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Master Thesis

Measuring the Transition Towards a more Circular Economy: An Introduction to a Monitoring Framework for Organizations

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Abstract

This empirical research proposes a monitoring framework to assess the performance of organizations in terms of their contribution to the circular economy (CE). CE-practices recently gained attention as an approach to create value by retaining resources within the economy through value retention options (ROs) such as reusing, repairing, repurposing, recycling, etc. Despite that the debate on circular metrics is a growing topic, no consensus to date has been reached on indicators for assessing the ROs. Organizations lack effective performance indicators to measure their CE-progress and enable effective implementation. In this research, a monitoring framework of indicators is developed, classified according to ten ROs of the 10R typology. With the use of a case study analysis by secondary data, indicators have been identified for the ROs to advance the CE-strategy implementation for organizations. As organizations play a key role in the transition towards a more CE, the focus during this research was on indicators at an organizational level. These indicators allow managers to evaluate CE-objectives to implement innovative improvements in the actions taken by organizations that want to contribute to a more CE. However, the results obtained show that organizations heavily rely on the preservation of materials rather than on focusing on extending the life of products. Little indicators are found for the ROs for life extension for products and components. Therefore, further empirical research is needed to determine indicators for these ROs to complete the proposed monitoring framework.

Key concepts: *Circular economy, Value retention options, Monitoring framework, Performance measurement, Circularity indicators, Implementation.*

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1 Introduction

In recent years, the need for a transition towards a more circular economy (CE) has gained substantial attention from relevant actors of the society such as academics, businesses, and politicians. CE is aimed at "*replacing the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes"* (Kirchherr, Reike, & Hekkert, 2017, p. 224). The contribution that organizations can make to more material circularity is often expressed by the adoption of a set of value retention options (ROs) in the organization's strategy (Blomsma & Brennan, 2017; Bocken, Olivetti, Cullen, Potting, & Lifset, 2017; Rahman, Kim, Lerondel, Bouzidi, & Clerget, 2019). The concept of ROs is introduced as a technological perspective for effective implementation to achieve core goals of CE and to be able to have a more transformative view of the CE (Matova, Vladislav, & Miroslava, 2019; Reike, Vermeulen, & Witjes, 2018). The ROs, as operationalization principle of CE, should contribute to the realization of a shift towards sustainability by promoting waste and resource cycling and retaining the value of the products through the extension of their useful life (Blomsma & Brennan, 2017; Jawahir & Bradley, 2016; Nasr & Russell, 2018).

The concept of ROs has been the subject of many studies, with a variety of designations (i.e. R-strategies, hierarchies, typologies, frameworks or imperatives) and definitions emerging (Allwood, Ashby, Gutowski, & Worrell, 2011; EMF, 2013; Morseletto, 2020; J. Potting, Hekkert, Worrell, & Hanemaaijer, 2017; Reike et al., 2018). This diversity has led to ambiguity and vagueness about the meaning of the concept. Reike et al. (2018) have made the effort to develop a typology that clarifies the concept based on a visual framework where ten ROs are identified. The 10R typology is a single systemic typology of the ROs, which gives a scientific basis for the implementation of circularity. This typology is a summary of the most common views of the different perspectives on ROs and has set the first step towards a better understanding of the CE. However, measurements of the effects of ROs and CE-activities used by organizations are still scarce (Reike et al., 2018). Attempts have been made in various ways to develop circularity indicators to measure and quantify the CE-progress (Di Maio, Rem, Baldé, & Polder, 2017; EMF, 2015; Huysman, De Schaepmeester, Ragaert, Dewulf, & De Meester, 2017). Despite that many circularity indicators are introduced in recent years, there is a lack of an instrument that measure and quantify the CE-progress implemented by organizations.

The variety of definitions has contributed to lagging behind the development of an accepted measuring instrument and policy development needed for the transition towards a CE (Garcia, Cintra, Torres, & Lima, 2016; Niero & Kalbar, 2019). From a strategic point of view, it is essential to make objectives measurable using indicators, so that evaluation can be conducted. Evaluation of CE-objectives enables improvements to be made in the actions taken by the organization to contribute to a more CE. The development of a measurement tool is on top of that important to advance the discussion about CE to a higher level by creating a shared understanding and common language (Blomsma & Brennan, 2017). Although businesses and academics are motivated to develop new business models for the adoption and evaluation of CE, a tool that can be used in real-time assessment has yet to be developed (Jawahir & Bradley, 2016; Rahman et al., 2019; Veleva, Bodkin, & Todorova, 2017). The attempts to establish a link between the scientific literature and the field level are at present incomplete.

With this in mind, the purpose of this research is to explore to what extent the quantification of ROs can help the strategy implementation of organizations that want to contribute to a more CE. A contribution is made to advancing the assessment of CE-activities by proposing a monitoring framework with indicators classified according to the 10R typology. Although on a larger scale (international, national, and regional) attempts are also being made to contribute to the measurability of CE, it is important to first clarify which measurement methods can be used within organizations. Organizations are key players in accelerating the transition to a CE and have a major impact through circular innovations, business models, and initiatives. In addition, more and better interpretable and implementable indicators can be found at organizational level in both the scientific and practical literature. The focus of this research is therefore on finding indicators and measurement methods at an organizational level to promote the implementation of CE-strategies, before working on a larger scale. Based on an intensive case study, the activities and behavior around CE of organizations within a geographical area (i.e. Rijk van Nijmegen) are analyzed to gain insight into indicators for circularity. As a result, this research not only contributes to the CE-debate by proposing a monitoring framework for the measurement of the CE-process but also provide insight in the CE-activities of organizations within the case-study by testing the real-world implementation of the various ROs. Taken into account the complexity of the CE, the following research question is derived:

RQ: How can the quantification of the value retention options be able to measure and evaluate the contribution of organizations to the circular economy?

The structure of this research is organized as follows. Section 2 describes the results of the literature review on the core concepts around measuring circularity as some concepts in this research are open to multiple interpretations or are more complex than others. After first analyzing the use of indicators to enable performance management within strategic management, a link is made with the measurement of circularity within an organization. In Section 3 an outline of the research design is presented of how the real-world data will be collected and analyzed for attaining the aim of this research. The following two sections present the results of this research (see Section 4) and discussion of this research (see Section 5). Finally, a conclusion is presented in the last section including the practical implications, limitations, and an outlook for future research for the measurement of CE (see Section 6).

2 Literature review

2.1 Value retention options as strategies for CE

Organizations can contribute to CE by implementing a different set of actions and strategies such as extending the life span and reusing products, materials, components, and energy from discarded products (Vermeulen, Witjes, & Reike, 2014). By reducing material input and minimizing waste generation, the burden to the environment can be minimized (Moraga et al., 2019). Strategies utilized for implementing CE are so-called value retention options (ROs), also referred to as R-strategies, typologies, imperatives, frameworks, or hierarchies (Campbell-Johnston, Vermeulen, Reike, & Brullot, 2020; Rahman et al., 2019).

The 3R principles (Reduce, Reuse, and Recycle) is introduced in 1980 which gained increasing attention and is mostly used as a typology for CE (Jawahir & Bradley, 2016; Reike et al., 2018). Although the 3R principle is the basic and accepted principle of CE in theory and practice, various other R-typologies are recently further developed ranging from 3R to 10R with different meanings assigned to it. Recently developed R-typologies do not consider the differences between business-to-business (B2B), business-to-consumer (B2C), consumer-to-consumer (C2C) activities, in contrast to the 10R typology. In addition, principles such as 3R and 4R lack emphasis on high resource value retention (Campbell-Johnston et al., 2020; Reike et al., 2018). The 10R typology is developed by translating the most common, yet different perspectives on the resource value ROs into a typology. In short, the 10R typology of Reike et al. (2018) involves a hierarchy that can be divided in the shortest loops (R0-R3: Refuse, Reduce, Resell/Re-Use), medium-long loops (R4-R6: Refurbish, Remanufacture, Repurpose), and long loops (R7-R9: Recycle, Recover, Re-mine). This hierarchy emphasizes the importance of reducing consumption rather than recycling and recovery. The longest loops are mainly intended for traditional waste management activities and are the least desirable, although they can contribute to the ROs with shorter loops. This synthesis of the most common perspectives on R-strategies provides a clear understanding in the conceptualization of CE. Since this research will analyze organizations with different business models, it is essential to use a typology that takes this matter into account for a correct interpretation. For these reasons, the synthesis of the 10R typology by Reike et., 2018 is adopted in this study.

The definitions of the ten R-strategies of Reike et al. (2018) are identified in Table 2.1 10R typology of Resource Value Retention Options (Reike, Vermeulen, & Witjes, 2018) Defining the typology makes it possible to analyze, discuss, and quantify the definitions later in this research. The R-strategies apply to different actors in the lifecycle; the first four loops and R7 are related to commercial or non-commercial actors, R2, R3, R4, R5, R7, R8, and R9 apply to producers, businesses, and retailers (Campbell-Johnston et al., 2020).

R-imperative	Description
R0: Refuse	Choice of the consumer and/or producer to buy or use less to prevent waste creation and the use of specific hazardous materials.
R1: Reduce	Reducing the use of materials in production or in product design. For consumers to reduce the use of or being more careful with purchased products.
R2: Resell/ Re-Use	Bringing a product back into the economy after its first use by selling or buying it as a second-hand product, without (major) adaptations.
R3: Repair	Prolonging the life of a product to put it back into operation or make it as good as new by, among other things, replacing broken parts.
R4: Refurbish	Upgrading a product by leaving the structure of the multi-component product intact, but replacing newer, more advanced components with the old ones.
R5: Remanufacture	The dismantling, checking, cleaning, and, if necessary, replacing or repairing the entire structure of a multi-component product using recycled components.
R6: Repurpose	Giving the material a new life cycle by reusing end-of-life goods or components that have been adapted for another function.
R7: Recycle Materials	Material recovery by processing mixed flows of post-consumer products or post-producer waste streams through shredding, smelting, and other processes to capture virgin materials.
R8: Recover (energy)	Collection of waste to generate energy recovery through the extraction of elements or materials from the discarded composites or biomass.
R9: Re-mine	Selective collection and recovery of valuable materials or components from end-of-life products that can be used in other products or components.

Table 2.1 10R typology of Resource Value Retention Options (Reike, Vermeulen, & Witjes, 2018)

2.2 Performance indicators for strategy evaluation

Developing a good strategy with measures and targets in line with CE is a critical step towards a more CE. Formulating and implementing a good strategy, which is an essential part of strategic management, has been addressed as the main concept by several well-known authors (Chandler, 1962; Kaplan & Norton, 2001; Mintzberg, 1994; Porter & Kramer, 2003). Frequently used elements in an organization's strategy are the mission, vision, values, and objectives (Gurley, Peters, Collins, & Fifolt, 2014; Mintzberg, 1994). In formulating a strategy for an organization, in addition to these four elements, the measurability of the strategy is often taken into account through the use of indicators (Fuertes et al., 2020). Making the strategy measurable using indicators, ensures that it is possible to evaluate the impact of the strategy and to take any necessary actions based on relevant information (Gallopín, 1996; Pérez-

López, Moreno-Romero, & Barkemeyer, 2015). To support managers in decision making and to adjust organizational objectives with quantitative data, Key Performance Indicators (KPIs) are used that measure the financial, physical, and attitudinal aspects (Adams & Frost, 2019). These KPIs support the evaluation and planning of developments, investments decision, and related risks within the organization (Pérez-López et al., 2015). Qualitative data enable managers to understand the causes and consequences of activities and make it possible to interpret a particular situation (Fuertes et al., 2020; Van der Aalst, La Rosa, & Santoro, 2016).

