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Master Thesis

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Master Sustainable Business and Innovation

Measuring the Circular Economy

Developing a Circular Economy assessment for company level

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Author: Olivier Benz (5901669)
Supervisor University: Dr. Laura Piscicelli
Second Reader University: Dr. Ir. Jesús Rosales Carreón
Supervisor Sustainalize: Rob van Tilburg

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Abstract

The Circular Economy has been gaining more attention in recent years. The concept has started to evolve from resource efficiency and closing material loops to a broader scope that covers the economic, social and environmental dimension. A large variety of assessments to measure circularity at different levels of analysis have been developed. However, especially assessments to measure circularity at a company level have not yet reacted to the shift of covering all three sustainability dimensions equally. Furthermore, existing assessments require in many cases a sophisticated analysis of the results, which remains a barrier to a higher usage of these assessments. The aim of this research was to develop a new, easy to use assessment to measure the circularity of companies, while covering the economic, social and environmental dimension. Circular Economy assessments are regarded to give guidance for companies on their transition to a Circular Economy, which they are currently lacking. This research was conducted by using a three step Circular Economy assessment development model, which consists of mapping, selection and validation. Using this process, the researcher mapped the indicators used by more than 35 existing assessments, then selected indicators for the new assessment based on a number of criteria and validated the indicators of the new assessment through interviews with Circular Economy experts from academia, companies and governmental institutions. This research gives a good overview over the existing Circular Economy assessments and, especially, the use of social impact indicators. The newly developed assessment is a first step to including the economic, social and environmental impact dimension into a company level Circular Economy assessment.

Keywords: Circular Economy; assessment; measurement framework; company; meso level; three sustainability dimensions

Executive Summary

This master thesis, conducted as part of the Sustainable Business and Innovation master programme at Utrecht University, set out to develop a Circular Economy assessment for companies that covers the economic, social and environmental impact dimension. The Circular Economy concept is a relatively new concept, which has been gaining a lot of attention by a diverse group of stakeholders. Companies are seen to take one of the key roles in the transition towards a Circular Economy. Some of the reasons for the increased interest of companies in the concept are higher resource prices, new legislations and policies, and the need to create future-proof business models and companies. However, companies are at the moment struggling to implement the Circular Economy concept into their daily business, as it requires in many cases among others a complete redesign of the business model. Therefore, companies are looking for guidance in the transition to a Circular Economy. Circularity assessments on company level can deliver a baseline evaluation to support the company in understanding where it stands in the transition towards a Circular Economy. It can additionally give guidance for the next steps and support the future decision making by providing a possibility to test the effect of potential next steps.

The Circular Economy is considered to be one of a few concepts to enable the transition to a sustainable society. However, it is argued that contributing to positive environmental benefit and social equity is not an integral part of the concept. Over time the focus has been shifting to also cover the broader impact of the circular activities, as it became clear that Circular Economy activities can lead to negative environmental and social impact. There have been developments to cover all three sustainability dimensions in the Circular Economy concept. This development, however, has so far not been represented in the assessments to measure circularity at a company level. In order to develop a new assessment that includes all three impact dimensions the current Circular Economy assessment landscape was studied. The analysis showed that there is already a larger number of assessments that measure circularity in numerous ways. However, the applied methodologies often require a sophisticated analysis of the data. The new assessment was being built on the basis of existing assessments, due to the fact that the existing indicators have already been applied and tested to measure an aspect of the Circular Economy. Indicators from the broader sustainability assessment would have required to be adapted and tested in more detail to capture the Circular Economy concept well and were therefore left outside of the research scope.

The new assessment was then discussed and validated with 12 Circular Economy experts from academia, companies and governmental institutions. Almost half of the experts, especially the practitioners, considered covering the social dimension to be less or not relevant. Their main argument was to keep the Circular Economy concept simple enough for companies to be able to implement it. Additionally, they were also worried that by including all three dimensions, the Circular Economy would not be distinguishable from the sustainability concept anymore. The experts, who were in favour of covering all three dimensions, argued that negative social effects from circular activities are possible and should therefore be in the scope of the assessment. A specific focus should, in their opinion, be placed on the implications of the Circular Economy activities on the supply chains. Next to the discussion on the social dimension, additional feedback for the improvement of all the indicators was given.

Based on the expert feedback the indicators were adapted, combined or removed to reach a final assessment, which comprises up to 17 indicators, depending on the assessed industry. As last step, the same experts were asked to score the importance of each indicator to derive individual weighting factors for every indicator. The assessment is however not considered to be applied independently and should be used only in combination with other qualitative and

quantitative evaluations (e.g. to measure the actual emissions reduction). After all the transition to the Circular Economy is not the end goal, but a means to reaching sustainability and therefore, economic prosperity, social equity and zero or positive environmental impact.

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1. Introduction

Since the publication of the report “Towards the Circular Economy” by the Ellen MacArthur Foundation (2013), the Circular Economy concept has been gaining more and more attention in academia and among companies. The number of peer-reviewed articles on the topic being published between 2014 and 2016 increased by more than factor three to more than 100 published articles. At the same time also international consultancy firms have published reports on the topic to show their expertise towards potential clients (Kirchherr, Reike, & Hekkert, 2017). The Circular Economy is commonly defined as a systemic change to move away from the current linear production system of “take – make – waste” to a circular system where materials are kept in the material flow without being lost as waste at the end of a product life. It focuses on the unnecessary destruction of resources, but its impact goes far further than mere recycling (Ellen MacArthur Foundation, 2013; van Buren, Demmers, van der Heijden, & Witlox, 2016). The Circular Economy is based on the following principles: preserving and enhancing natural capital, using materials at their highest utility and minimising the need for virgin materials, designing negative externalities out of the system and reducing leakages (Lieder & Rashid, 2016).

The increased interest in the Circular Economy can also be explained by the high importance the topic gained on political agendas, since it is seen as a positive contributor for sustainable development (Kalmykova, Sadagopan, & Rosado, 2017; Kirchherr et al., 2018). The Ellen MacArthur Foundation (2015b) estimated that through the Circular Economy CO_2-emissions could almost be halved, while also creating two million new jobs in the European Union by 2030. These are some of the reasons why the concept of the Circular Economy is often closely linked to the concept of sustainable development[1], which focuses on creating benefits in the economic, social and environmental dimension. The ultimate goal of sustainable development is sustainability and for this research the terms sustainable development and sustainability will be used interchangeably.

The recent discussions on the negative social impacts of the sharing economy, a similar concept to the Circular Economy, have shown the importance of including the broader implications of the activities. Also for the Circular Economy some criticisms have been raised that delivering the expected environmental and social benefits will also be a challenge, as especially the social benefits are not inherent to the Circular Economy principles (Andersen, 2007; Bjørn & Hauschild, 2011; Murray, Skene, & Haynes, 2017). In recent years researchers have started to include the economic, social and environmental dimension into the Circular Economy concept and new definitions of the Circular Economy have been developed to include all three dimensions (Cox, 2017; Frenken & Schor, 2017; Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Harris, 2018; Jericho, 2016; Kirchherr et al., 2017; Seiffert, 2014; WBCSD, 2018).

More and more companies are trying to incorporate Circular Economy principles into their business practices. This is due to increased material scarcity and, thus, higher resource prices, new rules and regulations or the opportunities to implement new business models (Ellen MacArthur Foundation, 2013, 2015b; European Commission, 2008; Khalamayzer, 2018). Some companies, such as KPN, Twentsche Kabelfabriek or the municipality of

[1] According to the Brundtland report sustainable development is defined as “(…) development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” （World Commission on Environment and Development, 1987, p. 16).

Rotterdam have already created goals towards being (near) 100% circular in the future (duurzam-ondernemen.nl, 2017; Gemeente Rotterdam, 2017; Twentsche Kabelfabriek, 2018). Yet, companies are struggling with assessing how circular they are, due to a lack of information on what and how they should measure the circularity of their business practices (Ellen MacArthur Foundation, 2015a; WBCSD, 2018).

Even though the concept of the Circular Economy is relatively new, a considerable amount of assessment methods has already been developed to measure circularity. These assessment methods often rely on existing methodologies used to measure sustainable development, as they are based on the same or similar data (European Academies Science Advisory Council, 2015). Geissdoerfer et al. (2017) who analysed the relationship between sustainability and the Circular Economy consider the Circular Economy as one among several systems that can lead to a sustainable development. Relying on existing sustainable development assessments makes therefore sense, especially since the concept of sustainable development has already been developed and researched in more detail (European Academies Science Advisory Council, 2015; VBDO, 2016).

The existing circularity assessments can be grouped according to three levels of analysis: product/process (micro) level, company/industry (meso) level or regional/national/international (macro) level. At the micro level, particularly the work by the Ellen MacArthur Foundation (2015a) with the development of a Material Circularity Indicator has to be mentioned as the most notable contribution to measuring product circularity. At the meso level, however, the availability of company specific assessment methods is more limited. One of the few ways to measure circularity at a company level is to add all the results from the above mentioned product-level assessment to get a circularity value for the whole company (Ellen MacArthur Foundation, 2015a). The majority of the available methodologies focuses on measuring circularity at a macro level. A reason for this is that a large share of the existing assessments has been developed for its initial use in China, as the Chinese government has been at the forefront of the implementation of the Circular Economy by passing a national law to promote the Circular Economy concept in 2008 (Ghisellini, Cialani, & Ulgiati, 2016; Kirchherr et al., 2017; Su, Heshmati, Geng, & Yu, 2013). What most assessment methods at all three levels of analysis have, however, in common is that they often do not cover the economic, social and environmental impact simultaneously, with a specific lack in capturing the social dimension. Including the social impact is, however, considered relevant to understand the broader effects of the Circular Economy activities (WBCSD, 2018).

Given the general lack of company-level circularity assessments that cover economic, social and environmental impact, the aim of this research is to develop and validate a suitable assessment to measure circularity at a company level, which incorporates all three dimensions of sustainability (i.e. economic, social and environmental). Additionally, due to the lack of assessments that do not require a sophisticated analysis and understanding of the concept, the assessment also needed to fulfil a series of requirements: (i) easy to use, (ii) return an instant result without needing an expert to validate and compare all the data and (iii) any type of company should be able to use it. These requirements were set in order to give any company a quick baseline assessment to define their progress in the transition towards a Circular Economy and to support the decision-making process.

Given the research gap the following research question was developed:
What existing circularity assessments and indicators can be used to measure the circularity of a company while covering economic, social and environmental impact?

The sub question was developed based on the general neglection of the social dimension in company assessments:
Is the social impact considered to be a relevant aspect to cover in a company level assessment?

This research contributes further to the academic development of the Circular Economy concept and, more specifically, to the scientific knowledge on including all three impact dimensions to measure circularity at a company level. It thus closes the gap between the available Circular Economy assessments specifically for company level, out of which almost all lack to assess the social impact, and the increased focus on including social equity into the Circular Economy concept. Furthermore, the perceived relevance of including social equity into the Circular Economy concept and more specifically the inclusion of it in company level assessments is analysed.

On the societal side, this research will, ultimately, provide companies with clear management information on their circularity performance and help identify the possible areas for improvement. At the same time, it can show the potential impact of implemented changes on the company's circular performance and, therefore, assist companies in the transition to a Circular Economy.

Whilst contributing to scientific literature and society, this research also has a practical value for Sustainalize. Sustainalize is a Dutch CSR- and sustainability management consultancy that is currently developing new services for companies in the field of the Circular Economy. This collaboration helps the author get expertise and data, while Sustainalize can use the research to signal to current and prospective customers the development of new services in the field of Circular Economy.

The thesis is structured as follows: in section 2, the theoretical foundation of this research is explained. It focuses on a brief description of the Circular Economy concept, introduces the current status of measuring the Circular Economy on a macro-, meso- and micro-level, and discusses established methodologies to develop sustainability assessments that can be used to create a development model for the new Circular Economy assessment. In section 3, the applied methodologies for the individual research steps are introduced. In section 4 the results are presented for each research step and in section 5 the results are discussed. This includes discussing the main findings and evaluating the used methodology, assessing the limitations of the research and elaborating on future research direction. The thesis ends in section 6 by answering the research question.

2. Theoretical foundation

This section describes the theoretical foundation on which this research was based on. First, the concept of the Circular Economy is explained. Second, the existing Circular Economy assessments at the micro (product/process), meso (company/industry) or macro (regional/national/international) level are introduced. As there is no literature on the development of a circularity assessment, the last part will be used to introduce methodologies to develop sustainability assessments, which can be adapted to build a development model for the Circular Economy assessment. The literature on sustainable development can be used, due to the similarity of the Circular Economy concept and the much further studied sustainable development concept.

2.1 The Circular Economy concept

The concept of the Circular Economy was already mentioned - using a different term - for the first time in 1970 (Ellen MacArthur Foundation, 2013). The term Circular Economy was only later introduced by two economists, Pearce and Turner (1989, as cited in Geissdoerfer, Savaget, Bocken, & Hultink, 2017), in their book “Economics of Natural Resources and the Environment”. The Chinese government and, later, also the Ellen MacArthur Foundation, among others, brought the concept to a bigger audience in the 21st century (Ellen MacArthur Foundation, 2013; Kirchherr et al., 2017). Since then, especially the Ellen MacArthur Foundation has been at the forefront to further develop the concept and increase the visibility of the Circular Economy approach. In the transition toward a Circular Economy, companies are regarded to take a critical role in the successful implementation of the Circular Economy (Geissdoerfer et al., 2017).

Since the concept of the Circular Economy is still very new and is bringing researchers from different fields (e.g. design, finance, marketing, sustainability, logistics) together, a commonly agreed definition has not yet been found. Especially in recent years more researchers have started to include the social dimension into the Circular Economy concept. Until recently the main or only focus of the concept was on resource efficiency and closing material loops (Andersen, 2007; Moreau, Sahakian, van Griethuysen, & Vuille, 2017; Murray et al., 2017; Sauvé, Bernard, & Sloan, 2016). The social dimension was largely neglected. Kirchherr et al. (2017) reported that less than 20% of all analysed 114 definitions included social equity. The study also identified that the general definition of the Circular Economy has changed over time. In the beginning the main focus was on environmental quality and economic prosperity, while in recent years this has transformed to a systems perspective, which includes all three impact dimensions. For this research, the definition for the Circular Economy developed by Kirchherr et al. (2017) is used, as it addresses the economic, social and environmental dimension:

> ”A circular economy describes an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies[2], consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.” (Kirchherr et al., 2017, p. 224)

[2] The only difference that in this research companies are considered to be part of the meso level.

This definition shows the clear linkage between the Circular Economy concept and the sustainable development concept, as both are based on creating economic, social and environmental value.

2.2 How and what is being measured?

In order to answer the research question and to comprehensively measure the transition towards a Circular Economy, it was important to examine the assessments that have so far been developed to measure circularity. As there is no literature on the development of Circular Economy assessments, in the second part of this chapter the literature on how sustainable development assessments are being developed is reviewed. This literature was used to derive a methodology to build a new development model for Circular Economy assessments.

2.2.1 Current ways to measure Circular Economy

A recent international study published by the World Business Council for Sustainable Development (WBCSD, 2018) discussed the current situation of how companies measure their Circular Economy performance. The study found that almost 75% of the interviewed companies are using own frameworks to measure their circularity performance. The positive aspect of using an own framework is that the company is aware of the specific aspect and material topics the transition towards a Circular Economy entails for the company, while on the negative side the indicator selection for a company specific framework can be more subjective and hinder comparability (WBCSD, 2018). A company specific approach to measure the progress of the Circular Economy transition has been applied by Philips. They measure and report their "Circular Revenue": the revenue from products and services that meet specific Circular Economy requirements defined by Philips themselves (e.g. refurbished products or performance based business models) (Philips, 2017). Another example for a company specific measurement is KPN, which is aiming to have close to 100% circular operations by 2025. KPN is reporting the process of this transition based on indicators that measure the percentage of equipment and material, which is reused or recycled (KPN, 2018).

The study by the WBCSD (2018) also identified the main reasons for businesses to measure circularity. The top 3 reasons were: 1) drive business performance or strategy, 2) justify achievement externally, and 3) integrate circularity across the business. According to these reasons and other findings the WBCSD (2018) identified 7 recommendations for the development of a future Circular Economy measurement framework (see Table 1). One of the main challenges to develop a new assessment is according to the WBCSD (2018) the number of unique and diverse definitions used for the Circular Economy.

Table 1: Recommendations for the development of a Circular Economy measurement framework (WBCSD, 2018)

Recommendations for Circular Economy framework development	
1.	Drive circular business performance
2.	Target specific audiences depending on company objectives
3.	Cover a comprehensive sustainability scope
4.	Ensure flexibility and inclusion
5.	Adopt a phased approach to incorporating capitals
6.	Build upon existing frameworks and standards
7.	Drive culture change and provide guidance

In terms of assessments to measure circularity developed by scholars the approaches have been widely different: from qualitative to quantitative, from questionnaires to the use of public data and from super data envelopment analyses to material flow analyses (Banaitė &

Tamošiūnienė, 2016; Cooper, Seiford, & Zhu, 2004). Based on the publication year of the assessments the general development of the Circular Economy concept can be observed (see Table 2). The first assessments to measure Circular Economy were developed for a macro level (national/regional). The meso (sector/company) and micro (product) level only followed at a later stage. In recent years they have been catching up in terms of numbers. Currently, the number of assessments for all three level of analysis is almost equally distributed. The amount of assessments that specifically focus on a company level has to be considered somewhat lower, as a number of assessments focus on a sector or industrial park level (e.g. Geng et al., 2012; R. Li & Su, 2012; Wen & Meng, 2015).

