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"Circular procurement in a project setting in the construction sector"

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Abstract

Purpose: In recent years, circular economy has attracted more awareness among academia, policymakers and businesses. Therefore, governments and businesses have implementing circularity as one of their goals. Procurement can play an essential role in reaching the goal of becoming circular because purchasers can influence the supply chain, and large portions of budgets consist of procurement. The focus of this research is on Waterworks, who has the goal to work fully circular by 2030, thus practice circular procurement. The company is not fully aware on all aspects of circular procurement and what actions it needs to consider to purchase circular. The purpose of the study is to provide Waterworks with insights on what circular procurement is, what it entails, the current situation on circular procurement and recommendations for actions to improve circular procurement.

Method: To fulfil the purpose of the study, a literature study was performed, semi-structured interviews were conducted with employees of Waterworks and procurement data was gathered. Data acquired from the interviews was analysed using inductive coding and the procurement data was categorised by the 80/20 rule. Both analyses provided input for the result and SWOT analysis chapters.

Main findings: The thesis found that, currently, circular procurement is considered at a few stages of the procurement process. Circular elements present in the process are evaluating the project as a whole and evaluating suppliers on circularity. Additionally, some interviewees ask suppliers or sub-contractors about circularity but often receive no answer on options from them. Strengths the company needs to exploit are a good knowledge base, a sustainability manager in place, the founder of ENI and commitment from the top. Weaknesses the company needs to counter are lack of uniform knowledge, lack of awareness, commitment to circular procurement and the project structure. Opportunities to exploit are market consultation, innovation partnership and working on pilot projects. Threats which need to be countered are suppliers, sub-contractors and clients not being ready, the market being price-driven, product availability and rules and regulations. Short-term goals for Waterworks are aligning employees on knowledge, awareness and commitment; and developing a circular procurement process. A long term goal is getting the supply chain and market along on circularity.

***Keywords**: circular economy, circular procurement, construction sector, civil engineering, circular construction*

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Abbreviations

What follows is a list of the most used abbreviations in the thesis.

3R	Reduce, Reuse and Recycle
CE	Circular Economy
CoPS	Complex products and systems
EoL	End of Life
ENI	Emissieloos Netwerk Infra (Zero Emission Network)
EMF	Ellen MacArthur Foundation
FSC	Forest Stewardship Council
H&I	Haven & Industrie (Port & Industry)
LCA	Life Cycle Assessment
MEAT	Most Economically Advantageous Tender
MKI	Milieu Kosten Indicator (Environmental Cost Indicator)
PVC	Porter's Value Chain
SWOT	Strengths, Weaknesses, Opportunities and Threats
TPF	Technical, Process and Financial.
WKI	Water & Kwaliteit Installaties (Water & Quality Installations)
WV&C	Waterveiligheid & Constructies (Water Safety & Constructions)

1. Introduction

According to literature research, circular economy (CE) has gained more awareness in recent years among academia, policymakers, non-governmental organisations and businesses. For example, the Dutch ministry of infrastructure and water management wants to reduce primary resource usage by 50% by 2030 and have a fully functioning circular economy by 2050. From 2030 all government tenders will be fully circular in the Netherlands[1]. The preliminary literature research showed there is no consensus among academia what CE means but one frequently cited source is the Ellen MacArthur Foundation (EMF) . The foundation defines CE as follows[2]:

> Looking beyond the current take, make and dispose extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, CE aims to redefine products and services to design waste out while reducing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital (p.884).

In reaching company sustainability goals, such as being circular, procurement can play an important role[3]. The reason for the important role is because purchasers can prompt the interest of suppliers in producing more conform the new market demands regarding circularity[4][5]. Secondly, most companies spend up to 50% of their budget of production or service costs on procurement[6]. Therefore, it is important to define circular procurement. There are many definitions but the following working definition is established based on reviewing the literature found in the preliminary study:

> Circular procurement is the process in which a product or service is purchased on the assumptions of a circular economy; economic and environmental. The procurement process should close energy and material loops within supply chains and avoid negative impacts on circular economy principles. During the process, technical aspects of products or services are as circular as possible and include financial incentives to ensure circular use.

The research is carried out at Waterworks, in the Netherlands, active in construction for the water sector. They realise and renovate dikes, port areas, sewers, water pumping stations,

[1] De Bouwagenda (2018)
[2] Farooque, Zhang, Thürer, Qu, and Huisingh (2019)
[3] Farooque et al. (2019)
[4] Migliore, Talamo, and Paganin (2020)
[5] van Oppen, Croon, and de Vroe (2018)
[6] Hald, Wiik, and Larssen (2020)

drinking water production installations and sludge treatment installations[7]. The company has divided its specialisms into divisions. The clients of the firm are diverse, varying from the (local) government to other companies[8].

The company uses a strategic business plan to keep the focus on the plans, ambitions, and goals for the company. The strategic business plan provides an overview of the intentions for the upcoming five years, in which it is decided where the focus should be on and what the results need to be[9]. The current plan is from 2021 to 2025[10], one of the focus points is becoming a pioneer in their industry in the area of circularity by 2025, and in 2030 the company plans on being fully circular[11]. The first goal is to close material cycles and offer circular solutions to the market[12]. Secondly, Waterworks aspires to be fossil-free with minimal energy consumption and wants to contribute to the energy transition by moving away from fossil energy[13]. The last ambition for 2030 is to work with neutral or positive environmental impact and provide solutions for positive environmental impact to the market[14]. Purchasing contributes generously to the circularity goal as a lot of turnover of the projects stems from purchasing[15].

The procurement of goods and services is mainly conducted in project settings, which makes that the company follows a project procurement structure[16]. There is one central purchaser at the company who purchases what is necessary for the larger projects and for a limited amount of framework contracts[17]. Besides that, the purchaser is also working on purchasing processes. The project teams have the autonomy to buy the materials necessary for the project[18].

Despite these goals, the company is not fully aware of what is labelled as circular procurement and what best practices are in this area. Additionally, there is a challenge with the central and decentralised structure within purchasing. With regards to suppliers, they do not know what they might already purchase circularly, and the company is also not aware yet of how to engage suppliers in the process of circularity and would therefore like to know how they can engage suppliers. Lastly, they would like to know how to measure circular purchasing as

[7] Waterworks (n.d.-b)
[8] Waterworks (n.d.-b)
[9] Waterworks (2020)
[10] Waterworks (2020)
[11] Waterworks Directie (2020)
[12] Waterworks (n.d.-a)
[13] Waterworks (n.d.-a)
[14] Waterworks (n.d.-a)
[15] Company supervisor 1, personal communication, April 8, 2021
[16] Company supervisor 1, personal communication, April 8, 2021
[17] Company supervisor 1, personal communication, April 8, 2021
[18] Company supervisor 1, personal communication, April 8, 2021

this is unknown to the firm. Therefore, the company is interested in research on circular procurement, what it entails and the application to their company. The emphasis of the study lies on the literature study, which will be presented in the next chapter, where the knowledge Waterworks needs, is elaborated and reviewed on. This leads to a central research question and sub-questions. The central research question is as follows:

'How can Waterworks define circular procurement process in a project procurement environment to establish a functioning procurement structure?'

The structure of this paper is as follows: it starts with a literature review which introduces and elaborates on the topics circular economy, circular procurement and procurement structures. Next, in the methodology chapter, is an explanation of the research methods used to carry out the research. Thirdly, the results chapter presents the findings of the research conducted. Fourthly, a SWOT analysis of the data is performed. The research finishes with a discussion of the findings of the research, containing the main findings, theoretical and practical implications, limitations and suggestions for further research.

2. Theoretical background

This chapter is the result of a literature study. The chapter will discuss prior academic research focused on concepts of circular economy, circular procurement, and the procurement structure. Next to the focus on those concepts, it will also feature a literature part on practice and policy. Finally, there is a discussion presenting the comparison of the key takeaways from the academic and practice and policy literature.

2.1 Circular economy

Before defining circular procurement, it is necessary to understand the circular economy since circular procurement is part of the overall circular economy. Circular Economy (CE) is not a new concept of the twenty-first century. The notion of CE has evolved since the 1970s (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). But in the last years, it received increased attention among policymakers (Geissdoerfer et al., 2017; Haas, Krausmann, Wiedenhofer, & Heinz, 2015). Lazarevic and Valve (2017) agree, and add that the concept has also gained awareness among academia, corporations and non-governmental organisations in recent years. The increased recognition among academia is seen in a growing body of literature in recent years on Scopus (Centobelli, Cerchione, Chiaroni, Del Vecchio, & Urbinati, 2020). Even though there is attention among academia, a lot of literature has a strong focus on the public circular economy and the industry level circularity is lacking (Vinante, Sacco, Orzes, & Borgianni, 2020).

Although CE has persisted as a topic in academic literature for nearly 30 years, there is still no academic agreement on the term (Hartley, van Santen, & Kirchherr, 2020; Yuan, Bi, & Moriguichi, 2006). According to the research of Kirchherr, Reike, and Hekkert (2017) there are 114 definitions of CE in the literature. CE is a reply to the consumerist system that is forcing resource depletion (Stephan, Muñoz, Healey, & Alcorn, 2020), and scarcity (Milios, 2018), but also a reply to the creation of damage to the biodiversity, pollution of water, air and soil (Marrucci, Daddi, & Iraldo, 2019). This depletion, destruction and contamination of the environment and the economy is the basis of the linear economy (Galvão, de Nadae, Clemente, Chinen, & de Carvalho, 2018; Milios, 2018). Galvão et al. (2018) note that this linear economy builds upon 'take, produce, consume and dispose of' (Bao, Lu, Chi, Yuan, & Hao, 2019), which serves as an unsustainable economy (Kristensen, Mosgaard, & Remmen, 2021; Milios, 2018). In 2019, only 9% of the economy worldwide was circular. This number shows that there is still 91% needed to become fully circular (de Wit, Verstraeten-Jochemsen, Hoogzaad, & Kubbinga,

2019). According to Hossain, Thomas Ng, Antwi-Afari, and Amor (2020), especially the construction sector can improve the percentage of the circular economy worldwide as it has the highest potential.

Even though there is still no agreement in the literature on what the term CE means, many articles name one organisation for the explanation: the Ellen MacArthur Foundation (EMF) (Bao et al., 2019; Holzer, Rauter, Fleiß, & Stern, 2021; Milios, 2018; Sönnichsen & Clement, 2020). Established in 2010, it was created to speed up the process of the circular economy (Ellen MacArthur Foundation, n.d.-b). According to Farooque et al. (2019), the foundation defines the circular economy as follows:

> Looking beyond the current take, make and dispose extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, CE aims to redefine products and services to design waste out while reducing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital (p.884).

In addition, to the above definition, CE intends to decouple economic activities from the utilisation of natural resources and ensure that waste is designed out of the economy (Ellen MacArthur Foundation, n.d.-a). This form of the economy relies on three principles, according to EMF(n.d.-a): designing out waste and contamination, ensuring that materials, components and goods remain in use and reproducing natural systems by sustaining and reinforcing resources such as using renewable energy sources. The social aspect of CE is often overlooked, but CE also aims to contribute to the social environment, e.g. by eliminating unhealthy working circumstances, increasing employment opportunities and being inclusive and diverse (Bao et al., 2019; Kazancoglu, Sagnak, Kumar Mangla, & Kazancoglu, 2021; Van Buren, Demmers, Van der Heijden, & Witlox, 2016). Another frequently cited source, Kirchherr et al. (2017), adds to CE that it replaces the End-of-life (EoL) idea by applying the 3R (reduce, reuse and recycle) principle of materials in the production and consumption cycles.

In the construction sector, CE can help to advance material efficiency by procuring sustainable materials, maximising material recovery and lowering waste generation (Hossain et al., 2020). According to recent academic literature, the main focus for implementing CE in the construction sector lies in the supply chain (Akinade & Oyedele, 2019). Hossain et al. (2020) state the following implications of using CE in construction: improving the usage and sourcing of sustainable materials, which should benefit multiple parties; promoting material efficiency by recycling and reusing supplies; and avoiding unneeded waste generation and disposal.

Associated with CE is the 3R principle known as reduce, reuse and recycle (Bao et al., 2019; Esa, Halog, & Rigamonti, 2017; Peng, Scorpio, & Kibert, 1997). The 'Rs' are hierarchically ranked according to the desirability of the R (Bao et al., 2019). According to Peng et al. (1997), the hierarchy is based on the minimisation of resource usage and damage to the environment. Esa et al. (2017) add to the 3R principles the components of reimagining and redesign to maximise the resource abilities with rethinking the process and the design created out of the waste streams, which produces the 5R (reduce, reuse, recycle, reimagining and redesign) principle. Reike, Vermeulen, and Witjes (2018) state that the 3R principle is most prevalent in literature and practice. Even though the 3R principle is the most common, Cramer (2017) says there are not three principles but ten essential principles. The 10R framework is split into two categories; reutilisation and preventive (Reike et al., 2018). In the 10R framework, the highest importance is the refusal of usage of raw (new) materials, and the second-highest is reduction. As seen in Figure 1 is the rest of the framework and the ranking of the remaining R principles. Recycle and recover score low because they are too close to the linear economy as there is no intention to high-quality reuse, and score low; from re-purpose upwards the principles are more directed towards a circular economy (Hanemaaijer, Delahaye, Hoekstra, Ganzevles, & Lijzen, 2018; Morseletto, 2020).

Figure 1 The 10R principles of Cramer (2017)

With the implementation of CE, the literature identified three levels of initiatives; micro, meso and macro (Klein, Ramos, & Deutz, 2020). The micro-level focuses on the production, the level of demands, and the adoption of a more sustainable production process and design (Esa et al., 2017). The micro-level thus takes place on a company level (Vinante et al., 2020). Next, the meso-level focuses on sustainable design that boosts the waste trading system of the 3R principle (Esa et al., 2017). Kirchherr et al. (2017) add to this that this happens in eco-industrial parks as structures. The macro-level is the shared network of industries that support the 3R principles; this is on city, region or even (inter)national level (Esa et al., 2017; Kirchherr et al., 2017). In the study of Pomponi and Moncaster (2017), these levels come back, but they relate it to the Cradle-to-Cradle concept. The Cradle-to-Cradle concept is the idea that resources have endless recyclability (McDonough & Braungart, 2010). The micro-level is on the material

or building component itself, the meso-level represents the entire construction as a whole and the macro-level represents whole eco-friendly cities (Pomponi & Moncaster, 2017).

To conclude, CE gained more attention over the years by academics and politicians, but there is no consensus on what the concept exactly means. The most widespread definition comes from EMF, and it is a reply to consumerism and depletion of resources. Intertwined with CE is the 3R principle which expanded to 10R. Lastly, the implementation of CE takes place on micro, meso and macro-level.

2.2 Circular procurement

In reaching company sustainability goals and a better world, procurement plays an important role (Farooque et al., 2019; Meehan & Bryde, 2011). There is an emphasis on procurement because it can prompt the interest of producers of services and products in changing their productions to comply with the new market demands and it can help with technological advances in sustainability (Migliore et al., 2020). Another reason is that in many corporations procurement costs report to 50% of the total production or service costs (Hald et al., 2020). CE creates industrial symbiosis. Industrial symbiosis is the recognition and utilisation of a firm its secondary outputs (waste), to replace primary materials in the production of other firms (van Capelleveen, van Wieren, Amrit, Yazan, & Zijm, 2021).

The European Union defines circular procurement as the course by which businesses or public agencies procure products or services that help to close the energy and material loops within supply chains, whilst reducing and even avoiding, negative impacts on the environment and waste creation in the entire life-cycle (European Commission, 2017). Hald et al. (2020) add to this definition, procurement should also take into account economic, environmental and social effects. This is in line with the aforementioned definition of CE. Zsidisin and Siferd (2001) suggest that circular procurement is linked to many activities in the value chain, such as design, procurement, production, logistics, use, reuse and waste of a company its products and services.

Introducing CE thinking into procurement will redefine prices, quality, time and value for money fundamentals of purchasing (Farooque et al., 2019). This change is because the materials to be purchased are to be restorative or regenerative. Regenerative materials are part of the biological cycle, these materials are part of the biosphere as natural resources and reused as inputs for manufacturing (Farooque et al., 2019). Examples of regenerative materials are bio-based, reusable, non-harmful and non-crucial materials (Circle Lab, n.d.). Restorative materials are part of the technical cycle, these materials are human-made and enable repair, refurbishing,

remanufacturing and recycling (Farooque et al., 2019). Examples of restorative materials are plastics, metals and chemicals (Ellen MacArthur Foundation, n.d.-a). Next to these fundamentals, purchasing needs to consider environmental life-cycle effects and social aspects (see section 2.1) associated with the origin of the materials purchased (Hald et al., 2020).

To conclude, circular procurement is part of CE, and there are many definitions out there on what it means. Circular procurement is an essential tool to influence other actors in the supply chain, especially suppliers of the purchasing firm. There are several implications of circular procurement, these are redefinition of prices, quality, time and value for money fundamentals of purchasing.

2.2.1 Measuring circular procurement

It is essential to measure and monitor circular procurement to progress to full circularity and show stakeholders the progress on it (Kristensen & Mosgaard, 2020). Even though, it is known why measurement is necessary, the academic literature is lacking standardised methods to measure circularity, as well as industry level methods (Hossain et al., 2020; Kristensen & Mosgaard, 2020; Vinante et al., 2020). Morseletto (2020) proposes to set targets as a first step to aid the transition to a circular economy and measure it. He (2020) says setting targets is important to determine a direction, require engagement to reach the predetermined outcomes, motivates relevant employees and are aiding measurement. Kristensen and Mosgaard (2020) state that to measure circularity there are three levels of indicators; macro, meso and micro. In their study, Vinante et al. (2020) performed a literature study on methods of circular assessment and categorised them based on Porter's Value Chain (PVC), one of the components from PVC is procurement. The authors (2020) link PVC to their model of Circular Value Chain categories, where supplier selection and auditing and material sourcing are linked to the procurement of the PVC. The measurement metrics corresponding to the aforementioned are the extent to which suppliers are selected based on CE performance, the presence of environmental procurement criteria when selecting suppliers and the extent to which the business is active in buying/using materials that are regenerated or recycled (Vinante et al., 2020). These metrics take place on the department level of the business.

Some metrics take place on the product level. According to Kristensen and Mosgaard (2020), these metrics are thus on the micro-level. In their (2020) review on circular economy micro-level indicators, they grouped indicators in categories that emerged from the data-driven coding. Next, an explanation of the categories will follow in Table 1, their corresponding indicators and their explanations are in Appendix A: Measurement indicators.

Category	Category Explanation
1. Recycling	Recycling is important for the development of CE but is not the most sustainable solution in CE (Blomsma & Brennan, 2017; Stahel, 2013). This category contains the most indicators, which can be divided among single focus indicators and indicators focusing on recycling combining other CE categories, but also among ratios and percentages (Kristensen & Mosgaard, 2020). The authors (2020) state that the approaches for calculating recycling are distinct with various inputs in the measures
2. EoL management	It covers several options for product recovery and are either analytical tools or composite measures (Kristensen & Mosgaard, 2020)
3. Remanufacturing	According to the authors (2020), it includes all that aims to use mechanisms or parts from a product or material in a new product or material and requires the addition of other parts and work (Kristensen & Mosgaard, 2020). There is a focus on economic feasibility in this category and therefore economic indicators are prevalent (Kristensen & Mosgaard, 2020)
4. Resource efficiency	It facilitates the use of fewer resources in products or materials (Bocken, de Pauw, Bakker, & van der Grinten, 2016). According to Bocken et al. (2016), Resource-efficiency is not a strategy for circularity on its own and therefore should be combined with other strategies to support CE.
5. Disassembly	*Disassembly* is essential for CE approaches of remanufacturing and recycling and its indicators assess the feasibility of the CE strategies for enabling remanufacturing and recycling (Kristensen & Mosgaard, 2020).
6. Lifetime extension	This category can be seen as a method to measure the success of different CE strategies and it represents an essential concept in CE (Kristensen & Mosgaard, 2020).

