- Lesson 1

Within industry, there is a lack of awareness/adoption of the EMF’s MCI and WBCSD’s CTI 3.0), which were considered for the development of ORIENTING’s circularity assessment at the time of writing this report. Further insight is needed to assess the reason for this, as it could be the case that these metrics are only relevant to very limited product types such as energy-using products where for example, it is easier to determine and measure the impact of a product’s ‘functional unit’.

- Lesson 2

Guidance is required on how to integrate PC into the assessment of the environmental, economic, and social sustainability domains. The interviews indicated that only 1/21 interviewees were starting to think about these inter-connections and were developing an internal tool to improve understanding and assessment.

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ANNEX 1: Interviews Classification: Product Circularity and Product Social

No.	Interview Participant	Industry sector	Size	Country of Ownership	Country where interviewee is based	Product category				Level of Awareness: (Zero, Basic, Intermediate &Advanced)	'Circularity Strategy Stage' based on WBCSD's 2018 report, 'Circular Metrics: Landscape Analysis'
						Intermediate	**Final**	**Service**	**Hybrid**		
1	Anonymised	Denim fashion brand	SME	Netherlands	Netherlands		x			Advanced	3
2	Anonymised	Sneaker brand	Start-up	Luxemburg	Luxemburg		x			Basic	1
3	Anonymised	Sensing technology for the optic fibre and wastewater industries.	Start-up	UK	UK	x		x	x	Basic	1
4	Anonymised	Home appliance manufacturer	Multinational	Sweden	UK/Sweden		x			Advanced	3
5	Anonymised	Toy manufacturer	Multinational	Denmark	Denmark/UK		x			Intermediate	2
6	Anonymised	Automotive manufacturer	Multinational	Sweden	Sweden		x			Advanced	3
7	Anonymised	Outdoor footwear	SME	Sweden	Sweden		x			Intermediate	2
8	Anonymised	Textiles	Start-up	UK	UK	x				Advanced	3
9	Anonymised	Furniture (Mattress/bed manufacturer)	SME	UK	UK		x			Intermediate	2
10	Anonymised	Hardware and software manufacturer	Multinational	USA	UK		x			Advanced	3
11	Anonymised	Aerospace and Defence	Multinational	UK	UK		x			Advanced	3
12	Anonymised	Fashion Industry	Start-up	UK	UK		x	x	x	Intermediate	2
13	Anonymised	Footwear Industry	Start-up	UK	UK		x			Basic	1
14	Anonymised	Flooring Industry	Multinational	USA			x			Advanced	3
15	Anonymised	Automotive Industry	Multinational	Germany	Germany		x			Advanced	3
16	Anonymised	Fashion industry	Multinational	Sweden	Sweden		x				2
17	Anonymised	Consumer goods	Multinational	USA	Belgium		x				3
18	Anonymised	Technology/software & hardware	Multinational	USA	UK		x	x	x		2
19	Anonymised	Material	Start-up	USA	Brazil	x					3
20	Anonymised	Steel Industry	Multinational	India	UK	x					2
21	Anonymised	Automotive Industry	Multinational	Sweden	Sweden		x				3

ANNEX 2: Interview Questionnaire

General

- Could you describe the company's sustainability goals?
- Could you name a few key sustainability decisions that the design and development department are responsible for?
- What are the biggest barriers to implementing product sustainably?
- To what extent have the design and development processes been altered, to include sustainability considerations?
- At what level would the company consider /conduct sustainability assessments?

Product Circularity (PC)

- Does the company see CE as part of sustainable development, or does it see CE as a separate topic?
- Based on the definition previously provided for product circularity, is this considered within company, if so, how? **(See ANNEX 3**, MC checklist as an aide memoire)
- What (PC) strategies are relevant to [Company X]'s products? **(See ANNEX 3**, MC Checklist)
- How is product circularity measured?
- Does the company have an eco-design strategy? And does it incorporate PC considerations?
- Do you conduct LCA's, internally or outsourced? How are PC issues taken into account in LCAs?
- What tools do you use to think through (PC) issues: has [Company x] developed internal tools and/or use existing tools that are adapted?
- Have you used the a) Ellen MacArthur Foundation's Material Circularity Indicator (MCI) or the b) World Business Council for Sustainable, Development's, Circular Transition Indicators (CTI) tool? If so, what are your comments on a) and/or b)
- What barriers have been identified when designing for circularity? A) external and b) internal?
- What are the main changes made to the product in order to align it with the CE?