Table 2: Existing Circular Economy assessments categorised according to the level of assessment

Macro	Meso	Micro
(Pintér, 2006)	(Geng et al., 2012)	(Evans & Bocken, 2013)
(Moriguchi, 2007)	(R. Li & Su, 2012)	(Park & Chertow, 2014)
(Geng, Zhu, Doberstein, & Fujita, 2009)	(Ellen MacArthur Foundation, 2015a)	(Di Maio & Rem, 2015)
(H. Li, Bao, Xiu, Zhang, & Xu, 2010)	(Wen & Meng, 2015)	(Ellen MacArthur Foundation, 2015a)
(Guo-gang & Jing, 2011)	(Accenture, Circle Economy, MVO Nederland, & DuurzamBedrijfsleven, 2016) & (Ruiter, 2015 in Verbeek, 2016)	(Cayzer, Griffiths, & Beghetto, 2017)
(Guo-gang, 2011)	(Scheepens, Vogtländer, & Brezet, 2016)	(Huysman, De Schaepmeester, Ragaert, Dewulf, & De Meester, 2017)
(Chun-rong & Jun, 2011)	(VBDO, 2016)	(Linder, Sarasini, & van Loon, 2017)
(Qing, Gao, & Mingyue, 2011)	(Verbeek, 2016)	(Mesa, Esparragoza, & Maury, 2018)
(Geng et al., 2012)	(Franklin-Johnson, Figge, & Canning, 2016)	(Lonca, Muggéo, Tétreault-Imbeault, Bernard, & Margni, 2018)
(Su et al., 2013)	(Potting, Hekkert, Worrell, & Hanemaaijer, 2017)	(Niero & Kalbar, 2019)
(Zaman & Lehmann, 2013)	(Di Maio, Rem, Baldé, & Polder, 2017)	
(Wu, Shi, Xia, & Zhu, 2014)	(Genovese, Acquaye, Figueroa, & Koh, 2017)	
(Haas, Krausmann, Wiedenhofer, & Heinz, 2015)	(Figge, Thorpe, Givry, Canning, & Franklin-Johnson, 2018)	
(Magnier, C., M. Auzanneau, P. Calatayud, M. Gauche, X. Ghewy, M. Granger, 2017)		
(Haupt, Vadenbo, & Hellweg, 2017)		
(European Commission, 2017)		

2.2.1.1 Macro level

The first developed assessments (Moriguchi, 2007; Pintér, 2006) were based on material flow analysis and therefore included the material and resource use, leaving the economic and the social dimension out of the assessment scope. The material flow analysis was later also adopted by more circularity assessments (Geng et al., 2012; Haas et al., 2015). What all these assessments have in common is that they do not deliver the result directly, but someone needs to analyse the data and compare it with data from other entities or a pre-defined standardised value. Geng et al. (2009) also used comparison to a pre-defined target ratio to assess the circularity performance of different Chinese cities on resource consumption, waste discharge/treatment/reclamation. In a study by Su et al. (2013), the same methodology with

the same indicators was applied. As the assessment was developed to compare performances of different entities, it requires additional data from each entity for the comparison. The assessments developed by Li et al. (2010), Guo-gang and Jing (2011) and Qing et al. (2011) were the first promising assessments, because they covered all three impact dimensions. The methodology by Guo-gang and Jing (2011) was developed to return a direct result and includes a validation procedure based on expert input on weighing factors for the individual indicators. Using an expert panel to define weighting factor was also applied by Qing et al. (2011). Guo-gang and Jing (2011) additionally developed four performance categories for their evaluation: 1) not development stage, 2) initial development stage, 3) moderately advanced stage and 4) highly advanced stage. The four categories are linked to defined thresholds, which are <25%, 25-49%, 50-74% and >75%. The difficult aspect of the assessment developed by Guo-gang and Jing (2011) lied in the fact that for each category limits (minimum and maximum thresholds) had to be pre-defined. In contrary to the three assessments Chun-rong and Jun (2011) specifically pointed out that they did not want to include indicators from all three impact dimensions in their assessment. They argued that the index could not be differentiated enough with indexes on sustainability and that such an index would not reflect the characteristics of the Circular Economy well. Instead they focused on reduce, recycle and reduce indicators with categories that had pre-defined limits. Also the zero waste index methodology by Zaman and Lehmann (2013) was constructed to focus solely on the waste topic and it is not developed to include the economic and social dimension. By including development over time Wu et al. (2014) were the only ones to include the performance on circularity over a certain time period as an element of an assessment. They used it to compare a number of Chinese regions on their circularity performance. This methodology required consistent data measurements over a period of five years and is therefore only useful for data that is collected periodically in a standardised manner, such as governmental statistics. The more recent publications of the European Commission (2017) and the French ministry of the environment, energy and marine affairs (Magnier, C., M. Auzanneau, P. Calatayud, M. Gauche, X. Ghewy, M. Granger, 2017) are not so much assessments, than merely 10 independent indicators each, which cover a specific topic of the Circular Economy that is considered relevant.

2.2.1.2 Meso level

The methodology of Geng et al. (2009) for the meso level is exactly the same as they had developed for the macro level. Li and Su (2012) developed a methodology to deliver a circularity score between 0 and 1. The calculation is based on absolute data, which is standardised to then calculate a weighted sum. The approach requires pre-defined values to standardise the absolute data, which reduces the general application of the assessment methodology. Wen and Meng (2015) built their methodology around resource productivity and the flow of the analysed substances. Its focus on materials made the inclusion of the social dimension into the methodology not possible. A different approach is used by the Ellen MacArthur Foundation (2015a), which developed a methodology for the micro level by including product specific values for the used material, the efficiency of the recycling process and the life time of the product. Based on the product's material data a product-specific Material Circularity Indicator (MCI) can be calculated. By calculating a weighted sum of all results of the individual products, a company circularity score can be determined. The methodology was constructed with a clear focus on quantifying every indicator of the formula. Due to the difficulties of accurately quantifying social indicators it would be difficult to adapt the methodology to include all three impact dimensions. Ruiter (2015, in Verbeek, 2016) developed a circularity assessment that tried to combine quantitative and qualitative methods together by developing four performance levels for each indicator. This categorisation makes it possible to compare companies from different industries and sizes with each other, as it is

not reliant on absolute data but ratios and percentages. By using descriptive performance levels instead of requesting absolute data the assessment can return an immediate result and is suitable to cover topics that are more difficult to quantify such as social indicators. Additionally, if a company does not score in the highest performance level, these higher levels can be used as guidance for the next steps. Ruiter (2015, in Verbeek, 2016), however, did not cover the social dimension in the assessment. Verbeek (2016) adapted in her research the indicators developed by Ruiter (2015, in Verbeek, 2016) for the consumer goods sector, but kept the same methodology. The basis for the circularity assessment by Scheepens et al. (2016) is again quantitative by using the eco-cost methodology, which is an environmental impact indicator that is linked to financial costs. The limitation, as also mentioned by the authors, is the lack of inclusion of the social dimension with their methodology. The developed methodology by Genovese et al. (2017) also assessed the environmental impact, but through Life Cycle Assessments (LCA). It was used to measure the circularity of the supply chain. LCAs require specific data, which can be an issue for smaller companies to collect. Additionally, it is considered to be unsuitable to cover the economic and social dimension. The assessment by the Dutch Association of Investors for Sustainable Development (VBDO, 2016) used two-way close ended questions (yes/no) for every indicator and was mainly qualitative. The result of each question was linked to a specific weighting factor and the assessment delivered an immediate result. Each company was at the end ranked according to the score of the assessment. The assessment covered only public available information. Potting et al. (2017) published also list of questions that can be used to determine which aspects of the Circular Economy are implemented. Its focus is, in comparison to the VBDO (2016) assessment placed more on giving guidance on the transition than to actually measure the circularity performance. Di Maio et al. (2017) used the economic price of scare resources to determine with a value based approach the efficiency of the resource use. The downside of this method is that external costs and therefore the environmental and social dimension are not well reflected in the market price (Atkinson, 2000). In the methodology by Franklin-Johnson et al. (2016) and Figge et al. (2018) a non-monetary method was chosen by focusing on longevity, which measured the time duration for which a material is in use.

2.2.1.3 Micro level

The methodology used by Evans and Bocken (2013) is similar to Ruiter (2015, in Verbeek, 2016). For every indicator three performance levels were defined, however only the low and the high level were described in a few words. The assessment returned a qualitative feedback categorised in different steps of a product life time (e.g. product development, use phase, end of life). Park and Chertow (2014) focused in their methodology on analysing available technologies and the price of these technologies to make materials reusable. They calculated the reuse potential of used materials based on the amount of available material that can be reused through different existing technologies at positive net marginal revenues. The amount of financially viable reused material was then considered as “resource-like” material, whereas the financially unviable part is rated as “waste-like” material. Similar to the meso level there were also a couple of assessments that took a market-based approach by focusing on material prices. The limitations of the methodologies by Di Maio & Rem (2015) and Linder et al. (2017) are again based on the fact that external costs are not priced into the material value; while the limitations of the micro level methodology from the Ellen MacArthur Foundation (2015a) were already mentioned in the previous chapter (see 2.2.1.2). The assessment by Cayzer et al. (2017), was similar to the MCI by the Ellen MacArthur foundation, developed to return a single-aggregated score to communicate the circularity of a product. The assessment covered the whole product life time from design to use and end of life. It also included a question rationale for each indicator and a short explanation for the data collection to improve the assessment’s usability. The weakness of the assessment is that the weighing of the different question seems

more arbitrary than in other assessments. The weighting factors were defined based on a qualitative evaluation of expert interviews. Additionally, the maximum points of the assessment were 152, which is not an intuitive scale. The methodologies from Huysman et al. (2017) and Niero and Kalbar (2019) were based on LCAs and therefore carried again the effort of gathering specific data for the assessment, while not including the social dimension. Mesa et al. (2018) proposed an assessment using a number of six different and independent indices that cover the potential recycle or reuse rate and the functionality of the product. The general methodology is similar to the MCI by the Ellen MacArthur foundation and therefore brought the same limitations in terms of including the social dimension into the assessment. The same was true for the methodology by Lonca et al. (2018), who combined the MCI with LCAs.

2.2.1.4 Summary methodologies

This overview over the existing circularity assessments showed that the methodological approaches differ depending on the level of analysis (macro, meso, micro), but also within the same level the assessments are diverse. However, all methodologies show a large focus on waste, as well as resource/material usage. The concept of the Circular Economy, as defined by Kirchherr et al. (2017) in chapter 2.1 of this research, goes beyond waste and resource use, which shows the necessity to develop a new circularity assessment that aligns with this definition and includes all three impact dimensions (economic, social and environmental). Also the WBCSD (2018) identified in its research the secondary role that is given to the broader impact of the Circular Economy activities. Knowing that not all circular activities lead to net social and environmental equity the organisation points out the importance of considering the economic, social and environmental impact in a new assessment.

A general limitation identified by analysing the existing circularity assessments is the reduction of complexity by making a number of assumptions, selecting indicators and defining the system boundaries. On top of that, the applied definition of the Circular Economy influences the focus and result of the assessment (Cayzer et al., 2017; Chun-rong & Jun, 2011; Scheepens et al., 2016; Verbeek, 2016).

In total three methodologies are considered to fulfil the defined requirements for the methodology for this research that were set out in the introduction (i.e. covering all three dimensions, easy to use, direct result and general applicability over all industries). These assessments are the performance level based methodology by Ruiter (2015, in Verbeek, 2016), the question based approach by the VBDO (2016) and the assessment developed by Cayzer et al. (2017). Out of these three, the assessment methodology from Ruiter (2015, in Verbeek 2016) showed to be the most promising. This is due to the fact that the performance levels were considered to be the best guidance, as the next higher performance level describes the necessary steps to reach the next higher level for each indicator. The procedure from the VBDO showed that with only yes/no answers the potential to differentiate is limited and therefore a high number of questions or indicators is required to achieve a differentiation. The methodology by Cayzer et al. (2017) might also require the evaluation by an expert, as the authors explained that they defined an ideal response and least preferred response option. How the answers that score in between are defined was not mentioned. By developing more response options, the methodology would be similar to the one developed by Ruiter (2015, in Verbeek, 2016). Nonetheless, the question rationale and the explanation for every indicator used by Cayzer et al. (2017) were identified as a useful aspect, which was not included in the concept by Ruiter (2015, in Verbeek, 2016). The assessment methodology by Ruiter (2015, in Verbeek, 2016) was chosen to be used as a basis for the development of the assessment in this research, while including the questions rationale and definition from Cayzer et al. (2017).

2.2.2 Methodologies to develop sustainable development assessments

To develop a new Circular Economy assessment and due to the lack of literature on developing a Circular Economy assessment, it was helpful to turn to the more established literature on the development of sustainability assessments. A wide variety of scholars have already discussed how sustainable development assessments have to be developed (e.g. Cloquell-Ballester, Cloquell-Ballester, Monterde-Díaz, & Santamarina-Siurana, 2006; Donnelly, Jones, O'Mahony, & Byrne, 2007; Girardin, Bockstaller, & van der Werf, 2008; Hak, Kovanda, & Weinzettel, 2012; Harger & Meyer, 1996; Joung, Carrell, Sarkar, & Feng, 2013; Keeble, Topiol, & Berkley, 2003; Krajnc & Glavič, 2005; Niemeijer & de Groot, 2008; Rahdari & Anvary Rostamy, 2015; Ramos & Caeiro, 2010; Tanzil & Beloff, 2006; Veleva & Ellenbecker, 2001; Veleva, Hart, Greiner, & Crumbley, 2001). This section provides an overview of methodologies used to build a development model for the Circular Economy assessment.

The existing literature on the development of sustainability assessments can be grouped in: (i) literature focusing on the whole development process of the sustainability assessment, and (ii) literature focusing on specific aspects of the sustainability assessment development process (e.g. selection criteria). Krajnc and Glavič (2005) proposed a multiple step process methodology to develop an assessment to evaluate companies on sustainability. At first indicators are selected and then grouped according to one of the three sustainability dimensions. Then the authors propose to define weighing factors for each indicator through involving experts. The data of each indicator should then be normalised and multiplied with the weighing factors. By summing up the products each company gets a one value score. Another approach is proposed by Keeble, Topiol and Berkley (2003) and starts with establishing a pool of indicators, then reducing the indicator list (shortlisting) through pre-defined selection criteria, and constructing a final key performance indicator (KPI) framework based on the shortlisted indicators. Other researchers distinguish the development process of the sustainability assessment in goal definition, indicator selection, target setting, trend analysis and policy responses (Parris & Kates, 2003). Moreover, Niemeijer and de Groot (2008b) put emphasis in their sustainability assessment development process on a transparent selection of indicators. In contrast, Girardin, Bockstaller and van der Werf (2008) put the testing and validating of the assessment method at the heart of their development process. They propose to test not just the sensitivity of the individual indicators in the assessment, but also the relevance of the indicators and the usefulness of the assessment with the end user. The importance of a rigorous validation of the developed indicators is also stressed by other researchers (Hak et al., 2012), especially if the previously existing assessments did not cover all the aspects of the new assessment (Donnelly et al., 2007).

In terms of selection criteria, Niemeijer and de Groot (2008a) have identified commonly used selection criteria for environmental indicators. Among the most often used criteria there are: the focus on a solid scientific basis, the ability to reveal change over time, the measurability and availability of the data and the relevance of the indicator for the assessed issue. These indicators align with the ones identified by other researchers, which focused on assessing all three dimensions of sustainability (Joung et al., 2013; Keeble et al., 2003; Ramos & Caeiro, 2010). Rahdari and Anvary Rostamy (2015) have proposed a selection filter that can be used to shortlist indicators from a large pool of indicators with key indicator requirements (e.g. measurability). The selection filter is used to exclude the irrelevant or redundant indicators from an extensive list (based on criteria similar to Niemeijer and de Groot (2008a)) to reach a shortlist of indicators. This indicator list can then be used as a discussion basis to further develop the assessment.

Waas et al (2014) point out that in general the development of sustainability assessments can be categorised in a “top-down” or “bottom-up” methodology. The “top-down” approach is characterised as expert driven, based on quantitative indicators, and being scientifically rigorous. In contrast, the “bottom-up” approach is defined as stakeholder driven, based on qualitative indicators, and being less methodical. The authors strongly recommend bringing the two approaches together. A methodology that integrates “top-down” and “bottom-up” approaches mentioned by Waas et al. (2014) is the one proposed by Cloquell-Ballester et al. (2006). It was developed to validate individual sustainable development indicators that are part of a sustainability assessment. The core of the methodology is the validation, which involves different stakeholders and is built on three complementary levels: 1) self-validation, 2) scientific validation and 3) social validation. The self-validation is conducted by the researcher, whereas the scientific evaluation is done by scientific experts and the social evaluation is done through stakeholders (e.g. company or governmental representatives, consultants). The validation is done on the relation between the indicator and the measured concept, the definition and construction of the indicator and on the applicability and data availability.

3. Method

This research's aim was to develop a circularity assessment at firm level, which is based on existing Circular Economy assessments and covers the economic, social and environmental impact. The choice to only consider existing assessments and indicators was made, because the number of existing assessments was large enough and has not been analysed in such detail before. Furthermore, the indicators were already adapted and tested to measure an important aspect of the Circular Economy. At the same time indicators from the broader sustainability field would have needed to be developed and adapted to fit the Circular Economy concept. In consideration that there has so far not been a development model for a Circular Economy assessment, as mentioned previously, the first step of the research was to map and define the necessary steps for the methodological approach. This was done on the basis of existing literature on developing sustainable development assessments (see 2.2.2). At first, the starting point and the end goal were defined based on the research question ("What existing circularity assessments and indicators can be used to measure the circularity of a company while covering economic, social and environmental impact?"). This meant that the starting point of the model are the existing Circular Economy assessments, while the end goal was the new Circular Economy assessment that covers economic, social and environmental impact.

The basis of this research is the development model for the Circular Economy assessment (see Figure 1), which was built in the first phase of the research. The development model was used as a guide and theoretical basis for the whole research. It was split into three main parts: (i) mapping of individual existing Circular Economy indicators, (ii) selecting and adapting existing Circular Economy indicators, (iii) validating and improving the new Circular Economy assessment. The first two steps were conducted in the desk research phase, while the validation was undertaken in practice with experts by means of interviews, and an online questionnaire.