7. Waste management	The category consists of two types of methods; waste generation through the linear flow of materials and zero-waste management in an organisation (Kristensen & Mosgaard, 2020). The goal of these indicators in *waste management* is to measure the minimisation of waste (Kristensen & Mosgaard, 2020)
8. Reuse	Reuse is the most sustainable solution in CE as materials are circulating for a longer periods (Korhonen, Honkasalo, & Seppälä, 2018; Kristensen & Mosgaard, 2020). According to the researchers (2020), its implementation in industries is hard, especially in current business models.
9. Multidimensional indicators	These indicators take into account and combine more than one CE strategy or CE category (Kristensen & Mosgaard, 2020). The category splits in employing either a lifecycle perspective or a broad CE perspective (Kristensen & Mosgaard, 2020)

Table 1 Measuring indicators of CE

A conclusion from Kristensen and Mosgaard (2020) their study is that there are a lot of different CE categories to measure CE on a micro-level but there is not a one-way approach. But they (2020) report that the most important aspect in indicators is the prioritisation of CE principles that fully capture the benefits of CE and do not necessarily equal reuse or recycling. The last conclusion they (2020) draw is that most indicators cover economical dimensions and are thus focused on costs and price instead of the environment. Kristensen and Mosgaard (2020) advise for further research to create indicators on the meso/industry level.

There are not many specific construction industry indicators, but a frequently stated method to measure circularity in construction is Life Cycle Assessment (LCA) (Hossain et al., 2020; Pena et al., 2021; Tóth Szita, 2017). The LCA considers all of the environmental consequences of using a material, product or service, from the beginning to the end of the lifecycle (Schut, Crielaard, & Mesman, 2016). Pena et al. (2021) state that LCA does not exclusively assess environmental impacts but also social and economic impacts. The LCA makes it achievable to compare the environmental impact of materials, products and services in a particular project (Schut et al., 2016). Its goal is to provide the most beneficial solution with the lowest environmental impact within a given period (Tóth Szita, 2017). Pena et al. (2021) state the LCA is a great tool to inform and advance CE strategies by analysing those strategies in terms of

sustainable performance and helps with decision-making. LCA can also help with the engagement of suppliers in improving their processes, to then advertising it through environmental material declarations (Pena et al., 2021). Asking suppliers to conduct a LCA can help a construction firm in making the right decisions in terms of circularity and sustainability, validate its environmental key performance indicators, but it can also help the firm to identify co-innovation solutions (Pena et al., 2021).

To conclude, there are measures available in the literature but there is a lack of standardised indicators to measure circularity. Besides standardised indicators there is also a lack of specific industry indicators (Kristensen & Mosgaard, 2020). Kristensen and Mosgaard (2020) created nine categories of indicators for measurement and a frequently named measurement for the construction sector is LCA. However, there is an obvious need for more industry specific indicators to measure progress on circular procurement.

2.2.2 Involving and influencing suppliers and sub-contractors on circularity

It is crucial to get suppliers, sub-contractors and other actors in the value chain involved in the circular economy. As mentioned earlier, by Farooque et al. (2019), procurement plays a vital role in transitioning to a CE because procurement can prompt interest in CE with suppliers and other parties in the market (Migliore et al., 2020). It is very important to have relationships with your supplier and sub-contractors in construction. Jelodar, Yiu, and Wilkinson (2016) state that the construction sector is seeking optimised relationships that can fulfil the purpose of procurement strategies according to the project situation. The authors (Jelodar et al., 2016) report that construction contracts need to be selected on the basis of relationship qualities hosted to fulfil the purpose of the project. Dubois and Gadde (2000) state that working together with suppliers has numerous advantages. For the construction sector, this requires that short-term focus on efficiency in single transactions needs to be replaced with longer-term-oriented relational deals on the basis of a close buyer-seller relationship (Dubois & Gadde, 2000). This means procurement needs to get away from a transactional tendering approach and needs to work towards a relational approach (Dubois & Gadde, 2000). Jelodar et al. (2016) state this move is happening, going from traditional procurement strategies to more adaptable and joint procurement styles. They (2016) name options such as partnering, alliance and joint ventures as such options as there is a need for co-operation and joint efforts.

According to Pollice (2018), a valuable tool for circular procurement is market consultation. Voda and Jobse (2016) recognise market consultation as a powerful method to close the communication gap between suppliers and demand before starting a tender procedure.

The authors (2016) also recognise that it is a practical and efficient method to generate awareness among suppliers of the needs of the procuring organisation, have good communication with suppliers and check if the demands meet the capabilities of the suppliers on the market. Reasons to conduct market consultation are to improve the specification of requirements and award criteria, verifying the demand question on the suppliers, gathering information on potential solutions and initiating the market interests of suppliers (Lenderink, Halman, & Voordijk, 2019; Rainville & Apostol, 2017). At the end of the market consultation procedure, the purchasing firm has to publish the outcomes of it, to ensure that all suppliers that want to sign in for the tender have the same information (PIANOo Expertisecentrum Aanbesteden, n.d.-e). It might also be a helpful method to involve sub-contractors in the process earlier on to share knowledge on circularity with all actors involved in the value chain (Gerding, Wamelink, & Leclercq, 2021).

Another method for influencing circularity on suppliers is the competitive dialogue. According to Haugbølle, Pihl, and Gottlieb (2015), the competitive dialogue is a flexible method in which procurers can discuss the assignment with potential suppliers. Contrary to market consultation, competitive dialogue is during the tender procedure (Nagelkerke, Oehler, Muntz-Beekhuis, & van der Staay, 2009). Uttam and Roos (2015) define competitive dialogue as a method in which any supplier can request to take part, whereby the purchasing firm performs a dialogue with the selected suppliers to create an appropriate or alternative solution that meets the tender requirements. The competitive dialogue is not always applicable (PIANOo Expertisecentrum Aanbesteden, n.d.-a). The dialogue is only used in specific situations, for instance when there is not a readily available solution without adaptions, it concerns a design or innovative solution, unusual circumstances, technical specifications are hard to determine beforehand, and there are some unacceptable and inappropriate registrations (PIANOo Expertisecentrum Aanbesteden, n.d.-a). Competitive dialogue can be beneficial for procuring circular and innovative solutions where technical specifications will hinder innovative and circular solutions not available to the market yet (Uttam & Roos, 2015). Competitive dialogue criteria are always based on the most economically advantageous tender (MEAT) (Haugbølle et al., 2015). Before starting with the competitive dialogue, it is vital to set the right intentions and prepare the dialogue (Nagelkerke et al., 2009). The right intentions are, in this case, the circular objectives the purchasing firm wants to achieve when procuring the material or product.

Lastly, a third method is called innovation partnership. From literature research performed, it is apparent the procedure is very prevalent in public procurement, but there are also articles mentioning non-public procurement and innovation partnerships (Vikkelsø, Skaarup, &

Sommerlund, 2021). As mentioned before, innovation is essential for circularity (Farooque et al., 2019). Therefore, innovation partnership is a suitable option in procuring for circularity. According to Eadie and Potts (2016), innovation partnership helps in advancing projects, services and supply contracts in both construction and civil engineering. Introduced by the European Union in 2014 to break the barriers of innovation in procurement, innovation partnership was introduced; no interaction between suppliers and procuring businesses; over specified technical tenders; poor education of purchasers; and inadequate risk management (Eadie & Potts, 2016). The European Parliament (2014) says that if there is a need for developing an innovative material, product or service and the procurement of existing solutions does not meet the required specifications of the procuring organisation, the organisation can use innovation partnership. The innovation partnership procedure consists of three phases, the competition phase, the research and development phase and lastly the commercial phase (Pashkov & Olefir, 2017; PIANOo Expertisecentrum Aanbesteden, n.d.-c). The competition phase is similar to the competition phase with regular negotiations, in the tender document is the problem definition and the goal of the innovative solution and the minimal criteria of the solution (PIANOo Expertisecentrum Aanbesteden, n.d.-c). The criteria need to address the capacity of the potential contractors to research and develop the innovative solution (PIANOo Expertisecentrum Aanbesteden, n.d.-c). These potential contracts have to describe their solution and practices for development as accurately as possible during the competition phase (PIANOo Expertisecentrum Aanbesteden, n.d.-c). Next are the negotiations, it is important to treat all parties equally and not negotiate on the minimum criteria and the awarding criteria (PIANOo Expertisecentrum Aanbesteden, n.d.-c). Lastly, according to PIANOo Expertisecentrum Aanbesteden (n.d.-c), it is crucial to make agreements on intellectual property rights if the innovation is valuable. The awarding of the innovation method is based on the price-quality ratio (Pashkov & Olefir, 2017; PIANOo Expertisecentrum Aanbesteden, n.d.-c). The research and development phase is the realisation of the innovative solution; creating a prototype or testing the solution in a pilot (PIANOo Expertisecentrum Aanbesteden, n.d.-c). During this phase, the number of partners can be reduced, done via terminating the partnership, or the partner does not meet the set requirements (Pashkov & Olefir, 2017; PIANOo Expertisecentrum Aanbesteden, n.d.-c). This phase has to be proportional to the expected purchases (PIANOo Expertisecentrum Aanbesteden, n.d.-c). Lastly is the commercial phase, where the delivery of the final solution comes forward, and the purchasing of the solution takes place (Pashkov & Olefir, 2017; PIANOo Expertisecentrum Aanbesteden, n.d.-c). The procedure has advantages and disadvantages, these are summarised in Table 2 below.

Advantages	Disadvantages
- Innovating together with partners (PIANOo Expertisecentrum Aanbesteden, n.d.-c); - More space for interaction between the client and probable contractor (Pashkov & Olefir, 2017; PIANOo Expertisecentrum Aanbesteden, n.d.-c); - Objective, transparent and non-discriminatory (PIANOo Expertisecentrum Aanbesteden, n.d.-c); - Sharing risks and costs of innovation (Vikkelsø et al., 2021).	- Procedure time is long and depends on the level of innovation (PIANOo Expertisecentrum Aanbesteden, n.d.-c); - The choice during the commercial phase is limited to only the participants, as other solutions that came to the market cannot be procured yet (PIANOo Expertisecentrum Aanbesteden, n.d.-c); - Conflicts on intellectual property rights (Vikkelsø et al., 2021).

Table 2 Advantages and disadvantages of innovative partnership

Besides, these three aforementioned methods, a collaboration tool to aid circular economy in the construction sector was developed by Leising, Quist, and Bocken (2018) (see Figure 2). The tool consists of five phases; preparation and vision development, involving market and supply chain, process design and collaboration, business model and implementation and usage and preparation for next use. The first phase starts with the clients asking questions and creating a vision for both the product and the process (Leising et al., 2018). Phase two is involving the market and the supply chain. During this phase, the team that will design, build and preserve the building is chosen based on the necessary disciplines needed for the project (Leising et al., 2018). These disciplines can have different backgrounds which can stimulate innovation and create value for the project and the whole chain (Leising et al., 2018). Process design and collaboration is phase three and here the formalisation between supply chain partners takes place using non-conventional contracts where over-specification is a not done (Leising et al., 2018). The second to last phase is the business model and implementation. During this step, the actual building process takes place, which is linked to investments and new business models (Leising et al., 2018). These models should comprise (financial) incentives for the collective goal of constructing a circular building instead of building one according to the former building situation (Leising et al., 2018). The last phase is usage and preparation for the next use. Phase five ensures that material value is guarded via reuse, repair or recycling of the building materials

(Leising et al., 2018). It is important to make a distinction between short and long-lived materials. For short-lived materials, suppliers should take responsibility via buy-back or take-back schemes and for long-lived materials, a material marketplace can be a solution to bring together supply and demand (Leising et al., 2018).

Figure 2 Collaboration tool by Leising, Quist, & Bocken (2018)

To summarise, there are three methods a purchasing firm can use to influence suppliers to come up with innovative and circular solutions. These three methods are market dialogue, competitive dialogue and innovation partnership. Market dialogue takes place before the tender phase, competitive dialogue during and the last is a tender procedure on its own. Lastly, the collaboration tool might provide guidance on how to collaborate along the chain on circular procurement.

2.3 Barriers and enablers of circular procurement

In transitioning from procurement to circular procurement businesses can face barriers that hinder the transition and enablers that can help the transition. In the following paragraphs some of these barriers and enablers of circular procurement are discussed.

The first barrier is the lack of knowledge and awareness among the chain. Authors Karhu and Linkola (2019) recognise there is not only a lack of knowledge on circular procurement in construction but also a lack of joint vision on how the sector can become more circular. The results of the survey of Adams, Osmani, Thorpe, and Thornback (2017) shows that clients and manufacturers ranked lack of knowledge, interest as medium significant. This survey (2017)

also shows that mid and large-sized businesses regard the lack of knowledge as a larger barrier than smaller companies. Lastly, the survey results also show that there is a lot of confusion about what exactly CE is and terms such as reuse and recycling (Adams et al., 2017). Not only general knowledge on CE is lacking but also building circularity knowledge is lacking (Guerra & Leite, 2021), policy regulation related to the circular economy and procurement and product design requirements for circularity (Guldmann & Huulgaard, 2020). Secondly, circular procurement is seen as expensive. The first reason is that recycled materials are expensive and there is no incentive to procure reusable materials (Gerhardsson et al., 2020; Hartley et al., 2020; Karhu & Linkola, 2019). According to Hartley et al. (2020), this is because the process of recycling is labour intensive (Rakhshan, Morel, Alaka, & Charef, 2020), which also makes that businesses have no incentive to go through this process. The absence of incentives takes place on both economic and regulatory levels (Karhu & Linkola, 2019). As there is no incentive, materials are not designed to be reused at the EoL (Adams et al., 2017). An enabler for this is having some form of responsibility as the producer of construction materials (Adams et al., 2017). De Angelis, Howard, and Miemczyk (2018) report that material recycling is seldomly considered as a value-creating system for businesses. A second reason for expensive circular procurement is that a closed-loop system, required in the CE, needs a large investment in resources, understanding the flows of information and distribution systems (De Angelis et al., 2018). It also requires more investment in the construction projects themselves, which increases the cost price, because procuring circular requires increased cost of labour, testing the new materials and testing design options (Rakhshan et al., 2020). According to Guerra and Leite (2021), implementing circular business strategies requires upfront costs to ensure future potential reuse of materials and products. Sometimes external consultants need to be hired because there is not enough in-house knowledge (Guerra & Leite, 2021). Another reason why it is expensive is that banks are often reluctant to provide support for the development and implementation of circular business models (Guldmann & Huulgaard, 2020).

The lack of information and transparency is the third barrier to transition to circular procurement. Hartley et al. (2020) state that it is important to bridge the information gap between the actors in the chain. They (2020) report that the market for secondary reused materials depends on linking buyers and sellers but that a buyer its understandings of the materials out there, suppliers and terms of sale are limited. Rakhshan et al. (2020) recognise this as well by stating that there is a lack of established markets for reused building materials. Companies also find it difficult to search for trustworthy CE partners that can offer circular materials (van Capelleveen et al., 2021). By not knowing what is on the market there is also

less awareness and understanding about the recycled and reused materials (Hartley et al., 2020). If the understanding and awareness increase, the perception of risk about the materials and new design methods can decrease (Hartley et al., 2020). An important way to do this is to collaborate in the development of standards (Hartley et al., 2020). Guerra and Leite (2021) state that there is a lack of transparent data to adopt to CE which leads to less informed decisions.

A fourth barrier is the governments. Governmental barriers take place on regulations, policies, taxation, funding and procurement (Guldmann & Huulgaard, 2020). The lack of support from the government blocks the innovation needed for CE (Kazancoglu et al., 2021). To overcome this lack, policymakers should work together with all parties of supply chain to create a joint vision (Kazancoglu et al., 2021). Governments are also very much still focused on the linear economy, policies are based on this and the system is mostly focused on recycling instead of reuse (Guerra & Leite, 2021; Kazancoglu et al., 2021). The authors Adams et al. (2017) state not having circular economy-specific regulations is an important challenge among practitioners in construction.

The first enabler of CE is creating more knowledge and awareness on the topic. Adams et al. (2017) report that an important enabler for lack of knowledge is an information campaign. Interviewees, in the study of Guerra and Leite (2021), stated that creating more awareness of the damage caused by the construction sector its linear economic model is the first step of the transition to circular economy. Everyone should understand the value of working in a circular economy so it is important to involve the whole chain (Guerra & Leite, 2021). Tirado, Aublet, Laurenceau, and Habert (2022) state that training and awareness of stakeholders in the chain throughout the whole life cycle of a construction project is necessary to stimulate to evolve to circular construction practices.

The second enabler is that cost savings can be realised. Realising cost savings can be done through procuring reused materials (Hartley et al., 2020). Cost savings are also realised through the reduction of waste and energy costs (Tura et al., 2019). The circular economy also allows chances for new value creations, new revenue streams, business growth and a larger margin and profits (Tura et al., 2019).

A third important facilitator is the government. The government its policies can be a barrier, but if there are good circular procurement policies it can help with the transition to the circular economy (Adams et al., 2017). In the study of Guerra and Leite (2021) the interviewees state that policies and financial (dis)incentives enable a more circular and environmentally conscious construction environment. Both public and private businesses need to work together to realise this (Guerra & Leite, 2021). Subsidies and a supportive tax system can help establish circular

procurement at businesses, as well as clear regulations and laws on circularity (Tura et al., 2019).

To summarise, there are four main barriers that hinder the implantation of circular procurement. These barriers are lack of knowledge and awareness, circular procurement is expensive, lack of information transparency and the government. Besides barriers there are also enablers, these are creating more knowledge and awareness, cost savings realisation and the government. The barriers and enablers contradict each other, which means that they can be threats to transitioning circular procurement but can also strengthen circular procurement.

2.4 Procurement structures

Businesses have several options to structure procurement in their organisation. Frequently identified options are by Johnson, Leenders, and Fearon (1998), who identify central, decentral and central/decentral purchasing structures in which the latter is labelled hybrid in a later paper by Johnson and Leenders (2001). In a central purchasing structure, one single person or group is in control of every purchasing activity for the whole organisation (Johnson, Klassen, Leenders, & Fearon, 2002). Purchasing in a decentralised structure is, in contrast, supervised by business plants, units or departments (Johnson et al., 2002) and is thus more dispersed around the business (Schoenherr, 2008). Lidegaard, Boer, and Møller (2015) add to this statement that the decision-maker is near to the exterior supplier and inherent customer. Research shows that the hybrid structure is more prevalent in larger companies (Lidegaard et al., 2015), and it is a popular approach to purchasing (Johnson & Leenders, 2006). The hybrid structure definition, according to Lidegaard et al. (2015), is as follows "in which local departments report to a local manager, while a centralised coordinating group managed by a corporate purchasing executive plays a key role in ensuring the effective contribution of the purchasing and strategic sourcing function to corporate strategy" (p.258). Thus, the purchasing activities are divided between the central purchasing person or group, and the business divisions or plants (Johnson et al., 2002). Trautmann, Bals, and Hartmann (2009) claim the headquarters is responsible for negotiating some longstanding contracts with the hybrid structure.