Performance indicators, developed for the evaluation of strategies, is a performance management component that contributes to strategic management. More than two decades ago, the concept of performance management was often debated but rarely defined, just as the concept of CE is today. Neely, Gregory, and Platts (1995) proposed a definition for performance management, which was "*the process of quantifying the efficiency and effectiveness of action"* (p. 80). This quantification can be done with performance measures, which are metrics that quantify the efficiency and/or effectiveness of actions (Neely et al., 1995). The emergence of performance measurements shows that organizations need and want to link strategic objectives to performance standards. As a result of this need, performance measurement systems were developed in the early 1990s (Bourne, Neely, Mills, & Platts, 2003). The translation of an organization's strategy into indicators is helpful to monitor improvements within the organization and allow managers to identify what needs to be done to contribute to these improvements and the organizational objectives.

2.3 Indicators for measuring circular economy

The use of performance indicators in CE-objectives is key to enable sustainable strategies improvements within the organization. Controlled data through performance measurement helps managers of organizations to provide transparent information to both internal and external stakeholders and to guide organizational change in the right direction with more sustainable objectives and strategy (Sroufe, 2017). Measuring instruments that monitor the effects of CE adoption are needed to support decision-makers and policymakers in investment decisions for sustainability. CE-initiatives and strategies are not sustained without a clear evaluation and monitoring framework, which has to be an integrated part of the implementation to achieve CE-objectives (Kalmykova, Sadagopan, & Rosado, 2018; Saidani, Yannou, Leroy, Cluzel, & Kendall, 2019).

Several attempts have been made to develop CE-indicators or other measurement methods in both professional and scientific literature (Blomsma & Brennan, 2017; Di Maio et al., 2017; EASAC, 2016; EC, 2015; EMF, 2015; Huysman et al., 2017; Moraga et al., 2019; Saidani et al., 2019). Di Maio et al. (2017) propose the value-based resource efficiency (VRE) indicator to measure resource efficiency and circularity. The VRE indicator focuses on the value of inputs to the economy, such as energy and raw materials, in relation to output which is the added value of the economy. The efficient use of resources can be monitored on a local and global scale through this indicator. The EMF (2015) has attempted to develop an indicator system at product and company level to measure how well they perform in the context of CE. An indicator that is used in this system, is the Material Circularity Indicator (MCI) which "*measures how recovering the material flows of a product or company are"* (EMF, 2015, p. 2). The properties of a product, components, materials, and potential waste generation is measured with this indicator (Moraga et al., 2019). The University of Utrecht wrote a report commissioned by Economic Board Utrecht (EBU) with an advice on a framework for assessing the economic, social, and environmental impact of circular purchasing. In this report, a basis has been laid for a measurement method of the impact of circular procurement utilizing four components which are related to the functions of impact measurements and roles of actors (Vermeulen et al., 2014). This framework relates to the measurement of CE by translating the levels of circularity (in this study 7R-levels) into the framework.

Several international standardized tools have been developed for organizations to systematically measure and evaluate their social and environmental performance (Adams & Frost, 2019; Bocken et al., 2017; Gilbert, Rasche, & Waddock, 2015; Pérez-López et al., 2015). However, these tools cannot directly be related to CE and therefore cannot be used to measure the total circularity within organizations. The Global Reporting Initiative (GRI), for instance, is currently used as a standard for reporting of Environmental, Social, and Corporate Governance (ESG) issues. The GRI is a global network organization of different stakeholders that publishes a sustainability reporting framework internationally to voluntarily and transparently communicate the impact of business on critical sustainability issues (Gilbert et al., 2015; Levy, Szejnwald Brown, & De Jong, 2010; Veleva et al., 2017). The widely used reporting framework with a generic set of standardized indicators has drawn up guidelines requiring the total weight of hazardous and non-hazardous waste to be reported through disposal methods, such as re-use, recycling, composting, energy recovery, incineration, and landfill (GRI, 2020). Another commonly used measurement method is Life Cycle Analysis or Assessment (LCA) for identifying and quantifying the environmental impact of products and production processes. This standardized method quantifies indirect material and energy flows and related environmental and health impacts throughout the life cycle of a product or activity (Dieterle, Schäfer, & Viere, 2018; Scheepens, Vogtländer, & Brezet, 2016). Although LCA analyses environmental aspects and can analyze circular systems, such as Product-Service Systems and recycling systems, the instrument falls short in carrying the interpreting of CE (Haupt & Zschokke, 2017; Vermeulen et al., 2014).

A completely different, yet relevant, method to make CE more measurable is the Sustainable Development Goals (SDGs). In 2015, at the Sustainable Development Summit in New York, the Agenda for Sustainable Development was adopted by all United Nations member states, announcing, and focusing on 17 SDGs (IAEG-SDGs, 2016). These goals mainly provide guidance for policymakers and businesses in shaping a sustainable development strategy for peace and prosperity for people and the planet. The objectives include improving education, reducing inequalities, stimulating economic growth combined with tackling climate change, and conserving oceans and forests. Among these objectives, indicators have been drawn up by the Inter-Agency and Expert Group on SDG Indicators, which ultimately form a global framework for sustainable development. An example of an established Sustainable Development Goal is number 12.5 that states: "*by 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse*" (United Nations General Assembly, 2015, p. 27). While the SDGs may be related to the CE-perspective, the importance of CE in meeting SDGs has been disregarded by scholars and practitioners (Principato, Ruini, Guidi, & Secondi, 2019; Schroeder, Anggraeni, & Weber, 2018).

Finally, within the grey literature CE-indicators have been defined by the World Business Council for Sustainable Development (WBCSD) by developing the Circular Transition Indicators (CTI) framework with 25 companies. The framework is quantitative in nature and has been developed for companies from each sector, value chain position, and size to provide insight into and measure their process towards circularity (WBCSD, 2020). The CTI determines the circular performance through self-assessment by focusing on the design, procurement, and recovery processes of the circular and linear mass in the company. The assessment consists of the completion of three modules (Close the loop, Optimize the loop, and Value the loop) in which all three modules contain indicators. Although the content of the framework contains strong elements, the recently developed framework needs to be further tested by scientific literature regarding its accuracy for practical application.

Encouraging organizations to systematically assess, measure, and communicate their social and environmental performance and physical impact has led to the emergence of standardized tools as GRI, LCA, SDGs, and CTI but also other tools as SA8000, ISO 14001, and the Global Compact's Ten Principles. These reporting standards provide different mechanisms to improve the accountability of companies for economic, social, and environmental reporting (Gilbert et al., 2015). Mechanisms such as indicators and guidelines help organizations to communicate their social and environmental impacts to interested stakeholders and to apply changes within strategy implementation (Rasche & Lenssen, 2010). Developing a framework or method, such as CTI, with mechanisms as Key Performance Indicators allow organizations to create transparency within decision-making, planning, and performance management. In summary, from the professional and scientific literature, it is evident that both quantitative and qualitative indicators are desirable for measuring the circularity of organizations. At present, various instruments and indicators have been developed that measure certain parts of circularity, such as waste data, energy use, or use of hazardous materials. A good comparison with the practice for evaluating the impact of multiple circularity activities or initiatives is, however, still lacking. The literature stresses the need to raise awareness and improve measurement methods to accelerate the transition to a more CE-standard. The emphasis here is on source and consumption reduction, re-use, redesign, and life extension of products and services. An effective approach to advance the CE should include indicators to measure both output and impact to provide transparency and measurability of organizations' contributions. This allows managers to adjust and improve the organizational objectives to contribute to the transition towards a more CE.

2.4 Conceptual framework

The conceptual framework provides the link between the scientific business literature for strategic management and the literature of CE. As stated, performance indicators help to formulate a strategy in which the impact of the implementation can be measured. Indicators for circularity have been identified within the existing literature and included in the conceptual framework (see Figure 2.1). Besides indicators, standardized instruments have been developed to make the CE-process measurable and transparent, which have also been included in the conceptual framework. The aim of this framework is to enable the identification of other possible measurement methods in addition to the CE-indicators and instruments found in the existing literature. The 10R typology functions as a scientific lens for analyzing the (secondary) data of this research and possible indicators or methods are classified according to the ten ROs based on the framework of Reike et al. (2018).

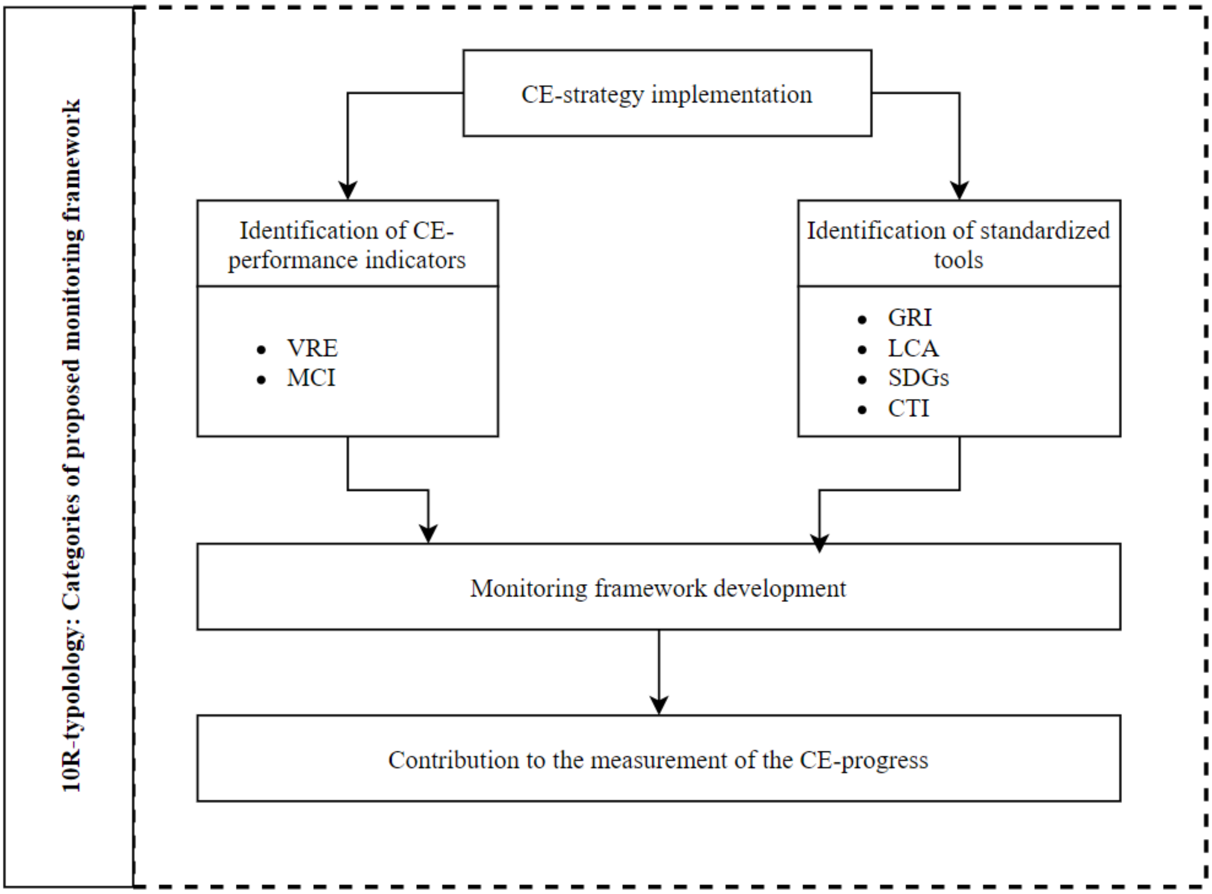

Figure 2.1 - Conceptual framework for classifying circularity indicators

3 Method

3.1 Research design

To provide an answer to the research question, a qualitative study with a descriptive nature was conducted. As the current situation regarding the quantification of CE for organizations will be identified during this research, the research method chosen is of a descriptive character. Concepts are operationalized in detail prior to the data collection by establishing a coding scheme, which gives the research a deductive way of reasoning (Bleijenbergh, 2015; Sekaran & Bougie, 2016). To determine which current measurement methods are used by organizations to quantify CE, a case study analyses was conducted. A case study focuses on collecting detailed information about a certain concept to gain a better understanding of the problem (Sekaran & Bougie, 2016; Yin, 2009). In this study, the sample case is the research strategy in which the phenomenon within its real context is examined using secondary data for data gathering. This case study provides in-depth qualitative data for analysis and interpretation. Therefore, the results of this research are presented by means of verbatim descriptions.