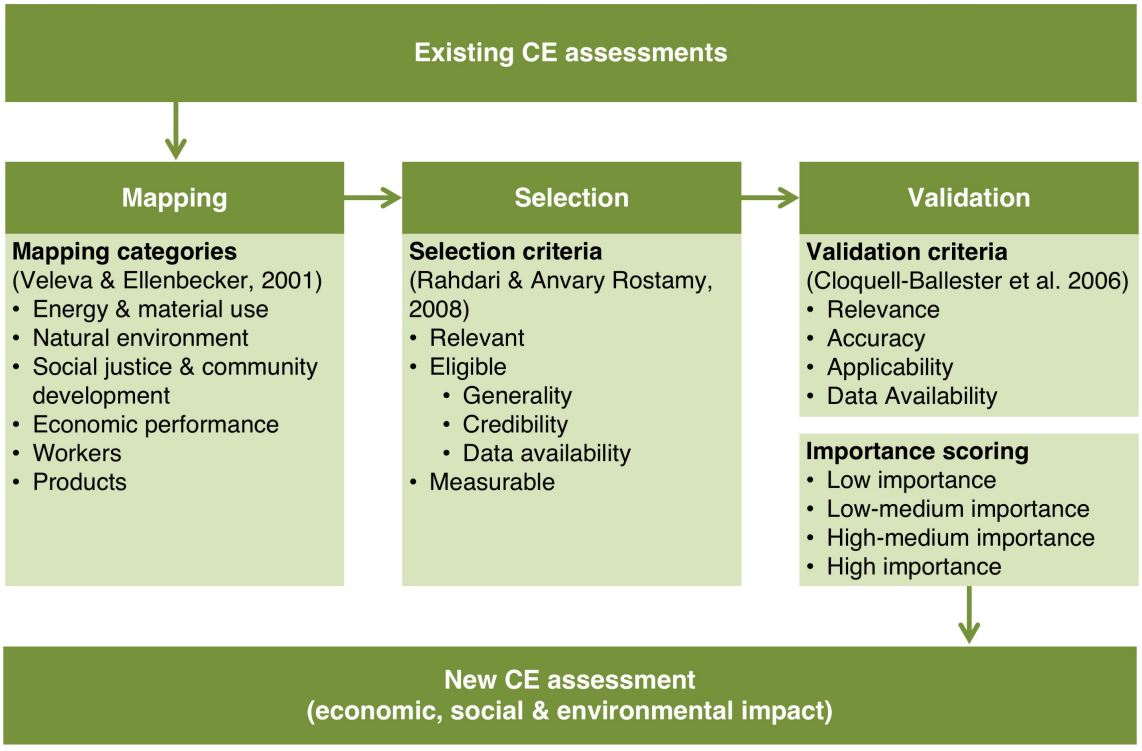

Figure 1: Development model for the Circular Economy (CE) assessment (own design)

By splitting up the research into these three research steps and supporting them with a theoretical foundation the development model for the Circular Economy assessment was created. The following chapters explain the individual methodological steps in detail and how this methodology is utilised to develop a circularity assessment that covers the economic, social and environmental dimension.

3.1 Data collection

This section will explain how the data is collected in each of the three steps of the development model for the Circular Economy assessment. An overview of the individual research steps is shown in Figure 2.

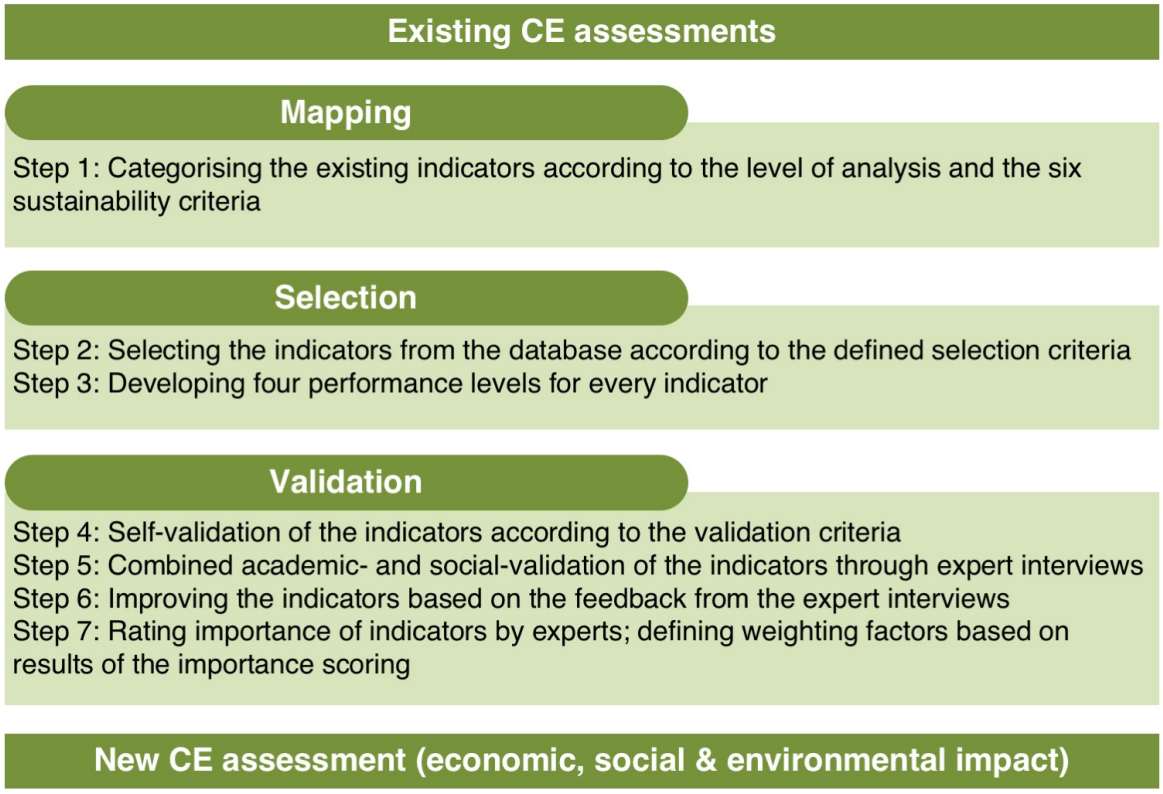

Figure 2: The research topics with the individual research steps

3.1.1 Mapping

The basis for the mapping was built up from secondary data from academic and grey literature. To prepare for the mapping the relevant literature on existing Circular Economy assessments had to be found and collected. Therefore, specific search terms were used in a number of search engines. The search terms were made up of the expression “Circular Economy” in combination with “indicators”, “index”, “assessment”, “measurement”, “measuring”, “analysis” and “evaluation”. These combinations were used to identify as many Circular Economy assessments as possible. The search engines used for this research were Scopus and Google Scholar for academic literature, as well as Google for grey literature. This choice was made based on the recognition of the quality and coverage of the search engines. The literature identified through the search query was scanned for relevance and if considered relevant, downloaded and catalogued in Mendeley, a research paper management software. At the moment of adding the literature to the database each article was categorised according to multiple tags. The tags were developed in an iterative manner, which meant that every time a source could not be categorised sufficiently with the existing tags, a new tag was created. The

most important tags were “Macro”, “Meso” and “Micro” to classify an existing Circular Economy measurement according to its level of analysis. The tags helped to easily retrieve the literature again for the mapping. For each combination of keywords used in the search engine the first ten pages were scanned for relevant literature. With every page the relevance of the articles was reduced and usually after the first ten pages no more suitable sources were found. However, if on the last three pages an applicable assessment was identified then the search was extended for another five pages. This procedure was repeated until the last three pages did not result in finding a new source or if the end of the search query was reached. Once every so far identified Circular Economy assessment literature was added to the research management software, they were analysed for other Circular Economy assessment methods that were mentioned and which had not been detected during the initial search. The newly identified Circular Economy assessments were again added and classified with Mendeley. The step of finding additional Circular Economy assessments was then again repeated but did not lead to any new discoveries. This part of the research was performed in September and October 2018. Therefore, any assessment published after this time period is not included in this research.

Table 3: Sustainable development indicator categories (Veleva and Ellenbecker (2001))

Six categories		
Energy & material use	**Natural environment**	**Products**
Economic performance	**Social justice & community development**	**Workers**

In order to create a new assessment based on the existing assessment, every indicator from the identified sources (see Table 2) had to be recorded individually into a database. The database was used in the selection phase to choose the indicators for the new Circular Economy assessment, which was based on the methodology of Ruiter (2015, in Verbeek, 2016). After adding each indicator to the database every single indicator was categorised according to the six sustainable development indicators (see Table 3), which were identified by Veleva and Ellenbecker (2001). The step of adding and classifying the individual indicators was used as preparation for the selection phase (see 3.1.2) and to make sure that indicators from all three impact dimensions were selected.

3.1.2 Selection

The aim of the selection phase was to select indicators from the database for the new Circular Economy assessment. All selected indicators together were used to build the new Circular Economy assessment that covers the economic, social and environmental impact dimension. The filter of criteria created by Rahdari and Anvary Rostamy (2015) to remove irrelevant or redundant criteria from a large list of indicators was chosen for this step of the research. The choice for this list of criteria was made, as it has proven to work to reduce a large number of indicators from a database in an objective manner and to result in an objective selection of applicable indicators. Rahdari and Anvary (2015) used seven different criteria in their research (see Table 4).

Table 4: Selection criteria according to Rahdari and Anvary Rostamy (2015)

Criteria	Description
Exhaustive	Including ESG & economic indicators
Minimal	Relevance of the indicator for the objective
Eligible	Generality, credibility, and availability of data for the indicator
Operational/Measurable	Quantitative or qualitative value of the indicator
Monotonic	Consistency of hierarchical structure
Cumulative	Individual and composite indicators can be used
Autonomous	Not selecting functionally related indicators
Communal	Selection of the reference in case of identical indicators

These seven indicators were reduced to three criteria, because other steps of the research fulfilled the same objective than the selection criteria. The classification in the six sustainability indicator groups, for example, was used to include indicators from all three impact dimensions making the "exhaustive" criterion obsolete. The criteria "monotonic" was already included in the development of the performance level and they were all formulated to analyse the same hierarchical level. After the selection of the indicators, the identified indicators were going to be grouped together if they covered a similar topic and no distinction between individual and composite indicator was made. This meant that the criteria "cumulative" and "autonomous" were covered in one of the following steps after the actual selection. As the aim of the research was to develop a new assessment that covers the topics of the existing indicators, it was not relevant to define the reference of the indicator, as the indicator was still going to be adapted. The selection criteria applied in this research can be found in Table 5.

Table 5: Selection criteria used in this research (based on Rahdari and Anvary Rostamy (2015))

Indicator	Explanation
Relevant	Removal of all irrelevant and/or redundant indicators based on linking to the Circular Economy definition, system boundary, applicability to company level.
Eligible (generality, comprehensiveness, data availability)	Selection of indicators based on generalisability for all sectors, comprehensiveness of the indicator definition and the availability of data on company level
Measurable	Selection of indicators based on quantification where possible

Companies in different industries play different roles in the transition towards a Circular Economy. For example a manufacturing company can design the products for easier repair, while for a logistics company that produces no tangible goods, the repairability is irrelevant, but it can offer the service to return the product to the producer (ABN AMRO, 2017; Ellen MacArthur Foundation, 2013; WBCSD, 2018). Therefore, not every indicator is equally relevant for each company and mostly depending on the type of industry it is from. Hence, a simple categorisation of industries was needed to allow for a certain flexibility in the assessment. A report by ABN AMRO (2017) brings up a simple three category classification for companies in the private sector, which helps specify their role in the transition towards a Circular Economy. It differentiates between "Producing companies", "Facilitating companies" and "Customer-oriented companies" (see Table 6). This classification was considered to be useful for the development of a new Circular Economy assessment by the World Business Council for Sustainable Development (WBCSD, 2018). Therefore, the proposed classification was also applied in this research. This classification allowed to still maintain a standardised approach but to recognise at the same time the necessary flexibility for the different roles that companies play in the transition towards a Circular Economy. Keeping the three categories in

mind during the selection phase was important, in order for the indicators to be as general as possible, but to still allow for indicators that might be more specific to one of the three sectors.

Table 6: Sector classification for the Circular Economy (ABN AMRO, 2017)

Producing sectors	Facilitating sectors	Customer-oriented sectors
Agriculture	**Technology, Media & Telecom**	**Retail**
Food	**Professional Services**	**Leisure**
Construction & Real Estate	**Transport & Logistics**	**Healthcare**
Manufacturing	**Government & Education**	
Utilities		

Once the indicators were selected, four performance levels for each indicator had to be developed according to the assessment by Ruiter (2015, in Verbeek, 2016). These performance levels were of a descriptive nature, so that for every indicator a company can select the performance level that describes the status of the company fully. Identical with the research by Ruiter (2015, in Verbeek, 2016) four different performance levels were used, but for this research the descriptions were adapted slightly to focus solely on the Circular Economy. The four performance levels with the specific score for each level can be found in Table 7.

Table 7: The four performance levels for each indicator

Performance levels				
Scoring	**0**	**1**	**2**	**3**
Description of the performance level	Doing nothing or little on Circular Economy	Starting the transition to a Circular Economy	Elaborated integration of Circular Economy principles	Frontrunner in the transition to a Circular Economy

3.1.3 Validation

Once the indicators of the assessment were selected, they needed to be validated. As Waas et al. (2014) pointed out the importance of combining the “top-down” and “bottom-up” approach in the indicator development process, the validation was based on the methodology from Cloquell-Ballester et al. (2006). The developed validation procedure for sustainability indicators by Cloquell-Ballester et al. (2006) consists of a rigid three level process: a self-validation by the researcher as a first step, and an academic- and social-validation as a second and third step.

Once the three validation steps were conducted the indicators were adapted and based on the improved indicators the interviewed experts were asked to rate the importance of each indicator. Based on the score of this rating, weighing factors for the indicators were developed to reach a more objective assessment result (Rowley, Peters, Lundie, & Moore, 2012). The individual steps of the complete validation procedure are explained in detail in the following chapters.

3.1.3.1 Self-validation

The self-validation was conducted during the development of the indicators as part of the selection process. During the self-validation each indicator was assessed on the same criteria, which the experts were using (see Table 8). The self-validation allowed the researcher to

make adaptions before the experts were going to validate the indicators. It was therefore a useful step to prepare for the expert interviews.

3.1.3.2 Expert validation (academic & social)

For this research the academic validation and the social-validation were combined and carried out through individual expert interviews. For the validation four criteria proposed by Cloquell-Ballester (see Table 8) were identified to cover the most relevant aspects of the validation, while still including the three main points of view of the assessment methodology developed by Cloquell-Ballester et al. (2006). These three pillars are: the relation between the indicator and the assessed aspect (conceptual coherence), defining the internal processes (operational coherence) and the suitability of the indicator (utility). The criteria "relevance" covered the conceptual coherence, "accuracy" covered the operational coherence, while "applicability" and "data availability" covered the utility. The criteria, which were not used were: definition, interpretation, formulation, data and units, measuring method, reliability (indicator & sources) and information (security & cost). The choice to exclude those criteria was made based on the selected measurement methodology that made some criteria less relevant (e.g. measuring method). Additionally, a reduction of the criteria had to be made to allow for all indicators to be discussed during the 45 minutes expert interviews. By using semi-structured interviews, the experts were however still able to give feedback on other aspects.

Table 8: Validation criteria (based on Cloquell-Ballester et al. (2006))

Criteria	Explanation
Relevance	The indicator assesses a relevant part of the Circular Economy
Accuracy	The indicator assesses a relevant part of the Circular Economy accurately
Applicability	The indicator is applicable for a company level assessment
Data Availability	The data for the indicator is available

At the combined second and third validation stage, experts on Circular Economy from academia, businesses and governmental institutions were interviewed. The selection to include experts from these three fields was based on their relevance for the transition to a Circular Economy and especially the relevance of their feedback to a Circular Economy assessment. Experts from academia were included, as lot of the (theoretical) development is carried by academic researchers and to keep the scientific relevance of this research high. Experts from businesses were involved in the validation, as they are the key target group for the new developed Circular Economy assessment. Their feedback is necessary to combine the theoretical knowledge and development of the Circular Economy assessment with the practical knowledge, which these experts can contribute to on the basis of their day to day work experience. Representatives from governmental institutions were included in the validation, as they play an important role in the research and development of new regulations and policies on the Circular Economy. These can influence the companies directly or indirectly, so it remains important for businesses to include this point of view into consideration. At the same time, governmental institutions too are researching and developing possibilities to assess the circularity of companies and products for their procurement.

Contact with the experts was established based on existing connections of Sustainalize or from the researcher's personal network of business representatives. The experts from academia and governmental institutions were contacted via LinkedIn based on research about existing publications on the Circular Economy in the Netherlands. Academic experts from universities as well as research institutes took part in the validation. The main criteria for the selection of the business representatives was to include at least one company from

each of the three sectors used to classify the indicators (see Table 6). This was done to include the different roles the sectors play in the transition towards a Circular Economy and to collect feedback for the applicability of the assessment. In total 12 experts participated in the validation. Six experts were representing companies, while the other six experts were from academia and governmental institutions (see Table 9). This was considered to be an equal distribution, as both academia and the governmental institutions are involved in the development of new rules and regulations and the collaboration on research is quite well developed. Only two governmental representatives were interviewed, as it was considered that more interviewees from this field would contribute less new feedback than experts from academia as they are bound to the position of the government in comparison to the academic experts.

Table 9: List of interviewees

Interviewee Code	Sector
Academic 1	**Academia**
Academic 2	**Academia**
Academic 3	**Academia**
Academic 4	**Academia**
Government 1	**Government**
Government 2	**Government**
Practitioner 1	**Business (Producing sector)**
Practitioner 2	**Business (Producing sector)**
Practitioner 3	**Business (Producing/facilitating sector)**
Practitioner 4	**Business (Facilitating sector)**
Practitioner 5	**Business (Facilitating/customer-oriented sector)**
Practitioner 6	**Business (Customer-oriented sector)**

The interviews were carried out in person and each lasted for at least 45 minutes. The interviews were based on a semi-structured questionnaire (see Appendix A1), which allowed the researcher to ask for more details if needed and to ask specific questions related to feedback from other interviewees in order to get additional information (DiCicco-Bloom & Crabtree, 2006). The interviewees were guaranteed to not be quoted by name or organisation, but just by the group (academia, business or government) or the sector their organisation belonged to in case of a business. This was done to get more honest opinions from the experts compared to if they were quoted by their organisation's name. Each interview was recorded in accordance with the interviewees and then transcribed in order to be analysed and coded in the following stage.