The last purchasing structure worth noting is the project procurement structure, which is in line with a hybrid procurement structure. Project procurement structure is a structure used in multiple business sectors, but especially in the construction sector (Gluch & Räisänen, 2012). The project purchasing organisation is characterised by the fact that it also purchases centrally for its day-to-day needs and that it purchases materials, products or services needed for the project (Moretto, Patrucco, Walker, & Ronchi, 2020). Moretto et al. (2020) and Jerbrant (2013)

state that working in project teams is much more common these days than it used to be. According to the authors (2020), projects can help businesses generate innovations and new products and services, which is needed for circularity. Hobday (1998) says that project teams are also often used for complex products and systems (CoPS), such as in the construction sector. Hobday (1998) defines CoPS as "highly customised, engineering-in-tensive goods which often require several producers to work together simultaneously, the dynamics of innovation in CoPS are likely to differ from mass produced commodity goods" (p. 1). Moretto et al. (2020) their results indicate that project procurement occurs more often if the project has a high score of uniqueness. These projects often involve customisation and need more technical knowledge. Project-oriented businesses are designed to be dynamic and only last to support the needs of the project at hand (Moretto et al., 2020).

Businesses using a project-based setting are defined by volatile, uncertain and complicated supply chains (Moretto et al., 2020). The emphasis on purchasing is especially true for project-based contexts, where the supply network has an important impact on the project its outcome and coordination of supplier activities is necessary to reach the project its needs successfully (Moretto et al., 2020; Wong, San Chan, & Wadu, 2016). According to Gann and Salter (2000), the main features describing a project-based firm in construction are their design and production processes established around the project, they usually produce one-off, or highly customised, products and services and the firm performs in a different coalition of companies along the supplier-customer chain. Projects concerning CoPS, according to Hobday (1998), are temporary of nature which goes across the barriers of single supplier firms. Pheng (2018) defines project procurement as follows "Procurement management is the process where-in the project manager plans for and purchases the goods and services required to achieve the needs identified in the project scope." (p.177). The author (2018) adds that the manager of the project should consider if there is a need to purchase or if it can be manufactured inhouse.

Project procurement moves through five stages called the management processes of project management, these are initiating, planning, executing, monitoring and controlling (Hobday, 1998; Pheng, 2018). To get through these stages, a suitable organisational design approach is essential to assure an effective interplay among the permanent and project structure (Bildsten & Manley, 2015; Moretto et al., 2020). This is important because many different people are involved and bring their own interpersonal and individual influences and beliefs on the environment and the organisation (Bildsten & Manley, 2015). Misalignment between both parties is therefore a threat, it arises out of decentralised authority and it can create tensions between expenditure, quality and shipment time for projects (Dubois & Gadde, 2000; Moretto

et al., 2020). According to Chan, Scott, and Chan (2004), other threats are replication of activities and central purchasing employees not having enough local information.

In their study, Moretto et al. (2020), identified two main typologies for procurement organisations, namely procurement-focused organisation and project-focused organisation. The first typology is irrelevant for the scope of this research as it covers central procurement structures. The second typology is applicable when the primary focus is on the effectiveness of project levels, purchasing is decentralised and the lifecycle of the team resembles the project span (Moretto et al., 2020). The procurers are full time involved with the project team, development team and other technical divisions (Moretto et al., 2020). Employees involved with procuring have a role that combines aiding communication with external suppliers and analysing demands with regards to the design and manufacturing arrangements and reporting all of this to the project manager (Moretto et al., 2020). There are no formal procedures in place for projects, as the procedures mature over time to meet the demands of the project on hand (Moretto et al., 2020). According to the authors (2020), in this typology suppliers are involved in projects from the design stage and represent the initial source of innovation. The researchers (2020) created a hybrid typology, where businesses that do not have the characteristics of either typology solely belong too. Business conforming to the hybrid structure merges the efficiency of the procurement-oriented typology with the effectiveness in supporting projects of the project-oriented typology (Moretto et al., 2020).

To wrap up, there are four main procurement structures recognised in the literature, these are central, decentral, hybrid and project procurement. In the central structure, one single person or group is responsible for procurement. In the decentral structure, business divisions hold the authority to purchase materials, products or services. A combination of central and decentral makes the hybrid purchasing organisation. Lastly is the project procurement structure where project members purchase for the purpose of the project, but there are also purchasing activities performed centrally for day-to-day needs.

2.5 Practice and policy of circular procurement

This chapter presents literature found on practice and policy. It starts off with defining circular procurement, continues with circular procurement processes and ends with a paragraph on measuring circular procurement.

2.5.1 Defining circular procurement according to practice and policy

In practice and policy different authors have different definitions of circular procurement, some of these are highlighted in the next few sentences. According to Platform CB'23 (2021), circular procurement has a goal and a definition. The goal is to use the procurement process to advance a conversion to a circular economy (Platform CB'23, 2021). The definition, according to Platform CB'23 (2021), is to procure a circular solution, this is a solution that contributes to two of the three goals of circular construction (protecting the environment, the stock of materials and the existing values) (Platform CB'23, 2021). Another definition is by van Oppen et al. (2018) and is as follows:

> Circular procurement is the process in which a product, a service or a project is purchased according to the principles of a circular economy. In this process the technical aspects of the product are as circular as possible, taking maintenance and return policies at the end of the use period into account, as well as including financial incentives to guarantee circular use (p.19).

Not only is procuring circular goods considered with circular procurement, van Oppen et al. (2018) state that the purchaser should also consider the circularity of use of a material or service, because to obtain the maximum achievable circularity, the use of materials, design, production and reuse for the future all needs to be considered (van Oppen et al., 2018). Procuring circularly creates space to satisfy existing demand in a different way, which affects the purchasing process in five linked ways: if one should purchase, what needs to be purchased, who you procure from, procurement collaboration in the value chain, and how to procure (van Oppen et al., 2018)

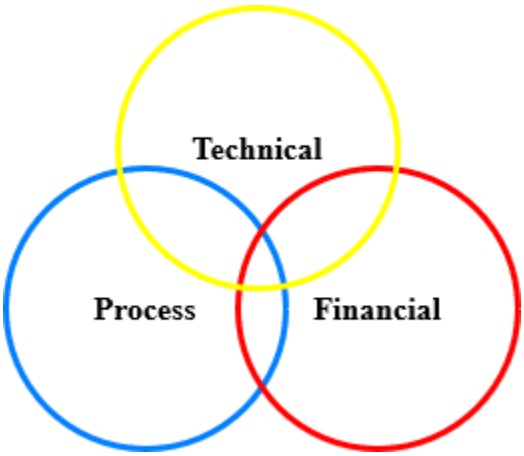

Figure 3 TPF Model (based on van Oppen et al. (2018), Bosch & van Oppen (2020) and Platform CB'23 (2021))

Before a circular economy can exist, a transformation is necessary for different aspects. This transformation is needed on three aspects (see Figure 3); technical, process and financial (Bosch & van Oppen, 2020; Platform CB'23, 2021; van Oppen et al., 2018). The technical aspect represents the system

in which a product is created from materials and produced following the principles of circularity (Platform CB'23, 2021; van Oppen et al., 2018). It also takes into consideration the extent to which disassembly of products or materials for reuse is possible (van Oppen et al., 2018). The process aspect also includes an organisational aspect, it represents the relationship of working together between different parties according to Platform CB'23 (2021). van Oppen et al. (2018) agree and add that the processes need to be organised to aid circularity and the circular adoption in the entire process. Lastly, the financial aspect is how suppliers and other partners aim to financially encourage the process of circularity, such as revenue models and ensuring a product has a longer lifecycle (Bosch & van Oppen, 2020; Platform CB'23, 2021; van Oppen et al., 2018).

The introduction of CE into procurement will have several implications, as aforementioned, in the book of van Oppen et al. (2018), the authors identify four. See Table 3 for these implications and their explanation.

Table 3 Implications of circular procurement

Change from procurement officer to procurement process With circular procurement, the procurement is not only the accountability of the procurement personnel, but relates to more departments of the company (van Oppen et al., 2018). Different departments have to collaborate for successful circular procurement (van Oppen et al., 2018).	**Change from transactional to relational** Within circular procurement relationship is important, so there is more to it than only the transaction (van Oppen et al., 2018). Within the relationship, circularity is the responsibility of both the supplier and the purchasing organisation (van Oppen et al., 2018).
Change from business cases to long-term value creation Circular procurement is based on life cycle costs instead of just one transaction and expense, thus all aspects are to be considered in the circular procurement process (van Oppen et al., 2018).	**Transition from technical specification to functional specification** Technical specifications limit innovative, creative and circular thinking at the supplier, which is necessary for circular procurement (Platform CB'23, 2021). To avoid that situation, the purchasing organisation has to functionally specify the demands, criteria and requirements (van Oppen et al., 2018).

2.5.2 Circular procurement processes

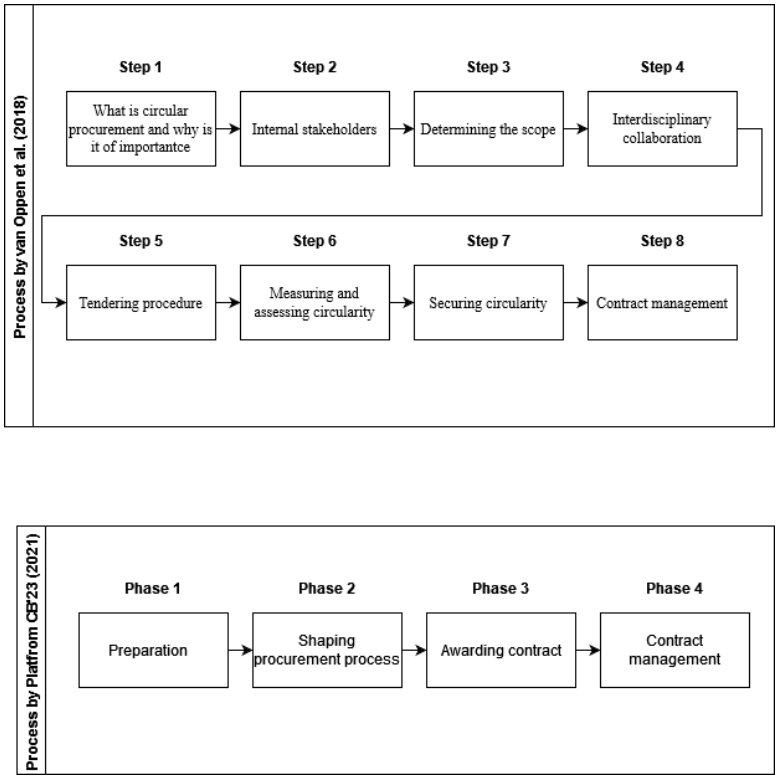

Figure 4 Circular procurement processes by van Oppen et al. (2018) and Platform CB'23 (2021)

The process of circular procurement consists of several steps. According to van Oppen et al. (2018), there are eight steps in this process. Platform CB'23 (2021) says the process has eleven steps divided into four phases in the circular procurement process. Both methods are in Figure 4 and will be elaborated on in the following sections, starting with van Oppen et al. (2018).

2.5.2.1 The procurement process in eight steps according to van Oppen et al. (2018)

As seen in Figure 4, there are eight steps distinguished to accomplish circular procurement in the model stated in the book of van Oppen et al. (2018). An additional source for the eight-step process is by Bosch and van Oppen (2020), which details the process for the construction sector.

1. In the first step 'What is circular procurement and why is it of importance', the organisation will have to formulate why circular procurement is important and consequently establish a working definition of circular procurement to create shared beliefs inside the organisation but also with suppliers (van Oppen et al., 2018). Both are important for selecting the right suppliers and other partners (van Oppen et al., 2018). It is important to establish why as this shows the motives, which is important in selecting prospective suppliers, as these suppliers should support the visions set (van Oppen et al., 2018). Helping with establishing the 'why' are ambition sessions, which are especially important for specific projects (Bosch & van Oppen, 2020). The established ambitions can create focus points to realise during the project (Bosch & van Oppen, 2020). Another tool that can help with setting the ambitions is the 'Maatschappelijk Verantwoord Inkopen'(Socially responsible purchasing) tool of the government, which

can also help them translate to criteria and requirements (Rijksoverheid, n.d.). It is important to create the focal points with all parties that are involved in the project, such as a project leader, purchasers, technical manager, contract manager and maybe even personnel from financing (Bosch & van Oppen, 2020). After the 'why' is established, the company should create a working definition. This working definition should be clear to ensure suppliers understand the objectives, it serves as a foundation for the award criteria in a tender (van Oppen et al., 2018). The company can align the definition with earlier used definitions or align them with other clients with similar projects (Bosch & van Oppen, 2020). It is essential to share this definition internally, and it might be worth considering a multidisciplinary working session to define circular procurement (van Oppen et al., 2018).

2. The second step is involving internal stakeholders. The procurement officer harmonises the interests of internal stakeholders on the circular procurement process and should thoroughly assess which departments and personnel are needed for circular procurement and circular use (van Oppen et al., 2018). According to Bosch and van Oppen (2020), the following three functions at least have to be part of the internal stakeholders; internal client, project management and technical engineers. For the internal clients, it takes time to incorporate circularity into the project, project management include those that have to deliver the project and should therefore know about the circularity of the company, and engineers should be included to assess the possibility of embedding the circularity ambitions into the technical demands (Bosch & van Oppen, 2020). Additional internal stakeholders suggested by van Oppen et al. (2018) are executive level, sustainability advisor, financial expert, legal affairs and communication. These personnel members collaborate and align interests to ensure the success of circular procurement (van Oppen et al., 2018).
3. Step three is determining the scope. Within this step, it is essential to specify what the buyer exactly needs as not procuring anything is the most circular option, thus the buyer should make a list of the demands (van Oppen et al., 2018). After the determination of the demands, the determination of the project scope takes place (van Oppen et al., 2018). In the scope, it is important to generate functional specifications, as this allows suppliers to create innovative solutions (van Oppen et al., 2018). The freedom in innovative solutions is critical for CE, and it can also prevent the specific use of materials (Bosch & van Oppen, 2020; van Oppen et al., 2018). In construction, there is occasionally a

need for technical specifications but is crucial for CE to keep these to a minimum (Bosch & van Oppen, 2020).

4. Step four is interdisciplinary collaboration. It is widely known that collaborating is critical for creating and working in a CE (Ellen MacArthur Foundation, 2021). It is crucial to align interests as much as possible for successful circular procurement and this can only be accomplished by looking in the value chain, both suppliers and other actors of the value chain (van Oppen et al., 2018). According to Bosch and van Oppen (2020), aligning interest is hard in construction projects as there are often conflicting interests. An approach to align interests is to involve suppliers with a market consultation (request for information, individual meetings or a plenary session) (Bosch & van Oppen, 2020; van Oppen et al., 2018). In the market consultation, it is possible to validate set ambitions for the project, avoid misunderstandings and get insights into the opportunities and technologies of suppliers (Bosch & van Oppen, 2020; Nagelkerke et al., 2009; van Oppen et al., 2018). In collaboration with value chain partners, it is wise to begin with a systematic analysis of the value chain and then proceed to a market consultation (van Oppen et al., 2018).
5. The tender procedure is step five of the process. During tendering, the collaboration aspect is still important and can be facilitated through conversations and ensure contact outside all of the paperwork involved (Bosch & van Oppen, 2020; van Oppen et al., 2018). Both Bosch and van Oppen (2020) and van Oppen et al. (2018) suggest dialogues, either with individual suppliers or other value chain actors or as a plenary session. van Oppen et al. (2018) add innovation as another essential principle in the tender procedure and dialogues.
6. Step six is measuring and assessing circularity. This step starts with selecting and awarding suppliers with the project (Bosch & van Oppen, 2020; van Oppen et al., 2018). During the selection phase, there are requirements on which suppliers can characterise themselves and criteria on which suppliers can distinguish themselves from the competition (van Oppen et al., 2018). It is vital to include circularity in both to get the suppliers their vision on it and how suppliers are implementing circularity in the project (Bosch & van Oppen, 2020; van Oppen et al., 2018). The latter is specifically relevant for the awarding phase of the tender (Bosch & van Oppen, 2020). When creating awarding criteria, it is necessary to consider what is possible and realistic in the market regarding circularity (van Oppen et al., 2018). For circularity, in the award phase, the following elements are of interest: the circularity of the offer, a plan for development

for the offer and the economic and organisational agreements that ensure circularity (van Oppen et al., 2018). In construction, it often happens that price is still prevalent in awarding the contract (Bosch & van Oppen, 2020), but with circularity, it is important to consider the set ambitions which might be reflected in the price (van Oppen et al., 2018). The next stage in step six is measuring and assessing circularity. van Oppen et al. (2018) are not convinced that the circularity of a product or material can be measured, but propose two aspects for determining circularity: the current circularity and the potential material circularity. The current circularity can be measured and identifies the percentage of reused materials or products the final material or product is made of (van Oppen et al., 2018). The potential material circularity can be both assessed and measured, and it is the percentage of how much of the product or material can be reused in the future and the chance of that happening (van Oppen et al., 2018). For measurement, a buyer can see if suppliers already use circular measurement options, and if so, try to align these (van Oppen et al., 2018). Measuring the level of circularity of a material or product can only happen at a specific time, measuring the future of circularity of a product is impossible (van Oppen et al., 2018). A measurement tool frequently used in construction is the 'Milieukostenindicator' (MKI) (Indicator of environmental costs), but this takes place on project level instead of product-level (Bosch & van Oppen, 2020; Prinssen, Rademaker, & den Boer, 2019).

7. Securing circularity is the seventh step. This step looks at achieving circularity in the long term, which can be through circular revenue models or circular contracts (van Oppen et al., 2018). The procurement of circular products is crucial but should be combined with circular use, this calls for a different relationship between the producers and its products and between the user and the product (van Oppen et al., 2018). This different relationship is enabled by circular revenue models, such as lease, rental, pay-per-use, residual value: buy-back schemes and product-service combination (Bosch & van Oppen, 2020; van Oppen et al., 2018). Found in Table 4 is an explanation of all the revenue models. The contract is the relationship initiated between buyer and seller via the tender, and it is crucial to maintain trust during the contract period (van Oppen et al., 2018). This trust can be demonstrated by prolonging the terms of the contract, it also allows suppliers to spend time on technologies that help with the circular use (van Oppen et al., 2018). By prolonging the contract, the buyer contracts for the uncertain future (van Oppen et al., 2018). Creating more certainty can be done by creating performance indicators with bonuses or fines (Bosch & van Oppen, 2020; van Oppen et

al., 2018). The performance indicators are relevant for framework contracts in the construction sector (Bosch & van Oppen, 2020).