3.2 Case description

A case study was carried out into a circular partnership that faces the problem of a lack of insight and clarity in measuring CE. This partnership is a collaboration between organizations, investors, knowledge institutes, entrepreneurs, consumers, and governments within a geographical area of eight municipalities (Rijk van Nijmegen (Rvn)), called RvN@. RvN@ was created in 2016 through dialogue sessions in each municipality in which 25 projects emerged that form the substantive basis of the movement (RvnN@, 2018). A separate collaboration within this partnership has been established with as focal theme circularity in the region, called RvN@Circulair (also referred to as the Circular Council). This partnership aims to contribute to more circularity in and around RvN by devising sustainable innovative solutions. Various initiatives have arisen in the field of renewable energy and CE through this network of various parties. Workshops are, for example, organized by the Circular Council to enable parties interested in becoming part of the transition to more circularity in the region (Roemers, Galle, & Kennedy, n.d.; RvN@Circulair, 2020). The implementation program presents objectives for achieving a more circular region. These objectives are coherent with municipal, provincial, and national plans.

However, there is a lack of a monitoring framework capable of identifying and monitoring the progress of the circularity within the region to allow the evaluation of these objectives. Although the research has taken place at an organizational level, it will contribute to the problem of the Circular Council by developing an instrument that can be used for implementation by the organizations within the RvN. This case study provides information needed to get insight into mechanisms that are used by organizations to make organizations' CE-objectives measurable. The 10R typology by Reike et al. (2018) functions in this case study as a scientific lens for analyzing and reviewing the CE-activities of the organizations within the geographical area of RvN. The scope of this study, therefore, includes the organizations that are located within the geographical area of RvN.

3.3 Data collection

The data collection took place over a short period with one research and measuring moment. The documents drawn up by and/or for RvN@ were collected for attaining an understanding of the problem regarding the measurability of CE. A total of ten documents attained by RvN provided insight into this matter. Based on these documents, the organizations were selected that are included in the analysis. When selecting organizations within the RvN, differences in size and sectors have been considered.

A necessary step in this research was to develop a national impression of the needs and experiences of Dutch organizations regarding the measurability of CE. The Netherlands Environmental Assessment Agency (PBL) has a wide range of information on CE within the Netherlands. These documents are analyzed to obtain a clear, rather objective understanding of the situation at a national scale regarding the current methods of measurement for CE at organizational level. In addition, it has been decided to included data of two organizations (Philips and KPN) in the analysis. Although these two organizations are not established within the RvN, they are active in contributing to the CE on a national scale through innovative initiatives, collaborations, and development. A total of 27 documents and websites were collected to gain an impression on how organizations in the Netherlands define and measure the concept of CE.

Finally, information about the organizations within RvN is collected. The document search was carried out by effectively collecting texts produced by the organizations. A total of 18 organizations within the RvN have been analyzed based on 69 documents and websites.

An overview of the documents and websites used that contained information regarding the current situation in the Netherlands, within the region RvN, and at the organizational scale is provided in Appendix I: Analyzed documents and webpages. These documents include annual reports, websites, policy reports, sustainability reports (SR), project proposals, and implementation programs. By performing the analysis within three different scales, a comparison can be made between the national, regional, and organizational scale regarding circularity using the 10R typology. As mentioned earlier, the focus of the analysis and interpretation is on indicators at the organizational level.

3.4 Data analysis

An intensive document-analysis is performed within three different scales with the ten retention strategies as a scientific lens. To analyze elements of the 10R typology and possible associated measurement methods a Computer Assisted Qualitative Data Analysis Software (CAQDAS) package was used. This package consists of content searching, coding, linking, and mapping tools to analyze and manage gathered information. After collecting the data, the first step in the analysis involved a detailed reading of the documents. The data is reduced to relevant data by developing a selective coding scheme. By selectively encoding the data, it becomes possible to identify patterns in the social phenomenon (Bleijenbergh, 2015). The coding scheme is derived from the 10R typology and contains predetermined categories to be able to systematically generate information and record what is analyzed (Sekaran &

Bougie, 2016). The purpose of the analysis is to examine the use of the ROs and how this is measured. Therefore, the coding scheme is focused on identifying and coding different perspectives on these ROs and their measurability. The coding scheme has been drawn up in Dutch, as the data analyzed are mainly written in Dutch. The coding scheme is made visible and added in Appendix II: Coding scheme.

Interesting parts of the analyzed documents are marked using the coding function within the CAQDAS package. This enabled easy retrieval of the relevant data during the interpretation. This method of coding is in line with the qualitative research method 'discourse analysis' (Bleijenbergh, 2015). The written literature has been placed in relation to its social context to better understand the language in real-life situations. The discourse analysis examined how the language surrounding CE functions with the 10R typology as perspective. Finally, also with the help of the CAQDAS package, the data has been interpreted for detailed information and possible connections. The findings were critically assessed for usability in order to relate them to existing literature. At the same time, this critical view ensured that contradictions in the data could be identified. The document analysis considered the distinction between measurement at the national, regional, and organizational levels in which the organizational level has been leading for the analysis of the current quantification of CE.

3.5 Limitations and research ethics

For validity, the coding scheme has been drawn up based on existing literature. The literature was selected based on its relevance to the research problem. In doing so, account was taken in the need to consult recent literature for this research context. This is particularly important for the concept of CE, as this concept is currently receiving enormous attention from academics, businesses, and politicians.

Since this study is qualitative, it is not possible to prove internal validity in a statistical way (Bleijenbergh, 2015). Instead, a plausible link will be demonstrated in the findings and discussion section. This is done by keeping a critical view and verifying in the existing literature whether the connection occurs in this way. The reliability of the study refers to the consistency of the measurement instrument used for this study. Since no more than one measuring instrument has been used, it is not possible to make a comparison of the result which decreases the reliability. Also, one case was used, while an increase in the number of cases can increase the reliability because there is less room for specific or coincidental variance. The reliability of the study has been increased, however, by using computer-assisted coding. The CAQDAS program ensures that coding is done according to a certain format. This allows the working method to be imitated by other researchers (Bleijenbergh, 2015; Hair, Black, Barry, & Anderson, 2017; Sekaran & Bougie, 2016).

The data used from PBL and the organizations was online available. Information from and conversations with stakeholders from RvN@, however, was shared in confidence. The exchange of information is handled with integrity, caution, and respect for intellectual property. The code of conduct during this investigation will be followed according to the guidelines of the American Psychological Association (2009). The researcher did not work for the parties studied during the research in order to be as objective as possible and to maintain a distance from the organizations.

4 Findings

The findings of the research are presented in this section according to the 10R typology. Within the three scales (national, regional, and organizational), it has been analyzed to what extent the strategies of the 10R typology have been used. Figure 4.1 presents these findings, which are calculated proportionally from the output of the CAQDAS program (see Appendix III: Output (ATLAS.ti)). During the analysis, it has considered that the definitions and interpretations relating to the ten R-strategies within the data are consistent with the literature used. This is an important aspect to note as there is a lack of clarity and a coherent conceptualizing concerning the CE. Table 4.1 enables a recognition of the R-strategies used by the analyzed organizations, including the organizations within the national scale (Philips and KPN). It was subsequently examined whether the specific R-strategy was measured using an indicator. The overall data resulted in 13 found indicators at an organizational level for the ten R-strategies. Additionally, three measurement tools or instruments are found within the data (see Table 4.2).

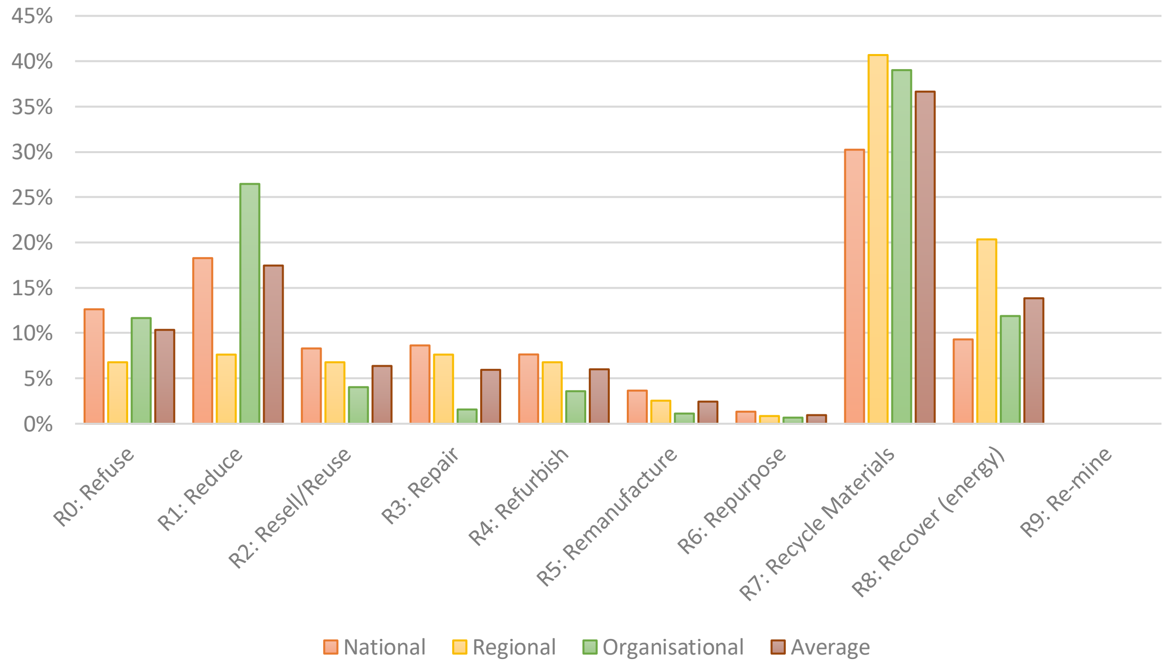

Figure 4.1 - Degree of use of R-strategies within the three scales

<u>Refuse: R0</u>

Within the national and organizational scale, the first retention strategy takes place above average compared to the regional scale, as can be seen in Figure 4.1. On average, this R-strategy is used for 10% within the three scales. The coding data shows that R0 is often related to the procurement process of organizations. Alliander procures, for example, a large proportion of its primary assets and materials circularly to prevent waste of raw materials in business operations and to enable re-use (Alliander, 2017). Radboudumc has, besides a circular purchasing strategy, developed a joint plan for the realization of 'zero waste' by, for example, working paperless and avoid food waste (Radboudumc, 2017).