During the interview every indicator was discussed with each expert, unless the indicator was not classified in a sector that the expert was representing (only for business representatives). The experts were asked to validate every indicator based on the list of selected criteria (see Table 8). The experts from academia and governmental institutions were asked to validate on relevance, accuracy and applicability, whereas the business representatives were asked to validate based on relevance, applicability and data availability. This had to do with the expertise of the company representatives to answer the question on data availability, whereas for the other two expert groups this is not their main area of expertise. To not extend the interview with the company representatives in comparison with the other experts, one of the four criteria had to be skipped, which in this case was "accuracy", as it was expected to not contribute much more new input than was already given by the other experts.

After all the interviews had been conducted the recordings were transcribed verbatim and coded with the software NVIVO 11. At first the answers were coded according to the indicator that the answer section was referring to. In a second round the individual segment that discussed a specific aspect was coded according to the validation criteria (relevance,

accuracy, applicability and data availability). At the same time the proposed changes were categorised into minor change (e.g. formulation, small addition to a performance level) or major change (e.g. removing the indicator, combining the indicator with another one). Additional codes were used for the open questions at the end of the interview. In these questions possible missing indicators and their opinion on the inclusion of the social dimension and therefore social indicator was inquired. The full coding scheme can be found in the Appendix (see A2. Coding scheme).

After all interviews had been transcribed and coded the indicators were adapted based on the feedback from the interviews. A majority of the minor changes were implemented, as their change to the indicators did not have a fundamental effect on the assessment. For the major changes the one which were mentioned more than three times were included, whereas the other major changes were not implemented, but were mentioned in the results section for further research. Also proposed new indicators were not added to the assessment and were only mentioned in the section for further research. Including and developing new indicators after the validation was out of the scope of this research.

3.1.3.3 Weighing factors

The interviewed experts were contacted one more time to define the importance of each of the indicators. The importance score was then translated into individual weighting factors. Without weighing factors, every indicator would have the same effect on the final result. Not including any weighing factors would be according to Rowley et al. (2012) more subjective and even less transparent, as the result would be influenced by the selection of the indicators. By developing objective weighting factors the result of the assessment became more objective, which strengthened the overall research (Rowley et al., 2012). Initially a panel for the definition of the weights as a group discussion with the interviewed experts according to the Delphi method was planned. Organising multiple rounds with feedback discussions would have allowed to reach a consensus for the weights of each indicator (Hsu & Sandford, 2007; Rowley et al., 2012). Due to sickness of the researcher on the date of the panel the meeting had to be cancelled. The panel was then replaced by a single-round online questionnaire (Rowley et al., 2012). The positive aspect of the online questionnaire was that it allowed also the experts who could not join the initial panel to participate in defining the weights of the indicators. On the downside side the online questionnaire did not allow for the possibility to find a consensus between the experts and their individual weights.

The questionnaire was developed with Google forms. It contained a short descriptive title for each indicator and four answer options. For every indicator the experts had to choose from four importance levels (see Table 10). The choice for an even amount of answer options was made to leave away a midpoint answer. This way each respondent had to choose for a side and therefore think in more detail about the choice (Weijters, Cabooter, & Schillewaert, 2010). The formulations “very low/high importance”, where purposely not used to reduce the aversion towards the extremes, which has been observed to be an issue in questionnaires (Choi & Pak, 2005).

Table 10: Weighing factor according to importance score

Importance answer option	Weighting factor
Low importance	**1**
Low-medium importance	**1.5**
High-medium importance	**2**
High importance	**2.5**

Once the results were collected the median score was calculated for each indicator. This was done by assigning each importance level a respective weighing factor (see Table 10). The median was rounded up or down to the nearest weighting factor. The result was then determined to be the weighing score of the respective indicator. It is used to multiply the score from each indicator (see Table 7) with the respective weight of the indicator. The median was chosen over the average in order to decrease the effect outliers have on the result.

4. Findings/Results

The results of the three research steps are presented in the following chapters. At first, in 4.1 the results of the indicator mapping are shown. In section 4.2 the results from the indicator selection phase are revealed, while section 4.3 addresses the results of the validation phase.

4.1 Mapping

More than 35 sources, which measure circularity on macro, meso or micro level were identified during the initial research phase of this study (see Table 2). From the identified sources that measure Circular Economy more than 360 individual indicators were identified and mapped in the database. The variety of indicators was very broad and reached from "Material consumption per GDP" (H. Li et al., 2010), "Share of resold products" (Accenture et al., 2016) to "Average lifetime of product" (Ellen MacArthur Foundation, 2015a). The database did consist of numerous duplicates or indicators that were similar. This was expected to be the case, but did not influence the research further, as duplicates or similar indicators were selected only once or merged during the selection phase (see 4.2). An observation, which was made already during the categorisation, was that the share of indicators was not equally distributed over the six categories (see Figure 3).

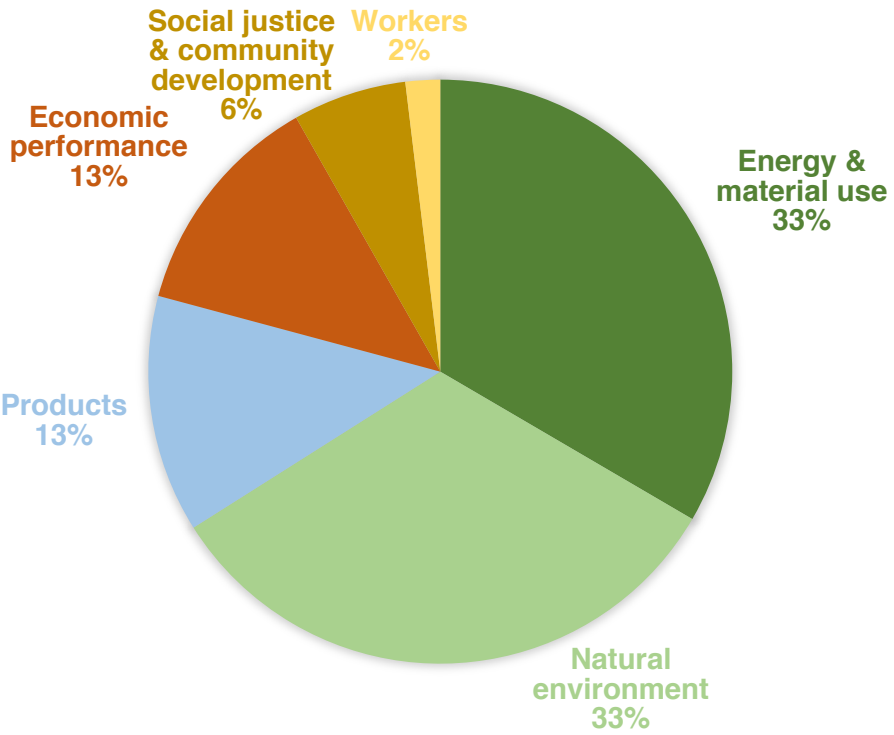

Figure 3: Share of indicators per category (including repeated indicators)

This became obvious when looking at the numbers and the actual share of each category. More than 240 indicators from the approximately 360 indicators were covering the environmental impact. This meant that ⅔ of the used indicators cover the environmental aspect of the Circular Economy, while leaving only ⅓ of the indicators to the economic and social impact dimensions. In practice it was even less, as also a considerable share of the indicators categorised in the "product" category could be considered to cover an aspect of the environmental dimension. The categorisation further showed that at least 13% of the used indicators to measure circularity were considered to cover the economic dimension. Some of

the indicators categorised in the “product” category were also recognised to cover to a certain degree the economic dimension and hence leading to a slightly larger share of economic indicators than just 13%. The categories “worker” & “social justice & community development” were the ones covering the social dimension. Less than 10% of all the analysed indicators that have been used to measure Circular Economy were categorised in one of these two categories, giving it the smallest share of all the three dimensions. In total about ¾ of the indicators covered the environmental dimension, while less than ¼ covered the economic dimension and not even 1/10 of the indicators were related to the social dimension.

4.2 Selection

In the selection round each indicator was assessed on the defined criteria (see Table 5). During the selection process the indicators were ruled out from the database based on the three defined criteria. Only the remaining indicators were used to create the assessment. In the first round more than 230 indicators were selected out, based on the relevance criterion. Mostly this was the case as they did not fit a company level assessment. During the first round also, the duplicates of an indicator were identified and selected out in order to continue with unique indicators. In the second selection round another 85 indicators were removed, based on the eligibility criterion. The indicators were mostly excluded in this step, as they were not general enough and could therefore not be applied to every industry. However, indicators that were general enough to apply to at least one of the three sector categories (see Table 6) were not excluded. In the last selection round 21 indicators were dismissed from the selection, based on the measurability criterion. In the last selection step the fewest indicators were excluded, as the measurability of the indicators was high due to the fact that all the indicators in the database had been developed to measure circularity in some way. The indicators which were then left belonged to the list of the selected indicators.

This list was then checked for if indicators from all six categories had been selected. It showed that in the categories of “Social justice & community development” and “Workers” only one indicator had been selected. Therefore, all the indicators from the database which were classified in these two categories were reassessed in a second round. During this revision a total of two indicators were selected by being less strict on the selection criteria and were therefore added to the selected indicator list. Considering that already from all the indicators in the database only a minority of them were classified in one of these two categories shows the lack of available indicators for the social dimension (see Figure 3).

The first list of the selected indicators was then grouped according to the six categories of Veleva and Ellenbecker (2001) to get a thematic overview of the 37 selected indicators. The classification showed overlap between some of the selected indicators. In order to keep the new assessment simple and straightforward it made sense to combine indicators together. For example, the indicators “Existence of future targets on Circular Economy” and “Strategy for the Circular Economy” were regarded as complementary and therefore it was reasonable to combine them together. The reason being that targets within a company are usually directly linked to a strategy and therefore one in general implies the other (Azapagic, 2003; Frank, Tobias, Stefan, & Marcus, 2002). Merging indicators together was done on a few occasions, which led to 21 indicators to measure Circular Economy at a company level.

Based on the selected assessment methodology of Ruiter (2015, in Verbeek, 2016) four different performance levels were developed for each indicator. The categories of the four performance levels can be found in Table 7. Additionally, to developing the performance levels, every indicator was assigned to the industry category (see Table 6) it covered. An indicator could therefore be for all industries or just for a specific industry (e.g. producing

industry). This was done, as not all indicators were considered equally relevant for each industry.

4.3 Validation

In preparation for the expert interviews the self-validation was conducted. It led to some minor changes in the description of the performance levels but showed that all the indicators fulfilled the criteria to a basic level. To what extent this was correct was shown during the expert interviews. The results of the expert interviews are discussed in general in section 4.3.1.1, 4.3.1.2 and 4.3.1.3, while the feedback per indicator is presented in section 4.3.1.4. At the end of chapter 4.3.1 the applied adaptations to the assessment based on the feedback of the expert validation are summarised in order to improve the overview of the section. The results of the weighting factors are reported on in section 4.3.2 of this chapter.

4.3.1 Interviews

In general, the feedback from the interviews can be considered to be varying and covering a broad range of aspects. The majority of the interviewees were in general positive about the indicators and on trying to measure the circularity of a company. The feedback which they gave was mostly related to the improvement of specific indicators. Two academic experts were in overall more critical about the topic of measuring the Circular Economy. They pointed out that taking the Circular Economy concept and developing indicators to measure the progress and defining indicators that cover the important aspects is almost impossible. They also considered it not the right way to go.

> *"Some KPIs are very high over, high level and this is very detailed and the more detailed you go the less connections I see with circularity and in order to achieve the higher level KPIs you need to comply with the lower level KPIs anyway. And just having said this I don't believe in just KPIs. I've seen companies out there just killing themselves, by just focusing on KPIs."* ***Academic 1***

The company representative in general seemed to be more open towards the concept of measuring circularity. Many of them were themselves developing specific indicators to measure the progress on the Circular Economy transition within their company. They were aware of the difficulties that come up when transforming the concept of the Circular Economy to indicators. It was also pointed out that if academia is not developing methods to measure circularity at a company level companies will further adapt the concept of the Circular Economy to the specific situation of the company, without considering the input from academia.

4.3.1.1 Social indicators

An important part of the expert interviews was the inclusion of the social impact dimension. The opinion on whether social indicators should be included in a company assessment on Circular Economy was very diverse. Half of the experts were against including the social impact dimension, since the Circular Economy concept in their opinion is purely focused on material efficiency.

> *"Social indicators on circularity, no."* ***Practitioner 2***

> *"Again, bring it back, if you want to use it for companies bring it back to resource efficiency. Period! That's it! And that's where companies are focusing on, because that's where they see efficiency. Efficiency to them*

means something. They can translate it to money. (…) don't make it bigger than it is. (…) Don't mix up the Circular Economy with sustainability" ***Academic 1***

The question is whether this is relevant for the Circular Economy. So far in my definition I have seen it more from a resource efficiency perspective and really on the basis of creating a new way of awareness on dealing with resources. (…) The question is whether it is relevant in such an assessment? ***Practitioner 6***

This point of view was in general shared by the company representatives. 5 out of 6 stated that including social indicators would not work for a company level assessment. One of the main reasons for this was that including the social dimension would make the concept of Circular Economy more complicated and would hinder the implementation of the concept for companies. This would in their eyes also slow down the transition towards a Circular Economy.

On the other side, which was made up of mostly academic and governmental representatives, the range of opinions and arguments was more diverse. Some were still not completely sure if the social dimension should be included but valued the research that is being done on the topic.

"I have my own difficulties with it as well. In the begging I also thought: don't just make it a sustainability, next sustainability concept, it is about economy and ecology and that's it, but (…) because of his higher links with supply chain management it is in a way easy to forget the social side also where hazardous substances are definitely bridging the two worlds, right? (…) it's relatively tough to make it not look like it's some weird add-on squeezed in. And I would like it if there was indeed more of a bigger understanding among the community on what that really intends. So, you've also listed the stakeholder engagement, and I think indeed it's very interesting to think well if this is such a supply chain topic, why should we not link all these typical sustainable chain items with circular economy. (…) social side is really really undeveloped so that's true and I'm not completely out myself whether it should be in or out." ***Academic 2***

Others regarded the inclusion or fulfilment of certain social indicators as more of a general requirement for a company to even be considered as transitioning towards a Circular Economy.

"I think the first one is at least you would have a basic level of social elements before being serious about this transition. The second one is use what you do to influence the social aspects in and around your company. Anyway, you would be foolish not to do that." ***Academic 4***

A few of the experts agreed that some social indicators would be necessary to assess a company on its circularity. While the technical aspect of the concept should still be the main focus, social indicators would help to guarantee a transparent supply chain and fair working condition.

"You need not only technical indicators, but also all kind of indicators on the transition process (…). We haven't been able to tackle the social indicators quite good, in my opinion. Still some work to be done." ***Government 1***

"Circular Economy can't only be about the technical terms. (…) you can have a very circular economy but if this means that people in China or in

Africa are separating our circuit boards from our laptops and they die at your age because they come in contact with dangerous materials, toxic materials. I'm not so sure whether that's a Circular economy I'm looking for." ***Practitioner 1***

One expert was a very strong believer of the necessity to include the social dimension in an equal manner to create not just a Circular Economy, but also a resilient economy where also the people are resilient.

"I definitely believe that those social issues are also part of the Circular Economy, because Circular Economy is also really about a resilient economy. And if your environment is very resilient but your people are not that doesn't quite match. You need both to be resilient. So, I firmly believe that (…) you can't just have one without the other." ***Academic 3***

Additionally, the experts that were in favour of including social indicators were asked which topics should be covered, on top of the current indicators in the assessment. The topics brought forward by the respondents were human rights, health, education, freedom and local community development. Many of these aspects can be considered to be supply chain related topics.

By looking at the feedback that was given on the aspect of social indicators, it can be summarised that one of the main reasons to not consider the social dimension was to not make the concept of the Circular Economy more complicated than it might already be. Additionally, there is scepticism that a Circular Economy concept that addresses economic, social and environmental aspects would not be distinguishable anymore from the sustainability concept. The experts in favour of including the social dimension argued that certain aspects should be considered in the transition towards a Circular Economy to reduce the chance of negative externalities occurring. What struck out the most was the contrast on this question between the business representatives, being mostly against the inclusion, while the academic and governmental representatives were mostly in favour of including specifically supply chain related indicators to cover the social impact.

4.3.1.2 Thresholds

Another general remark from the experts was on the chosen values for the thresholds for the quantified indicators. For these indicators the thresholds were set to <25%, 25% - 50%, 50% - 75% and >75%. These threshold were chosen, as they had already been successfully implemented in the Circular Economy assessment by Ruiter (2015, in Verbeek 2016) and also Guo-gang and Jing (2011) proposed these four categories. The thresholds were chosen for their simplicity of creating four equal categories. The experts however considered a hockey stick shaped curved to be more fitting to a transition than the linear curve. Because the transition towards a Circular Economy is still at the early steps a hockey stick shaped curve was considered to improve the distinction between the early adopting companies. Especially because hardly any company was considered to reach the highest two performance levels at the current stage.

"Well thinking on the s-curve that you have in most transitions and not sure whether you might use one on one for a company as well. The fact that they are starting something and that they have some revenues and then they will have some more, and, in the end, they might never reach this (100%). Is that a bad thing that they don't have all their revenues from circular products and services? I think you can rethink this one, you might rethink this one, how to put the numbers there." ***Government 1***

"I think 25% is quite high as a beginning value." ***Academic 3***

"So, I think if you would use this measure today then many companies would be in column one. So, there's not much differentiation. So that would plead for a more hockey stick scale." ***Practitioner 5***

By implementing a hockey stick shaped transition curve the thresholds should be changed to 0%, <10%, 10%-25% and >25%. Once more companies have started to transition towards a Circular Economy, the thresholds could be adapted to the previous version in order to make the assessment become stricter over time.

4.3.1.3 Indicator definition

From the beginning it was planned to include a definition for each indicator. However, the definitions were not included in the indicator list that was given to the experts during the validation. On one side the interviews were used to understand if the experts also felt that a definition for each indicator was necessary. On the other side, the definition was excluded in the validation phase in order to put the focus on the individual indicators instead of the definition. The majority of the experts brought up the necessity of a definition to be included for every indicator in order to improve the comparability and usability of the assessment.