Table 4 Circular revenue models

Lease	The product or material is bought by a financier from the producer and sold to the user (van Oppen et al., 2018). The ownership is transferred from the producer to the financier (van Oppen et al., 2018). The financier searches for a user, if found, the user becomes the owner or the financier remains owner (van Oppen et al., 2018). The relationship between the actors affects securing circularity in ownership and economic perspective (van Oppen et al., 2018). According to van Oppen et al. (2018), leasing is suited for CE especially if the residual value at the end of the lease is zero or less than zero. But the lease agreement must assure that the producer takes the product back at the end of the contract (van Oppen et al., 2018),
Rental	In this model, the producer or supplier rents the product to user, which thus concerns a direct relationship (van Oppen et al., 2018). The producer or supplier is the investor, which this party must be capable of being financially (van Oppen et al., 2018). Rental is relevant when there are temporary needs for products or materials with low volumes purchased (van Oppen et al., 2018).
Pay-per-use	In the pay-per-use model the price is calculated by the amount of consumption that is measured (van Oppen et al., 2018). With regards to circularity, it is of relevance when there is more than one user involved (van Oppen et al., 2018). The reason for this is that the asset is effectively shared, which is beneficial for both producer and users (van Oppen et al., 2018).
Residual value: buy-back schemes	The model is an agreement between the producer or supplier and the user (van Oppen et al., 2018). Here the producer purchases the products back at the EoL for a price that is determined beforehand (Bosch & van Oppen, 2020; van Oppen et al., 2018). An assumption of this model is that producers are interested in the residual value of the used product or its materials for recycling or reuse (van Oppen et al., 2018).

Product-service combination	Within this model, a tender is published in which is asked for both the product and a service related to it (van Oppen et al., 2018). The model is especially beneficial if the supplier offers a high quality circular product, as this decreases the maintenance necessary (van Oppen et al., 2018).

8. Step eight, the last step, this is circular contract management. The procurement is the start of a relationship with a buyer, which starts taking shape when the project is carried out (Bosch & van Oppen, 2020; van Oppen et al., 2018). During this relationship, it is essential to give attention to the previously established ambitions for which both parties are responsible (Bosch & van Oppen, 2020). In the construction sector, the client is often more dominant but to realise circular ambitions it is important to see each other as equals (Bosch & van Oppen, 2020). These ambitions should be defined to key performance indicators (KPIs), which should be finetuned with the winning supplier and regularly checked by the buying party (van Oppen et al., 2018). It often helps to put a contract manager in place to maintain the relationship (Bosch & van Oppen, 2020; van Oppen et al., 2018). After the contract has ended, it is important to evaluate the process, seeing as circular working (of which circular procurement is part) is a learning process (van Oppen et al., 2018).

2.5.2.2 The procurement process in eleven steps according to Platform CB'23

Figure 1 shows the four phases of circular procurement, according to Platform CB'23 (2021), under which eleven steps are divided, starting with the preparation phase.

1. In the preparation phase, the following steps should be performed: market research, market consultation and specification (Platform CB'23, 2021). The performed market research is meant to give insights into what possibilities and solutions are offered by different suppliers (Platform CB'23, 2021). After this step, a market consultation might be useful; as mentioned before, it helps to validate ambitions for a project, avoid misunderstanding and get insights into the opportunities, visions and solutions of the suppliers on the market (Nagelkerke et al., 2009; Platform CB'23, 2021). Within the market consultation, the TPF-model of Figure 3 can be a guide (Platform CB'23, 2021). The last step in phase one is the specification. During this step, it is important to specify specifications as functional as possible, instead of technical, to allow suppliers freedom (Platform CB'23, 2021).

2. The second phase is shaping the procurement process. The first step is the selection stage, during this phase, the purchaser selects those buyers that are deemed suitable for the project (Platform CB'23, 2021). The framework for selection can consist of exclusion, suitability and selection criteria (Platform CB'23, 2021). The next step is the dialogue stage, however, this is an optional step in the procurement process (Platform CB'23, 2021). The goal of the dialogue phase is to finetune the specification for the market, identify and divide the risks of innovative solutions and lastly to aid selected buyers with adapting their solution to the specification (Platform CB'23, 2021). The registration step follows, here the specification of criteria for awarding takes place which most often happens on the MEAT (Platform CB'23, 2021). MEAT consists of different awarding criteria of which best price-quality relation and lowest life cycle cost are the most beneficial to ensure circular procurement (PIANOo Expertisecentrum Aanbesteden, n.d.-d; Platform CB'23, 2021). An essential aspect of the specification criteria is circularity to guarantee it, the purchasing organisation should be consistent with circularity in measuring and use the TPF-model (see Figure 1).
3. Phase three is the awarding of the contract. Step one in this phase is assessment, here the purchasing organisation assesses the registrations of the potential supplier (Platform CB'23, 2021). Secondly, is awarding the tender on the MEAT. Thirdly, is working out the tender between the tender winner and the purchaser, here it is essential to verify if both parties have interpreted each other correctly (Platform CB'23, 2021). Lastly, according to Platform CB'23 (2021), is signing the contract on which both the buyer and supplier agree.
4. The last phase is contract management. The first step in this last phase is contract management (Platform CB'23, 2021). Contract management is there to ensure that circular ambitions and performances are achieved, as well as, that all agreements are fulfilled (Platform CB'23, 2021). According to Platform CB'23 (2021), the collaboration between buyer and supplier in this step is crucial, and even the whole chain can collaborate to ensure circularity. Other aspects to ensure circularity, reported by Platform CB'23 (2021), are:
    - Regularly monitor agreements of circularity from the contract;
    - Ensure everyone involved interprets the agreements and promises the same;
    - Both supplier and the procuring organisation are responsible; and
    - If the construction project has short life cycle, agreements at the EoL should be honoured.

For monitoring circular agreements between the parties the following methods are recommended (Platform CB'23, 2021):

- Use certificates as evidence for circular performance;
- Use evidence for circularity when purchasing materials from equipment services, such as receipts;
- Let suppliers deliver an index of material passports in different phases of the project; and
- Suppliers should demonstrate, with purchase orders or receipts, that released materials are reused elsewhere.

The last step in the circular procurement process of (Platform CB'23, 2021) is contract evaluation. Evaluation of the contract takes place between buyer and supplier and provides points for improvements and successes of the project (Platform CB'23, 2021).

To summarise, the process of van Oppen et al. (2018) consists of eight steps. These steps are 'what is circular procurement and why is it of importance', 'internal stakeholder, 'determining the scope', 'interdisciplinary collaboration', 'tender procedure', 'measuring and assessing circularity', 'securing circularity' and 'contract management. The process by Platform CB'23 (2021) consists of four phases, these are 'preparation', 'shaping the procurement process', 'awarding the tender' and 'contract management'. The steps in both processes of van Oppen et al. (2018) and Platform CB'23 (2021) platform roughly correspond to each other. The main differences are that Platform CB'23 (2021) does not include knowledge of circular economy and procurement and the measurement of circular purchasing in its process.

2.5.3 Measuring circular procurement

An important element of CE and circular procurement is measurement. This importance is highlighted by both van Oppen et al. (2018) and Platform CB'23 (2021). Additionally, according to Platform CB'23 (2021), it helps the company to learn and develop from the circular procurement process. But just as in the academic literature the practice and policy field also recognises there is a lack of good measurement indicators (Vos et al., 2019). According to Platform CB'23 (2021), there are three types of monitoring a company can undertake on either project or company level; effort monitoring at the project level, effect monitoring at the project level and process monitoring at the organisational level.

- Effort monitoring takes place at the project level, this means that efforts to procure circularly should be tracked and kept up-to-date (Platform CB'23, 2021). The company must define when an effort counts as circular (Platform CB'23, 2021). In this monitoring

method, the purchaser should mention the price paid for the purchase, so the company can report what percentage of purchasing is circular (Platform CB'23, 2021). Platform CB'23 (2021) created two instruments for effort monitoring, the first one is for companies starting with circular procurement and the other is for companies more advanced in circular procurement. These checklists are based on Vos et al. (2019), however, the authors (2019) do not differentiate between the beginning and advanced companies. These checklists are in Appendix B.

- Effect monitoring focuses on completed circularity at the end of a project (Platform CB'23, 2021). This method is unattainable for most projects, as not all necessary data is accessible or available to the purchasing department (Lijzen et al., 2020). Zijp et al. (2020) are working on developing a method to measure the effects of circular procurement, this method should enable the measurement of retained materials. In this case, purchasers need to keep track of the materials purchased and used in what quantities and how many materials were transported elsewhere (Zijp et al., 2020). However, what is possible to measure is the impact on the environment via CO_2-footprint, this data can be retrieved from the LCA (Platform CB'23, 2021). When MKI is used in the tender it is easy to retrieve the data for this particular part of the project (Platform CB'23, 2021). It is essential to validate the MKI score at the end, to see if the target from the contract is reached (Platform CB'23, 2021).
- Process monitoring takes place at the organisation level (Platform CB'23, 2021). The process includes getting from ambitions on circular procurement to circular procurement strategies (Platform CB'23, 2021). The method is especially meant for the organisation to learn and to develop, in which internal involvement and commitment are crucial (Platform CB'23, 2021).

2.6 Discussion of academic literature and practice and policy

When comparing the definitions of circular procurement of the two literature sections, it shows the definitions are not far off from each other but are not the same. The definitions complement where the other is lacking. The definitions take key aspects of the definition of EMF and combining this with procurement. Platform CB'23 (2021) reports that in order to call something circular procurement it only needs to satisfy two out of three goals of circular procurement, this is a difference from all the other definitions provided. The implications of using circular procurement differ among academics and practice and policy. In the academic literature the implications are redefinition of prices, quality, time and value for money fundamentals of

purchasing (Farooque et al., 2019). In practice and policy these are change from procurement officer to procurement process, change from transactional to relational, change from business cases to long-term value creation and change from technical specification to functional specification. The only similarity is the value creation.

There is an emphasis on working together with the supply chain for circular procurement in academic literature, which matches the practice and policy its collaboration emphasis. There are similarities in the way this is achieved, both name market consultation and competitive dialogue as means. There are, however, two differences namely the emphasis on innovation and how to enhance more innovation along the chain. van Oppen et al. (2018) and Platform CB'23 (2021) state innovation is important for more circular procurement, but the authors do not provide a mean. The academic literature provides a possibility to enhance innovation with innovative partnership. This method can help with the innovation in the processes of the practice and policy.

Academic literature and practice and policy agree that it is important to measure the circularity progress and recognise a lack of good indicators, although van Oppen et al. (2018) are sceptical on whether or not circularity of a product can be measured. Both literature strands report that a method to start measurement is by reporting what percentage of the purchases is circular or the specific percentage of a material or services used (Kristensen & Mosgaard, 2020; Platform CB'23, 2021; Vinante et al., 2020). Academic literature has a strong focus on measuring the circularity of product, materials or the whole building and what is purchased circularly, whereas the practice field also states that processes should be measured to learn and develop circular process (Platform CB'23, 2021).

3. Methodology

This chapter presents the methodology of the research. The chapter addresses the research design, research setting, data collection and data analysis to ensure a reliable and valid outcome.

3.1 Research approach and setting

The research was carried out for a better understanding of circularity and circular procurement and to gain an insight at how the current situation of circular purchasing is at Waterworks. The study calls for an explorative, qualitative study approach (Babbie, 2016; Saunders, Lewis, & Thornhill, 2019). To gather data to answer the research questions and gather information from the field of practice, a literature study was performed and semi-structured interviews were conducted. The researcher reached out to the company supervisors and employees of Waterworks for the interviews. The final sample consists of nine participants from the two most important different clusters of the firm and different responsibilities. Some quantitative data was gathered in this study to back up the interview data and support possible circular procurement practices.

The setting of the research was at the company Waterworks located in the Netherlands. The study only included two divisions of the company; Civil Engineering and Services. The reason for this is that within these clusters procurement plays an important role and the clusters left out are already providing a service in the direction of circularity (Company supervisor 1, personal communication, April 8, 2021). An important note about the study is, due to the setting, that it is chosen to leave the social aspect out of the definition of circular procurement as this does not cover and fit the goals of circularity of Waterworks.

3.2 Conducting literature search in both academic and practice and policy

At first academic literature was researched to gather relevant studies to create a literature review on the topics circular economy, circular procurement and types of project procurement structures. Academic literature was used to gain a deeper understanding of the topics. During the research on academic literature, there was a lot of relevant literature on practice and policy on the subject of circular procurement, which can also be named grey literature. Grey literature is often published by experts who are in a particular area and whose main goal is not to publish academic literature (Pappas & Williams, 2011; Rothstein & Hopewell, 2009). This type of literature is often not included in the regular channels of publication or distribution (Benzies,

Premji, Hayden, & Serrett, 2006). These authors (2006) state that grey literature may be government publications, academic papers, theses, newspapers or conference proceedings. The below practice and policy is of particular interest to Waterworks because it includes sources from, among other things, the Dutch government and the construction sector on circular procurement and its implementation.

3.3 Conducting semi-structured interviews with employees and coding them inductively

To gather the qualitative data, individual interviews were conducted with nine employees of the company. The interviews took place in September 2021. Eight of these interviews took place physically at the office of the company, and one of them took place via Microsoft Teams. Potential interviewees were approached by email stating if they would like to participate in the research, if agreed the next step was to call and make an appointment. To ease the burden on the participants, they could choose the date, time and place of the interview. The interviewees were selected on the following criteria: their function, their cluster, how often they purchase, being on the process side of procurement, experience with purchasing for the business. The employees selected came from the clusters Civil Engineering and Services. The reason for these clusters is that these are in the scope of the research and the biggest achievement on circular procurement at Waterworks can be reached in these clusters. The interviewees hold different positions within the two different clusters. The reason for different positions is to get a better and complete view of the current situation on circular procurement. The previous selection criteria were used to ensure that interviewees were the best sources fit for this research. Table 5 below provides an overview of the conducted interviews. With the interviewee their consent the interview was recorded using a mobile phone. After which the interviews were transcribed.

Table 5 Overview of interviewees

Respondent	Respondent code	Cluster	Position of interviewee	Interview duration	Transcript length
1	SER1	Services	Project leader	73 min	12 p
2	WVC1	WV&C	Senior project leader	75 min	10 p
3	WKI1	WK&I	Senior project leader	52 min	10 p
4	WKI2	WK&I	Planner	29 min	5 p
5	WKI3	WK&I	Senior project leader	33 min	6 p
6	HI1	H&I	Planner	18 min	4 p

7	WVC2	WV&C	Project leader	40 min	7 p
8	SER2	Services	Project leader	68 min	13 p
9	WVC3	WV&C	Senior project leader	60 min	8 p

The interviews were semi-structured. In semi-structured interviews, there is a series of predetermined themes, concepts and key questions to regulate the interviews (Saunders et al., 2019). Key themes from the interview include the definition of circular procurement, involving suppliers and sub-contractors and the current situation at the company regarding circular procurement. Appendix C shows the detailed key questions of the interview, both in English and Dutch as the interviews were conducted in the Dutch language. The questions were derived from conversations with the company supervisors and the literature. An important advantage of semi-structured interviews over structured interviews is that this type allows for discussions and to probe the interviewees about their opinions or meaning or discuss what they said before (Saunders et al., 2019). Discussion can lead to more and richer data beyond the key questions. During the semi-structured interviews, an interpretive approach was used. The characteristic of an interpretive approach is the more flexible way in which the questions are asked as the follow-up question can continue what the interviewee says and what data is shared (Saunders et al., 2019). Throughout the interviews, this was the case, if the interviewee shared some data that was also relevant for other questions the corresponding question was asked afterwards or if the researcher wanted to know more about a particular aspect of the answer of the interviewee.

After gathering the data from the semi-structured interviews, the interviews were transcribed. The transcript of the interviews only contains the text on what was discussed during the interviews and, therefore, does not include other things such as timestamps, expression of emotions, hesitations etc. Subsequently, the data from the interviews was put in Excel. The columns contained the interviewee number and the rows contained the questions and the corresponding answers provided by the interviewee. The answers of different interviewees were structured alongside each other if the answers provided contained the same or similar aspects. Some of the data from the interviews did not fit any of the questions and were, therefore, put on a separate tab in Excel to easily navigate back to. After all the data was put in Excel, the process of coding could start. An inductive coding method was used to analyse the data. This means there was no coding book prior to the coding process. The answers from the interviewees were the first set of codes, then the second set of codes was developed from similar answers of interviewees, and, lastly, an overarching category was derived. The overarching category codes are challenge, CP process, definition, knowledge and commitment, process, products bought, progress and roles. With these coding categories, the foundation for the results of this study was

created. The coding also provided strengths, weaknesses, opportunities and threats for the SWOT analysis performed.

3.4 Gathering purchasing data and categorising them according to the 80/20 rule

As stated before, besides the qualitative data, quantitative data, in the form of money spent on purchasing materials or services, was collected. The first purpose of the creditor data was to see if there was data in there to see if Waterworks was already procuring circularly and what percentage of purchases is circular. After analysing the data, a conclusion was that data on circular aspects of the data not included. So, the next purpose of the data is to show where Waterworks can achieve the biggest impact with circular procurement towards its goal of 2030 as it shows the amount procured per supplier or sub-contractor. This quantitative data was collected via an employee of the administration department. An email was sent if it was possible to receive this data and at what time would be best suitable to talk about it. A physical meeting took place to explain what was needed for the research. After this meeting, the data was sent via email. The data includes all creditors of the clusters Civil engineering and Services. In the Excel document containing the data, the following items can be found: company code, company name, number of invoices from 2020 up to June 2021 and the amount invoiced from 2020 up to June 2021. The data did not include a description of the creditor nor what was sold to the company. Thus, research on what the creditor sold was necessary. This research was performed by searching the creditor via several search engines and unknown companies were presented to the first company supervisor. The last resort if unknown was asking the administration employee for help. In the end, all companies were identified.

The quantitative data from the administration was analysed by the 80/20 rule, to show the 80% largest suppliers or sub-contractors of Waterworks and the 20%. The 80/20 rule was performed based on the total amount credited to Waterworks by the creditor. The total amount credited by the creditor was divided by the total number credited. From that calculation, a percentage was derived, this was sorted from high low and then the cumulative percentage was calculated. This cumulative percentage gave the top 80% of creditors for both the clusters Civil engineering and Services. With this 80% and the descriptions of the creditors, fifteen categories were created. Every creditor was then put in one of the categories that fit the most. Some creditors were removed due to the nature of business, such as pension funds, banks and recruitment organisations. With the categories in place, it was possible to see what category has

the biggest impact on the procurement of Waterworks by seeing how much is spent on purchasing from the categories. Table 6 shows the categories from the creditor analysis.

Table 6 Creditor analysis categories

Category number	Category description	Category number	Category description
1	Contractors	9	Plastics
2	Raw materials	10	Asphalt
3	Concrete	11	Electrotechnology
4	Reinforcement steel	12	Various lease
5	Steel constructions	13	Prefab concrete
6	Piping	14	Various trade
7	Mechanical engineering installations	15	Wood
8	Foundations		

3.5 Performing a SWOT analysis based on the data received

Before the conclusion could be reaches a SWOT analysis was performed. SWOT stands for **S**trength, **W**eakness, **O**pportunity and **T**hreat (Dyson, 2004). Strength and weakness are part of the internal environment and opportunities and threats of the external environment (Helms & Nixon, 2010; van Liemt & Koot, 2018). The SWOT analysis is a systematic way of trying to gain insights from the interviews and the results section. The SWOT analysis provides recommendations for Waterworks to continue doing business as it is, exploiting a strength or opportunity and/or mitigating weaknesses and threats. As stated before, input for the analysis came from the interviews and other parts of the results. The coding scheme provided helpful insights in grouping insights of the interviews in strength, weakness, opportunity or threat. The SWOT analysis provides recommendations for Waterworks, which are used in the discussion and conclusion of this study.

4. Results

This chapter presents the findings of the earlier described research. It starts with the critical characteristics of Waterworks its knowledge on the topic, next is the procurement structure and the processes.