Two measures have been found that are linked to R0. The first measurement method found in the data corresponding to R0 is the percentage of circularly purchased materials/goods, which is applied by one analyzed organization. Alliander reports that the organization procured 30% of its purchasing volume in circular form in 2019 and is aiming for 60% circular procurement of its primary assets by 2025 (Alliander, 2017). The procured products designed and produced without the use of hazardous or virgin materials and for the avoidance of waste are monitored as a result. A second relationship was found between R0 and the application of SDG 12 in the objectives of the analyzed organizations. After analyzing the global indicator framework on the 17 Sustainable Development Goals for the relevance of measuring the CE, it emerged that SDG 12 can assist when measuring R0. Both within the national and organizational scale, SDG 12 has repeatedly come to light. A sub-goal within Goal 12 is, for example, to achieve sustainable management and efficient use of natural resources. The indicators used by this sub-goal are the material footprint (per capita/per GDP) and material consumption (per capita/per GDP). Philips, Alliander, KPN uses the SDGs when reporting the activities of the organization that contribute to the CE (Alliander, n.d.-c; KPN, 2020; Philips, 2020).

Reduce: R1

As shown in Figure 4.1, Reduce (R1) is more frequently analyzed in the data than R0. However, like R0, R1 is more analyzed in national and organizational data compared to the regional data. On average this strategy is applied for 17%, while within the regional scale this strategy is applied for 8%. The coding data revealed that different types of initiatives take place within this strategy. In national data, for example, initiatives have been found to participate in the sharing economy. Sharing washing and drying facilities are identified by PBL to make more effective use of a product over time (J. Potting, Hekkert, Worrell, & Hanemaaijer, 2016). Deploying the R1-strategy in this manner is not found in the regional and organizational data. Within the organizational scale, reference is mainly made to the more economical use of products and more efficient use of primary raw materials. Frequently used terms were minimization, reduction, and less use.

The majority of the initiatives found in the data to contribute to the CE through R1 have not been measured in specific indicators. An example of an initiative found within all the three scales is the Green Deal Sustainable GWW 2.0. This initiative aims to make the concrete chain more sustainable by reducing the use of primary raw materials by making the products and materials smarter (Dura Vermeer, 2019). However, it is reported that quantitative targets and indicators are lacking in these agreements (Ganzevles, Potting, & Hanemaaijer, 2016) and are therefore not included in this study. Indicators for R1 that have been found, however, have been used in the same way by several companies. Reducing the generation of waste has been monitored by five organizations by the indicator: reduction of (residual) waste. Radboudumc has set itself the target of reducing residual waste by 5% in 2020 compared to 2015 through sustainable procurement (Radboudumc, 2017). While there is a similarity in the monitoring of the amount of (residual) waste in order to reduce this amount, these figures are recorded in different units and/or definitions. KPN shows this volume for non-hazardous & hazardous waste in tons, while Radboudumc and Dar have focused on the volume of residual waste in kilograms (Dar, 2019a; KPN, 2020; Radboudumc, 2017). Philips and AVR measure the volume of residual waste in kilotons (AVR, 2020; Philips, 2020).

Food waste is related to both R0 as R1. Reducing food waste is mentioned in the data which differs from preventing food waste. Although the reduction of food waste is an objective for some of the analyzed organizations, no more than one organization seems to measure this contribution to the R1. Radboudumc has set the target of reducing food waste by no more than 8% by 2019 (Radboudumc, 2018). The use of fossil fuels was monitored by four organizations and can be linked to R1 as these organizations aim to reduce this use. For NXP and Philips, fossil fuel includes the use of hydrocarbons, primarily coal, fuel, oil, or natural gas, and is measured in Gigajoule (GJ) (NXP, 2018a; Philips, 2020). KPN measures fuel consumption in liters for petrol, diesel, and LPG (KPN, 2020). SGB-SMIT measures the use of fuel oil in tons (SGB-Smit Group, 2017). Finally, like R0, SDG 12 can be related to R1. SDG 12 provides indicators, such as the efficient use of natural resources and the reduction of food waste, which are linked to R1. Like R0, seven organizations relate their activities to SDG 12, as can be seen in Table 4.2.

<u>Resell/Re-Use: R2</u>

Resell/Re-Use as RO is used less frequently in contrast to the first two ROs (see Figure 4.1). During the analysis of R2 difficulties were encountered in making a distinction between the re-use of products with the same function with little or no changes in the structure (R2) and the re-use of products after they have been discarded (R7). The concept of re-use was a commonly used term within the data that was open to multiple interpretations. Although at first sight this term would be interpreted and coded as Resell/Re-use (R2), the critical perspective during the analysis allowed a distinction to be made between the actual Resell and Re-use (R2) and the Re-use after disposal (Recycle (R7)). Within the context of the data, the re-use of products and materials was more often used as a strategy for Recycling (R7) since the products and materials were not explicitly resold or re-used but re-used after disposal. Specific initiatives on R2 that have been found within the three scales, are re-using PC hardware, re-use of carpets (REBus, 2017), circulation of, for example, home decoration, furniture, bikes, and whiteboards (BikeWerk, 2016; Dar, n.d.-b; Het Goed, 2020; Radboudumc & Radboud Universiteit, 2016), re-use of batteries (ARN, 2019a), and re-use of construction materials (Dura Vermeer, n.d.-a; Roemers et al., n.d.). Although these initiatives have been identified and explained by organizations, none of the analyzed organizations indicated how these initiatives are measured or monitored. Table 4.2 presents that no indicators for R2 have been found in the data.

Repair: R3

As Figure 4.1 shows, the R-strategy for maintaining and repairing products to prolong their lifecycle is a non-common strategy in the data. Although repair shops are included within the organizational scale, repair activities are used four times as many within the national and regional scale as the organizational scale. Preventive maintenance of the organizational assets (Alliander, 2017; AVR, 2019b; NXP, 2018a) and repairing consumer goods (BikeWerk, 2016; RepairCafé Nijmegen, n.d.) are main activities performed for R3 within the data on the organizational scale. Within the regional scale, mainly activities of initiators have emerged that repair furniture or consumer electronics to bring it back into the same function. Repair activities take place in craft centers or special 'repair cafes' to bring a product back into the economy by putting it back to work (Gemeente Nijmegen, 2019a; Roemers et al., n.d.). R3 is most frequently used as a strategy to contribute to the CE within the national scale compared to the other two scales. This can be traced back to all repair shops that PBL includes in its analysis. According to PBL, most of the circular activities within the Netherlands are in the field of R3, of which 69% consumer goods (Kishna, Rood, & Prins, 2019). While there is extensive reporting on this strategy within the national scale and some initiatives have been found in the other two scales, no indicators have been found that can contribute to the measurement of repair activities related to R3.

Refurbish: R4

Replacing components to give a complete upgrade to a product (R4) is a strategy that is the least common within the organizational scale. The procurement or use of refurbished products (REBus, 2017) and refurbishment of facilities, goods, and instruments (NXP, 2018a; Radboudumc, 2018; Royal HasKoningDHV, 2020) are ways within the organizational scale to contribute to CE using R4. A model project for this strategy is Royal HaskoningDHV's approach to its office furniture by having 375 refurbished chairs in possession for its offices (REBus, 2017). Within both the regional and national scales the upgrading of medical equipment is identified which can be linked to this strategy (Philips, 2020; Roemers et al., n.d.). Within the national scale, KPN and Philips, in contrast to the organizations within the organizational scale, are strongly committed to this strategy by applying it in their business activities (KPN, 2018; Philips, n.d.). However, no measurement methods have been found within the three scales that can make R4 quantifiable.

Remanufacture: R5

Remanufacture is one of the three least used strategies of the 10R typology within the data. The implementation of this strategy was often not explicitly mentioned but in terms such as 'disassembled of', 're-use of (recycled) components', and 'sustainable repair'. Alliander reported some innovative approaches to manufacturing such as using current assets longer and, where possible, replacing assets with recycled materials (Alliander, 2020b). Unlike the other documents, Royal HaskoningDHV specifically refers to the deployment of this strategy by referring to 'remanufacturing desks' (RoyalHasKoningDHV, 2020). Yet the data does not provide indicators to measure R5.

Repurpose: R6

The last and least used strategy of the medium loops is Repurpose (R6) which has been used negligibly within the three scales. The strategy has been used for only 1% within all three scales. Some initiatives have been found, such as using interior doors as flooring and reusing furniture in a different function (Roemers et al., n.d.). In addition, the use of coffee grounds as a growth substrate for oyster mushrooms is coded in this category as it is used for a completely different function before disposal (Radboudumc, 2017; Versfabriek, 2020). No separately reported indicators for R6 have been found in the data.

Recycle Materials: R7

Recycling of materials is the most frequently used strategy of the ten ROs within all three scales, as the strategy is used for 37% on average (see Figure 4.1). The use or generation of recycled materials to avoid the use of new raw materials is practiced by 17 of the 20 organizations analyzed, as can be seen in Table 4.1. The recycling of waste electronic devices, agricultural residues, plastics, and raw materials is a small selection of the many recycling initiatives. This strategy has been used more frequently within the regional and organizational scale than within the national scale. One reason may be that various waste processing organizations/waste plants are located within RvN and these are also included in the analysis of the organizational scale. However, PBL reports in its documents that most initiatives within the Netherlands are mainly focused on the recycling of materials, such as the goals and ambitions of Green Deals Circular Economy (Ganzevles et al., 2016). In addition, most innovative projects for CE within the Netherlands are aimed at recycling, such as the development of innovative technologies to replace fossil raw materials with raw materials from residual flows (Kishna, Rood, et al., 2019).

An indicator for R7 used by seven organizations is the recycling rate, as shown in Table 4.2. Radboudumc, Alliander, Dura Vermeer, NXP, and Philips monitor the percentage of their waste that is recycled (Alliander, 2017; Dura Vermeer, 2019; NXP, 2018a; Philips, 2020; Radboudumc, 2018). KPN reports how many tons of its total waste is recycled (KPN, 2020). A second indicator found in the data is the waste separation rate. The separation of waste is an important step for making recycling possible. For this reason, Dar and Radboudumc have monitored the percentage of separated waste (Dar, 2017b; Radboudumc, 2018). E-waste are discarded devices and energy-efficient lamps that can be recycled to avoid the use of new materials. Dar has monitored the amount of kilograms of e-waste that is returned to the eco-streets to clarify what percentage of the raw materials for new products are returned. This indicator is therefore twofold. Firstly, the indicator monitors how much e-waste is returned; secondly, a percentage of the returned raw materials is calculated (Dar, 2017a). Radboudumc has additionally monitored the percentage of its waste that is electronic (Radboudumc, 2017). A final indicator that has been reported for R7 is the amount of raw materials repaired or separated by AVR. These materials consist of minerals, plastics, synthetics, metals, molybdenum, and TopCrete that are recovered for re-application (AVR, 2020).