"Again, here is the big definition issue. There's always an issue and all this kind of things, so that's not specific for your research here. But what does it mean to have Circular products and services? Is it clear to the reader of this? Or could a company score itself if you only give it the label circular products or services?" ***Government 2***

"it's important to have that definition." ***Practitioner 1***

4.3.1.4 Indicators

For every indicator except for the indicator on virgin material use the experts did see some potential for improvement. The feedback on the four criteria is presented individually for each indicator in this chapter. The feedback for improvement of the indicators mostly focused on the accuracy and the data availability of the indicator, while the relevance and applicability were high for most indicators. A number of indicators did however score low on the relevance and the applicability criteria. Therefore, the experts also recommended to remove three indicators without replacing them, as the other indicators did already cover the most important aspects of the Circular Economy.

1	Strategy for the Circular Economy (incl. targets)			
All industries	We do not have a strategy on the Circular Economy	We have a strategy on the Circular Economy and are developing KPIs to measure our progress	We have a strategy on the Circular Economy and are measuring our progress on a yearly basis	We have a strategy on the Circular Economy, which is integrated in our organisation's strategy. We have targets on the Circular Economy and measure our progress on at least a half-yearly basis

The first indicator focuses on whether the company has a strategy on the Circular Economy and how the progress is measured. This was considered relevant by a majority of the interviewees. The accuracy was considered by a couple of interviewees to be a bit low, as it is not further specified how the strategy needs to look like and how detailed it has to be to fulfil the highest level. The applicability was then again considered good, as developing a strategy for the Circular Economy is something that needs to be done at a company level therefore it fits the meso level of the assessment. The company representatives also considered the availability of data as an aspect which should not be a problem. The person who would fill out the assessment would for sure know whether the company does have a strategy on the Circular Economy and would therefore be able to answer the question.

> *"Indeed, I can see that the KPI on strategy and target is relevant, (…). that you define that it can accurately measure a contribution to the Circular Economy, so definitely I would agree with that and then lastly the applicability that also makes very good sense."* ***Academic 2***

> *"within a company it is relevant. I think a strategy indeed can be open ended. You have then in the next step that you measure progress. That sounds logical. I'm not sure of the frequency or measuring it annually or with a shorter interval or a longer interval. (…) I think companies are reporting more and more for example in an annual report on their progress."* ***Practitioner 5***

Especially the aspect that some companies might not be familiar with the term Circular Economy and therefore not have a specific strategy on it, but that their core business model would be in line with the Circular Economy concept was mentioned. One of the interviewees mentioned the example of a repair company, which has as its core business model and strategy the focus on repairing goods. In this way they contribute to a Circular Economy, but internally they might not consider this as a strategy on the Circular Economy.

> *"(…) a company where 100 people are working on lifetime extension of ICT equipment. A very relevant activity. None of these companies would have a strategy on Circular economy (…) well I'm in the business of prolonging the life time of ICT equipment. (…) this is interesting we call it a circular activity. Would you think that improving your repair activities is part of your activity? Yes. Okay so then you have a strategy on Circular Economy (…) If you ask this, they don't have a strategy on Circular economy."* ***Academic 4***

The recommendation was therefore to include a more general explanation of the Circular Economy in the definition of the indicator in order for every company to be aware of what the Circular Economy implies. As additional feedback it was brought up that the progress measurement would need to have an assurance statement from an independent assurance company and that there should be an external progress report, which is used to communicate the progress on the implementation of the Circular Economy to external stakeholders.

2	Embeddedness of the Circular Economy			
All industries	Circular Economy is not embedded in our organisation	Circular Economy is embedded in our sustainability/CSR department	Circular Economy is embedded in all departments (e.g. marketing, production, purchasing, R&D, accounting & finance, HR) of our organisation	Circular Economy is embedded in all departments (e.g. marketing, production, purchasing, R&D, accounting & finance, HR) of our organisation and the executive board stands behind the transition

The relevance of the embeddedness aspect was acknowledged by the interviewees, as they pointed out the link with the embeddedness of sustainability, which has shown to be an important factor for a company to be more sustainable.

> *"I think this is a more relevant one because it can be a steering tool from the board towards all the departments that they actually have to have it embedded."* ***Practitioner 3***

The accuracy of measuring this indicator was considered to be lower, as it should be explained in more detail how the embeddedness can be measured on a company level. Examples of how embeddedness could be measured was linking the bonus structure to goals related to the Circular Economy, the availability of policies on the Circular Economy in the different departments and training the employees on Circular Economy.

> *"You could check whether these programs are available and then you say okay this is done."* ***Practitioner 2***

> *"We made an e-learning on Circular Economy with an external party. (…) it was to train the front office (…) on what is Circular Economy, so they can use it as an agenda item with their clients (…) This is the first step, first the front office and then the rest of the company."* ***Practitioner 4***

It was proposed to also explain the embeddedness in the definition of the indicator. The applicability was considered to be fulfilled, as it fits a company level assessment. The critique in terms of data availability was linked to the accuracy of the indicator and by improving the accuracy it was mentioned that the data availability would not pose a problem.

3	Cooperations for Circular Economy			
All industries	We are not involved in cooperations on the Circular Economy	We are analysing possible cooperation on the Circular Economy	We are involved in cooperations through memberships in associations (e.g. MVO Nederland, WBCSD) and cooperate with our suppliers	We are actively involved in cooperations with associations, NGOs, other companies and suppliers to increase our Circular Economy performance

Assessing the cooperations on the Circular Economy was regarded as a really important aspect of the assessment, as cooperations are regarded one of the key requirements for the transition towards a Circular Economy due to the systemic change.

> *"But especially when you talk about the optimisation of the use of resources, so efficiency, resource efficiency then this co-designing process is very important. This is not necessarily a co-designing with the supply chain, it's not only procurer, supplier it's also about the companies that are around a procurer or a producer."* ***Academic 1***

One interviewee pointed out that cooperations and collaborations are important in every sort of business-related activity and that it was not a specific aspect that allows to assess whether a company is doing well on the transition towards a Circular Economy. The interviewee mentioned that due to the high level of connectivity in the globalised value chains nothing could be achieved anymore without collaboration with each other.

> *"I wouldn't see why that is particularly relevant (…) I would try to find any other decisions that you make that you do in splendid isolation."* ***Academic 4***

However, the majority of the interviewees stated the importance of the collaboration aspect to successfully transition to a Circular Economy. A few experts pointed out to distinguish the two highest levels better between active and passive cooperations.

4	Revenue circular products/services			
All industries	< 25% of our revenue comes from circular products/services	25% - 50% of our revenue comes from circular products/services	50% - 75% of our revenue comes from circular products/services	All our revenue comes from circular products/services

The interviewees considered the revenues from circular products or services as one of the key aspects to measure the success of the transition towards a Circular Economy. Since the economy is still built very much around financial indicators the revenue indicator can show very clearly how successful a company has been in adapting the Circular Economy into its core business.

> *"I think it's relevant because this is adding the monetary aspect to it."* ***Academic 3***

As part of the accuracy validation of the indicator they stressed out that a definition for the indicator should include the types of business models that are considered to make a product or a service circular. This way the person who fills out the assessment can allocate the revenues to the circular products or services. Without having a clear definition of the circular products and services they worried that the results of the assessment would not be consistent among different companies.

> *"I think it's a very very interesting one. Although, you know, what is a circular product? That's a very different one of course. (…) I think this one is very relevant, it is very applicable and also the data is quite easy, I think."* ***Practitioner 3***

The interviewees were positive about the applicability of the indicator as well as the data availability, as companies who sell circular products or services will already be collecting this sort of data. Philips was named as one of the companies that already communicates its revenues from circular products and services in their annual report.

5	Supplier selection			
All industries	We have no selection criteria based on Circular Economy for our suppliers	We encourage our suppliers to transition to a Circular Economy, but have no specific selection criteria	We assess and select our key suppliers on their Circular Economy performance	We assess and select all our suppliers based on their Circular Economy performance

Supplier selection already plays an important role in the field of sustainability according to the interviewees and many companies have already included sustainable supplier assessments. Therefore, the relevance of assessing the suppliers also on their Circular Economy performance is considered high.

> *"Yes, very relevant. (…) For us it's very important and also most of our impact is in our value chain as we do not produce anything, but we buy products and we sell services."* ***Practitioner 5***

At the same time, most experts pointed out that currently sustainability is only a part of the supplier selection and among price, quality and availability suppliers are not selected solely on their sustainability performance. Hence it should be made clearer in the definition as well as in the two highest performance levels that the circular economy performance is only part of the supplier assessment. In order to control for other aspects, especially social sustainability a company will have to assess the supplier on sustainability criteria before adding circular economy criteria. The experts pointed out that otherwise the transition to a Circular Economy could lead to negative impacts on other sustainability related topics. In terms of the accuracy the feedback was to focus on the actual money spent in procurement. In general, 20% of the suppliers are responsible for 80% of procurement spend.

> *"The 80, 20 rule: 20 percent of your suppliers often deliver 80 per cent of your materials. So that you look at the suppliers that are most relevant of course"* ***Practitioner 1***

Additionally, a company might have many small or even inactive suppliers, which require a considerable effort to assess them, while the positive effect of it would be minor. Focusing on spend instead of the number of suppliers could increase the accuracy of the indicator. Since companies have already started to assess their suppliers on sustainability the experts did not consider the data availability to be an issue for this indicator.

6	Use of circular business models			
Producing & consumer-oriented industries	We are not using circular business models	We are working on a pilot for a circular business model	<50% of our products/services are based on a circular business model	>50% of our products/services are based on a circular business model
Facilitating industries	We are not facilitating circular business models	We are working on a pilot for a circular business model	<50% of our services involve circular business models	>50% of our services involve circular business models

The relevance of the business model indicator was considered to be low, as it is seen to be repeating the revenue indicator without adding additional knowledge to the assessment. All experts agreed when asked if it was useful to include the business models into the definition of the revenue indicator.

"You do need to provide a legend with the business model to choose from" ***Academic 3***

Additionally, they also scored the accuracy as well as the data availability for this indicator as low, because products or services could be sold with different business models, however differentiating them as well as allocating them would pose challenges. Furthermore, the consistency of the use of other thresholds in comparison with the other indicators was criticised. It was recommended to keep a certain consistency of the applied thresholds and adapt them (see 4.3.1.2). The applicability of using and assessing business models on a company level was considered reasonable and could therefore be included in the revenue indicator.

7	**Extension of life-time**			
Producing & consumer-oriented industries	We do not offer a service to extend the lifetime of our products	We are developing a service to extend the lifetime of our products	We offer a service to extend our products	We actively encourage our customers to extend the lifetime of the products instead of buying a new product

The extension of life-time was in general considered to be relevant, even though a couple of experts pointed out that extending the life time of a product is not always the best or most sustainable choice. However, this critique was considered to be not valid by more than two other experts, as they pointed out that for most products an extension of life-time is beneficial in terms of environmental and social aspects.

"It's an often-used argument but the big efficiency gain has already been realised. So, when you look at water and energy (…) we have a machine and we can put in a new tin plate and it gets more efficient. I'm not too pessimistic on that." ***Government 1***

This indicator was considered to be more of a qualitative indicator and therefore the accuracy might be lower, however by including a definition and by differentiating level 3 and 4 better from each other the accuracy was considered to be high enough for this indicator. In terms of data availability, the experts considered it easy to place a company in one of the four performance levels based on the available data.

8	**Take back scheme/Reverse logistics**			
Producing & consumer-oriented industries	We do not actively take our products back	We are setting up a reversed logistic system to retrieve our sold products	We offer a reversed logistic system	We actively encourage our customers to return the product to us through the reversed logistic system
Facilitating industries	We are not involved in facilitating reverse logistics	We are setting up a reversed logistic system	We have successfully facilitated a reversed logistic system	We are facilitating multiple reverse logistic systems

This indicator was considered to be similar to the previous one, but nonetheless relevant too. The experts emphasised the importance that a company did not have to have its own reverse logistic system, but that it could be part of a system which ensures that the components of the

product are kept within the material loop. It was emphasised that there should be a financial incentive to return the product, as this is seen as a step that increases the return rate drastically. The financial incentive should however be linked to the state of the returned product to make sure that products are well taken care of during the use and the return phase.

> *"I think encouraging is still too soft here. (…) you can also say the TV or refrigerator that I deliver I want to get back after you have used it. That's less voluntary than we actively encourage. If you say: 'well, you can get an amount of money back depending on the state you deliver it in'. then it's much more of an incentive to deliver the product in a decent way."* ***Government 1***

The producer responsibility was pointed out during the interviews as something that should be additionally added to the definition of the indicator and that contracts should be in place to guarantee the return of the product, especially if it is not a company's own reverse logistic system. The applicability for a company level assessment of this indicator was acknowledged to be appropriate. The data availability or the possibility to answer the question was not considered to be a problem for this indicator.

9	**Consumer awareness**			
Consumer-oriented industries	We are not involved in creating consumer awareness on the Circular Economy	We are planning to create consumer awareness for the Circular Economy	We are creating consumer awareness for the Circular Economy through our communication	We are creating consumer awareness for the Circular Economy through our communication, advertisement, sponsoring, community engagement

The experts agreed on the relevance of consumer awareness. A majority of the experts pointed out that it should be adapted to customer & consumer awareness. By also including the customers a company can demonstrate its will to transition to a Circular Economy, while creating a higher demand for circular products and services. Not just the consumer but also the customers are considered to be a vital stakeholder group in the transition towards a Circular Economy.

> *"So, the rules are very regulated (…) What we do now and what is part of my job is trying to make sure that people see the opportunity to actually engage with (…) their provincial governments, regional government to start the dialogue sooner and say okay, we can offer circular options, but we need you. So, I think this is definitely whether or not you are reactive or proactive, it's a big difference."* ***Practitioner 3***

In terms of accuracy the experts made clear that the distinction between the highest and the second highest performance level is not large enough and that every company that would belong to level 3 could also automatically classify itself even to level 4. It was proposed to make a clearer distinction by activating the customer and consumer to make circular choices and defining the specific actions that should be taken to reach the highest level. The company level applicability was regarded as being higher, once the consumer awareness would be changed to consumer and customer awareness, as the first one would only be applicable to the category of consumer-oriented industries. In terms of data availability, the experts thought it would be easy for a company representative to rank its own company on this scale.

10	Job creation			
All industries	We have not created any jobs for the Circular Economy	Through the Circular Economy we have created jobs directly, but do not know how many	Through the Circular Economy we have created jobs directly and indirectly and we know how many	Through the Circular Economy we have created jobs directly and indirectly, know how many and are planning to create more jobs in the next year

The experts, especially the company representatives pointed out that a company's aim does not lie in job creation. In general, it would even be considered that a company would want the work to be done by the lowest number of employees possible. Therefore, they regarded this indicator as not being applicable and relevant for a Circular Economy assessment at a company level.

> *"It is not a topic for us. It's relevant for sustainability of course, but not specific circularity."* ***Practitioner 2***

> *"I think for a company it's not relevant, because jobs created means basically, that more money was spent."* ***Practitioner 6***

A couple of experts did point out that it would be very interesting to know the amount of jobs that a company has created in the field of Circular Economy. However, especially the allocation of jobs to the Circular Economy was considered to be very difficult and therefore the measurement would become inaccurate and inconsistent. Because of that they also considered that the data would not be available for this indicator. In terms of applicability many experts considered this to be more applicable for a macro level assessment in order to determine the amount of jobs that have been created on a country level, since job creation is a relevant part for that level of assessment.

> *"On a macro level I can imagine that you want to measure it. (…) So, I would not consider this very relevant at the company level."* ***Practitioner 5***

11	Internal & external stakeholder engagement			
All industries	We have not involved our internal or external stakeholders yet	We have involved our internal or external stakeholder (e.g. through dialogues, work sessions, round tables)	We have involved our internal and external stakeholders (e.g. through dialogues, work sessions, round tables	We have involved our internal and external stakeholders (e.g. through dialogues, work sessions, round tables), developed products/services based on the input and we have conducted trainings for our employees

The indicator on internal & external stakeholder engagement was considered relevant by the experts, but they felt that it plays an important role specifically in the strategy development. In the field of sustainability, the internal and external stakeholder opinions are in most occasions

included in the strategy development and therefore the experts proposed to include this indicator into the first indicator.

> *"I would rather relate it to them participating and formulating our vision and strategy on CE (…) related to your first indicator, (…) even setting the targets that are then attainable for us. So that would be something let's say logical in that categories to address"* ***Academic 2***

Including the indicator would make it more applicable to the company level assessment. In this way it would also be more accurately measurable, and the data would be available as the company can show in a clear way how the internal and external stakeholders have been engaged. It was also recommended to integrate the element on employee trainings into the second indicator, which focuses on the embeddedness of the Circular Economy within the company

> *"I think that the training of the employees that goes with your cross-fertilisation in departments."* ***Academic 2***

12	Re-use rate of materials in production			
Producing & (consumer-oriented industries)	<25% of the waste materials from our production process (e.g. scraps, water) are reused	25% - 50% of the waste materials from our production process (e.g. scraps, water) are reused	50% - 75% of the waste materials from our production process (e.g. scraps, water) are reused	>75% of the waste materials from our production process (e.g. scraps, water) are reused

The relevance of the amount of re-used material, was considered to be of relevance once the indicator was explained in more detail. Hence it was made clear that a definition for the indicator is needed in order to explain how the resources should be reused in order to score high on this indicator. One expert pointed out that water plays such a relevant role that it should be assessed in a separate indicator. Other experts however pointed out that water remains important for some industries, but not important enough for all industries that it would deserve a separate indicator at the moment, especially when the assessment is mostly used in a country such as the Netherlands, where water is up to this moment not considered to be a scarce good. In general, the accuracy, the applicability and the data availability were considered to be good for this indicator and a company representative emphasised that they do have these numbers already available.