4.1 Critical characteristics of Waterworks; organisation, procurement process and materials and services procured

This subsection provides an overview of the findings regarding the knowledge of circularity, the procurement processes of Waterworks and the products and services procured. These findings will be linked to the circularity aspect from both the interviewees their answers and relevant literature.

4.1.1 Knowledge at Waterworks is widespread and there is not one definition of circularity

The interview opened with the question 'What is circular procurement according to you?' to see what the interviewee their knowledge is on the subject. This question received many different answers and interpretations of circular procurement. Summarised in Table 7 are the explanations and interpretations per interviewee. The table shows how different the employees define circular procurement. SER1 recognises the different interpretations and definitions and states: "because if you ask me what circularity is, you will get a very different answer than if you ask a colleague". This difference can be traced back to the argument of SER2, who says it does not mean a lot and other interviewees who gave a more elaborated answer. WVC3 stresses the fact that knowledge is lacking by stating that what would help to procure better or more circular lies in having an actual answer to what is circular procurement according to you. But this interviewee is also interested in circularity, as they believe it is needed to understand circularity before circular procurement. Most interviewees their answers are in line with what are the key principles of circularity for Waterworks, as mentioned in Introduction. However, circular procurement can be interpreted as a more encompassing term rather than restricting itself to simply reusing and recycling. According to the literature, the essence of circularity lies in maintaining the highest value possible. Many interviewees did not mention anything about what should be done with materials after they are no longer necessary or when the project gets demolished. This aspect is essential in the circular economy as its purpose is to keep materials in the economy. Only one interviewee spoke about where it should go after the material or

product is no longer necessary. Additionally, two others said something about buy-back schemes, but that was after questioning them on it.

Another aspect of knowledge is that the interviewees are not aware of circular procurement. Interviewees WKI2 and WVC3 indicate that they do not consider circular procurement because they have no or too little awareness. SER1 states that they are not aware of the importance or necessity of circular procurement. Another interviewee also states that the most extensive opportunity within Waterworks for circular procurement lies in awareness. Six out of nine interviewees say that awareness is a fundamental element for circular procurement. The last aspect of knowledge is that interviewees do not know where to incorporate circularity in the projects. They are unaware of what circular products to procure or do not know how to include circularity in the project (SER1, WKI1, & WKI2). This awareness and knowledge gap goes for both new and current projects (WKI3, HI1, & SER2). This can also be traced back to the fact that two interviewees express a feeling that circular procurement is easier to incorporate in utility construction or a different cluster of Waterworks (WKI3 & SER2).

Table 7 Answers, of the interviewees to the question 'What is circular procurement according to you?

Interviewee	**Definition of circular procurement**
SER1	"I think it is knowing what you are buying and knowing what purpose it should serve."
WVC1	"Number 1 is not purchasing but reusing materials. Number two is, of course, minimising the emissions you create when producing that material or equipment."
WKI1	"Purchasing in which materials and production have a as low as possible CO_2 footprint."
WKI2	"Circular procurement for me is the reuse of things."
WKI3	"Circular purchasing means in any case purchasing something with which you are working towards an objective." "In other words, a product or service, in this case a product, that can be reused or recycled."
HI1	"Purchasing materials as sustainably as possible, talking to both the client and the supplier." "Not only the product itself but also the way of delivering it"
WVC2	"When I look at circular procurement, the focus is on equipment to limit emissions as much as possible." "The second is the materials you use. The materials that you have to buy externally, you just have to look at how you can do that as sustainably as possible." "

SER2	"Well to be honest not much so far"
WVC3	"With procurement you want to achieve that you at least have an influence on the chain." "I think it is a difficult question"

According to the interviews, commitment is also lacking at the company to procure circularly. Two interviewees revealed that they think that the older generation is more hesitant to the change of circularity. These interviewees feel that the younger generation is more willing to adapt circular procurement and thinks more about it. One of the two did say not all members of the older generation are like that, a few are willing to adopt and see the long-term picture. The results from the interviews do not confirm the statements on generations from these two interviewees. One interviewee is less committed as it feels like circularity is a compulsory social issue and also revealed "In the sense of it not helping our business model, I do not believe that. It is not going to make more money.". Others show no commitment related to that they do not consider circularity when purchasing materials or services. This issue might link back to the fact that knowledge on circular procurement is limited, but this relationship was not researched in this study. This problem is not only an issue related to individuals. WKI1 reveals that this happens in teams too. This interviewee reveals "I do notice that when I bring it up in my team, not many ideas come up about how we could apply circularity. Not everyone is actively working on it." This interviewee also feels that employees are more likely to remain with a supplier they know and trust than switch to another more unknown circular supplier. One interviewee has trouble with the goal of working circular in 2030. This interviewee finds it vague as there is nothing concrete yet and does not believe that 100% circularity in the construction sector is achievable. Whereas another colleague thinks 2030 is doable in terms of becoming fully circular but this colleague makes a side note on this that the steps already taken should be kept in place.

4.1.2 The procurement process that Waterworks follows in order to procure services and materials

Procurement happens in two possible phases at Waterworks. The first phase is the tender management, in which the whole process can be followed or only a few steps. The second phase is during the project management phase. During this phase, all steps will be followed. The process for a potential project starts with the tender team of Waterworks preparing an offer to the tender announced by the client. The tender team often already sends out requests for quotations to suppliers and sub-contractors, as the team needs an indication of the costs to submit a price (HI1 & WVC3). This situation means that frequently a party is already chosen before starting with the realisation phase of the project but that is not always the case. Based on

the lowest price, a party is selected (WVC3). WKI2 feels the tender team can play an important role in selecting circular suppliers and has the idea the tender teams are working on this already. When Waterworks wins the tender, the project goes to the realisation phase. In the realisation phase, the realisation team takes over.

The purchasing process can differ per cluster, but there is a written procurement management process that transcends all clusters, but the below process has a slight more focus on the Civil engineering cluster (Waterworks, *Inkoop-B001 Beleid d.d*., accessed on October 1, 2021). The interviewees gave similar answers on how they start the purchasing process when asked: '*Which steps do you undertake during the current purchasing process?'*. The first step in the process is knowing what needs to be purchased (All interviewees). The work planner or the calculator decides on the necessary purchases (WKI1& WKI2). It can happen that the tender team already compiled a list of suppliers available for the materials that need to be purchased. Some purchases are done during the period of construction on the site, according to WKI1.

The next step according to the policy is determining the procurement strategy. However, none of the interviewees stated this step in their process explanation. This step entails filling in the Kraljic matrix. Also, none of the interviewees mentioned this. In the Kraljic matrix, the supply risk on the x-axis is the risk associated with buying the product. The matrix can also help assess placing circular materials and services. Questions asked are: are the materials widely available, are there few or many suppliers and are there alternatives? (Caniels & Gelderman, 2005; de Vries jr. & Borchert, 2018). On the y-axis, there is the profit impact. The question asked is does the purchase impact the profit of the organisation? Products with a high impact have more effect on profit and/or project (Waterworks, *Inkoop-B001 Beleid d.d*., accessed on October 4, 2021). Products are classified into four quadrants: routine commodity, bottleneck, leverage and strategic (Monczka, Handfield, Guinipero, Patterson, & Waters, 2010). In the purchasing planning, there is a column where project members can fill in what quadrant the material or service is in, but this is not mandatory (Company supervisor 1, personal communication, September 29, 2021). The output is a document containing all information needed for procurement such as the purchaser, service or material to purchase, name of the supplier or sub-contractor, type of contract, budgeted amount versus the actual amount, result, Kraljic quadrant and the schedule of purchasing (Waterworks, *F-004 Inkoopschema*, accessed on October 4, 2021). However, a procurement specification is not always drafted, according to WKI3.

Preparing the purchase and awarding the contract are the next steps. The preparation is done by the work planner based on offers received (WKI2, WKI3, & HI1). These offers are then

compared based on earlier experiences and supplier evaluations. The earlier experiences can also stem from other colleagues or the central purchaser (WKI1, WKI2, & WKI3). If there are multiple quote requests, a quote comparison is used (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 4, 2021); WKI3). In this comparison, various parties are compared based on the results of purchases, and some additional aspects, including risk arrangements, guarantees, and, importantly, safety (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 4, 2021). Safety was mentioned as an essential procurement criterion by all but one interviewee. Based on the outcome of the quotation comparison, a concept purchase agreement is drawn up. After internal agreement on the concept the awarding of a contract is done (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 4, 2021). The chosen party is most likely based on the lowest price, this is implied or stated by interviewees SER1, WKI1, WKI2, WKI3, SER2 and WVC3. The lowest price decision is frequently based on the fact that Waterworks is also judged on price in the tender application and not on, for example, circularity or sustainability (SER1, HI1, & SER2). Price is often the reason why the circularity is not chosen according to the literature and WKI2. WVC1 contradicts this by revealing that the company does not go for the lowest price but goes for stability. If more criteria than price are considered, the most competitive solution, that suits the client needs and the risks of the business, is chosen (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 4, 2021).

The following step is to contract the purchase. This contract can be performed in a sub-contractor agreement, a supplier agreement or an engineering agreement (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 4, 2021). A critical factor in the contract is guaranteeing the Forest Stewardship Council (FSC) label (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 5, 2021). FSC is a non-profit organisation that has a mission to maintain and safeguard the world its forests (FSC, about us). FSC created a label to show that companies adhere to their mission (FSC, about us, n.d.).

The final steps in the purchasing process of Waterworks are monitoring and evaluating suppliers and sub-contractors. Monitoring if the materials or services purchased meet the criteria is performed via the processes of technical management (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 5, 2021). The evaluation takes place according to the following criteria: process control, safety and environment, value for money, security of supply, service-oriented (service provided by the supplier which was not in the purchasing contract) and circularity (Waterworks, *Inkoop-B001 Beleid d.d.*, accessed on October 5, 2021). There were only two interviewees who named the evaluation step (WVC2 & WVC3). This lack of stating can happen because the evaluation step has not been in place for a long time (Company

supervisor 1, personal communication, October 6, 2021). WVC3 states that the tender team is also involved in the evaluation because the team also provides suppliers to the project team. In the evaluation process, not all suppliers and sub-contracts are evaluated. A selection of suppliers is created with a minimum of five parties to evaluate (Company Supervisor 1, personal communication, September 29, 2021). The evaluation may take place at several stages: at the end of a project phase (tender, design, realisation and maintenance) or during the realisation phase if this phase takes some time (Company supervisor 1, personal communication, October 5, 2021). The evaluation takes place in an online programme called '12build' and also shows the results. The results are also made public for the evaluated supplier (Company supervisor 1, personal communication, October 6, 2021). The publicly shared grades and comments can be different from the actual grades given by Waterworks in the evaluation as other suppliers can see the grades as well (Company supervisor 1, personal communication, October 6, 2021).

The measuring of purchases takes place on the project level at Waterworks, according to the interviewees. The measuring items are in the purchasing planning. The following aspects are: measured the actual amount of purchased materials and services and the difference between the budgeted and the exact amount spent (SER1, WKI3, HI1, & WVC3). Interviewees HI1 and WVC3 state that quantities are also reported, but WKI2 contradicts this by saying that quantities are not reported. An analysis of the different purchasing planning documents shows that quantities are not always provided in the planning.

During the analysis of the interviews and coding them, in the context there was a hint of Waterworks not being fully mature on the purchasing process yet. Interviewees mostly did not mention the process at all or only parts of it. Most interviewees also do not have a background fully dedicated to purchasing. This might hinder the process of circular procurement because not everyone is fully aware of what procurement fully entails. However, it did become apparent during talks with company supervisor 1 that this is a work in progress. Furthermore, the general process of the procurement policy leaves a lot of room for improvements on circular procurement. The policy document does not describe any circular aspects that need to be followed during procurement. For employees, there is thus no uniformity in the procurement process on circularity as it is not prescribed in the policy document.

4.1.2.1 A variety of employees is involved in the purchasing decision

To get an overview of who is involved in the decision making of where and from whom to purchase, the following interview question was asked 'Do you purchase materials or services on your own or are other people involved during the decision making of where and from whom

to procure?'. The question was asked based on literature which reports that the construction sector often uses project procurement structures. All interviewees revealed that more employees are involved in the process, some added that they also decide themselves. The interviewed project leaders state that they are in charge of the purchasing but most often let the work planner do the actual purchasing. The interviewed work planners stated that they purchase, but if it is above their authorisation, they need to go to the (senior) project leader. Project leaders, depending on seniority, either go to the senior project leader or the director when the amount of money exceeds their authorisation. Some interviewees revealed that the central purchaser is sometimes involved with purchasing in the project, most often for contracts (WKI1, WKI2, WKI3, & SER2). WKI1 states that there are four options for purchasing, and in each option different people are involved. The first option is the work foreman doing the purchasing independently. Secondly, the work foreman does the purchasing independently but keeps the project leader informed. Thirdly is purchasing together with the work planner. Lastly, the project leader purchases together with the central purchaser. The central purchaser is also asked in case of a new supplier or sub-contractor, to see if it is a familiar contact or to join in conversations with this new supplier or sub-contractor. Furthermore, interviewees WKI1 and WKI2 both stated that support from the central purchaser would help with more circular procurement in the projects in the form of creating circular awarding criteria and measuring purchases on circularity. Collaboration between different parties is important in circular procurement, according to van Oppen et al. (2018). It is important to ensure multiple people from the company and the project are involved, so option one and two of WKI1 are not ideal situations for circular procurement.

4.1.3 Circular aspects in Waterworks its procurement process are mainly included in the evaluation stage

During the interviews, the interviewees provided points on where they already incorporate circularity or not in their project procurement process. Questions relating to this section include 'Do you already consider circularity when purchasing materials or services?', 'Do you involve sub-contractors for circularity whilst purchasing?' and 'Do you involve suppliers for circularity whilst purchasing'.

The process of 'actual' purchasing materials or services starts when the client awards the project to Waterworks. However, as stated before, in the tender phase suppliers, or sub-contractors are already contacted. A few interviewees (WKI3, WVC2, & SER2) say that the tender team needs to consider circularity when bidding on the tender. WKI3 reveals "That is where it starts in the tender. I think the tender team already has to choose on these points. I also

think that the tender team members are quite focused on this. They know that this is something we simply have to organise together next year because that is what is going to bother us in the selections." Some others point out that the clients ask for certain circular or sustainable aspects in the tender, and the tender team of Waterworks has to prove these things. These aspects include LCA (SER1), reduction of CO_2 emission (SER1, WKI1, & WKI2), and nitrogen calculations (WKI2).

According to several interviewees, the problem of circular procurement does not lie with the tender or design team but, in most cases, the client. The client is not ready yet to include circularity or sustainability in the criteria, or they are conservative and hesitant to change their ways. Within the cluster Services, the clients often prescribe certain parts or suppliers. This description leaves no freedom for design, purchasing and circular aspects (SER1 & SER2). This phenomenon is also known as technical specifications. Functional specifications would allow for more circularity in projects, as stated in section 2.5.1 by van Oppen et al. (2018) and Platform CB'23 (2021). Interviewees SER1 and SER2 both feel like this could also help with purchasing more circularly. Within one of the departments of civil engineering, the interviewees tend to have a more positive view of the clients their willingness to incorporate sustainability and circularity. This more positive view likely stems from them working together with the client in the plan execution phase (WVC1 & WVC2). WVC1 states "We opt for tenders and contracts in which, before making a final decision on what to choose, we make the decisive choice with the client and the engineering firm". Interviewee WVC2 states that the company is becoming more involved in the earlier stages of the project, such as the exploration phase and the plan execution phase. WVC1 also admits that the involvement of the company is earlier in the process. WVC2 reveals that the firm is part of innovative partnerships within these phases of the projects, but these are limited to the parties involved in the project. Sometimes, involving other parties in the exploration and plan execution phase happens (WVC1 & WVC2). This collaboration helps with incorporating circularity in the process, according to WVC1. Working together is an essential aspect of the circular economy (Ellen MacArthur Foundation, 2021).

On the evaluation side, there is a circular evaluation method based on project levels. WVC2 states that the projects are evaluated on circularity based on a star rating system. This star rating system is only applicable on the projects of civil engineering and those projects of Services that have a tender phase (Waterworks, *Circulaire Sterren rating voor project omzet*, accessed on October 5, 2021). Sometimes, it happens that the company is the main contractor in combination with another contractor. These combinations are only considered for the star rating in ratio to the contract sum (Waterworks, *Circulaire Sterren rating voor project omzet*,

accessed on October 5, 2021). The star ratings correspond to the three earlier stated themes Waterworks has for circularity (raw materials, energy and ecology) (Waterworks, *Circulaire Sterren rating voor project omzet*, accessed on October 5, 2021). The goal of assigning stars to projects is to have an overview of the contribution the firm realises through their projects, the results are displayed in a dashboard, and the results then go into the reports of the directors (Waterworks, *Circulaire Sterren rating voor project omzet*, accessed on October 5, 2021). Shown in Appendix D are the answering options. The criteria for the star rating differ per theme, as shown in Appendix E. There is a second evaluation method that takes place on the supplier or sub-contractor level. One of the categories is sustainability/circularity. The category contains four questions and are as follows:

- To what extent does Waterworks contribute to reducing energy requirements or emissions (to be fossil-free)?;
- To what extent does Waterworks contribute to closing the material cycles (e.g. eliminate waste, enable reuse, use recycled material)?;
- To what extent does Waterworks contribute to maintaining or increasing ecological values?; &
- To what extent has Waterworks proactively contributed ideas/acted to the issues of circularity and sustainability?

This method was only mentioned by WVC2. After analysing the reports, a conclusion is that the questions frequently receive the answer not applicable. During the interviews, there was no question on why this is the case, but a logical explanation could be a lack of clear understanding of what circular and circular procurement mean among the company its employees.

With regards to measuring circular procurement, interviewees said this was not done. Four out of nine interviewees reveal they do not know what can be done to measure circular procurement. A few interviewees came with different ideas such as LCA, using material passports, giving circular products codes, giving codes to products that can be easily used somewhere else or adding a column in the purchase planning with yes or no on circularity. With the latter, it is important to have defined conditions on what makes a material or service circular or not. LCA is not a good measurement technique for circularity, according to WKI2 and one of the company supervisors. The reason is that LCA measures the emission of certain materials used in the construction and is not about the whole chain (Company supervisor 2, personal communication, n.d).

To conclude, there are some aspects of circular procurement included in the process of procurement at Waterworks such as collaborating with clients or suppliers and evaluating projects and suppliers on circularity. However, there is room for improvement on adding aspects of circularity to the procurement process. It is important to include circularity in the whole procedure and not just at the end. Including the aspects in the process will create uniformity on what needs to be done for circular procurement and everyone is confronted and aware of circular procurement aspects necessary.

4.1.4 The largest circular impact on the procurement spend of Waterworks are sub-contractors, electrotechnology and mechanical engineering installations

As Waterworks is a construction firm, a wide array of materials are procured. Besides materials, services are procured as well at Waterworks. This outcome became apparent in the interviews carried out after asking the question 'What materials or services do you purchase for the projects of the company?'. Answers varied in the purchased materials, but frequent answers were sheet piling, steel constructions, concrete, sand, pumps, electrical installations, cables, other mechanical engineering parts. The interviewees also listed several services procured, the most stated service was sub-contractors. Next to sub-contractors, other services are transport and earthmoving, including machines. From the interviews, there was no clear distinction on what is purchased between civil engineering and services, apart from fewer purchased services.