Recover energy: R8

Recover energy is, after R7 and R1, the most frequently used strategy found in the data. Within the regional scale, energy recovery is more common as a strategy for CE compared to the other two scales. Similar to R7, this is due to the number of waste processing plants that are located within the RvN, about which more has been reported. Using the collected e-waste as fuel through energy recovery is an example from the organization Dar (Dar, 2017a). Converting (residual) waste into energy and district heat (AVR, 2019b; Dar, 2017b) and burning diaper material with energy recovery (ARN, 2019b) are other examples related to R8. In addition, this strategy has been found in the data several times in combination with or in addition to R7. For instance, the paper is used as a heat source by AVR after recycling seven times, after which it can no longer be re-used (AVR, 2018a).

AVR monitors three different corporate activities that can be related to R8. A first quantification is the amount of kilotons of waste is processed annually by AVR. The processing of this quantity of waste results in energy output in electricity, steam, and heat which are recorded in Pj (AVR, 2019b). The last quantification found is a percentage of biogenic/green energy supply supplied by AVR (AVR, 2020). An indicator found that is consistent with this, but is produced and reported differently, is the amount of green gas and fertilizer production by incineration of waste. This indicator is quantified by ARN by reporting how many tons of waste is processed using a fermentation and composting plant (ARN, 2018). As stated earlier in R7, the Dar keeps track of how much e-waste has been collected for recycling for raw materials. In this process, some end-of-life devices cannot be used for recycling, resulting in them being used as fuel with energy recovery. This activity is monitored by the Dar in percentages which contribute to the measurability of R8 (Dar, 2017a). A final indicator for R8 that is also reported by several organizations is the monitoring of SDG 7. SDG 7 is linked to R8 as it has included indicators for renewable energy. The overall objective for SDG 7 is to guarantee affordable, reliable, sustainable, and modern energy for all. In total, six analyzed organizations relate their business activities to SDG 7.

Re-mine

Within all three scales no results were found regarding the use of quantification of the last strategy R9.

Company	*Fair Coffins*	*Alliander*	*ARN*	*AVR*	*Dar*	*Dura Vermeer*	*NXP*	*Radboudumc*	*Trash'ure Taarten*	*RoyalHasKoning DHV*	*SBD Smit Group*	*Het Goed*	*Van Eigen Deeg*	*Bike Werk*	*Be O Bottle*	*Stadsboom*	*Versfabriek*	*Repaircafé Nijmegen*	*KPN*	*Philips*
Refuse (R0)	x	x		x		x	x	x	x	x			x		x				x	x
Reduce (R1)		x	x	x	x	x	x	x		x	x					x			x	x
Resell/Reuse (R2)					x	x		x		x		x		x		x			x	x
Repair (R3)		x		x			x			x				x				x	x	x
Refurbish (R4)		x				x	x	x		x									x	x
Remanufacture (R5)		x								x									x	x
Repurpose (R6)						x		x									x			x
Recycle Materials (R7)	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x		x	x
Recover (energy) (R8)			x	x	x			x		x							x		x	x
Re-mine (R9)																				

Table 4.1 - Application of the ten R-strategies

As can be seen in Table 4.1, none of the organizations applies all ten R-strategies. The findings revealed that for certain sectors in which organizations are active, it is more unusual and challenging to implement R3 and the medium loops R-strategies. For these sectors, such as the food sector and waste processing sector, their core activities cannot be designed for these R-strategies, making it impossible to develop a business plan that implements these R-strategies. The life extension of food by refurbishment or manufacturing, for instance, is practically not possible to accomplish. In addition, organizations were not aware that these ten ROs contribute to CE and do not report on these ROs. Since CE is a relatively unknown concept for organizations, partly due to the lack of unambiguous definitions, the development of the 10 R-options may be an unknown concept for organizations. Within the national scale, for example, the strategy Repair (R3) was mentioned to a higher degree compared to the other two scales. This is due to that PBL is aware of the contribution of Repair (R3) to CE in contrast to the organizations. PBL reports in its data a high contribution to CE through the repair of consumer products by including all repair shops in the Netherlands. This creates a distorted picture of the use of strategies, as the other two scales do not report specifically on Repair (R3) as a strategy.

Monitoring framework interlinking 10R typology and indicators found in the data

Table 4.2 has been developed by linking the indicators found in the data to the ten R-strategies, which represent the final proposed monitoring framework from the data. 13 indicators were found used by the organizations that could be allocated to an R-strategy. In addition, the data analyzed repeatedly referred to CE by means of SDG, LCA, and GRI. These measurement methods or systems could not be directly assigned to an R-option, except for SDG 12 and SDG 7 (as shown in Table 4.2). Although the categorization of SDG, LCA, and GRI was not directly possible, they may be useful for providing information on circularity. For this reason, the methods/systems are included in the analysis and added at the bottom of the monitoring framework.

Table 4.2 shows which indicators have been found in the data and which organizations use them. During the analysis of the data, patterns were found in the extent of R-strategies used and indicators developed. The more often an R-strategy was used within the data (Figure 4.1), the more corresponding indicators were reported (Table 4.2). The performance indicators for quantifying Reduce (R1), Recycle (R7), and Recover energy (R8) have been defined in more detail, which is also the most commonly used R-strategies within the data (as shown in Figure 4.1).

	Alliander	ARN	AVR	Dar	Dura Vermeer	NXP	Radboud umc	RoyalHas KoningDHV	SGB-SMIT	KPN	Philips
Refuse (R0)											
• Percentage circular purchasing	x										
• SDG 12	x				x	x		x		x	x
Reduce (R1)											
• (Residual) waste reduction			x	x			x			x	x
• Food waste reduction							x				
• Fossil fuel reduction						x			x	x	x
• SDG 12	x				x	x		x		x	x
Resell/Reuse (R2)											
						N.a.					
Repair (R3)											
						N.a.					
Refurbish (R4)											
						N.a.					
Remanufacture (R5)											
						N.a.					
Repurpose (R6)											
						N.a.					
Recycle materials (R7)											
• Recycling Rate	x	x			x	x	x			x	x
• Waste separation rate				x			x				
• Quantity of kilograms of handed in e-waste				x			x				
• Quantity of recovered and separated raw materials*			x								
Recover energy (R8)											
• Amount of waste processed in kiloton			x								
• Total Energy Output (Steam, Heat, Electricity)			x								
• Percentage biogenic/ green energy supply			x								
• Amount of gas/fertilizer produced through incineration of waste		x									
• Percentage e-waste as fuel with energy recover				x							
• SDG 7	x				x	x		x		x	x
Re-mine (R9)											
						N.a.					
Other CE-measurements											
• SDG	x				x	x		x		x	x
• LCA	x	x	x		x			x			x
• GRI	x					x	x	x	x	x	x

*Minerals, synthetics, metals, plastics, molybdenum and TopCrete

Table 4.2 - Reported indicators classified according to the 10R typology

5 Discussion

Within Refuse (R0) the relevant coding data shows that this strategy is frequently reflected in the procurement process of organizations as the purchasers and designers of a product or service avoid the use of specific hazardous materials. The connection between the activities of circular procurement and strategy is an important, yet often missing factor (as discussed by Vermeulen et al., 2014). Closing the loop by circular purchasing is measured in the data by the indicator: the percentage of circularly purchased materials and goods. The impact of the circular procurement process by refusing the use of specific hazardous materials can be evaluated by this indicator, which is therefore been included in the proposed monitoring framework (provided in Table 5.1). Although this indicator provides insight into an organization’s purchasing decisions, it does not provide insight into the product design of a business model, which is also an integral part of R0. The MCI indicator of the Ellen MacArthur Foundation focuses on both aspects: the product design and purchasing decisions (Saidani et al., 2019). For this reason, the MCI indicator has also been added to the proposed monitoring framework for the first RO. The inclusion and application of these two indicators enable organizations to make a statement about the strategy Refuse (R0).

Formulating KPIs to evaluate the performance of an organization’s strategy against existing objectives provides insight into the impact of a process (as discussed by Pérez-López et al. (2015) and Adams and Frost (2019)). The outcomes show that sustainable strategies and KPI’s are developed by linking the SDGs to business activities and objectives. Contributions made by organizations to the SDGs are reported in the data based on self-formulated KPIs. Although the SDGs are appointed by the organizations analyzed, it is evident from the data that the organizations do not use the corresponding indicators of the SDGs. This is because the indicators of the SDGs have been developed at the regional and national level, which means that these indicators cannot directly be assessed by organizations (see IAEG-SDGs, 2016). While the list of indicators for SDGs offers a set of useful and appropriate indicators for measuring CE, steps still need to be taken to make them applicable to organizations. In addition, the relationship between the SDGs and business activities for CE may depend on current insights and understanding of CE. The contributions to SDG 7 (Energy recovery) and SDG 12 (Material consumption and recycling) found in the data can be linked to CE, which contradicts the argument made by Schroeder et al. (2018) who suggested that CE is related to SDG 6, 7, 8, 12, and 15. As there is a lack of clarity as to which SDGs are related to CE, they have been identified as general indicators besides R0, R1, and R8 for measuring circularity. The analyzes show that the corresponding indicators of the SDGs can be utilized by organizations when formulating KPIs for circularity, therefore these targets have been added to the proposed monitoring framework.

Besides using SDG's to set up KPIs for Reduce (R1), three measurement methods for R1 were found in the data (see Table 4.2). Two indicators are linked to the reduction of waste creation: in terms of waste itself and terms of food. Indicators focused on waste are reliable data, as waste data contains accurate information (as confirmed by Moraga et al., 2019). The use of fossil fuels as an indicator can likewise be seen as accurate quantitative data. Measuring the efficient use of resources and the reduction of waste streams requires attention in order to measure progress towards the CE-objectives set by decision-makers (as discussed by Di Maio et al., 2017). The addition of these three indicators to the monitoring framework will, therefore, contribute to measuring the progress regarding Reduce (R1) (see Table 5.1).

In addition to using Reduce (R1) as a strategy for circularity, several organizations also reported this strategy intending to improve financial interest through efficiency gains. The efficient use of resources and the reduction of waste contributes to the financial interest of organizations as they reduce emissions and waste, have better resource security, and low resource price volatility (Kalmykova et al., 2018). The application of Reduce (R1) therefore contributes to the reduction of the environmental impact of an organization's activities and the organization's profitability. The use of fuel and waste reduction can be monitored using the indicators found in the data to assess the performance of organizations in terms of resource efficiency and CE. The efficient use of resources can also be monitored by applying the VRE indicator (as stated by Di Maio et al., 2017). Although this is a performance indicator for industry and governance and is therefore not been used in the data, in the proposed monitoring framework this indicator is classified under R2 to enable the assessment of resource efficiency of a service or product.

The information on life extension of products and components can currently not be monitored (as discussed by Moraga et al., 2019). This is reflected in the data as no indicators have been found for Resell/Re-Use (R2), Repair (R3), Refurbish (R4), Remanufacture (R5), and Repurpose (R6). Despite the strong contribution of these strategies, organizations have not reported effective indicators that can contribute to the monitoring framework. The analyzed data seems not to focus on the re-use or life extension of products, such as remanufacturing. The definition of specific strategies for the preservation of functions still needs better clarification (as concluded by Moraga et al., 2019), as organizations are not aware of these ROs to contribute to CE. The proposed monitoring framework does currently not include specific indicators for the underdeveloped ROs. However, when implementing this monitoring framework, organizations can consider the underdeveloped ROs to better conceptualize CE within the strategy of the organization and its activities to contribute to CE.