> *"It's very very important topic for us. Looking at all the waste streams. We have programs on all those things to reduce and to reuse it and we are measuring it."* ***Practitioner 2***

13	Use of virgin material use			
Producing & (consumer-oriented industries)	>75% of the materials in our products are virgin materials	50% - 75% of the materials in our products are virgin materials	25% - 50% of the materials in our products are virgin materials	<25% of the materials in our products are virgin materials

At first this indicator confused the experts, as the threshold values are exactly the other way around as with the other indicators. In general, they did consider it relevant to assess the use

of virgin material instead of the amount of recycled content, as this is easier to define and also simpler to explain instead of mentioning all possible sources of recycled, reused, refurbished or upcycled material. The indicator also fulfilled the requirements in terms of data availability, accuracy and applicability according to the expert opinions.

> *"So, relevance? Yes? Accuracy? Yes, could be? Reliability? Yes, I would think so. Applicability? Yes"* ***Academic 1***

14	Toxic substances			
Producing & (consumer-oriented industries)	We use "Substances of Very High Concern" in our products	We do not use any Substances of Very High Concern in our products	We do not use any substances that are on the SIN[3] list in our products	We do not use any substances that are on our list of forbidden substances, which is stricter than the SIN list

The relevance of not using toxic substances in the production process was accepted by the majority of the experts as very relevant. The high acceptance for this point can be explained, as it is one of the three key requirements of Cradle-to-Cradle, a concept that has been around for many years and all the experts were aware of this rule.

> *"I wanted to say take care that you include the toxic elements, but you have included them so that's fine."* ***Government 2***

It was pointed out during the validation by a couple of experts that the toxic substances can also be created during the production even if there are no toxic input materials present. Therefore, the definition of the indicator should be adapted to also exclude any toxic materials from occurring during the production process. Due to legislation that prohibits or reduces the use of toxic substances the experts were positive that the data on this indicator would be available and that it can be measured accurately whether any of the above substances are present or not.

15	Design for repair, remanufacturing			
Producing & (consumer-oriented industries)	<25% of our products are designed for repair, remanufacturing and/or disassembly	25% - 50% of our products are designed for repair, remanufacturing and/or disassembly	50% - 75% of our products are designed for repair, remanufacturing and/or disassembly	>75% of our products are designed for repair, remanufacturing and/or disassembly

The relevance of design for repair and remanufacturing was considered to be relevant and the experts pointed out that this is already very much the case with large Business-to-Business products. However, they agreed that for Business-to-Consumer products this is so far not being done and that it would be one of the aims of the Circular Economy to increase the repairability of products and to improve the possibilities for remanufacturing old or broken products.

[3] List of chemicals that have been identified by ChemSec, an independent organisation, to fulfil the criteria of Substances of Very High Concern. According to ChemSec these chemicals should be added to the REACH legislation. The list is available here: https://sinlist.chemsec.org/

> *"Obviously it's relevant. It's applicable at this level, very very much, very crucial (…) generally I like the category. It's also intuitive, but it's also good to work forward."* ***Academic 2***

In order to increase the accuracy of the assessment the experts proposed to change the percentage from number of products to value of sales. According to the experts, the major difficulty with this indicator was defining well enough at what stage a product can be considered to have an improved design for repair and remanufacturing. By adapting the definition, the accuracy and data availability were considered to increase.

> *"I think that's a crucial question. And I think it's also quite measurable. (…) Only when maybe a large company and when they have many various products maybe it's slightly more difficult, but I can tell you they have the numbers."* ***Practitioner 1***

16	Separation of technical and biological cycle			
Producing & (consumer-oriented industries)	We separate <25% of our products technical and biological materials	We separate 25% - 50% of our products technical and biological materials	We separate 50% - 75% of our products technical and biological materials	We separate >75% of our products technical and biological materials

The experts understood the importance of keeping technical and biological cycles apart. However, they unanimously pointed out the problems of defining at what stage of the product life the different materials should be separated.

> *"I find that one is very hard to understand in practice how that would work. What I said, is it during production, is it disassembly or I find this one isn't measurable."* ***Academic 3***

It was acknowledged that this would ideally be the case if the design for remanufacturing was done well. However, no one considered this indicator to be valuable and especially not easily measurable. Therefore, not passing the accuracy and the data availability criteria.

17	Sustainable biological input materials			
Producing & (consumer-oriented industries)	<25% of our biological materials is produced in a sustainable manner	25% - 50% of our biological materials is produced in a sustainable manner	50% - 75% of our biological materials is produced in a sustainable manner	>75% of our biological materials is produced in a sustainable manner

In the interviews this indicator was considered to be not relevant, as it would already be included in a sustainable supplier selection. This was confirmed by a number of company representatives who explained that this was already part of their sustainable procurement and could therefore be removed from the assessment. Furthermore, some experts criticised the missing link with the Circular Economy.

> *"The question is: compared to the others does it carry the same relevance?"* ***Academic 2***

Also, the definition of sustainable biological input material was considered to be not clear enough, but also difficult to include a general definition, which would fit with any kind of raw material.

18	Material passport/LCA for products			
Producing & (consumer-oriented industries)	We have conducted LCAs and/or created material passports for <25% of our products	We have conducted LCAs and/or created material passports for 25% - 50% of our products	We have conducted LCAs and created material passports for 50% - 75% of our products	We have conducted LCAs and created material passports for >75% of our products

The experts considered LCAs and material passports to be an important part of understanding the impact of a product.

> *"You need an LCA if you say we have a lot of materials that have a high environmental impact, but if you want to do something useful with your products, you need to know what's in there. That's a no-brainer"* ***Government 1***

> *"Well if you take the above serious then you should have done this; otherwise, I wouldn't know how to take this serious. It's almost a condition, so again if you don't know about your activities then indeed so you're right in that."* ***Academic 4***

At the same time, they pointed out that for smaller companies it is difficult to conduct LCAs, because the costs are still relatively high, and the data can be difficult to get. Therefore, it is at the moment mostly used by larger companies. Nonetheless some interviewees also proposed to split this indicator into two indicators, one for the LCAs and one for the material passports. Apart from the data availability the feedback from the experts was that this indicator is accurately measurable and that the relevance and the applicability are high.

19	Disposed material			
Producing & (consumer-oriented industries)	We do send waste to incineration & landfill	We do not send any waste to landfill, but to incineration	We do not send any waste to landfill, but to incineration and have managed to reduce that amount substantially	We do not send any waste to incineration or landfill

Reducing the disposed material within a company, but especially in the whole value chain was regarded by the experts as one of the key goals of transitioning to a Circular Economy. The interviewees did at the same time point out that this indicator is very hard to fulfil and that most companies will never reach a zero-waste stage, but because this is the ultimate stage of an ideal Circular Economy, they consider the indicator to be relevant and that it should be kept this way.

> *"I agree that this is something that you would like to minimise you will never be able to bring it back to zero. If you look at it, this is kind of the Holy Grail then it's okay but otherwise you won't realise it."* ***Government 1***

"To be honest I don't think any company can say that, but I think it's a good question." ***Practitioner 1***

Even if most companies will not be able to score high on this indicator the experts still believed that every company can rank itself on one of the four performance levels, because they have data available and can therefore accurately answer this question.

20	Share of renewable energy use			
All industries	<25% of our consumed energy (electricity & heat) is from renewable sources	25% - 50% of our consumed energy (electricity & heat) is from renewable sources	>50% of our consumed energy (electricity & heat) is from renewable sources	>75% of our consumed energy (electricity & heat) is from renewable sources and more than 25% is produced by ourselves

Even if some experts did not consider energy use as being one of the main aspects of the Circular Economy, they still regarded it as a relevant aspect of an assessment on Circular Economy.

"Yeah, we have added energy to our circular economy programme. You can have a discussion about it. If you look at (…) the narrow definition would be around materials, close loops around materials and energy can be used to transform materials. But I think it's relevant to include" ***Practitioner 5***

In terms of data availability and accuracy they also did not recognise any problems as this data is already part of the sustainability performance management of most companies. Two experts did point out that the production of renewable electricity or heat at the site is not something that comes only at the highest level, as it can be financially viable to produce it on site, while on the other hand buying renewable electricity or heat does not deliver direct financial benefits.

"This one is fine I would say. You could also zoom in on the below 25 percent, but renewable energy is in that sense so common nowadays, so it's not really needed." ***Government 2***

21	Share of renewable energy in transportation			
All industries	<25% of our transportation is fuelled by electricity or bio-fuels	25% - 50% of our transportation is fuelled by electricity or bio-fuels	50% - 75% of our transportation is fuelled by electricity or bio-fuels	>75% of our transportation is fuelled by electricity or bio-fuels

In accordance with the previous indicator, also this indicator was considered relevant even though it is not a central aspect of the Circular Economy. Some experts brought up that the choice of the renewable energy source should not be pre-made through the indicator, as other technologies could emerge in the future. Also, the sustainability of transportation on electricity was questioned by one expert. In general, however, the experts pointed out that at the current stage there is no alternative and that the sustainability of electricity powered transportation will increase especially in the field of road, sea and air transport. As the data of the transportation emission is already part of most emission reporting, especially at larger companies the experts did not see any problems with the availability of the data or the accuracy of the indicator.

"It is a very relevant aspect I would say. 20 and 21 obviously touch a lot on the whole CO_2 debate. That's also increasingly linked with Circular Economy." ***Academic 2***

4.3.1.5 Missing indicators

At the end of the interview the experts were asked about indicators that were missing to complete the assessment. As the (missing) social indicators were addressed in chapter 4.3.1.1 this section only covers the indicators that do not belong to the social dimension. In general, the experts felt that the main topics of the Circular Economy were covered by the selected indicators. A few experts ended up naming terms, which in their opinion could or should also be covered by such an assessment. The topics were biodiversity, scarcity of materials, energy use reduction in production, energy use in the use phase, the use phase in general and the absolute decrease of emissions due to the transition towards a Circular Economy. Each topic was mentioned by two experts at most.

4.3.1.6 Adaptation of assessment

After the expert interviews the feedback from the interviewees was analysed based on the coded parts. Based on the feedback, the indicators were improved to create a final version of the assessment (see Appendix A5). During the improvement of the assessment for almost all indicators the performance levels were reformulated to be clearer, to differentiate better between the performance levels or to include additional aspects. The numerical thresholds were also adapted in order to resemble the transition curve and allow a better distinction at this early stage of the transition towards a Circular Economy. As planned in the methodology sector and emphasised by the interviewees, a definition was added to every indicator to improve the accuracy and also the comparability of the assessment. The indicator on stakeholder engagement was integrated into the strategy indicator, while the indicator "use of circular business models" was combined into the revenue indicator. This was done to prevent covering certain aspects twice, and at the same time it should also increase the accuracy of the indicator. Most importantly three indicators were removed based on the feedback from the interviewees. The indicators considered not to be measurable and not relevant for a company assessment were: "job creation", "separation of technical and biological cycle" and "sustainable input material". At last, the order of the indicator was reorganised to follow a more comprehensible structure, which follows the production steps better and is therefore more logical.

4.3.2 Weighting factors

From the 12 interviewed experts 8 filled out the questionnaire to define the importance of each of the 17 final indicators (see Table 11, for more details see Appendix A3). This is a considerably high return rate of 66% and, since 2/3 of the interviewees participated, the results can be considered valid enough for this research. The importance score assigned to each indicator was at least "high-medium", apart from only one indicator.
Customer/consumer awareness was considered to be less important. Three indicators scored with a "high importance". These are the indicator on strategy, revenues and the reduction in toxic material use.

Table 11: Importance scores and weighing factors for indicators

Indicator	Weighting factor	Result
1. Strategy for the Circular Economy (incl. targets)	2.5	High importance
2. Embeddedness of the Circular Economy	2	High-medium importance
3. Cooperations for Circular Economy	2	High-medium importance
4. Revenue circular products/services	2.5	High importance
5. Supplier selection	2	High-medium importance
6. Customer & consumer awareness	1.5	Low-medium importance
7. Design for repair, remanufacturing	2	High-medium importance
8. Reducing the use of virgin material use	2	High-medium importance
9. Reducing the use of toxic substances	2.5	High importance
10. Extension of life-time	2	High-medium importance
11. Take back scheme/reverse logistics	2	High-medium importance
12. Material passport for products	2	High-medium importance
13. LCAs for products	2	High-medium importance
14. Re-use rate of by-products in production	2	Low-medium importance
15. Disposed materials	2	High-medium importance
16. Share of renewable energy use (heat & electricity)	2	High-medium importance
17. Share of renewable energy use (transportation)	2	High-medium importance

Based on the weighting factors and the number of indicators being assessed for each of the three different industry categories the normalisation constant was calculated. The normalisation constant is necessary in order for each assessment to result in a highest possible score of 100. As the three industry categories have a different number of indicators that they are assessed on three different normalisation constants had to be defined (see Table 12). For the producing industry all 17 indicators were considered relevant. The highest score without a normalisation constant was 105, therefore every assessment result for the producing industry has to be normalised with the factor 1.05. The same procedure is applied for the facilitating industry. Since only 10 indicators were considered relevant for this industry, the normalising factor is set to 0.615. Companies from the consumer-oriented industry have to be differentiated based on their control over the value chain. Companies from the consumer-oriented industry, which decides on the design and the sourcing of a product are assessed on all 17 indicators. This means the normalising factor (1.05) is identical to the one of producing industry. Companies, which do not have control over the production are only assessed on 13 indicators and hence a normalisation constant of 0.795 is applied. The detailed calculations can be found in Appendix A4.

Table 12: Overview of indicators per industry category

Indicator	Producing industry	Facilitating industry	Consumer-oriented industry
1. Strategy for the Circular Economy (incl. targets)	X	X	X
2. Embeddedness of the Circular Economy	X	X	X
3. Cooperations for Circular Economy	X	X	X
4. Revenue circular products/services	X	X	X
5. Supplier selection	X	X	X
6. Customer & consumer awareness	X	X	X
7. Design for repair, remanufacturing	X		(X)
8. Reducing the use of virgin material use	X		(X)
9. Reducing the use of toxic substances	X		(X)
10. Extension of life-time	X		X
11. Take back scheme/reverse logistics	X	X	X
12. Material passport for products	X		X
13. LCAs for products	X		X
14. Re-use rate of by-products in production	X		(X)
15. Disposed materials	X	X	X
16. Share of renewable energy use (heat & electricity)	X	X	X
17. Share of renewable energy use (transportation)	X	X	X

To rate the end score of a company the four performance categories were proposed (see Table 13). For the thresholds, the hockey stick shaped transition curve was used, as proposed during the interviews for the individual indicators. The exact values were, however, slightly adapted in order to reduce the amount of companies in the highest two performance categories.

Table 13: The four performance levels for the final result of the assessment

Performance levels				
Score	**0 – 15**	**16 – 30**	**30 – 60**	**60 – 100**
Status of the transition towards a Circular Economy	Doing nothing or little on Circular Economy	Starting the transition to a Circular Economy	Elaborated integration of Circular Economy principles	Frontrunner in the transition to a Circular Economy

5. Discussion

After having presented the results, this section addresses the main findings of the research. Additionally, the applied methodology will be critically analysed, and the limitations of the research are discussed before the recommendations for further research are addressed.

5.1 Social dimension

The close link between sustainability and Circular Economy was pointed out during the validation interviews. Many of the experts related the Circular Economy indicators to existing indicators that were developed to measure sustainability. At the same time, they pointed out that a problem of the Circular Economy concept could be not being distinguishable enough from the sustainability concept. Especially when the definition of the Circular Economy goes beyond the topic of resource and material efficiency and includes all three impact dimensions (economic, social and environmental). Some experts felt that including the social dimension would feel like an add-on that was forced onto the Circular Economy concept. In their opinion the main ambition of the Circular Economy should be to focus on resource efficiency and closing material loops. Keeping a narrow definition was considered to help companies to implement the Circular Economy concept. This is in line with the argumentation from a number of researchers that consider this step important to protect the characteristics of the Circular Economy (Chun-rong & Jun, 2011). In most cases this is not stated directly, but made clear by neglecting the social dimension (Andersen, 2007; Moreau et al., 2017; Murray et al., 2017; Sauvé et al., 2016). Still a number of experts, mostly academics, argued that creating a broader definition of the concept and including social indicators, especially covering the supply chain, is necessary to create an overall positive societal benefit. The experts pointed out that neglecting external costs could lead to a negative perception of the Circular Economy, as it has already been observed with the Sharing Economy or the biofuel discussion (Kirchherr et al., 2017; Murray et al., 2017). The differing opinions by the expert were also in line with the variety of existing definitions of the Circular Economy identified by Kirchherr et al. (2017). The WBCSD even considered this wide range of different definitions as a “challenge to creating a consensus-based framework for measuring circularity” (WBCSD, 2018, p. 6). Also, the interviewed experts had used different definitions of the Circular Economy concept, which led to them disagreeing on the importance of the social dimension. This research confirmed that this challenge is one of the most imminent challenges in creating a new measuring framework.

Mapping and categorising the indicators according to the six sustainability categories supported the process of understanding the coverage of the currently existing circularity indicators. Many of the identified assessments focus on resource and waste aspects and, therefore, the environmental and to some extent the economic dimension. The social dimension is neglected, which can be seen in the low number of indicators. Less than 10% percent of all the identified indicators from these assessments were related to the social impact dimension. This suggests that in the development of many of these assessments the social dimension was not considered relevant enough to be included in the assessment. This finding is in line with the results the WBCSD (2018) presented. They identified that less than 30% of the companies covered the broader impact of their circularity activities in their measuring frameworks. The broader impact is especially the aspect where the social dimension plays a role. Measuring the broader impact is difficult, as that impact has not yet been researched enough in detail (Kirchherr et al., 2017). In the expert interviews already half of the experts were in favour of including the social dimension. This could be explained by the higher attention the discussion has been receiving in recent times, a more pragmatic approach by the experts who are looking at the topic from a Dutch context or purely based on the selection of the experts.