The spend analysis is a powerful tool in procurement, allowing businesses to enhance their buying power (Ambe, 2019). According to Luzzini, Amann, Caniato, Essig, and Ronchi (2015), spend analysis is the act of analysing the purchasing spend of a specific category. As stated in the previous chapter, a procurement spend analysis was performed for the business but on a cluster level instead of a category level. The procurement spend analysis for civil engineering shows that contractors have the highest percentage of spending of the total procurement spend of Civil engineering with 17.3% (see Figure 5) Within this category are companies such as sub-contractors, contracting firms, road construction and demolition firms. The second-largest spend category is electrotechnology, with a percentage of 15.8. Electrotechnology includes suppliers that sell electronic components, control panels and measurement instruments (SER1 & SER2). The third-largest spend categories are asphalt and mechanical engineering installations, both corresponding to a percentage of 11.9. Products in the last category include complete mechanical engineering installations, pumps, water treatment equipment and fittings. The category asphalt contains, as named, asphalt products. Thus for the part of the cluster of

Civil engineering, the most extended enhancement of buying power lies in the categories of contractors, electrotechnology, asphalt and mechanical engineering installations.

In the spend analysis of Services, as seen in Figure 6, there is a similar outcome. However, the order is different. The largest spend category is the category of mechanical engineering with 27.1%. The second place is for sub-contractors corresponding to 18.1% of the total procurement spend. The third category is electrotechnology with 8%.

Unfortunately, from this data, it cannot be concluded what products are procured circularly, but the purchasing spend analysis can help with where to start with circular procurement and where the most significant impact on procuring circular products can be achieved. In their research, Knight, Blessner, Olson, and Blackburn (2017) researched if spend analysis can help a company with sustainability goals. The authors (2017) concluded that spend analysis could help an organisation with sustainability goals by identifying true strategic partners. With true strategic partners, the development of relationships can take place (Monczka et al., 2010). As stated before, relationships are essential in circular procurement (van Oppen et al., 2018). The bond can help establish mutual ambitions on the aspect of circularity (van Oppen et al., 2018). WVC3 indicates that an overview containing items that have the most effect on circular purchasing would be a solution to help procure more circularly. It would motivate the interviewee to see concrete steps being finished (WVC3).

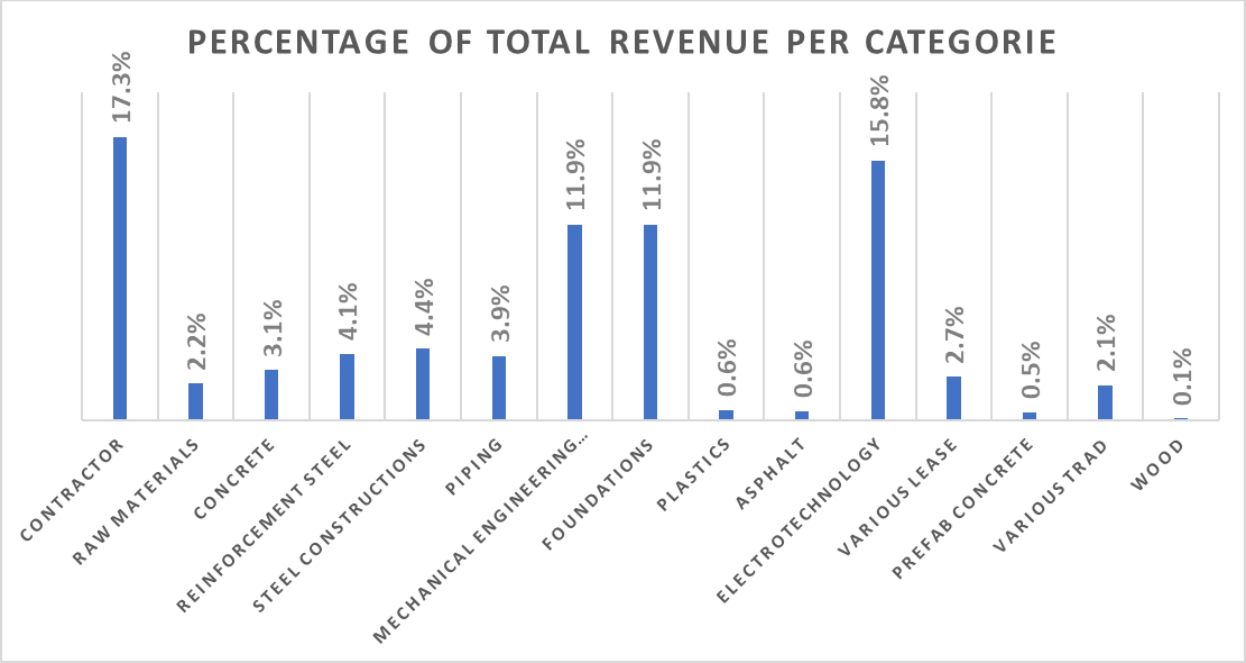

Figure 5 Percentage of total revenue of Civil engineering per category

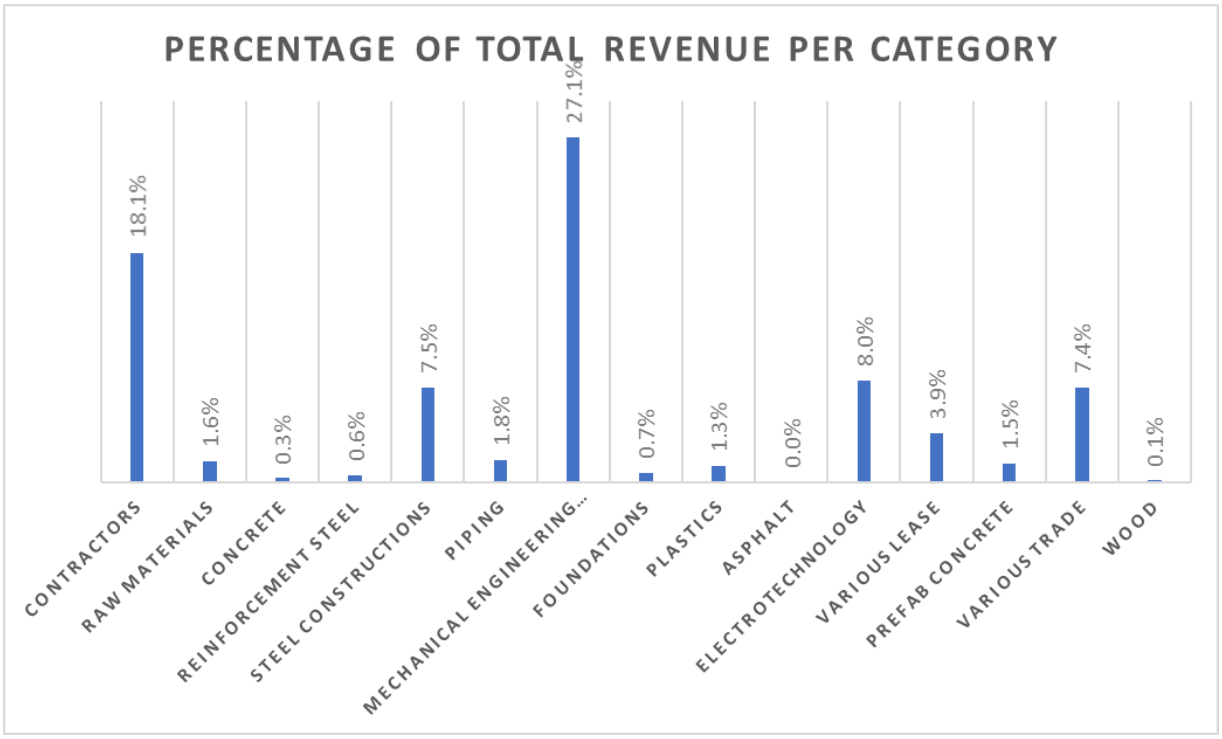

Figure 6 Percentage of total revenue of Services per category

4.1.5 Circular aspects in the materials or services purchased by interviewees

As written in the previous section, it was not possible to see if materials or services were circularly procured. It was not explicitly asked if products were already purchased in circular fashion. However, from some interviews, it became apparent that some (raw) materials are purchased circularly. The interviewees did not mark this as circular, but it can be labelled as circular as materials are reused and nothing is purchased. Interviewees not considering a purchase as circular can be due to a knowledge gap. WKI2 revealed a situation where poles were needed to be procured to block off the road. There were still some other poles on the site that would be thrown away, these poles would provide the same function as these new poles (WKI2). After all, no new poles were procured, and the leftover poles were used. The most circular action in circular procurement is not purchasing (van Oppen et al., 2018). But the interviewee did not realise that this was also considered circular. A similar situation happens with sand. Multiple interviewees (WVC1, WVC2, SER2, & WVC3) state sand is put aside after digging it up at the project. The sand is often needed again for the project. So, instead of purchasing new additional sand, the sand is reused again. For the interviewees, this is a common situation, but it is circular. WKI3 subconsciously recognises this and said: “Maybe there are things that are circular but that we think are not circular at all”. WVC1 recognises something similar about a project at the Ijsselmeer. During this project, there was a need for sand which can be retrieved from the lake. The lake is often subject to removal of sand in order to maintain

the necessary depth for ships. However, WVC1 states that a government client does not consider this opportunity and sells this sand to other interested parties.

Another circular aspect with products purchased is using a circular business model as stated by e.g. van Oppen et al. (2018); buy-back schemes. WVC3 mentions the buy-back scheme specifically for concrete planking. The concrete planking is used for the project, but in the end, no longer needed for the company. In that case, the company goes back to the supplier to ask if they are interested in buying them back so they can reuse them again. Interviewees WVC3 and WKI1 state buy-back schemes but did not elaborate on them further. SER2 reveals that an idea sparked to put a box at site, where they can gather old materials that can be recycled, revised or reused. The box is from a party that said they can work with the products.

Multiple interviewees and company supervisor 2 mentioned that certifications of products and services labelled as circular are often lacking. Materials and services are not tested long enough to ensure the durability and lifecycle. Clients see these materials as risks for their construction and therefore do not want it included in the finished structure. HI1 does recognise that there is progress in this area. WVC1 says the company is testing materials with research agencies on durability and stability. Besides certifications, regulations also play a particular role in choosing the material or service (WKI1). Not all materials can be chosen because due to regulations they are not allowed to be chosen or because they are not certified because of regulations. Besides the regulations and certifications, clients are also unaware of the option regarding circularity. One of the interviewees stated a possible solution for this problem. The respondent said that the cluster wants to take clients to a business that reuses or revises materials or parts to be used again (SER1). The purpose is to show the client how it exactly works and the quality of the products (SER1). The ultimate goal is to persuade the client to use the circular alternative (SER1).

To wrap up, there are materials procured circularly but nothing was implied about the procurement of services. Most of these circularly purchased materials were subconsciously procured circularly. This leaves room for both awareness and knowledge on what is considered circular and actually including circular procurement practices to purchase circular materials and services. It is also important to show the durability and quality of circular products as this is a problem for clients.

4.1.6 The involvement of clients, suppliers and sub-contractors in circular procurement

Involving the supply chain is very important with circular procurement and the contractor is in an ideal position to do so. Several actions or events are happening in the supply chain of

Waterworks concerning circular procurement. These actions are listed in the following paragraphs.

Waterworks is one of the main initiators of 'Emissieloos Netwerk Infra' (ENI), according to WVC1 and company supervisor 2. ENI is a foundation created to design and make zero-emission building materials, especially focused on the machinery used. ENI wants to connect throughout the whole chain, thus everyone in the chain is involved from suppliers, knowledge institutions, clients (governments, regional water authorities etc.), contractors and construction sector organisations (Emissieloos Netwerk Infra, n.d.). Several conversations between all parties took place to show there is a need for a sped-up process to create zero-emission building materials and together they will realise this (Emissieloos Netwerk Infra, n.d.). So, together they will develop this building material.

Secondly, several interviewees (SER1, HI1, WVC2) admit that they ask suppliers and sub-contractors what they can do with circularity for the project or at least they start the conversation on the possibilities. WVC2 mentions innovative partnership as one of the methods to involve circularity in the procurement process. WVC3 says that they often ask sub-contractors to use certain types of machinery to reduce emissions. However, almost all interviewees do recognise that, during the procurement process, suppliers and sub-contractors often are not ready to have a conversation on circularity. According to interviewees, this is often due to the lack of knowledge, lack of awareness, not consciously working on circularity and the construction sector wanting to use new materials only (SER1, HI1, SER2).

Lastly, those who are on top of the chain are often not ready yet to accommodate circularity in their tenders. A difference between the departments can be observed; WV&C often has more collaboration with clients and can thus steer more on sustainability and circularity. However, the interviewees from WV&C do recognise the challenge. All interviewees but one revealed that clients are a barrier to circularity. A huge portion of the power to include circularity lies with the clients. There are many different reasons clients are a threat to the company. The first one is during the tender, according to interviewees SER1, WKI1 and SER2, there is an over-specification of tenders. This over-specification leads to limited or no freedom in material choice. Some clients provide a list containing specific brands and materials that need to be used (SER1). Clients also do not include circular criteria in their tenders (WKI1 & SER2). Some clients require LCA, MKI or a CO_2 emission reduction, but that is as far as sustainability goes (SER1, WVC1, WKI1, WKI2, WKI3, & SER2). This exclusion of criteria means Waterworks cannot score points on this or gain an advantage on the sum required to realise the project (SER2). Frequently, the criteria used are price, quality and time (WKI1). Secondly, clients are

often conservative and reserved (SER1 & WVC3). They are reluctant to change to new working methods (SER1), however, SER1 feels like this differs among generations and that a younger generation is more willing to think about circularity. The difference among generations is not a conclusion that was agreed upon by other interviewees. The third reason clients are a threat is that often they are price-driven, which is also another threat to the business (SER1, WKI1, WKI2, HI1, WVC2, SER2, & WVC3). Many interviewees feel like including circularity will drive the price up (WKI1 & WKI2). This higher price can result will not be winning the tender as Waterworks is not the cheapest anymore. Price is at the expense of sustainability. HI1 says "But the moment you come up with a slightly more expensive price for sustainability, they suddenly stop wanting it."

To conclude, interviewees reveal that some suppliers, sub-contractors and clients are willing to work with circularity but most of them are not ready for it yet. This might imply that Waterworks is early on circular procurement even though the Dutch government wants part of the economy to be circular by 2030. Waterworks got the market moving with ENI, which interviewees feel like is a step in the right direction. The collaboration between different parties on circular alternatives, initiated by Waterworks or where they participate, might help get the market along. Although, a few are willing to collaborate, interviewees feel like a lot of actors in the supply chain are not ready for circularity yet.

5. Points of influence for circular procurement

This chapter starts with a presentation of the SWOT analysis, it follows with detailed sections on the elements of the SWOT. It will start with the weaknesses, followed by the threats, strengths and opportunities

A SWOT analysis is created, as seen in Table 8below. The purpose of the SWOT analysis is thus to determine the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats (Dyson, 2004). The SWOT was created based on the coding scheme of the interviewees and detailed answers provided by the interviewees. It identifies points Waterworks can exploit (the strengths and opportunities) and counter (the weaknesses and threats) with regards to circular procurement. The SWOT analysis also provides input for recommendations for the discussion chapter of this study.

Table 8 SWOT analysis of Waterworks on (circular) procurement

Strength	**Weaknesses**
- Good knowledge base, stemming from the working groups and knowledge sessions - Sustainability manager in place - Founder of the foundation ENI - Commitment from the top of the company	- Not one single definition of circular procurement among employees - Not everyone is aware of circularity in materials, services or projects - Not everyone is committed - Project structure
Opportunities	**Threats**
- Market consultation - Innovative partnership and working together - Pilot projects	- Suppliers and sub-contractors not being ready - Clients not being ready - Market is price driven - Product availability - Rules and regulations

5.1 Weaknesses at Waterworks are knowledge, awareness, commitment and project structure

A frequently stated challenge with circular procurement and working circularly is a lack of knowledge. This challenge is frequently stated in the academic and grey literature (Gerhardsson et al., 2020; Karhu & Linkola, 2019; Platform CB'23, 2021; van Oppen et al., 2018). As stated

in the results chapter, the employees gave many different answers to the question 'What is circular procurement according to you?'. This question received many different answers and interpretations of circular procurement (see **Error! Reference source not found.** on page 46). T he results indicate that there is knowledge on the topic but it does not encompass all elements of circular procurement. Knowledge should be common ground among employees of the company. To achieve this WVC1 suggests creating a standard document regarding circular procurement so everyone has the same basis.

Due to the lack of or insufficient knowledge, interviewees are not all aware of circular procurement. Therefore, lack of awareness is the second weakness of Waterworks. Many interviewees stated that this is the opportunity for the company in order to procure circularly. WKI1 says that with awareness, an important aspect is knowing why one should procure circularly. So, the added value of circular procurement needs to be highlighted. SER2 had an idea on increasing awareness of circularity. The interviewee said what might work was doing the same as which is done for safety now, by awarding "prices" to good circularity practices and bringing it to the attention of the other employees.

The second to last challenge is commitment. As mentioned before not everyone is on the same level of commitment to circular procurement. Two interviewees indicate that they feel the older generation is more hesitant to the change of circularity. They feel that the younger generation is more willing to adapt circular procurement and thinks more about it. From the other interviews, this statement about generations was not confirmed. Others have no commitment related to that they do not consider circularity when purchasing materials or services. This problem is not only an issue related to individuals but happens in teams too (WKI1). This interviewee also feels that employees are more likely to remain with a supplier they know and trust than switch to another more circular supplier.

Whilst the project (procurement) structure can also have its advantages, it can also be seen as a weakness. Often the situation arises that tasks might be replicated, this also includes purchasing tasks. Additionally, the central purchasers might have less feeling for local information. Although, that does not necessarily seem to be the case at Waterworks. Several employees know how to find the central purchasers for a discussion on what their best strategy for procurement is. One of the greater weaknesses is that many different people are involved. These different people bring in their own beliefs, knowledge and values and this can create tension between project members. At Waterworks, this problem can also be found with circular procurement. Among the interviewees, all had their interpretation and explanation of circularity which makes that not everyone works according to the same circularity principles. Furthermore,

not all interviewees are on the same commitment level to procure circularly, which can create possible tensions. Due to working on different projects, some interviewees feel like they miss information on circular options other project teams have. Some feel like a meeting overarching multiple projects where circular aspects and ideas can be shared is beneficial. Alongside the project procurement, there are many more teams involved in a construction project such as the tender team. The tender team is a separate team from the procuring and building team. The tender team sometimes decides on aspects that the procurement and building team might not agree on. Here it might also help to have meetings together on what is to be expected when procuring circularly for a project.

To summarise, the weaknesses of Waterworks for circular procurement are knowledge, awareness, commitment and the project structure at the company. These weaknesses should be countered to ensure circular procurement will work within Waterworks. An increase in knowledge will most likely solve problems related to awareness and commitment, but awareness might also be a starting point of knowledge. Knowledge can be increased by knowledge sessions, workshops and sharing ideas on circular procurement within in the company.