The coding corroborates that Recycling materials (R7) is the most common strategy used within the three scales, which is in line with the findings of the study of Kirchherr et al. (2017). Organizations rely primarily on recycling rather than focusing on extending life or refusing the use of products and materials. The four indicators found within the data for Recycle (R7) measure the quantitative characteristics of the recycled and secondary materials. The strategies of the analyzed organizations aimed at recycling often include better-developed actions and targets to contribute to CE compared to the strategies for other ROs. To go beyond recycling, steps should be taken towards promoting prevention, reduction, re-use, and prolongation. As recycling activities can now be measured by four indicators within the proposed monitoring framework, scientists and managers/decision-makers can focus on the promotion and refinement of the underexposed CE-activities.

According to the results, the degree of energy recovery can be assessed by five indicators (see Table 5.1). Within this strategy, most indicators have been found in comparison with the other strategies that provide qualitative information on the process towards CE. As a result, the focus within the monitoring framework is on recycling and energy recovery rather than source reduction. Most organizations are currently focused on recycling and energy recovery to achieve the waste reduction targets, leaving aside other, more ecological options of source reduction and re-use (Veleva et al., 2017). As stated earlier, more attention should be given to the higher options within the 10R typology. An aspect of the framework that needs to be considered is the highly interrelated nature of the ROs. In reality, the ROs cannot be separated clearly from each other (Reike et al., 2018), which was experienced when analyzing the data. The ROs can be closely aligned, as seen in the data of Refuse (R0). The circular procurement of products can, for example, lead to products being easier to repair, refurbish, or recycle. This strategy can therefore contribute or is related to other strategies of the 10R typology. The aim of the proposed framework is to identify the application of the R-options within the organization and to understand and relate the interdependent aspects. While considering the complexity of CE and the high interrelation of the strategies, a combination of the application of multiple ROs may influence the possible results of the impact measurement.

Re-mine (R9) is an ignored and under-addressed strategy among ROs which receives the least attention in business (as stated by Reike et al. (2018) and (Morseletto, 2020)). This is confirmed in the data, as Re-mine (R9) as a strategy to contribute to CE is not reflected in the data within the three scales (see Table 4.1). Since Re-mine (R9) receives no attention from the organizations and is at the same time the least desired strategy, this unpopular strategy is excluded in the monitoring framework to stimulate the focus on the other higher ROs.

LCA is seen as a method for evaluating CE utilizing of a set of methods (as discussed by Dieterle et al., 2018). Within the data, the use of this method by organizations has been found to gain insight into their environmental impact. Whilst LCA provides information on circularity (as stated by Haupt and Zschokke., 2017), no direct indicators were found in the data that enable evaluation of the R-strategies. Even if the instrument contains, for example, credits for replaced materials, it is not fully suitable for a meaningful interpretation within the CE. This similarly applies to the use of GRI for measuring and reporting CE data. This framework is primarily used for reporting waste data by various disposal methods and does not provide indicators that measure source reduction, remanufacturing, and reusing materials and products (Veleva et al., 2017). No specific relationship was found in the data between the GRI and LCA to one of the ten ROs to allocate. The challenge of these two methods is that multiple R-strategies cannot be measured, making the methods unsuitable for measuring the circularity of an organization. In accordance with the literature review, these methods lack specific indicators and good interpretation of CE. Both methods mainly support the reporting of organizations' CE-activities in terms of qualitative data. For this reason, these methods are added in the proposed monitoring framework as a general method to support the evaluation of CE to be used in combination with other indicators.

Finally, the CTI tool designed by WBCSD is not found in the data, although it contains relevant indicators for measuring the transition to circularity. Awareness of the tool is not yet advanced due to its recent development. Although the usefulness of the instrument will have to prove itself for implementation in the coming years, the CTI-tool has been added to the proposed monitoring framework. The indicators of the CTI-tool include analysis capabilities of the short, medium-long, and long loops that focus on how the material is recovered and recirculated in the value chain (WBCSD, 2020). The indicator % Recovery type takes, for example, into account the proportion of recovered material that is Re-used (R2), Repaired (R3), Refurbished (R4), Remanufactured (R5), and Recycled (R7). Other indicators that may be useful for measuring circularity have also been added to the proposed monitoring framework, which is the % Critical Inflow (R0 and R1), Circular Material Productivity (Reduce R1), and % Renewable Energy (R8).

The proposed monitoring framework contributes to the CE-debate on the selection of indicators for measuring circularity at an organizational level. The framework is developed by combining the indicators found in the data and the existing scientific and grey literature, as shown in Table 5.1. While no indicators were found for Repurpose (R6), this strategy is included in the framework due to its relevance and contribution to CE. This is contrary to Re-mine (R9), which is not included in the framework, partly because it did not appear as a used strategy in the data. As argued, several ROs still need to be recognized by organizations to fully contribute to the CE. It is essential during the implementation of the monitoring framework to take into account the differences in interpretations and possibilities of the measurement methods and indicators.

RO\Type	Single Indicator	Multiple Indicators
Refuse (R0)	Percentage circular purchasing	SDG 12
	MCI-indicator	
	% Critical Inflow (CTI-tool)	
Reduce (R1)	(Residual) waste reduction	
	Food waste reduction	SDG 12
	Fossil fuel reduction	
	VRE-indicator	
	% Critical Inflow (CTI-tool)	
	Circular material productivity (CTI-tool)	
Resell/Reuse (R2)	% Recovery Type (CTI-tool)	
Repair (R3)	% Recovery Type (CTI-tool)	
Refurbish (R4)	% Recovery Type (CTI-tool)	
Remanufacture (R5)	% Recovery Type (CTI-tool)	
Repurpose (R6)		
Recycle materials (R7)	Recycling Rate	
	Waste Seperation Rate	
	Quantity of kilograms of handed in e-waste	
	Quantity of recovered and separated raw materials*	
	% Recovery Type (CTI-tool)	
Recover energy (R8)	Amount of waste processed in kiloton	SDG 7
	Total Energy Output (Steam, Heat, Electricity)	
	Percentage biogenic/ green energy supply	
	Amount of gas/fertilizer produced through incineration of waste	
	Percentage e-waste as fuel with energy recover	
	% renewable energy (CTI-tool)	
Other life cycle based		SDGs LCA GRI-framework CTI-tool

Table 5.1 - Proposed monitoring framework of CE-indicators

6 Conclusion

Organizations play a major role in the transition to a more circular economy (CE) by exploring the possibilities of devising innovative business models and solutions for circularity. The redesign of production processes, re-use of products and materials, application of life extension, repurpose of products, and the separation of raw materials for continuous re-use are possibilities and opportunities for organizations to contribute to the CE. The urgency of measuring and evaluating the implementation of CE-initiatives in practice has been stressed by businesses and scientists. At present, the long-term effects of organizations' initiatives are often unknown due to the lack of indicators to monitor the CE-progress. This research initiates the construction of a monitoring framework that identifies existing CE-indicators within organizations to carry out an evaluation that can focus on set objectives. Using a case study, indicators have been analyzed to set up a monitoring framework that can be used practically as a standard when measuring an organization's circularity. The proposed framework is based on the quantification of circularity in the perspective of the 10R typology. This typology provided structure when analyzing and interpreting the data by classifying the indicators by the retention options (ROs) according to the 10R typology. The monitoring framework provides an answer to the research question of this research and contributes to the need for a measuring instrument and completing this framework will eventually advance the shared understanding of the circularity within organizations. As a result, managers and decision-makers can implement, measure, and evaluate CE-objectives utilizing qualitative and quantitative data to make improvements in their contribution to CE.

6.1 Practical implications

The proposed monitoring framework allows organizations to start measuring and evaluating their performance on CE-activities and objectives. The monitoring framework contains specific indicators for most ROs in the 10R typology, allowing the first step towards a measurable CE. Managers and decisionmakers can sharpen the objectives with meaningful and achievable performance. The framework is useful for organizations to focus on strategies of which they were previously unaware, or which were underdeveloped in their business activities. Managers can, for example, quickly obtain information and an overview of which ROs the organization better or still needs to implement to deliver an improved performance towards the CE. The implementation of all ten R-strategies can be challenging for organizations in some sectors. By focusing on achievable ROs within the business activities, reform from business models to circular business models can take place. The further development of the monitoring framework should look into the differences between the sectors in the possibility to implement the ten ROs. Focusing on a single sector can ensure greater consistency and comparability of reported data (Veleva et al., 2017). An implementation that considers the differences in sectors will lead to an accelerated acceptance as a standard for the measurement of CE. When the different variances within and between sectors are taken into account, the establishment of a standardized measurement can allow for comparison within and between sectors.

This research contributes to the knowledge development of the sustainability program of RvN@Circulair by making the activities of affiliated organizations more transparent and measurable. As it is now transparent to what extent the organizations within the RvN apply the ten R-options, targeted and substantiated actions can be taken by the Circular Council. A greater focus on life extension could be a new objective in the implementation program of RvN@Circulair. By facilitating meetings or workshops from RvN@ to communicate the contribution of the shorter and medium-long loops strategies, these strategies can be more promoted in the region. Stimulating initiatives that are underdeveloped within the RvN can ultimately accelerate the transition to a circular region.

The government should take the initiative to work with the parties involved in a monitoring method that can measure the CE-transition process. The development in circular metrics will help the government to set and coordinate CE-targets and advance legislation (García-Barragán, Eyckmans, & Rousseau, 2019). Although this monitoring framework is set up at an organizational level, the indicators allow organizations to provide insight into their CE-process and effects to the government. This supports the government in providing subsidies, funds, and other incentives to organizations that contribute to CE. As stated by Reike et al. (2018), this support from the government can help organizations to develop innovative business models that contribute to circularity.

6.2 Limitations of the research

The research and proposed monitoring framework have several limitations. First, could the geographic restriction influence the findings of this research. Although two additional organizations have been included in the study located throughout the Netherlands, the study focuses mainly on organizations located within the geographical area of RvN.

Secondly, the research was based on a rather small sample of only 20 organizations. Due to this low number of organizations, the external validity can be restricted. In addition, contrary to the larger analyzed organizations, the small organizations analyzed did not have published annual reports or sustainability reports. A limiting factor of this research is for this reason that only the websites of the smaller organizations are being analyzed. As a result, the analysis provided less useful information for these organizations than for the larger organizations analyzed, which may affect the reliability of the research. Moreover, the used data is secondary data written by organizations with a commercial interest. This negatively affects the reliability of the research, despite considering the organizations' motives for sharing information, whether the information was written recently, and whether there is clarity about the origin of certain data. Although differences in size and sector have been taken into account in the selection of organizations, there is limited reliability and external validity. Consequently, this study cannot make hard statements for the full population.

In-depth testing of the 10R typology using a case study has increased the external validity of the typology, which can contribute to the overall understanding of CE. However, the complexity of the measurability of circularity and its effects was a barrier to the interpretation of results. The subjectivity of the researcher is acknowledged in the analysis and interpretation of the data.