A certain analogy can be drawn to past sustainability assessment related evolutions and discussions. This field was considered for a long time to place the focus on measuring merely environmental related topics. With time a transition started to take place, which led to a step by step inclusion of the social dimension into the assessments (Boström, 2012; Labuschagne, Brent, & Van Erck, 2005; Omann & Spangenberg, 2002). It has to be said that measuring social sustainability showed to be much more difficult than environmental or economic sustainability, due to the struggle of transforming social sustainability into measurable indicators (Epstein & Roy, 2001; Lamberton, 2005). For a long time, Life Cycle Assessments were considered an ideal methodology to assess the impact of a product or service on the environment. Over time, with the increased focus of aspect beyond the environmental impact, it became clear that LCAs are not able to cover all three impact dimensions of sustainability. Hence the development of a social LCA methodology has been pushed forward in recent years (Finkbeiner et al., 2010; Jeswani, Azapagic, Schepelmann, & Ritthoff, 2010). Assefa and Frostell (2007) proposed in their research to combine material flow analysis (MFA), substance flow analysis (SFA), and life-cycle assessment (LCA) for the ecological dimension; life-cycle costing (LCC) for the economic dimension, and social impact assessment (SIA) for the social dimension. Similarly, it can also be possible to use independent assessments to measure circularity, but only by conducting these assessments together a full picture on the circularity of a company can be created.

Nowadays all the three dimensions are considered equally relevant for sustainability assessments. It is possible that the Circular Economy concept will experience a similar development, which would lead to the inclusion of all three dimensions. Which effects this development could have on the adoption of social indicators in circularity assessment remains an additional question. The WBCSD will be presenting a framework to measure circularity at a company level in the current or the following year. Based on the already published reports (e.g. WBCSD, 2017, 2018) it is expected that the framework will also cover the social dimension. Because of the high reputation and the close relation to companies this might lead to a higher acceptance of including the social dimension, especially with company representatives, who in this research were the most critical about including the social dimension into the assessment. However, the success of the Circular Economy is dependent on the overall acceptance of various stakeholders. Including the social dimension into the Circular Economy against the resistance of companies could affect the standing of the Circular Economy with the practitioners. Therefore, a continuous exchange is necessary. In general, this research has shown that it is important to keep a distinction between the concept of the Circular Economy and the sustainability concept. This means that not all aspects of sustainability are regarded equally important for the Circular Economy. Since not all Circular Economy activities are considered to create a positive social and environmental impact, observing and covering at least the prevention of potential negative impact will be important for the Circular Economy to contribute to true sustainability (Andersen, 2007; Moreau et al., 2017; Murray et al., 2017; WBCSD, 2018).

5.2 Quality of the assessment

The validation of the indicators in the expert interviews can be considered an important aspect of the methodology in connection with the quality of the overall assessment. Through the validation phase the indicators were put to the test by a variety of experts. Each expert delivered important feedback from his or her point of view. By analysing and implementing the feedback the assessment was improved in a number of aspects. One example for the quality improvement based on the feedback can be shown by the new thresholds, which were proposed during the validation. First, the revised thresholds fit better with the definition of each of the four performance levels (see Table 7). More importantly, it can be seen that the

assessment became more realistic when looking at Circular Economy frontrunners. Philips for example had in 2017 11% of its revenues coming from circular products & services (Philips, 2017). Cisco, another frontrunner in the transition towards a Circular Economy reaches a recovery rate of around 18% of its products (Triodos, 2017). Considering these numbers, the new thresholds are closer to what is currently reached in practice by the frontrunners and therefore allowing for a more detailed distinction between frontrunners, followers and laggards. The only two indicators for which the old linear thresholds were kept are the indicator on the reuse rate of by-products and the energy use from renewable sources (electricity and heat). Based on the interviews, a lot of companies are already using their by-products because of efficiency reasons. The transition towards renewable energy use is already more advanced than other topics. This can be seen by initiatives such as the RE100, where companies pledge to get 100% of their electricity and heat from renewable sources in the future (there100.org, n.d.). Keeping the threshold as it was for these specific indicators was also proposed during the validation.

The low availability of indicators in the database that cover the social dimension posed a challenge for the selection process to even consider and include social indicators. Therefore, it can be argued that the selected methodology of selecting indicators from existing methodologies was not a suitable approach. This low availability led to reassessing the mapped indicators in the two social impact categories and in lowering the requirements of the criteria, actually affecting the quality of the selected social indicators for the assessment. This led to the result that the differences between the original assessment based on the selected methodology by Ruiter (2015, in Verbeek, 2016) and the assessment by Verbeek (2016) and the newly, for this research, developed assessment might be considered minor. This is certainly true to a certain extent; the indicators of the new assessment are very alike and sometimes even exactly the same. The possibility of this being the case should have been considered earlier in the research. Adaptations to the methodology could have been made to include indicators from other sustainability assessments in order to create a larger database with higher quality indicators. However, even if more social impact related indicators would have been selected, during the validation round the experts could and most likely would have made clear that these indicators should be removed. So even if the database and therefore the selection of the indicators would have been based on a larger database of social indicators, the end result of the assessment could still have been very similar to the existing version. This shows that the developed assessment by Ruiter (2015, in Verbeek, 2016) covers already a lot of important topics of the Circular Economy, even though it does not include the social dimension. However, the assessment developed in this research shows some general improvements compared to Ruiter's (2015, in Verbeek, 2016) assessment. First, a next step has been taken to measure also the social impact by defining the indicator for the supply chain management in more detail and by setting the sustainable supply chain management as necessary basis to even reach a higher level. Second, by including an indicator on toxicity, which can show the reduced effects on workers, local community and also the user, the social impact can be evaluated on this aspect. Lastly, the indicator on customer/consumer awareness covers another aspect, which was not included in the assessment by Ruiter (2015, in Verbeek, 2016). The indicator was even considered relevant enough by the experts during the validation, even thought they were in general against including the social dimension. In terms of the economic dimension, the new indicator on revenues addresses this dimension in a more understandable way for companies. This is backed by the high importance score the indicator received by the expert panel. In general, almost all of the selected indicators received a relatively high importance score, which shows that the covered topics are considered to represent the Circular Economy concept well. Additionally, considering the transition stage at which the Circular Economy currently is and including this into the threshold values improves the possibility to distinguish a company's position in the transition more appropriately. In

combination with the added definition, the accuracy and usability of the assessment is considered to be improved in comparison to the original assessment. These benefits show clearly that the applied methodology delivered reliable results and a new Circular Economy assessment. However, the low relevance of covering all three dimensions simultaneously in the existing assessments and according to the experts influenced the development of the new assessment the most.

When analysing and comparing the developed assessment to the 7 recommendations (see Table 1) by the WBCSD (2018) it can be concluded that most of them were fulfilled. The aim of the research was to develop an assessment, which covers all three dimensions of sustainability. Since the availability, but also the acceptance, of social indicators was considerably low, recommendation number 3 (i.e. cover a comprehensive sustainability scope) is considered to be partially fulfilled. By using the proposed industry categories from ABN AMRO (2017) (see Table 6) and basing the indicators on this categorisation the assessment allows for flexibility, while still being generally applicable and therefore fulfilling recommendation number 4 (i.e. ensure flexibility and inclusion). The adopted methodology with the performance levels allows for a step by step approach and every company no matter of its transition status can use the assessment. The performance levels can furthermore be used as a guidance and idea generation for the next steps to be implemented by the company. Whether the developed assessment can lead to a culture change and if it can increase the circular business performance of a company would need to be researched separately. The performance levels as guidance can definitely help to drive the change. The chosen methodology hence fulfilled recommendation 5 (i.e. adopt a phased approach to incorporating capitals) fully, and 1 (i.e. drive circular business performance) and 7 (i.e. drive culture change and provide guidance) partially. By only selecting existing indicators, who were themselves to a large extent based on existing indicators also recommendation 6 (i.e. build upon existing frameworks and standards) can be considered partially fulfilled. The different stakeholders were not taken into consideration during the development of the assessment. Combining a variety of indicators and building an assessment, which delivers a one value result allows to communicate the outcome in a simple manner. At the same time, it includes much more information than a single metric, which is for instance used by Philips (2017) (revenue from circular products/services). To target the communication to a specific audience a company can additionally use the score of a specific indicator to add an information level to the assessment result. Therefore, also the recommendation number 2 (i.e. target specific audiences depending on company objectives) can be considered at least partially fulfilled. In total it can be seen that the assessment fulfils at least partially all the recommendations and therefore can be used as a next step in the field of company level circularity assessments.

After this research the general question remains of whether it is useful to measure a systemic change, like the Circular Economy is, on a company level. For each assessment system boundaries have to be drawn. The Circular Economy however leads to connecting all sorts of stakeholders, companies and material flows with each other, so that the system boundaries will always cut off a certain aspect, which could still be relevant for the Circular Economy assessment. An assessment will therefore never be able to include the holistic approach of the Circular Economy, but it can try to depict the aspects of the concept as close as possible. As brought forward by Medows (1998) there is a need for indicators and measurements to understand the world, which is so complex. Even if indicators mean simplifying the state, they can give guidance, and this is exactly what has been done with this research: giving guidance for companies to transition towards a Circular Economy. Hence it remains important that academia is accompanying the demand from companies to create useful indicators and assessments to measure the progress of the transition towards a Circular Economy and keeping the discussion on the inclusion of the social dimension going. Therefore, this research

is considered to be a next step in the collaboration and consultation of companies, academia and the government. The assessment that was developed in this research is not considered to stand by itself. Other assessments, whether quantitative or qualitative, are necessary to make the progress of the transition towards a Circular Economy visible and tangible (e.g. LCAs to measure the specific actual emissions). It is therefore considered to be only one of multiple puzzle pieces that support and accompany the transition of businesses to a Circular Economy. In the end it has to be pointed out that reaching the “Circular Economy” is not the end goal, but a means to reaching sustainability and therefore, economic prosperity, social equity and zero or positive environmental impact.

5.3 Limitations

Based on the applied methodology there are a few limitations, which are part of this research. The methodological limitations are the usage of grey literature, the choices made and creating one general assessment for different industries.

Since the field of Circular Economy has only gained traction in the last ten years and the development has also come from practitioners, the amount of grey literature on Circular Economy is relatively high (Kirchherr et al., 2018). Therefore, this research was also making use of grey literature (e.g. non-academic reports, newspaper articles, websites, etc.) as important references in order to be able to capture and represent the latest developments in this field. Also, a number of the identified Circular Economy assessments were developed by practitioners rather than academics. However, the use of grey literature could not be avoided without losing relevant information. In general, it remains relevant to openly disclose all the used literature to give the reader the possibility to re-evaluate the quality of the sources used.

The selection of the indicators is very much based on choices that were made. Even though the selection was based on objective criteria found in academic literature, in the end the selection was influenced by the experience and knowledge of the researcher. Therefore, the replication of the selection process by another researcher could actually lead to another group of selected indicators. In light of these circumstances the validation of the indicators played a highly important role in the whole development process. Testing the indicators with a number of experts reduced the effects of the choices made. In replicating this research, it is still possible to obtain different results, but through the validation the probability of it was reduced.

The last limitation is the creation of a general assessment for all industries, which can lead to not being able to depict sector specific aspects a company is facing in the transition to a Circular Economy. This is definitely the case for this assessment, as it was developed to cover all industries and therefore a number of simplifications had to be made. In order to reduce the effects of the limitation, representatives from all three sector groups were interviewed to identify and adapt some of the shortcomings. Even though constructed to assess any kind of company, no matter which role it has in the value chain, the assessment is not equally useful for every company. An end-user testing of the assessment could have further improved the assessment, as it would have meant to be an additional round of validation. Due to this limitation, the result of the assessment should be considered with caution and always in combination with additional evaluations. The assessment can however be considered as a first starting point to then implement specific measures to transition towards a Circular Economy.

5.4 Further research

This research can be considered as a next step in the development of Circular Economy measurement frameworks at a company level. Based on the results and the scope of this research, a number of potential topics have risen that should be covered in future research on this topic:

I. The social impact dimension in the Circular Economy has so far been neglected, but a rising number of researchers are focusing on the topic. In order to improve the availability of social indicators research on the social impact of the Circular Economy is needed. Analysing and understanding this impact helps to improve and foster the positive aspects, while the negative effects can be monitored and addressed accordingly. Furthermore, especially the practitioners were sceptical of the inclusion of the social dimension in the assessment. Understanding the social impact of circular activities can lead to convincing more practitioners to include the social dimension into the concept.

II. For this assessment the indicators were slightly adapted for different industry groups to allow for flexibility. In order to match a Circular Economy assessment even better to the diverse roles that companies play in the transition it is recommended to research and develop a few sector specific indicators, which can be added to a general assessment. By including sector specific indicators, the assessment can reproduce the actual situation of a company and its transition towards a Circular Economy even better.

III. During the validation of the Circular Economy assessment the experts proposed a few possible additional indicators for the assessment. Additional research could analyse if these indicators are to be included, and in a second step, how they could be integrated into a future assessment.

IV. This research has shown that adapting an assessment to the transition status of the transformation process leads to a better distinction between frontrunners, followers and laggards. This is specifically relevant in the early stage of a transformation process, as the differences between assessed entities might only be minor. Researching this aspect in a more detailed and generalisable way, can be useful for the development of any sort of future assessment that measures a transformation process.

6. Conclusion

This research started off with the increased attention the Circular Economy has been receiving over the past few years. Due to an increase in resource scarcity, it is considered one of a few possible concepts to enable the transition towards a sustainable future. Businesses have been identified to be one of the main drivers for the transition from a linear to a Circular Economy. Many companies are, however, at the current stage struggling to implement the Circular Economy concept, as it means in most cases redefining their whole business model. This is where circularity assessments come into play to provide guidance on the transition process: on one hand, by conducting a baseline assessment of a company to define the current status of the transition to a Circular Economy; on the other hand, by providing recommendations for future steps based on the assessment result. Researchers have already developed a number of assessments to measure circularity on national, regional, industry, company and product level. In recent years, the focus of the Circular Economy concept has also shifted to the potential negative effects of circular activities, leading to the inclusion of the economic, social and environmental dimension. This development is so far not displayed in circularity assessments at company level. Hence this research set out to answer the following research question:

What existing circularity assessments and indicators can be used to measure the circularity of a company while covering economic, social and environmental impact?

As a sub question the following was defined:
Is the social impact considered to be a relevant aspect to cover in a company level assessment?

To answer these questions, a methodological framework was created to develop a new circularity assessment based on existing methodologies and indicators from more than 35 different sources (see **Error! Reference source not found.**). Next, indicators for the new assessment were selected through a number of criteria (see Table 5). After the selection of the indicators, four performance levels for each indicator were defined to enable an easy assessment of a company on every indicator (see Table 7). In experts interviews the indicators were then validated and, based on the feedback, adapted, combined or removed. Each indicator of the new assessment was then evaluated by the experts on its importance. These results were transformed into weighting factors for the calculation of the single metric result the assessment delivers.

Overall it can be said that the developed assessment includes indicators that cover all three impact dimensions. It is simple to use and makes it possible to assess companies from different industries. The single value result can be communicated and understood easily, while including more relevant aspects than just a single key performance indicator such as “revenue from Circular Economy services/products”. The result of the assessment (score between 0 and 100) in combination with the achieved performance level (see Table 13) can be used as a baseline assessment for a company to understand where it stands in the transition towards a Circular Economy. Furthermore, for every indicator, each performance level higher, than the actual performance level of the company can be used as guidance on the next steps in the transition towards a Circular Economy. The assessment can also be applied to test the effect of different choices and through that be used to support management decision making.

The research showed that the availability of existing indicators and assessments that cover the social dimension is fairly low. The absence of social indicators shows that the researchers did not consider it relevant to include the social dimension. Also, half of the experts in the

validation interviews were not in favour of including social indicators into the assessment. This is well in line with the neglection the social dimension has received in the field of the Circular Economy. The gap of considering all three impact dimensions has been starting to close in recent years and this research is considered to add a part to this transition. The sustainability concept and assessments have had a similar transition from a large focus on the environmental dimension in the early stage, towards including more economic and social aspects over time. Since the Circular Economy concept is considered to foster a sustainable system, but can also have negative effects on sustainability, covering all three dimensions should be the aim. Otherwise reaching true sustainability through Circular Economy could be difficult or impossible to achieve.

In conclusion, the Circular Economy is still in the early phase of the transition. Companies need guidance to be able to transition to a Circular Economy. The broader impact of circular activities is expected, based on the expected increase of sustainable development activities, to further increase in importance. Researchers and practitioners have started to realise this, but still more research is needed to identify and evaluate the broader impact of the Circular Economy. This goes along with identifying and agreeing on a common definition for the Circular Economy. In the end, the Circular Economy is not the end goal, but it can be one of only a few possible ways to reach a sustainable future.

7. References

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Appendix

A1. Interview guide

Introduction
Thank you for taking the time to help me in the validation process.

During the last few weeks and months I have been analysing and mapping more than 35 assessments that measure Circular Economy on macro (country or regional), meso (industry or company) and macro (product level) in order to select indicators to measure circularity at a company level.

At this stage I'm now validating the indicators with experts from academia, companies and governmental institutions based on 3 criteria.

Validation process
I propose to go through each indicator, and I would like to hear your opinion on each indicator according to the criteria. (Handing over the list of indicators and the overview of the criteria)
In case you would like to give some additional feedback, feel free to do so, especially If you feel like there should be improvements made to the indicator.

If you feel there is an indicator/topic which is missing in the current selection I would like to hear that from you at the end of the validation, unless, it fits with another indicator that we are discussing during the assessment.

Can I record our interview?

Criteria	Explanation
Relevance	The indicator assesses a relevant part of the Circular Economy
Accuracy	The indicator assesses a relevant part of the Circular Economy accurately
Data Availability	The data for the indicator is available
Applicability	The indicator is applicable for a company level assessment

Missing indicators
Did you miss any indicator?
What kind of indicator did you miss?

Social indicators
What is your opinion on the inclusion of social indicators into the assessment?
Did you miss any social indicators?

Expert panel
I would like to define weighting factors for each of the indicator after I have implemented the changes based on the feedback from the expert interviews. Would you be interested to participate in an expert group panel to define these weighting factors and discuss the adaptions of the indicators?

Thank you very much for your feedback and your time. I will send you the updated version of the assessment and a questionnaire to find a date for the focus group workshop.