5.2 Threats for Waterworks are clients and suppliers

As written in the previous chapter, suppliers and sub-contractors are a threat to Waterworks. Suppliers or sub-contractors are often not ready to deliver circular products or services (SER1, WVC1, HI1, & SER2). This might link back to the knowledge as interviewees are unaware or do not know what suppliers offer on circularity. In this threat, there is no apparent difference among the different clusters of the company. Interviewees SER1, WVC1, HI1 and SER2 reveal that suppliers and sub-contractors do not consciously work on circularity. SER1 stated that when questioning suppliers on circularity, the answer includes receiving many questions on circularity in return. A second problem here is that the representative of a supplier or sub-contractor gets questioned on circularity, this is most likely not the one making decisions on circularity in this company. This means that from the representative, it needs to go higher up and there is no method to check if this happens (SER2). According to WVC1, suppliers are an important element and working and developing together can provide circular solutions. WKI2 agrees on this and voices that when a party (subcontractor or supplier) funds and contributes to a circular aspect, Waterworks should bind the party to themselves to become partners. The last

problem is that suppliers are always looking to make a profit. This problem means that they will not set circularity as number one. This issue is revealed by both WVC1 and SER2.

The client who awards the project to Waterworks is the second threat. As stated before, a difference between the departments exists, which is also applicable to this challenge; WV&C often has more collaboration with the client and can thus steer more on sustainability and circularity. Clients often have the power to decide on circularity in the tender phase, when awarding the project. In the tender, the client over-specifies requirements on both material selection but also on selection criteria (SER1, WKI1, & SER2). Secondly is that clients are often conservative and preserved and therefore they are reluctant to change to new methods of working (SER1 & WVC3).

The third threat is that often the client is price-driven, which is also another threat to the business (SER1, WKI1, WKI2, HI1, WVC2, SER2, & WVC3). According to most interviewees, including circularity in the project will drive up the price (WKI1 & WKI2). Higher prices can result in not winning the tender as Waterworks is no longer be a cheap actor in the market.

Many interviewees reveal that the availability of (non-)circular materials and services are in some cases scarce and become more expensive (SER1, WVC1, WKI1, HI1, & SER2). Interviewees WKI1 and SER2 state that delivery times are going up for products, such as sheet piling. The delivery times are increasing because of capacity problems. This increase could stem from COVID-19 (WVC1 & WKI1). SER2 already had to say to clients that projects would be delayed because of prolonged delivery times. Admitting, WKI1 says that if the product is available in, e.g. India, circularity is no longer of concern as the product is needed fast. A problem with raw materials is going to be a construction sector problem, according to HI1. This interviewee states it is already happening with oil, as there is a surge in prices. So, because price is still prevailing, there is a tendency to buy it now and store it. The reason is that at the moment, it is cheaper, and circularity is then overlooked (HI1).

As stated in the previous chapter, many services and products that can be purchased and be labelled as circular are often not certified for construction. Materials have to meet certain rules and regulations before being certified for use. Without the certifications, clients are hesitant to incorporate them in their construction work as the lifecycle of the product is unknown (WKI1 & SER2). Especially, because construction materials often have to meet certain conditions, criteria and certifications, one cannot incorporate uncertified products into the work. So, for Waterworks, clients can be a threat because they will not allow them to

purchase circular materials and services as these do not fulfil certification needs and/or rules and regulations.

To conclude, threats faced by Waterworks are suppliers and sub-contractors, clients and availability of products. Suppliers and sub-contractors are not ready for circularity. Clients are not including circularity in the tender, are conservative and price driven. Lastly, the availability of products poses a threat as this is often at the expense of circularity and sustainability. It is important that Waterworks counters these threats to prepare for when the rest of the market is ready for circular procurement. Furthermore, what Waterworks can do is inform the market about knowledge and the possibilities of circular procurement and collaborating with others. By sharing knowledge, the company might find others who want to collaborate on circular procurement and together they might change the market. The biggest threat of the above is clients as these often are governments who are strict on rules and regulations, and Waterworks cannot change these but have to adapt to these rules and regulations. Something they can do is testing projects and materials and showing the results to those who make the rules and regulations through market consultation sessions or inspiration sessions.

5.3 The strengths of Waterworks in the process circular procurement

The first strength of the company is knowledge, which can thus also be seen as a weakness. From the interviews, it became apparent that employees are aware of circularity. Most of the interviewees had an answer to what circular procurement meant according to them, which was frequently in line with parts of the circularity goals of Waterworks. Several interviewees indicated that knowledge sessions on different aspects of circularity took place (SER1, WKI3, WVC2, & SER2). The knowledge that is available and known is shared on the intranet of the company, so everyone in the company can read this. There are also working groups on different circularity aspects, where step by step is discussed and determined how Waterworks is going to handle circularity. These groups are on the department level but also company level. HI1 states that these groups generated some ideas. Interviewees SER1 and WKI1 feel like with the knowledge the business has and will gain, they can help clients, suppliers and sub-contractors with (starting) circularity by providing information.

A second strength is that Waterworks has a sustainability manager in place. WKI1 made known that when encountering an issue with sustainability, the sustainability manager is called to help resolve it. Interviewees WKI1 and SER2 both state that the sustainability manager is also involved in projects that require more sustainability or circularity than is asked for

nowadays. According to WKI3, when the sustainability manager was hired more steps were taken to consider sustainability and circularity. The manager encouraged more employees to think about sustainability (WKI3). SER2 states: "The fact that the sustainability manager is here with us shows that the company has the intention to become circular. The sustainability manager implemented tools to help employees with circularity in their projects." Examples include the star rating (see 4.1.3), lists of companies that are willing to buy materials back (SER2) and a decision matrix to compare suppliers or sub-contractors on circularity (WKI1). WVC3 indicates that the positive attitude of the sustainability managers helps to gain a positive mindset towards circularity.

Thirdly is being one of the founders of ENI. With ENI, Waterworks brought multiple parties from the construction sector together. The goal of ENI is, as aforementioned, to create zero-emission construction material for the sector together. Waterworks worked hard to successfully get others involved, others are in this case suppliers of machinery, other contractors and clients such as the government.

Commitment from the top can be seen as the fourth strength. Circularity is something that is promoted by the board of the company, as revealed by SER1. WVC1 said that with ENI, they got the director to promote the foundation among other relevant directors. With the director involved, more other companies were willing to join as it showed that the top of the company was committed (WVC1). Directors are in some situations also involved in the procurement of services and materials, so they can also choose on circularity in that case (WVC1). WKI1 also says that stimulating circularity is part of the job of the board of directors. In the quarterly memos from the board, circularity is included as a section (internal documents).

Conclusively, the strengths of the company with regards to circular procurement lie in already having quite a bit of knowledge about the subject through knowledge sessions and working groups. Secondly, having a sustainability manager in place that can help with these issues and has a positive attitude which works infectious. Lastly, having commitment from the top. The company should and can exploit these strengths to counter the weaknesses and threats in its internal and external environment to ensure the goal of working and becoming fully circular is reached.

5.4 The opportunities of circular procurement at Waterworks include public authorities and pilots

The first opportunity of the firm is that they work with public authorities and district water boards (Waterworks, home page, n.d.). These parties have goals in terms of circularity and need

means to realise this (Ministerie van Infrastructuur en Waterstaat, 2019). These parties most likely have to conform to regulations of tenders set by the European Union and are, therefore, more likely to use market consultation or innovative partnerships if needed (PIANOo Expertisecentrum Aanbesteden, n.d.-b). These two are public procurement tools for innovation (Georghiou, Edler, Uyarra, & Yeow, 2014). WVC2 reveals that the firm is involved in market consultation, especially with clients. The interviewee said that the company signs up for this through 'Tendernet'. WVC2 states the clients use it to gain advice on their problems. Also, SER2 states that Waterworks is invited to market consultation sessions. However, it is hard to talk about circularity and sustainability there (SER2). With market consultation, Waterworks does have a potential way to influence clients for circularity and provide knowledge on the subject. The innovative partnership is also something in which the company is involved, according to WVC2. This partnership is happening at a dike reinforcement for a project, where zero-emission is central to the project. So, they are looking into how they can realise this project with little to zero emission. The focus lies on the machines they use. But Waterworks is also the founder of ENI in which they also work together with, e.g. clients such as governments, to create a zero-emission construction site. So, they also work together and share knowledge with the public authorities besides the market consultations and the innovative partnership.

The second opportunity is some clients that are open to doing test "projects" or pilots. Interviewees WKI1 and SER2 both describe the same project where the client wants to test circular aspects on the project. They both declared that the sustainability manager was also involved in seeking solutions. Both said it was difficult to find solutions, but the client was open to hearing the ideas. WVC1 indicates that in collaboration with the client and a Dutch water programme, they performed tests at a testing company with clay. These tests had to show if clay would be strong enough or to replace sheet piling or not. Secondly, they also tested that all classes of clay could be used, not only the highest class. WVC2 revealed they are currently doing a pilot project on letting machines necessary at construction site run on liquid hydrogen to create a zero-emission environment. A pilot project to see how circularity would work and how materials would last was stated as a tip for circular procurement by Interviewees WVC2 and SER2.

To conclude, opportunities at Waterworks include participating in market consultations set out by clients, collaborating in innovative partnerships and being part of test projects or pilots. These opportunities should also be exploited by Waterworks to counter the weaknesses, but especially the threats in its external environment. The opportunities can help get the market along on circularity which might help purchase more materials and services more circular.

6. Discussion

This chapter will start by presenting the conclusion and discussion of the research, followed by the theoretical and practical implications of this research. The limitations of the study and suggestions for further research will close this chapter.

6.1 Main findings

The aim of this study was to answer the research question "*How can Waterworks define circular procurement process in a project procurement environment to establish a functioning procurement structure?"* At the end of the study, it became apparent that the research strayed off from the initial research question presented in the introduction. Therefore a new research question was formulated as follows: *"How does circular procurement work at Waterworks?"* The answer to the question was reached through a literature study, interviews with employees of Waterworks and purchasing information of Waterworks.

The main findings and results from this research are defined in two parts. The first is critical characteristics of Waterworks and the second is points of influence for circular procurement. Waterworks follows a project procurement structure, because it procures items for a day-to-day need centrally, but, next to that, procures materials and services to successfully fulfil the needs of the project at hand (Moretto et al., 2020). The business also fulfils the features of a project procurement organisation of Gann and Salter (2000); the design and production processes established around the project; they usually produce one-off or highly customised products and services; and the firm performing in a different coalition of companies along the supplier-customer chain. The current procurement situation consists of the process which goes through the following stages: knowing what to purchase, determining the procurement strategy, preparing the purchase, awarding the contract, contracting the purchase, following up on the agreement, evaluating suppliers and sub-contractors. The general procurement process does not differ a lot from the eight step circular procurement process of van Oppen et al. (2018), apart from the fact that circularity aspects are not included at Waterworks. Multiple employees from the project teams are involved in the purchasing of materials and services and therefore eventually need to purchase circularly. Knowledge about the circular economy and circular procurement is widespread at Waterworks. Interviewees all gave different definitions of what circular economy and procurement means to them. Besides knowledge being widespread, awareness is not large at Waterworks. Often interviewees were not aware of current practices

they performed which can be regarded as circular procurement. This is all in line with written literature on barriers to circular economy and procurement (Adams et al., 2017; Gerhardsson et al., 2020; Guerra & Leite, 2021; Karhu & Linkola, 2019). Circular aspects included in the current procurement process, according to the interviewees, are mainly in the evaluation step. In the evaluation step, a star rating of circularity is given to the project. This considers the whole project, so no specific steps, materials, services, suppliers or sub-contractors. The other tool in the evaluation step is the evaluation system of suppliers where there are four questions regarding circularity. Circular aspects that are missing in the process of Waterworks are the measurement of procured materials that are circular and collaboration among the chain to successfully finish a construction project circularly. Collaboration in particular is necessary for the circular economy (Ellen MacArthur Foundation, 2021). According to the literature, actions that can be taken to enhance collaboration is ensuring transparency of information, working together among the chain via market consultation, competitive dialogue and innovative partnership. Of these three, market consultation is often used by the clients of Waterworks and innovative partnership is used for one current project of Waterworks. It is important to monitor circular procurement to show how the transition to circularity is going and to show stakeholders the progress made (Kristensen & Mosgaard, 2020). Waterworks is currently only monitoring circularity on a project level but it also needs to monitor on a product level to see if circular procurement targets are met or not. The other researched area of the critical characteristics was a spend analysis of the products and services procured for both Civil engineering and Services. The biggest spend categories were sub-contractors, mechanical engineering suppliers and electrotechnology. These categories can help Waterworks identify where the highest percentage of achievement can be reached if all products in the category were to be purchased circularly. It also can also help identify partners with whom Waterworks can collaborate on circularity.

The points of influences contains a SWOT analysis of Waterworks with regards to circularity. The revealed strengths are a good knowledge base, stemming from the working groups and knowledge sessions, having a sustainability manager in place and commitment from the top of the company. It is important that with these strengths the company counters the weaknesses. The weaknesses are many different definitions of circular procurement among employees, not everyone is aware of circularity in materials, services or projects, not everyone is committed. The weaknesses should be countered in the internal environment so they do not overshadow the strengths. The revealed opportunities are market consultation, innovative partnership and working together and, lastly, pilot projects. Waterworks should exploit these opportunities to ensure circular procurement practices in the external environment and to

counter the threats. Threats the company may be or is currently facing are suppliers and clients not being ready, the market being price-driven and product availability. These threats should be countered by the opportunities and strengths to ensure the company can procure circularly by 2030.

To conclude, to establish a procurement structure considering circularity in a project setting at Waterworks some actions need to be considered. At first, employees need to be more on one line about what circular economy and circular procurement mean as currently there are too many different ideas about this. A definition of circular procurement that Waterworks can use is: "Circular procurement is the process in which a product or service is purchased on the assumptions of a circular economy; economic and environmental. The procurement process should close energy and material loops within supply chains and avoid negative impacts on circular economy principles. During the process, technical aspects of products or services are as circular as possible and include financial incentives to ensure circular use." Next to knowledge, awareness needs to be created on why it is important that Waterworks procures circularly. This can be done by internally setting up a campaign to share knowledge and generate awareness and ideas on how to procure circularly. This can happen by putting together people from different projects to enhance the involvement of internal stakeholders. After the basic foundation of circular procurement in knowledge terms has been laid down, it is important to involve the supply chain on circularity. Collaboration is important in the circular economy. The company currently only asks suppliers and sub-contractors what they can do about circularity for them, which is often nothing. Besides asking questions, they join market dialogues about the circularity of the client. To get the supply chain along it might be a good step to go through a market dialogue with different actors of the chain to see how they can work more circularly together. Important actors can be identified among categories from the spend analysis performed. The market dialogue might then even turn into an innovative partnership like Waterworks did with ENI. The last, but also very important, step is the measurement of circular procurement. Currently, the company only measures on a project level and in the supplier evaluation what was done on circular aspects. This measurement satisfies the Process monitoring of Platform CB'23 (2021). This is not enough, it is important to monitor more on material and machinery procurement. This monitoring will allow Waterworks to set targets for circular procurement and get a good outlook on what proportion of a project was circularly procured. Measuring on the product level can be performed on what percentage or absolute number of the materials or sub-contractors are circular or are working circular. This will satisfy the Effort monitoring partly, by noting the price of the purchases it will satisfy it completely

(Platform CB'23, 2021). Measuring by making an LCA is often already performed as some clients require this in the tender, but it is important to assess the LCA at the end of the project. Assessing the LCA, fulfils the effect monitoring provided by Platform CB'23 (2021).

6.2 Theoretical implications

This research contributes to the literature by linking circular procurement to a project procurement structure and reviewing it in light of a real company. This study on Waterworks confirms the barriers of circular procurement mentioned in the literature, such as lack of knowledge and awareness, rules and regulations, practitioners considering circularity expensive and lack of information and collaboration among the chain (Adams et al., 2017; Gerhardsson et al., 2020; Guerra & Leite, 2021; Hartley et al., 2020). The study also shows that knowledge and awareness are at the very basis of circular economy and circular procurement. If knowledge and awareness are larger people will realise some procuring actions are already considered circular and which are not.

6.3 Practical implications

Many "problems" the interviewees, in the research, faced can be traced back to gaps in knowledge and experience. That there is a lack of knowledge is also acknowledged in both academic and grey literature (Gerhardsson et al., 2020; Karhu & Linkola, 2019; Platform CB'23, 2021; van Oppen et al., 2018). As a short term goal, Waterworks needs to get everyone aligned with regards to circular procurement, this is especially true for those working in the project procurement setting because there are a lot of people from different backgrounds (Bildsten & Manley, 2015). By getting everyone aligned is meant that everyone has the same knowledge and definition of circular purchasing, is aware of the value of circular procurement and committed to it. Getting everyone aligned can be done by sharing the same definition of circular procurement, as well as ensuring that everyone knows why it is important to procure circularly. According to van Oppen et al. (2018), this can be done by having knowledge, ambition and working sessions to set ambitions and to create a definition of circular procurement. Waterworks already had some knowledge session, it is very important to continue these and involve everyone in these. Additionally, Waterworks can set up an internal campaign to increase awareness and commitment on circular procurement.

Developing a circular procurement process which transcends the relevant clusters at Waterworks is a second short term goal for Waterworks. Here it is important that in all steps of

the purchasing process circularity is considered, but also before the actual purchasing, in the tender team. The tender team should consider circularity as well when it reaches out for suppliers or sub-contractors. For developing their own process, it might be useful to look through the handbooks of van Oppen et al. (2018) and Platform CB'23 (2021). Important is that the process is focused on collaboration within the company and along the chain. Next to that, the process needs to include measures that show progress on circular procurement besides the measurement options already taken.

Involving the supply chain and market should be a long-term goal of Waterworks. Collaboration in the whole chain is very important with circular procurement. This is also recognised in the article by Jelodar et al. (2016). As a contractor, who is in between the client who provides the project and the supplier and sub-contractors who are contracted, they have a lot of influence in the whole chain. Collaboration does not necessarily need to come from the client alone. Construction companies themselves can also start the collaboration to innovate and make circular materials or services. This can be done via, for example, market consultation to see which suppliers or sub-contractors have matching ambitions but also via a spend analysis that identifies true strategic partners. Another option to change the market is making use of circular revenue models in contracts, this will change the relationship between partners in the chain (van Oppen et al., 2018). Models to consider for this option are lease, rental, pay-per-use, residual value: buy-back-schemes and product service combination.

6.4 Limitations of the research

Concerning the qualitative research method, some limitations can lead to a biased or limited outcome of the study. The first limitation is that participants their responses might be biased. Participants may want to illustrate the company or themselves in a diverse, better or good light (Boyce & Neale, 2006), which may lead to biased answers by the interviewees. A second limitation regarding interviews is that researcher has limited experience in conducting interviews. This may have resulted in asking yes or no questions and asking leading questions (Boyce & Neale, 2006). Nonetheless, the interviews still provided rich data. In the future, this can be prevented by following training in interview techniques or doing more research.

6.5 Recommendations for future research

The first point for future research should focus on circular measurements. There is a lack of circular measurements on multiple levels, this is also recognised by the authors Kristensen and Mosgaard (2020) and Vinante et al. (2020). CE indicators are needed for supporting

practitioners and policymakers and the indicators names in the literature are not sufficient yet to use and have the trust of the aforementioned groups (Kristensen & Mosgaard, 2020). Vinante et al. (2020) report that measurements on different business departments are necessary to measure circularity, in this case, this would be on purchasing. This is especially necessary because purchasing is an essential part of businesses nowadays. More research on indicators in specific industries is necessary as well, not all indicators are useful for construction or the usability of the indicator is not good for the construction sector.