Furthermore, as stated in the method section, the case study research is conducted with one research- and measurement moment. This means that the information has been collected and analyzed at a certain point in time, so no comparisons can be made. In addition, the research is qualitative in nature, which means that it contains less statistical power than quantitative research.

6.3 Suggestions for future research

Future research is needed in order to refine the proposed monitoring framework for measuring the transition towards a more CE. The application of this framework should be extended in future case studies involving more organizations of different sizes and from different sectors to identify and include more comprehensive performance indicators. By repeating the same study for other countries, the monitoring framework can be extended with indicators in an international context. For instance, using scientific and/or grey literature about the tools and indicators developed by WBCSD. In addition, future research should consider improving the validity and generalizability of the monitoring framework by applying other research methods to allow for more extensive statistical analysis. Whereas this research only applied a case study as a research method, future research should involve surveys, interviews, and observations. It would be convenient to analyze the performance of organizations from an evolutionary perspective to measure the effects of CE. Longitudinal studies are needed to identify relationships between the implementation of CE-objectives and activities and the development of CE-indicators within organizations.

More research should look into the further development of the monitoring framework in which the use of the 10R typology is suggested. In this context, a focus on the differences between sectors is an important aspect, as discussed in section 6.1. Future research should expand the sample with several organizations in different sectors to examine these cross-sectoral differences. This enables comparisons to be made within and between different sectors to obtain better practical implications.

To further explore the process of integration of CE-activities within organizations, it is recommended to study the applications and approaches in practice. The identification of best practices on their contribution to a more CE can be made possible through extensive practical research. Similar to this study, the effects of ROs could be demonstrated by indicators, tools, or instruments developed in practice. This will help to refine the monitoring framework and provide insight into practice.

As discussed, is the interrelationship amongst the ROs acknowledged, and should be better explained in future studies. No evidence of a pattern to identify these interrelationships is provided in this research, which may affect the implementation and evaluation of the proposed monitoring framework.

Finally, despite this research contributes to the field of the measurement of the CE, this field of research remains largely understudied. Future research on CE and possible indicators is needed to provide insight into the effects of CE, as it is still far from being clear. More research could also focus on the 10R typology as classification of the CE in strategies in an organization.

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7 Appendix

7.1 Appendix I: Analyzed documents and webpages

	Institution/ Organizations	Reference Type	Title, author, and year
National			
1.	PBL	Report	*Evaluatie Green Deals circulaire economie* (Ganzevles et al., 2016)
2.			*Circulaire economie: Innovatie meten in de keten* (J. Potting et al., 2016)
3.			*Achtergrondrapport bij Circulaire economie in kaart (Kishna, Rood, et al., 2019)*
4.			*Circulaire economie: Wat we willen weten en kunnen meten. Systeem en nulmeting voor monitoring van de voortgang van de circulaire economie in Nederland* (J. Potting et al., 2018)
5.			*Doelstelling circulaire economie 2030* (Kishna, Hanemaaijer, Rietveld, Bastein, & Delahaye, 2019)
6.			*Waarom een circulaire economie?* (Rood & Hanemaaijer, 2017)
7.			*Van betalen voor bezit naar betalen voor gebruik* (Remmerswaal, Hanemaaijer, & Kishna, 2017)
8.			*PBL-notitie: Reflectie op Van Afval Naar Grondstof (VANG)* (Rood & Hanemaaijer, 2014)
9.			*Opties voor een afvalstoffenbelasting* (Hanemaaijer, Rood, & Kruitwagen, 2014)
10.			*Grondstof voor de circulaire economie* (Hanemaaijer & Rood, 2016*)*
11.			*Voedsel voor de circulaire economie* (Rood, Muilwijk, & Westhoek, 2016)
12.			*Notitie: Circulaire economie: opties voor beleid* (Planbureau voor de Leefomgeving, 2017)
13.			*Vergroenen en verdienen. Op zoek naar kansen voor de Nederlandse economie* (Planbureau voor de Leefomgeving, 2013)
14.	Philips	Report	*Annual Report 2019* (Philips, 2020)
15.			*Closing the Materials Loop* (Philips, 2016)
16.			*Methodology for calculating the Environmental Profit & Loss Account* (Philips, 2019b)
17.			*Our journey to become a leader in sustainable health technology* (Philips, 2019c)
18.			*Sustainability Commitments* (Philips, 2017)
19.			*Refurbishing solutions for MRI systems* (Philips, 2014)
20.		Webpage	*Decoupling growth from resource consumption* (Philips, n.d.)
21.			*Philips koploper in de transitie naar een circulaire economie op RSNA 2019* (Philips, 2019d)

22.			*First do no harm. Why healthcare needs to change* (Philips, 2019a)
23.	KPN	Report	*Integrated Annual Report 2019* (KPN, 2020)
24.			*Circular Manifesto and Appendix* (KPN, 2018a)
25.		Webpage	*Duurzame Ontwikkelingsdoelstellingen VN* (KPN, n.d.)
26.			*KPN breidt samenwerking met leveranciers verder uit voor circulaire bedrijfsvoering in 2025* (KPN, 2018b)
27.			*KPN en grote leveranciers streven naar circulair bedrijfsmodel in 2025* (KPN, 2017)
Regional			
28.	**RvN**	Report	*Notitie Rijk van Nijmegen Circular. Regionale Visie en Uitvoeringsprogramma.* (Roemers et al., n.d.)
29.			*Kans voor Nijmegen* **-** *Economische visie 2020 – 2025* (Gemeente Nijmegen, 2019a)
30.			*Projectvoorstel: Het "vermogen" van circulaire economie in Arnhem en Nijmegen* (Grol & Keunen, 2018)
31.			*Circulaire Economie in de Regio Arnhem Nijmegen.. het borrelt* (KPMG, 2018)
32.			*Circulaire Raad Rijk van Nijmegen – Best Practice* (Circulaire Raad, 2020)
33.			*Monitoringsrapportage Energie gebouwde omgeving 2008-2018* (Erades, 2019)
34.			*Uitvoeringsagenda duurzaamheid* (Gemeente Nijmegen, 2019c)
35.			*Naar een circulaire economie in de regio Arnhem-Nijmegen* (Bastein, Rietveld, & Keijzer, 2016)
36.			*Arnhem Nijmegen: circulaire economie van de toekomst* (The Economic Board, 2018)
37.			*Versneld naar een circulair Gelderland* (Bastein & Dortmans, 2019)
38.		Webpages	*Circulair* (RvN@, n.d.)
39.			*Nijmegen presenteert economische visie 2020-2025* (Gemeente Nijmegen, 2019b)
Organizational			
40.	Dar	Report	*Maatschappelijk Jaarverslag 2017* (Dar, 2017a)
41.			*Jaarverslag 2018* (Dar, 2019a)
42.			*Strategisch plan tot 2020. In verbinding waarde creëren* (Dar, 2017b)
43.		Webpage	*Kringloop* (Dar, n.d.-b)
44.			*Missie & Visie* (Dar, n.d.-c)
45.			*Wat doet Dar?* (Dar, n.d.-d)
46.			*Maatschappelijk Jaarverslag 2018 Dar NV [Video File]* (Dar, 2019b)

47.			*Kijk! Afval = grondstof (Dar, n.d.-a)*
48.	AVR	Report	*Jaarbericht 2018* (AVR, 2019b)
49.			*Jaarbericht 2019: Klimaat in de hoofdrol* (AVR, 2020)
50.			*Hoe groen is afvalwarmte?* (AVR, 2018a)
51.			*CO2 reductieplan 2019* (AVR, 2019a)
52.			*Waste to Energy: empowering the transition to a more circular economy. Position paper on the circular economy in the European Union* (AVR, 2015)
53.		Webpage	*Toekomst denken en vooral doen (AVR, n.d.-e)*
54.			*Smart City (AVR, n.d.-d)*
55.			*Nijmegen Beste Circulaire Regio van Nederland* (AVR, 2018b)
56.			*De cirkel is rond* (AVR, n.d.-c)
57.			*AVR in de energietransitie* (AVR, n.d.-b)
58.			*100% Waardevol* (AVR, n.d.-a)
59.	ARN	Report	*Stroomschema Infographic* (ARN, 2018)
60.			*Milieujaarverslag 2018* (ARN, 2019c)
61.			*LCA afvalverwerking luiermateriaal* (Odegard, Lindgreen Roos, & Broeren, 2018)
62.		Webpage	*Van oude grondstoffen naar nieuwe toepassingen* (ARN, 2019c)
63.			*Milieu & Duurzaamheid* (ARN, n.d.-b)
64.			*Luierrecycling* (ARN, n.d.-a)
65.	Radboudumc	Report	*Duurzaamheidsplan 2017 – 2020* (Radboudumc, 2017)
66.			*Jaardocument 2018* (Radboudumc, 2018)
67.			*Duurzaamheidsagenda (*Radboudumc & Radboud Universiteit, 2016)
68.			*Duurzaamheidsbeleid* (Radboudumc, 2016)
69.		Webpage	*Van afval naar grondstof* (Radboudumc, n.d.-c)
70.			*Medicijnen uit het afvalwater* (Radboudumc, n.d.-b)
71.			*Duurzame dienstkleding* (Radboudumc, n.d.-a)
72.	Alliander	Report	*The resource passport. Working together towards a circular economy* (Alliander, 2017)
73.			*Jaarverslag 2019. Samen werken aan transitie* (Alliander, 2020b)
74.			*Jaarplan 2020. Onze initiatieven voor 2020* (Alliander, 2020a)
75.		Webpage	*Strategie* (Alliander, n.d.-d)
76.			*Maatschappelijke impact* (Alliander, n.d.-c)
77.			*Impact meten* (Alliander, n.d.-b)
78.			*Circulaire netwerkbeheerder* (Alliander, n.d.-a)
79.	NXP	Report	*Corporate Responsibility Report* (NXP, 2018a)

80.			*Green Innovation Bond Framework* (NXP, 2020)
81.			*NXP Auditable Standards on Social Responsibility* (NXP, 2018b)
82.			*Annual Report for the Financial Year Ended December, 31 2018* (NXP, 2019)
83.		Webpage	*Sustainability* (NXP, n.d.-b)
84.			*Energy, water, and waste* (NXP, n.d.-a)
85.	Royal HaskoningDHV	Report	*Royal HaskoningDHV Circular pilot projects* (REBus, 2017)
86.			*Responsible & Sustainable Business Update 2019* (RoyalHasKoningDHV, 2020)
87.			*Annual Report 2019* (Royal HasKoningDHV, 2020)
88.		Webpage	*Corporate responsibility* (Royal HasKoningDHV, n.d.)
89.	Dura Vermeer	Report	*Activiteitenverslag 2018* (Dura Vermeer, 2019)
90.			*CO2 Prestatieladder DV Scope 3 Analyse 2019 (Dura Vermeer, 2020a)*
91.			*Jaarverslag 2019* (Dura Vermeer, 2020b)
92.			*Communicatieplan duurzaamheid 2018-2019* (Dura Vermeer, 2018)
93.		Webpage	*Duurzaamheid* (Dura Vermeer, n.d.-a)
94.			*Een tweede leven voor bouwafval* (Dura Vermeer, n.d.-c)
95.			*Grote stap naar circulaire weg in Overijssel* (Dura Vermeer, n.d.-d)
96.			*Ecopave XL: Asfalt met twee keer langere levensduur* (Dura Vermeer, n.d.-b)
97.			*Circulair renoveren hoofdkantoor* Alliander (Dura Vermeer, 2016)
98.	SGB-Smit Group	Report	*Sustainability Report of the SGB-SMIT Group* (SGB-Smit Group, 2017)
99.		Webpage	*Sustainability* (SGB-Smit Group, n.d.)
100.	FairCoffins	Webpage	*Over ons.* (FairCoffins, 2018)
101.	Van Eigen Deeg	Webpage	*Van Eigen Deeg. Over ambachtelijke verantwoorde koeken.* (Van Eigen Deeg, 2020)
102.	Stadsboom	Webpage	*Stadsboom. Bewust met hout.* (Stadsboom, 2020)
103.	Trash'ure Taarten	Webpage	*Trash'ure Taarten. Onze Visie.* (Trash'ure Taarten, 2020)
104.	Be O Bottle	Webpage	*About home* (Be O Bottle, 2020)
105.	Het Goed	Webpage	*Kringloop Het Goed. Over Ons* (Het Goed, 2020)
106.	RepairCafé Nijmegen	Webpage	*RepairCafé Nijmegen* (RepairCafé Nijmegen, n.d.)
107.	BikeWerk	Webpage	*Wat we doen* (BikeWerk, 2016)
108.	Versfabriek	Webpage	*Versfabriek* (Versfabriek, 2020)