Product Social (PS)

- Is the social impact of products considered within (x company)?
- If so, what social issues are considered? And which business function coordinates this?
- What social issues are considered within design and development?
- At what stage are social issues considered within design and development?
- Is social impact measured at a design and development level?
- What tools are used within design and development to consider social impact(s) at a product level?
- Has a particular methodology been adapted or developed internally for the purpose of measuring (PS) impact?
- Does the company use social LCA? And what is its experience of social LCA?
- What data sources does the company use in relation to (PS) issues?

ANNEX 3: Eco-design Checklist developed by Martin Charter.

Generic eco-design checklist that features product circularity considerations in *italics* (non- exhaustive) Source: ORIENTING D1.4

Design Focus Area	Options for Design Improvement	Comments by one of the LCA-trained authors of D1.4
Design for Material Sourcing	*Reduce weight and volume of product*	As an indicator, I would rather use only the weight and/or volume of a product.
	Increase use of recycled materials to replace virgin materials	Potential indicators: percentage (relative to total weight) or amount of recycled or virgin material
	Increase use of renewable materials	Potential indicator: percentage of renewable material
	Increase incorporation of used components	Potential indicator: number of re-used components
	Eliminate hazardous substances	Potential indicator: amount of hazardous substances (note however that there are the impact categories toxicity, ecotoxicity and ionising radiation whose score gives an indication on the amount of hazardous substances present in a product)
	Use materials with lower embodied energy and/or water	In LCA, we regularly assess the cumulative energy demand, sometimes even split into different sources of energy. The same goes for the amount of water used.
Design for Manufacture/Assembly	Reduce energy consumption	See above (energy is part of LCA)
	Reduce water consumption	See above (water is part of LCA)
	Reduce process waste	In LCA, waste is regularly assessed. We should check how complete this is and which impact categories exist, though.
	Use internally recovered or recycled materials from process waste	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
	Reduce emissions to air, water and soil during manufacture	In LCA, we quantify any releases (i.e. into air, water or soil). Given that one cannot directly add all those releases, however, these are afterwards converted into impact categories. When distinguishing the life cycle into different stages, one can distinguish the impact category indicator results of the manufacturing stage from the other stages.
	Reduce number of parts	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
Design for Transport and Distribution	*Minimise product size and weight*	See above
	Optimise shape and volume for maximum packaging density	Very much related to the line just above and maybe too special to be dealt with separately in the LCSA.
	Optimise transport and distribution in relation to fuel use and emissions	In LCA, we quantify all transports and notably their fuel use and related emissions. As mentioned above: given that one cannot directly add all those releases, however, these are afterwards converted into impact categories. When distinguishing the life cycle into different stages, one can distinguish the

		impact category indicator results of the transportation stage from the other stages. Question: what does transportation and distribution refer to? Only after manufacturing until the point of sale? Or also any other transportation (i.e. raw materials' transport from the mine to the next processing step(s) until the manufacturing and also from the point of sale to the user etc.)?
	Optimise packaging to comply with regulation	Packaging is part of LCA.
	Reduce embodied energy and water in packaging	See line just above
	Increase use of recycled materials in packaging	Couldn't this be dealt with as part of overall recycled material use?
	Eliminate hazardous substances in packaging	See above
Design for Use (Including installation, maintenance and repair)	Reduce energy in use	See above (energy is part of LCA)
	Reduce water in use	See above (water is part of LCA)
	Increase access to spare parts	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
	Maximise ease of maintenance	First: does this only refer to the maintenance of the product or also to machinery in the manufacturing etc.? Second: Maintenance should be part of any LCSA where relevant. It could be defined as a separate stage. However, this might lead to very many stages, with a risk of overdoing things. (TBD)
	Maximize ease of reuse and disassembly	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
	Avoid design aspects detrimental to reuse	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
	Reduce energy used in disassembly	See above (energy is part of LCA)
	Reduce water used in disassembly	See above (water is part of LCA)
	Reduce emissions to air, water and soil	See above (emissions are part of LCA)
	Eliminate potentially hazardous substances that can be released during use	See above (toxicity/ecotoxicity/ionising radiation are part of LCA)
	Maximize ease of materials recycling	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
Design for End of Life	*Avoid design aspects detrimental to materials recycling*	No suggestion how to integrate this in LCSA for now; there could be dedicated indictors for it, but I wonder whether this would be overdoing it (TBD)
	Reduce amount of residual waste generated	See remark on waste above
	Reduce energy used in materials recycling	See above (energy is part of LCA)
	Reduce water used in materials recycling	See above (water is part of LCA)

Source: Adapted from Charter M, Designing for the Circular Economy, 2017 [Routledge]

ANNEX 4 EMF Circular Economy Butterfly Diagram