More research on project procurement with regards to circular procurement or in the context of circular procurement should be considered. A lot of the literature reviewed for the theoretical background focuses on the circular economy in general for the construction sector. This is an essential basis needed for the next stages which are going deeper into the processes of construction such as procurement. In procurement, there should also be a focus on the project structure used frequently in the construction sector. This type of procurement differs from other procurement types as a lot more actors are involved. More research on circular procurement in the context of project procurement can help set guidelines and regulations for procurement and who is responsible for what and how circularity can be measured when procuring in a project setting.

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Appendix

Appendix A: Measurement indicators

Category	Indicator	Description	Measure-ment	Other information
Recycling	Sustainability indicator for CE (SICE)	This index has a potential recycle index which considers part of recyclable mass in the material, number of parts, the efficiency of the recycling process etc. (Mesa, Esparragoza, & Maury, 2018)	Ratio	Split focus on recycling with also considering other CE categories
	Product-level circularity metric (PLCM)	This metric adopts the economic worth of recirculated materials and the economic worth of all parts to calculate the circularity of a product (Linder, Sarasini, & van Loon, 2017).		Split focus on recycling while also considering other CE categories
	Material circularity indicator (MCI)	This indicator measures the recycled components in a product as well as the waste and utility of a material, according to EMF and Granta Design (Kristensen & Mosgaard, 2020).		Split focus on recycling with also considering other CE categories
	Combination matrix (CM)	This matrix analyses recycling as the input of material recycling to the overall circularity of a material (Figge, Thorpe, Givry, Canning, & Franklin-Johnson, 2018).		Split focus on recycling with also considering other CE categories
	Circular economy index (CEI)	The index calculates the rate between the material value reached from recycling EoL material(s) and the component value needed for (re)producing EoL material(s) (Di Maio & Rem, 2015).		Single focus indicator
	Recycling desirability index (RDI)	This index calculates how desirable product recycling is by considering the proportion of total product, its materials jointly with a material security index, technological readiness level and a		Single focus indicator

		simplicity index (Mohamed Sultan, Lou, & Mativenga, 2017).		
	Recycling index (RI)	This index consists of two indices; a product and material index (Van Schaik and Reuter as cited in Kristensen and Mosgaard (2020)). The product index indicates the total rate of recycling and recovery of a product, the material index indicates the recycling ratio of the individuals components of a product (Van Schaik and Reuter as cited in Kristensen and Mosgaard (2020)).	Percentage	Single focus indicator
	Material reutilisation score (MRS) in cradle-to-cradle certification problem	This score links the proportion of recycled or renewable components in a product with the proportion of material in a product that is either recycle, biodegradable or compostable (Kristensen & Mosgaard, 2020).		Single focus indicator
	Reuse potential indicator (RPI)	The goal of this indicator is to define how waste-like and how resource-like a waste component is (Park & Chertow, 2014)		Single focus indicator
	Circularity calculator (CC)	This calculator, developed by IDEAL&CO Explore, determines the recycled content of a material, including recycled components in the main material and recycled components through closed-loop recycling (Kristensen & Mosgaard, 2020).		Split focus on recycling with also considering other CE categories
EoL management	Design method for end-of-use product value recovery (EPVR)	In this method, the end-of-use options are compared on the basis of disassembly costs necessary to follow a strategy by design adjustments to lower disassembly costs (Cong, Zhao, & Sutherland, 2019).		Cost-based indicator
	EoL index (EOLI)	This index by Lee, Lu, and Song (2014) consists of three EoL sub-indices for modules, sub-assemblies and components of a product. These three present an		

		indication of how the material will perform at EoL regarding disposal, disassembly and recovery on the basis of the total costs of all EoL processes (Lee et al., 2014).		
	EoL indices (design methodology) (EOLI-DM)	This is a design method for improving material EoL performance by using a cost/revenue way to calculate EoL indices (Favi, Germani, Luzi, Mandolini, & Marconi, 2017).		
	Mathematical model to assess sustainable design and EoL option (SDEO)	This is a simulation-optimisation model created to assess the sustainable design performance of a product family, taking into consideration costs, profit, social and environmental impact of different design and Eol options (Ameli, Mansour, & Ahmadi-Javid, 2019).		Social and environmental based indicators
	Product recovery multi-criteria decision tool (PR-MCDT)	EoL strategies are evaluated based on significant economic, environmental and social indices (Alamerew & Brissaud, 2019).		
Remanu-facturing	Product-level circularity metric (PLCM)	In this metric remanufacturing is examined as part of recirculation by calculating circularity as a ratio between the economic worth of recirculated components and the economic worth of all components (Linder et al., 2017).		Single measures indicators
	Decision support tool for remanufacturing (DSTR)	The tool evaluates if remanufacturing is economically and environmentally viable by comparing several different costs of purchasing used materials and different remanufacturing revenues to calculate the total costs of the process (van Loon & Van Wassenhove, 2018).		
	Combination matrix (CM)	The matrix links circularity and longevity of a material and takes into consideration the contribution made by product		Multiple measures indicators

		remanufacturing together with recycling (Figge et al., 2018). This is calculated as the proportion of circularity and longevity (Figge et al., 2018).		
	Eco-efficient value creation method (EEVC)	This method links costs, market worth and eco-costs to assess the potential of remanufacturing and presents a sustainable strategy matrix to evaluate the market prospects of materials (Vogtlander, Scheepens, Bocken, & Peck, 2017).		
	Remanufacturing with product profiles (REPRO^2)	This tool is online and guides designers of remanufactured goods (Zwolinski, Lopez-Ontiveros, & Brissaud, 2006). It helps to evaluate different product profiles that are applicable for remanufacturing based on costs etc. (Zwolinski et al., 2006).		
Resource-efficiency	Eco-cost/value ratio (EVR)	The ratio looks at how clean or dirty a product is and shows resource-efficiency in terms of the ratio between eco-costs and the value of a material (Scheepens, Vogtländer, & Brezet, 2016).	Ratio	
	Value-based resource efficiency indicator (VRE)	This indicator is a mass-based indicator of the resource-efficiency of materials or processes, and it focuses on the economic worth of resources (Di Maio & Rem, 2015).		
	Typology for quality properties (TQP)	It is a tool that evaluates the inherent, designed and developed quality aspects of materials, components and products with the goal of improving the resource-efficiency of these (Iacovidou, Velenturf, & Purnell, 2019).		
Disassembly	Ease of disassembly metric (eDiM)	The metric calculates the disassembly time of a product and therefore supplies insights into the time needed for different	Percentage	

		disassembly jobs for each part in a product (Vanegas et al., 2018).		
	Effective disassembly time (EDT)	EDT calculates the disassembly time for disassembling a product to isolate the target part, it considers all components of the product, the disassembly depth, model of liaison, liaison corrective factor and the best sequence to disassemble (Mandolini, Favi, Germani, & Marconi, 2018; Marconi, Germani, Mandolini, & Favi, 2019).	Count	
	Disassembly effort index (DEI)	Compared to the other two, DEI acknowledges the work and processes necessary to disassemble a product and provides a score, which can calculate the disassembly costs and return on investment in the end (Das, Yedlarajiah, & Narendra, 2000).		
Lifetime extension	Longevity indicator (LI)	According to Franklin-Johnson, Figge, and Canning (2016), the indicator calculates the period of time for which is retained in a product system.	Percentage and count	
	Combination matrix (CM)	The CM in this case combines a revised LI with a circularity metric, additionally it thus considers the lifetime and circularity of resources, and differentiates resource use between short linear, short circular, long circular and long linear (Figge et al., 2018).		
	Material circularity indicator (MCI)	MCI takes into account the use of products, which considers the lifetime and utility of a product, as well as the industry average lifetime and utility (EMF and Granta Design as cited in (Kristensen & Mosgaard, 2020).	Ratio	

Waste management	Sustainability indicator for CE (SICE)	The indicator calculates the movement of non-recycled or non-recyclable materials, this is done for product families (Kristensen & Mosgaard, 2020; Mesa et al., 2018).	Count and ratio	Linear flow of materials
	Material circularity indicator (MCI)	The indicator calculates the movement of non-recycled or non-recyclable materials, this includes the production process (Kristensen & Mosgaard, 2020).	Ratio	
	Model for expanded zero waste practice (EZWP)	The measure allows users to develop their own set of indicators for waste management, CE strategies and employee involvement (Veleva, Bodkin, & Todorova, 2017). Its aim is to measure the result and effect of circular strategies	Count	Zero waste management in organisations
Reuse	Circularity calculator	This calculator, developed by IDEAL&CO Explore, includes a reuse index in assessing circularity of products, it considers the lease periods of the product by a user (Kristensen & Mosgaard, 2020).	Percentage and count	
	Sustainability indicator for CE (SICE)	For reuse, this indicator represents the anticipated reuse but it is sensitive to the user (Mesa et al., 2018).	Count and ratio	
Multidimensional indicators	CE indicator prototype (CEIP)	According to Cayzer, Griffiths, and Beghetto (2017), this indicator links quantitative and qualitative measures into a material rating, material rank, point score and a visual representation of a material its circularity across five lifecycle phases. Allows a circularity assessment of materials, where CE strategies are given priority and allows to include circular business models (Kristensen & Mosgaard, 2020).		Employing a lifecycle perspective
	Multi-criteria decision analysis	This indicator is a framework where multiple dimension or products its		

	combining material circularity indicators and life-cycle based indicators (MCDA-ML)	circularity are assessed (Niero & Kalbar, 2019). This is done by linking material circularity indicators such as MCI and MRS with LCA (Niero & Kalbar, 2019).		
	Circular design guidelines (CDG)	This measure has five categories presenting 30 design guidelines. The categories represent important CE principles for extending lifespan, product reuse, disassembly, material reuse and material recycling (Bovea & Pérez-Belis, 2018). CDG includes an evaluation of material design subject to the margin of improvement and the applicability to the material guidelines, which can help classify circularity improvement capabilities (Bovea & Pérez-Belis, 2018).		Employing a wide CE perspective
	Circular economy toolkit (CET)	This is an online toolkit created by Evans and Bocken in 2013 (Kristensen & Mosgaard, 2020). It can help businesses evaluate their potentials for improvement (Kristensen & Mosgaard, 2020). It includes 33 questions that assess potential circular improvement points along seven categories (Kristensen & Mosgaard, 2020; Niero & Kalbar, 2019).	Count	

Appendix B: Checklist for effort monitoring

B.1 For starting companies

The following questions should be asked when procuring circular:

1. Market research; Did research take place on what the market development is and what opportunities for circular procurement for construction are out there? (Platform CB'23, 2021; Vos et al., 2019)
2. Request; Are there criteria or requirements in the tender that contribute to the three goals of circular construction? (protecting material inventories, protecting the environment and preserving existing value) (Platform CB'23, 2021)
3. Contract; Are the requirements and wishes secured in the contract and are there agreements on what happens to the product or materials after the first life cycle? (Platform CB'23, 2021; Vos et al., 2019)
4. Guarantee; Is circularity guaranteed during the contract and are there evaluations afterwards? (Platform CB'23, 2021; Vos et al., 2019)

According to Platform CB'23 (2021) all questions should be answered with yes to count the purchase as circular. For Vos et al. (2019), this is when only one of the questions is answered with a yes. So, it really depends on what the purchasing organisation sets as ambition level.

B.2. For advanced companies

Advanced companies should focus on the technical, financial and process aspects for circular procurement (see chapter 2). The following is an extension on the list for beginning companies (Platform CB'23, 2021), the check list includes:

Technical criteria:

- Are there requirements on the usage of secondary materials or renewable materials? If so which?
- Is there an insight in the environmental impact and are there requirements on the reduction of it?
- Are there requirements on excluding toxic chemicals, to protect the biodiversity or adding extra eco-friendly options? If any, which?
- Are there requirements on the reusability? If any which?

Financial criteria:

- Was there thought given to the revenue model of the tender and how it can be incorporated in the contract?
- Did this lead to any of the circular revenue models being included in the tender contract? If any, which? (see chapter 2)

Platform CB'23 (2021) advices to count the purchase as circular when in all of the criteria at least one question is answered with a yes.

Appendix C: Interview questions

English questions

1. What is circular procurement according to you?

2. What materials or services do you purchase for the projects of Waterworks?
   2.1 How would you classify these materials or services according to the Kraljic model?

3. Which steps do you undertake during the current purchasing process?

4. Do you purchase materials or services on your own or are other people involved during the decision making of where and from whom to procure?
   4.1 If the latter is applicable, who else is involved in the purchasing decision?

5. Do you already consider circularity when purchasing materials or services?
   5.1 If yes, in what fashion? And what do you consider?
   5.2 If no, might there be a reason for not considering it yet?

6. Which challenges do you expect to face or are you facing in procuring circularly?

7. Which positive outcomes do you expect from purchasing circular?

8. Do you involve sub-contractors for circularity, whilst purchasing? (Sub-contractors are those that perform part of the job at the project location)
   8.1 If yes, how do you involve them? What tactics do you use?
   8.2 If no, might there be a reason for not involving them for circularity?

9. Do you involve suppliers for circularity? (Suppliers are those that produce or/and sell but do not perform part of the project at the location)
   9.1 If yes, how do you involve them? What tactics do you use?
   9.2 If no, why do you not involve them for circularity?

10. Do you report circular procurement somewhere within the organization to gain insight into circular procurement?
    10.1 If yes, where do rapport these?
    10.2 If no, why do you not rapport them?

11. How could you measure whether or not your purchasing was circular, and to what extent?

12. What would help you or what do you need to purchase (even) more/better circularly?

13. Where do you think the greatest opportunities lie within in Waterworks for circular procurement?

14. Referring to the goal of Waterworks to build fully circular in 2030; which tip(s) do you have to realise this with regards to procurement?

Dutch questions

1. Wat betekent circulair inkopen volgens jou?

2. Welke materialen of diensten koop je in voor de projecten van Bedrijf X?
   2.1 Hoe zou je deze materialen of diensten indelen volgens het Kraljic kwadrant?

3. Welke stappen onderneem je nu tijdens het inkoopproces?

4. Koop je zelfstanding materialen en/of diensten in, of zijn er anderen betrokken in de besluitvorming van wat je waar inkoopt?
   4.1 Indien, dit laatste van toepassing is, wie is of zijn er nog meer betrokken in het inkoop besluit?

5. Houd je al rekening met circulariteit als je materialen of diensten inkoopt?
   5.1 Zo ja, hoe houd je hier rekening mee? Of; Op welke wijze vul je dit in?
   5.2 Zo niet, is er een reden dat je hier nog geen rekening mee houdt?

6. Welke uitdagingen verwacht je tegen te komen of kom je tegen met circulair inkopen?

7. Welke positieve uitkomsten verwacht je met circulair inkopen?

8. Betrek je onderaannemers op circulariteit tijdens het inkopen? (Onderaannemers die een deel van het werk maken op de projectlocatie zelf)
   8.1 Zo ja, hoe betrek je ze dan? Welke manieren gebruik je?
   8.2 Zo nee, is er een reden waarom je onderaannemers niet betrekt voor circulariteit?

9. Betrek je leveranciers op circulariteit tijdens het inkopen? (Leveranciers die iets produceren of verhandelen, maar dit niet verwerken op het project zelf)
   9.1 Zo ja, hoe beïnvloed je ze dan? Welke manieren gebruik je?
   9.2 Zo nee, is er een reden waarom je leveranciers niet betrekt voor circulariteit?

10. Rapporteer je circulaire inkopen ergens binnen de organisatie om zo inzicht te houden op circulair inkopen?
10.1. Zo ja, waar en hoe rapporteer je deze?
10.2. Zo nee, waarom rapporteer je deze niet?

11. Op welke wijze zou je kunnen meten of je inkoop wel of niet circulair was, en in welke mate?

12. Wat zou je helpen of heb je nodig om (nog) meer/beter circulair in te kopen?

13. Waar liggen volgens jou de grootste kansen binnen Bedrijf X om circulair in te kopen?

14. Referend aan de Bedrijf X doelstelling om in 2030 volledig circulair te bouwen; welke tip(s) zou jij hebben om dit te kunnen realiseren op gebied van inkoop?

Appendix D: Answering options in the star rating

Rating	Definition	Explanation / Example
Not applicable (n/a)	The theme does not play a role in this project and would also not play role in any other way of designing or executing	E.g. A sewer renovation in the city centre has no meaningful impact on ecology or energy and would therefore score n/a.
0 stars ☆☆☆	The theme plays a role in this project, but the choice is made to not meet the criteria for one or more stars.	With zero stars, on average, you are working to comply with the strictly necessary laws and regulations. It is not important whether the choice was made on the basis of customer requirement or other valid reasons. It does not make the project 'bad', but we notice that it does not meet the criteria for stars.
1 Star ★☆☆	The theme plays a role in this project and the measures meet the criteria for one star.	With one star you are on average doing a little more than is required by law and regulations
2 Stars ★★☆	The theme plays a role in this project and the measures meet the criteria for one and two stars.	With two stars you are well on your way to boosting the circular economy. You visibly go further than obliging laws and regulations. It does not matter if the initiative comes from Waterworks or the client is not relevant for the rating. It is important that it happens at all.
3 Stars ★★★	The theme plays a role in this project and the measures meet the criteria for one, two and three stars.	With three stars, you are really working within the rules of the circular economy. This category includes projects that contribute to sustainability in their fundamental objective. Think e.g. of building windmill foundations, setting up nature reserves or working without waste streams.

(Waterworks, *Circulaire Sterren rating voor project omzet*, accessed on October 5, 2021)

Appendix E: Criteria for star rating

Rating	Outgoing material flows	Energy transition	Added ecological value
	Exception: Industrial waste and waste that by law must be incinerated or landfilled as waste are not taken into account in this valuation	*Exception: This valuation is not about construction machinery and construction work, but about the final, complete construction and the use phase*	*Exception: This valuation is not about construction machinery and construction work, but about the scope of the final construction and the use phase.*
Not applicable (n/a)	In this project there are no material flows that could be released, such as demolition or residues of purchased material.	This building/project has no energy consumption or generation in the use phase.	This building/project has no impact on the environment and ecology.
0 Stars ✻✻✻	Materials released from this project are (partly) removed for incineration or landfill.	This building/project does not involve energy savings or the generation of renewable energy, but that could have been done with a different design or implementation.	This building/project meets ecological requirements that apply from legislation and regulations, but does not exceed them.
1 Star *✻✻	All (residual) materials released from this project are recycled (downcycling) (i.e. not incinerated or landfilled as waste).	The building/project realises a higher energy efficiency/higher return than in the initial situation (less energy per unit of output) and/or part of the energy requirement is met with autonomous generation of renewable energy.	In this construction/project, a number of extra-statutory, nature inclusive measures are applied (e.g. next boxes, green roof, grass concrete tiles, extra flowery verges etc.).
2 Stars **✻	More than 50 wt% of products and materials released in this project are reused in at least its current function or quality (upcycling), the rest is recycled (see one star).	The building/project provides for its own energy needs with renewable energy (autonomous energy supply, purchased green electricity does not count).	Habitat (living space for plants and animals) is created on more than 50% of the construction site that connects to the environment.
3 Stars ***	All products and materials released in this project are reused at least with the same quality/function (upcycling).	The structure/project produces more renewable energy than for its own energy needs (so in the end the structure supplies energy to the power grid/environment). Windmill, aqua thermal, biogas and green hydrogen projects always score three stars on energy	The main aim of this project is to restore or create nature, or this project demonstrably creates more ecological value than was found in the initial situation.