7.2 Appendix II: Coding scheme

Code 1: R0 (Refuse)	
Vanuit de consument legt dit concept de nadruk op de keuze om minder te kopen of minder te gebruiken, wat van toepassing kan zijn op elk consumptieartikel dat gericht is op het voorkomen van het ontstaan van afval. De afwijzing van verpakkingsafval en boodschappentassen. Vanuit de producent verwijst dit begrip eerder naar het concept en de levenscyclus van het ontwerp waar productontwerpers het gebruik van specifieke gevaarlijke materialen, ontwerpproductieprocessen om afval of elk nieuw materiaal te vermijden, kunnen weigeren. Het afzien van het product, of deze met een radicaal ander product te leveren.	
-	Inkoop; (circulair/duurzaam) inkopen
-	Vermijdt; vermijden; preventie; voorkomen; weigeren
-	Klant / producent keuzes; materiaalkeuze; ontwerpkeuze
-	Afwijzen; afwijzing; afstoten; afstoting; afzien
-	Ontwerp(fase); constructiefase
Code 2: R1 (Reduce)	
Het elimineren van de productie van afval in plaats van het verwijderen van afval zelf nadat het is ontstaan. Vanuit de consument omvat dit concept het minder vaak gebruik maken van aangekochte producten, zorgvuldiger en langer gebruiken, of reparaties uitvoeren voor levensduurverlenging. Vanuit de producent verwijst het naar de pre-market stadia van het concept en de levenscyclus van het ontwerp, waarbij minder materiaal per productie-eenheid wordt gebruikt, of waarbij wordt verwezen naar dematerialisatie. Het efficiënter fabriceren of gebruiken van een product.	
-	Ontwerp(fase); constructiefase; productie(fase); ontwerpen; (circulair) ontwerp
-	Klant / producent keuzes
-	Dematerialisatie
-	Efficiëntie; efficiënt(er) gebruiken
-	Levensduurverlenging; levensduur verlengend onderhoud; langer gebruiken; gebruiksfase verlengen
-	Deelplatformen
-	Reparatie
-	Reductie; terugdringen; verminderen; elimineren
Code 3: R2 (Resell/Re-Use)	
Hergebruik van een afgedankt, nog zo goed ‘als nieuw’ product in dezelfde functie door een tweede consument, zonder opknappen, herbewerken of repareren. Consumenten, verzamelaars, detailhandelaren en producenten. Het kopen van een tweedehands product, of het vinden van een koper voor een product dat niet of nauwelijks in gebruik was. Enkele schoonmaakwerkzaamheden of kleine aanpassingen zijn mogelijk.	
-	Tweedehands koop en verkoop; verhandelen van tweedehands materialen
-	Klant / producent keuzes
-	Hergebruik; opnieuw gebruik(en)
-	Platforms voor verkoop
-	Kringloopwinkel
Code 4: R3 (Repair)	

Verlengen van de levensduur van het product - vervangen van kapotte onderdelen - waardoor het zo goed als nieuw is. Reparatie kan worden uitgevoerd door verschillende actoren en met of zonder verandering van eigenaar. Bedrijven kunnen herinnerde producten naar hun eigen reparatiecentra of naar reparatiecentra van derden sturen. Geplande reparatie en ad-hocreparatie onderscheiden zich.	
-	Revitalisering; reviseren – revisie
-	Levensduurverlenging
-	Reparatie
-	Vervanging
-	Upgrade; opknappen
-	Repaircafés; Ambacht(scentrum); Reparatiebedrijven en -centra
-	Onderhoud; innovatief onderhoudsmethode
Code 5: R4 (Refurbish)	
De algemene structuur van een groot meercomponentenproduct blijft intact, terwijl veel componenten worden vervangen of gerepareerd, wat resulteert in een algemene 'upgrade' van het product. Een bepaalde kwaliteit die het product 'op de nieuwste stand' brengt door het gebruik van nieuwere, meer geavanceerde componenten. Het opknappen/moderniseren van een oud product.	
-	Upgrade; opknappen
-	Modernisering
-	Vervanging; componenten /elementen vervangen
-	Revisie - reviseren
-	Renovatie
-	Refurbishment
Code 6: R5 (Remanufacture)	
De volledige structuur van een meercomponentenproduct wordt in een industrieel proces gedemonteerd, gecontroleerd, gereinigd en indien nodig vervangen of gerepareerd. Reconditionering, herbewerking of restauratie. De referenties op het gebied van behouden kwaliteit zijn meer getemperd dan bij renovatie, uitgedrukt als tot de originele staat, als nieuw. De resterende levensduur zal naar verwachting korter zijn dan bij nieuwe producten en omdat er gerecyclede componenten worden gebruikt in het gereviseerde product. Gereviseerde producten zouden volledig kunnen bestaan uit gerecycleerde componenten.	
-	Restauratie; herbewerking
-	Revitalisering; reviseren; controle
-	Levensduurverlenging
-	Hergebruik van (gerecyclede) materialen; Gerecyclede componenten/elementen
-	Herfabriceren
-	Upgrade; Kwaliteitsverbetering
-	Reconditionering
Code 7: R6 (Repurpose)	
Door hergebruik van afgedankte goederen of onderdelen die zijn aangepast voor een andere functie, krijgt het materiaal een duidelijke nieuwe levenscyclus.	
-	Up/downcycling

-	Hergebruik in andere functie
-	Kringloop
Code 8: R7 (Recycle)	
Het wordt gebruikt voor elke vorm van het vermijden van het gebruik van nieuwe mijnbouwmaterialen of -bronnen. Elke vorm van herstel voor welk doel dan ook. Verwerking van gemengde stromen van post-consument producten of post-producent afvalstromen met behulp van dure technologische apparatuur, waaronder shredding, smelten en andere processen om zuivere materialen af te vangen. Gerecycleerde materialen behouden geen enkele oorspronkelijke productstructuur en kunnen overal opnieuw worden toegepast.	
-	Vermijden nieuw gebruik
-	Gerecyclede materialen
-	Versnipperen; smelten
-	Opnieuw toepassen; opnieuw gebruik; hergebruik (van afval)
-	Herstel
-	Scheiden; afvalscheiding; scheiding voor hergebruik; afvalinzameling
-	Downcycling
-	Verwerking
-	Cascadering; verwaarding
Code 9: R8 (Recover energy)	
Terugwinning betekent het opvangen van de energie die in het afval zit, waarbij het wordt gekoppeld aan de verbranding in combinatie met de productie van energie of het gebruik van biomassa.	
-	Energie terugwinning; opwekken
-	Restafval verbranden; afvalverbranding en -verwerking; mestverwerking
-	Verlichtingsinstallatie; biogasinstallatie;
-	Bio-energie en -gas; biobrandstof
-	Compost; organische afvalstromen; restafval; mest
-	Restwarmte; groene warmte
-	Biobased productie; biobased verpakkingsmaterialen / grondstoffen
-	Cascaderen organische reststromen
-	Recycling van organische afvalstromen
-	Bio raffinaderij / raffinage
Code 10: R9 (Re-mine)	
Het terughalen van materialen na de stortingsfase. Het slopen van waardevolle materialen en voorwerpen van stortplaatsen. Het ontginnen van de waardevolle grondstoffen die zijn opgeslagen op oude stortplaatsen en in andere afvalverwerkingsinstallaties, die stortplaatsmijnbouw of stadsmijnbouw worden genoemd.	
-	Terughalen
-	Ontginnen
-	Stortplaats (mijnbouw)
-	Afvalverwerkingsinstallaties

7.3 Appendix III: Output (ATLAS.ti)

	○ R0: Refuse Gr=99	○ R1: Reduce Gr=181	○ R2: Resell/Reuse Gr=51	○ R3: Repair Gr=44	○ R4: Refurbish Gr=47	○ R5: Remanufacture Gr=19	○ R6: Repurpose Gr=8	○ R7: Recycle materials Gr=312	○ R8: Recover (energy) Gr=104	○ R9: Re-mine Gr=0	Totals
Alliander Gr=34; GS=6	19	19	0	2	2	3	0	17	0	0	62
ARN Gr=12; GS=4	0	1	0	0	0	0	0	10	5	0	16
AVR Gr=68; GS=6	2	5	0	1	0	0	0	37	33	0	78
Be O Bottle Gr=2; GS=1	1	0	0	0	0	0	0	1	0	0	2
BikeWerk Gr=2; GS=1	0	0	1	1	0	0	0	0	0	0	2
Dar Gr=24; GS=3	0	5	1	0	0	0	0	14	5	0	25
Dura Vermeer Gr=57; GS=5	11	27	4	0	2	0	1	40	0	0	85
FairCoffins Gr=3; GS=1	1	0	0	0	0	0	0	3	0	0	4
Het Goed Gr=2; GS=1	0	0	2	0	0	0	0	0	0	0	2
KPN Gr=43; GS=3	9	12	9	5	4	1	0	21	1	0	62
NXP Gr=37; GS=4	3	16	0	1	3	0	0	18	0	0	41
Philips Gr=33; GS=7	3	2	3	2	8	2	2	6	2	0	30
Planbureau Leefomgeving Gr=167; GS=13	26	41	13	19	11	8	2	64	25	0	209
Radboud UMC/Universiteit Gr=55; GS=5	8	24	7	0	2	0	1	18	1	0	61
Rijk van Nijmegen Gr=79; GS=10	8	9	8	9	8	3	1	48	24	0	118
RoyalHasKoningBHV Gr=42; GS=3	4	18	2	2	7	2	0	9	6	0	50
SBD Smit Group Gr=4; GS=1	0	1	0	0	0	0	0	1	0	0	2
Stadsboom Gr=1; GS=1	0	1	1	0	0	0	0	1	0	0	3
Trash'ure Taarten Gr=2; GS=1	2	0	0	0	0	0	0	1	0	0	3
Van Eigen Deeg Gr=2; GS=1	1	0	0	0	0	0	0	1	0	0	2
Versfabriek Gr=2; GS=1	0	0	0	0	0	0	1	1	2	0	4
Totals	98	181	51	42	47	19	8	311	104	0	861