A2. Coding scheme

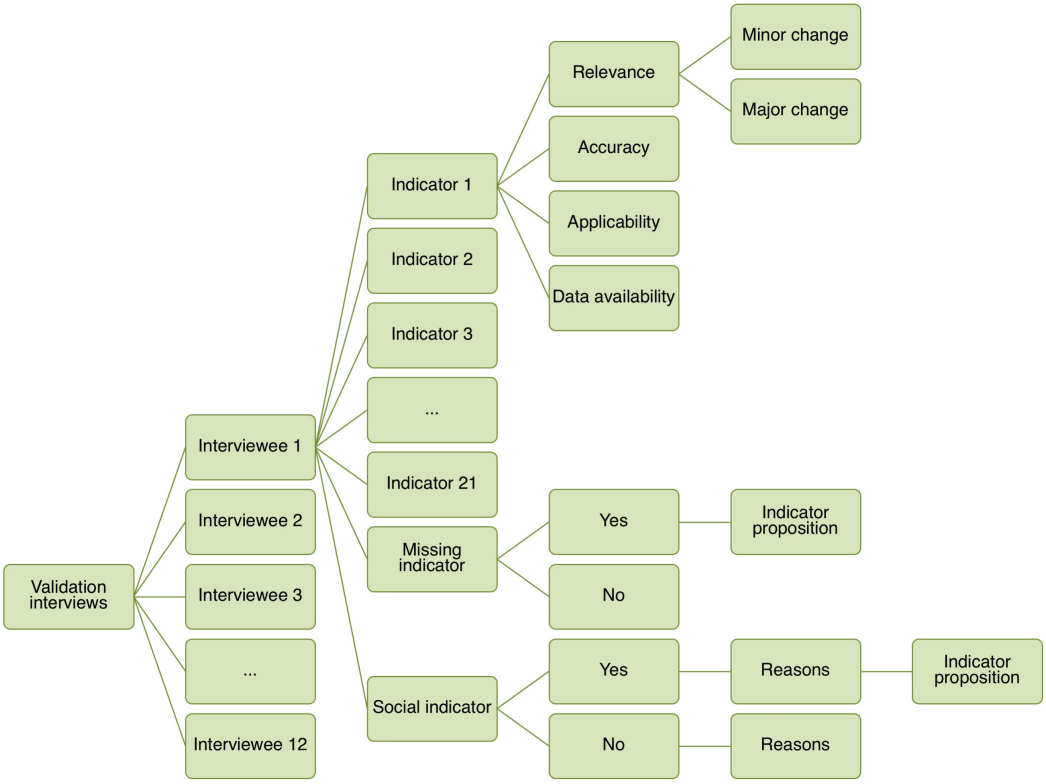
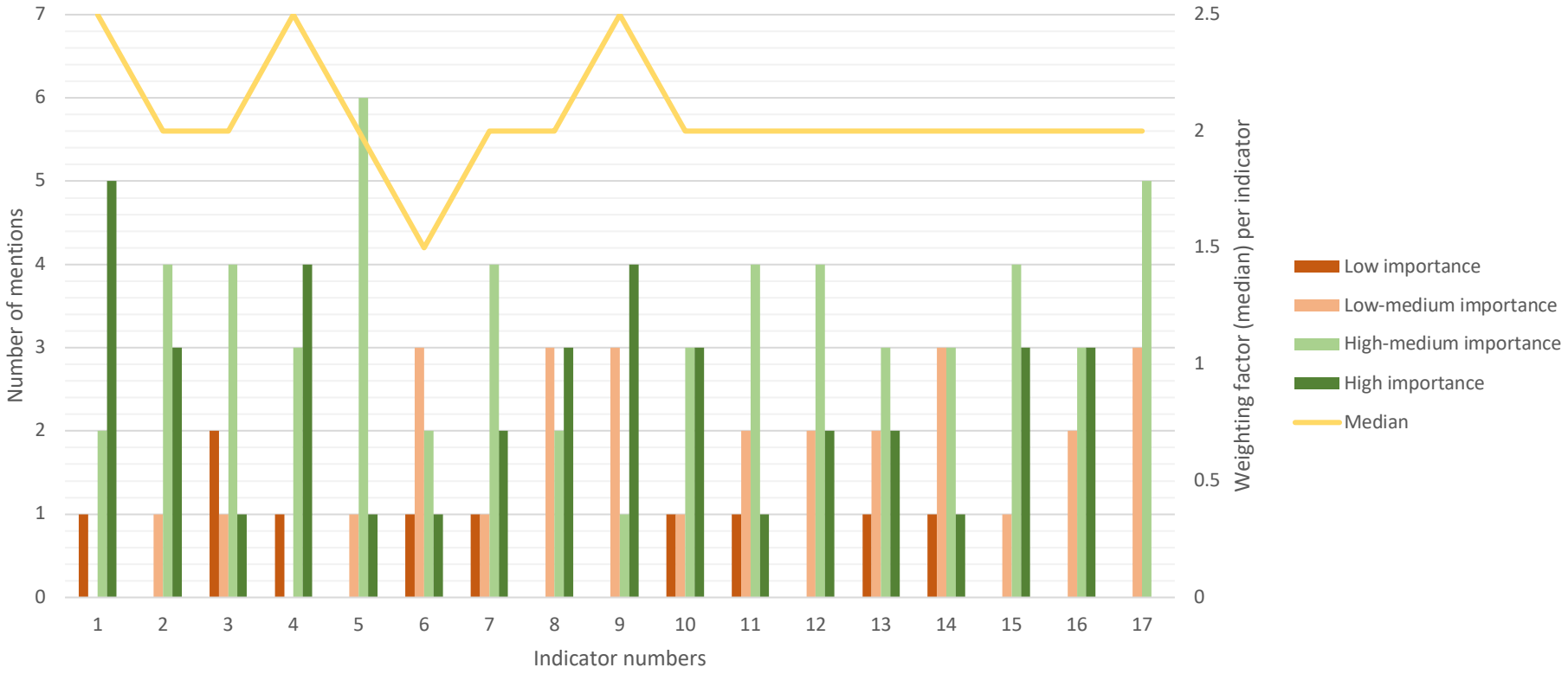


Figure 4: Coding scheme for interview coding

A3. Results importance scores



1. Strategy for the Circular Economy (incl. targets)	7. Design for repair, remanufacturing	13. LCAs for products
2. Embeddedness of the Circular Economy	8. Reducing the use of virgin material use	14. Re-use rate of by-products in production
3. Cooperations for Circular Economy	9. Reducing the use of toxic substances	15. Disposed
4. Revenue circular products/services	10. Extension of life-time	16. Share of renewable energy use (heat & electricity)
5. Supplier selection	11. Take back scheme/reverse logistics	17. Share of renewable energy use (transportation)
6. Customer & consumer awareness	12. Material passport for products	

Figure 5: Results of importance scores (frequency & median)

A4. Normalisation constants

Table 14: Calculation of normalisation constants for the three industry categories

Indicator		Producing industry		Facilitating industry		Consumer-oriented industry	
	Weighting factor	Indicator applicable	(max. score per indicator)	Indicator applicable	(max. score per indicator)	Indicator applicable	(max. score per indicator)
1. Strategy for the Circular Economy (incl. targets)	2.5	X	7.5	X	7.5	X	7.5
2. Embeddedness of the Circular Economy	2	X	6	X	6	X	6
3. Cooperations for Circular Economy	2	X	6	X	6	X	6
4. Revenue circular products/services	2.5	X	7.5	X	7.5	X	7.5
5. Supplier selection	2	X	6	X	6	X	6
6. Customer & consumer awareness	1.5	X	4.5	X	4.5	X	4.5
7. Design for repair, remanufacturing	2	X	6		0	(X)	0
8. Reducing the use of virgin material use	2	X	6		0	(X)	0
9. Reducing the use of toxic substances	2.5	X	7.5		0	(X)	0
10. Extension of life-time	2	X	6		0	X	6
11. Take back scheme/reverse logistics	2	X	6	X	6	X	6
12. Material passport for products	2	X	6		0	X	6
13. LCAs for products	2	X	6		0	X	6
14. Re-use rate of by-products in production	2	X	6		0	(X)	0
15. Disposed materials	2	X	6	X	6	X	6
16. Share of renewable energy use (heat & electricity)	2	X	6	X	6	X	6
17. Share of renewable energy use (transportation)	2	X	6	X	6	X	6
Max. possible points			105		61.5		79.5
Max. points after normalising			100		100		100
Normalisation constant			**1.05**		**0.615**		**0.795**

A5. Final assessment

1	**Strategy for the Circular Economy (incl. targets)**			
Definition	*A strategy on the Circular Economy means that the company is committed to close the material cycles, which it can do by reselling, repairing, remanufacturing, refurbishing or recycling products or by bringing back the biological nutrients to the biosphere to name a few examples. An important aspect is to keep the value of the products at the highest possible value or to increase the intensity of the product use. For examples of possible business models see Indicator 4.*			
All industries	We do not have a strategy on the Circular Economy	We are developing a strategy on the Circular Economy and are also developing KPIs to measure our progress	We have a strategy on the Circular Economy and are starting to measure our progress on a yearly basis	We have a formulated strategy on the Circular Economy, which is integrated in our organisation's strategy and was developed through involving internal & external stakeholders. We have targets towards a Circular Economy and measure our progress internally on at least a half-yearly basis and we communicate our progress at least once a year externally
2	**Embeddedness of the Circular Economy**			
Definition	*Embeddedness means that every department within the company is aware of the role each department plays in the transition towards a Circular Economy. This means that policies are in place which show the path of the transition towards a Circular Economy. Furthermore, budgets are allocated for the transition.*			
All industries	Circular Economy is not embedded in our organisation	Circular Economy is already or is about to be embedded in our sustainability/CSR department	Circular Economy is embedded in some of our departments (e.g. marketing & communication, production, purchasing, R&D) of the organisation	Circular Economy is embedded in all departments (e.g. marketing, production, purchasing, R&D, accounting & finance, HR) of our organisation, included in the bonus structure, trainings for the employees are organised and from the executive board down to the common employee everyone stands behind the transition

3	**Cooperations for Circular Economy**			
Definition	*Cooperations are needed to enable the transition towards a Circular Economy. The active involvement in these cooperations shows that a company is willing to learn and exchange with others to close the loops of its material flows. The highest level includes an active participation (e.g. co-design, cascade use of materials, policy influence).*			
All industries	We are not involved in cooperations on the Circular Economy	We are analysing possible cooperations on the Circular Economy	We are passively involved in cooperations with external stakeholders (e.g. association membership) and starting active cooperations	We are actively involved in cooperations with at least three different external stakeholder groups (e.g. associations, NGOs, other companies, competitors, governmental institutions and suppliers) to transition to a Circular Economy
4	**Revenue circular products/services**			
Definition	*The revenues from circular business models, show that a company has been able to implement the Circular Economy into its core business. Circular business models are considered to be (Product-based services (e.g. repair) - Pay per use (e.g. pay-per-wash) - Rent - Sales with a take-back premium or deposit - Lease (excluding financial lease and conventional car leasing) - Sharing platforms (e.g. car sharing) - Service with performance-based contracting). For a company in the facilitating industry this can mean, facilitating these business models.*			
All industries	We do not have any considerable revenues from circular products/services	<10% of the revenue comes from circular products/services	10% – 25% of our revenue comes from circular products/services	>25% of our revenue comes from circular products/services
5	**Supplier selection**			
Definition	*The sustainable supplier selection has already been implemented in more and more companies. On top of that if a company wishes to transition towards a Circular Economy it also needs to collaborate with its suppliers and at the same time set criteria for its suppliers (e.g. minimum amount of recycled/reused content in the product).*			
All industries	We do not encourage our suppliers to transition to a Circular Economy and we have no Circular Economy criteria for our suppliers	We encourage our suppliers to transition to a Circular Economy and are implementing Circular Economy criteria (additionally to the sustainable supply chain criteria)	More than 20% of our procurement spend is covered by Circular Economy criteria (additionally to the sustainable supply chain criteria)	More than 75% of our procurement spend is covered by Circular Economy criteria (additionally to the sustainable supply chain criteria)

6	**Customer/Consumer awareness**			
Definition	*Creating customer or consumer awareness for the Circular Economy can for example improve the client relation, grow the market share for a company or support innovation management. Customers or consumers that are aware of the Circular Economy value the ambitions of the company to transition towards a Circular Economy.*			
All industries	We are not involved in creating customer/consumer awareness on the Circular Economy	We are planning to create customer/consumer awareness for the Circular Economy	We are creating consumer awareness for the Circular Economy through our communication	We are creating consumer awareness for the Circular Economy through at least three different ways (e.g. communication, contracts, products, stakeholder engagement, procurement)
7	**Design for repair, remanufacturing**			
Definition	*Considering the end of life of a product already at the design phase, shows that the company is aware and wants to influence what happens to the product at the end of the use phase. It is considered to fulfil the indicator if the company has a higher repairability or possibility for remanufacturing than the industry average.*			
Producing & (consumer-oriented industries)	We have no sales of products, which are designed for repair, remanufacturing and/or disassembly	<10% of our product sales are designed for repair, remanufacturing and/or disassembly	10% – 25% of our product sales are designed for repair, remanufacturing and/or disassembly	>25% of our product sales are designed for repair, remanufacturing and/or disassembly
8	**Use of virgin material use**			
Definition	*The aim of the Circular Economy is to reduce the use of virgin material. Virgin material is considered to be virgin if it was produced or harvested specifically for the production of the product. Please consider for the ratio of the virgin material use the value of the material and not the weight.*			
Producing & (consumer-oriented industries)	100% of the materials in our products are virgin materials	>90% of the materials in our products are virgin materials	75% – 90% of the materials in our products are virgin materials	<75% of the materials in our products are virgin materials

9	**Toxic substances**			
Definition	*Toxic substances in products hinder the reuse or recycling of the material and can negatively affect the biosphere and are therefore considered to be removed from the products. Since toxic substances can also negatively affect the environment (e.g. workers, local communities, flora & fauna) they should also not be created in the process of the production even if they are not traceable in the product.* *For forbidden substances according to Cradle2Cradle see page 107ff:* *http://s3.amazonaws.com/c2c-website/resources/certification/standard/C2CCertified_ProductStandard_V3.1_160107_final.pdf* *For the SIN-list see:* *https://sinlist.chemsec.org/*			
Producing & (consumer-oriented industries)	Our policy on toxic substance use is to only stay within the law	We are currently adapting a list of forbidden chemicals, which goes further than the law	We do not use or produce any substances that are on the SIN list in our production	We do not use or produce any substances that are on the SIN list and on the C2C list in our production
10	**Extension of life-time**			
Definition	*Extending the life-time of a product makes better use of the invested energy and materials over the whole product lifetime. This can be done through different measures (e.g. extended warranty, offering repair services, setting up a second-hand market).*			
Producing & consumer-oriented industries	We do not offer a service to extend the lifetime of our products	<10% of our product sales are covered by a service, which leads to an extended product life time and is actually used.	<10% – 25% of our product sales are covered by a service, which leads to an extended product life time and is actually used.	>25% of our product sales are covered by a service, which leads to an extended product life time and is actually used.
11	**Take back scheme/Reverse logistics**			
Definition	*Setting up or being part of a take back scheme shows that the company puts a value at the end-of-life status of its products, and it is willing to return it to the material cycle. The reverse logistic system can be operated by the company itself, but it is also possible to be part of a larger take back scheme (e.g. industry operated).*			
Producing & consumer-oriented industries	We are not involved in taking our products back	We are setting up a reversed logistic system to retrieve our sold products	We offer a reversed logistic system for our products	We take producer responsibility for our products and actively encourage (e.g. through financial incentives) our customers to return the product in the highest possible quality to the value chain through reversed logistic systems

12	**Material passport for products**			
Definition	*Material passports are documents or files which include the amount all the materials that are included in the product. They are considered to be a useful source of information for the remanufacturing or recycling process at the product's end-of-life.*			
Producing & consumer-oriented industries	We do not have material passports for our products	We have material passports for <10% of our sold products	We have material passports for 10% – 25% of our sold products	We have material passports for >25% of our sold products
13	**LCA for products**			
Definition	*Life Cycle Assessments (LCA) calculate and document the environmental effects of the production and the use of a product on the environment. Ideally the LCA is conducted as an environmental product declaration or another applicable standard.*			
Producing & consumer-oriented industries	We have not conducted LCAs for our products	We have conducted LCAs for <10% of our product categories	We have conducted LCAs for 10% – 25% of our product categories	We have conducted LCAs for >25% of our product categories
14	**Re-use rate of by-products in production**			
Definition	*Re-using by-products of the production process help to close the material loops. The by-products can either be reused in the own production process or reused by another company. The re-use of the by-products should take place within 150km of the plant where they occurred.*			
Producing & (consumer-oriented industries)	<25% of the by-products from our production process (e.g. scraps, water) are reused	25% – 50% of the by-products from our production process (e.g. scraps, water) are reused	50% – 75% of the by-products from our production process (e.g. scraps, water) are reused	>75% of the by-products from our production process (e.g. scraps, water) are reused
15	**Disposed material**			
Definition	*Disposed materials consider all the materials which do not end up in the product or which are not used in another production process and are therefore landfilled or incinerated.*			
All industries	We send waste to incineration & landfill	We do not send any waste to landfill, but to incineration	We do not send any waste to landfill, but to incineration and have managed to reduce that amount substantially	We do not send any waste to incineration or landfill and enable this in the complete value chain

16	Share of renewable energy use			
Definition	*Renewable electricity or heat is considered to be renewable if it comes from wind, solar, water or biomass. Emissions which are offset with CO2 certifications do not count to be energy from a renewable source. Please consider the energy use in kWh or another suitable metric prefix.*			
All industries	<25% of our consumed energy (electricity & heat) is from renewable sources	25% – 50% of our consumed energy (electricity & heat) is from renewable sources	50% – 75% of our consumed energy (electricity & heat) is from renewable sources	>75% of our consumed energy (electricity & heat) is from renewable sources
17	**Share of renewable energy in transportation**			
Definition	*The transportation is considered renewable if it is powered by renewable electricity, biogas (2nd generation) or hydrogen from renewable energy sources. Please consider the payload-distance in tkm for this indicator.*			
All industries	None of our transportation is fuelled by renewable energies	<10% of our transportation is fuelled by renewable energies	10% – 25% of our transportation is fuelled by renewable energies	>25% of our transportation is fuelled by renewable energies