MASTER THESIS

Towards circular municipalities;

Circular Economy principles in municipal policies and procurement practices

Geert Geerts BSc

Faculty of Engineering Technology
Department of Construction Management & Engineering

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SWECO

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Author
G.N. (Geert) Geerts BSc
gngeerts@gmail.com
Student number: S1340212
Study: Construction Management & Engineering

University supervisors
Prof.dr.ir. L. (Leentje) Volker
Department of Construction Management & Engineering
University of Twente

Dr.ir. M.C. (Marc) van den Berg
Department of Construction Management & Engineering
University of Twente

Company supervisor
Ir. R.G. (Richard) Sleumer
Teammanager Techniek
Sweco Nederland B.V.

SWECO

UNIVERSITY OF TWENTE.

PREFACE

This master thesis is the final part of finishing the study Construction Management & Engineering at the University of Twente. Prior to this I finished the bachelor of Civil Engineering, also conducted at the University of Twente, which gave me the insight to pursue a career in the construction industry of which this master programme is the last step in my academic career. In my carrier I hope to use the gathered knowledge, especially at the topics sustainability and circularity, in my daily workings.

I conducted this research at Sweco Netherlands. They have provided me with the experience of the workings of a construction consultancy firm and a pleasant work environment. Many thanks to Richard for his patience and calmness and ofcourse the rest of the teams for their insights in the weekly fika's. I also want to thank my UT supervisors Marc en Leentje with their help in steering this research to an academic sound one.

G.N. Geerts
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SUMMARY

A lot of attention in science and politics goes to the use of natural resources in regards to sustainable development. The current linear economy is not a sustainable model to be upheld. In opposition to this is the Circular Economy (CE) which has been made an objective of the Dutch government to be fully implemented by 2050 at all levels of Dutch society. Municipalities, as part of the Dutch government, have to be an example and facilitator in implementing the CE in their activities. Especially in their construction related activities, which causes a lot of Construction & Demolition Waste (CDW), a lot can be gained by implementing the principles of the CE.

This transition can not be made without fundamentally changes in procedures, processes and business models. The CE itself is not bound and many variances are found throughout literature on what the CE should achieve, which methods should be used and what indicators are of the CE. Municipalities who have started applying CE principles in their construction related activities therefore differ in their outcomes in policies and practices. To study this implementation of the CE by municipalities the objective of this research is:

To analyse the use of circular economy principles by municipalities in their construction related policies and procurement practices.

Methodology

A case study research has been conducted on eight Dutch municipalities which are deemed to be frontrunners in implementing CE principles in their construction related policies and procurement practices. It is firstly determined which set of targets municipalities have to focus on in their construction related policies and procurement practices. Per target principles are determined which are indicators for each target. For each principle policy documents and tender documents of the cases are analysed through pattern matching to see if and to what extent CE principles are used. These outcomes are then compared for each case to see the differences and similarities per case between policies and procurement practices.

Results

The case study analysis resulted in the following; The topic of the CE has been gaining traction the last decades and this largely shows in municipal policies. There are however principles which are more present than others. This division in which principles to use can also be seen in their tenders. The principles which are more or less present in policies tend to be also more or less present in their tenders. Overall however the principles are more frequently present in their policies than in their tenders. This shows that the cases tend to be more ambitious in their policies than they are in their procurement practices. This however is not true for every case. There are cases which have more principles present in their tenders than in their policies.

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1 INTRODUCTION

The way we currently live has its limits; it causes global warming, depletion of natural resources and air and ground pollution to name just a few. This current linear model can be described as a take-make-dispose system; Resources are extracted, products are made and after use it is disposed [Merli et al., 2018; EMF, 2015b]. As opposed to the linear economy is the CE. Kirchherr et. al describes the CE, based on 114 definitions, as follows [2017];

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

This concept builds upon the Cradle to Cradle (C2C) concept which uses five criteria: material health, material reutilization, assessment of energy required for production, water usage and social responsibility [Braungart and McDonough, 2009]. This new approach, in contrast to the linear economy, addresses the problem of large scale depletion of natural resources and the accumulation of waste. The Dutch government has therefore made it its target to be 100% circular by 2050 [Rijksoverheid, 2016]. This is also in line with the European Green deal which aims to have zero net emissions of greenhouse gasses by 2050 [European Commission, 2019]. The Dutch government has defined a 100% CE as an economy without waste where everything runs on renewable resources. This new economy has to be implemented in all layers of society; from national to local levels of government. The potential of the CE lies in resource-intensive industries. For instance the construction sector which is one of the largest consumers of materials [PACE, 2020]. Taken in mind that the urban built environment will grow by 60% by 2050 [PACE, 2019] this material usage is not likely to decrease.

1.1 RELEVANCE OF THE RESEARCH

This research centres around the position of the municipality. As part of the Dutch governmental system they play a vital role in the transition towards the CE. Municipalities have different tasks and responsibilities where they can encourage, facilitate or demand circularity. In regards to the built environment municipalities can set policies on how they want to make their municipality more circular. Municipalities are also responsible for the built and maintenance of roads and other civil objects. These works are procured to the market; which means that contractors can make a bid on a tender in order to get the contract. Municipalities can make circularity part of their procurement strategies. Current research however is mainly focused on micro level interventions with a short lifespan and not on macro level situations with a long lifespan [Prendeville et al., 2018]. This research should bring more insight on the meso and macro level scale at which municipalities operate in their construction related activities. With this research municipalities can improve their policies and procurement practices in order to accelerate the transition to the CE.

1.2 PROBLEM STATEMENT

The CE can be further defined as a set of principles which can be used in order to achieve the CE. The research of Kirchherr et. al, which made a definition of 114 definitions, state that they are not an institution to exactly define the CE [2017]. Therefore alterations of the definition and corresponding principles occur throughout literature. The CE can be seen as an umbrella concept that is used as a broad heuristic to develop strategies and policies [Blomsma and Brennan, 2017]. Research on the position of the municipality on their tasks and responsibilities in their construction related activities is limited and underexposed. Municipalities may want to work towards the CE in their municipality, but there is a lack of knowledge on what this actually means for their position and situation. Municipalities can hire expertise, but even they can advice different approaches. There are municipalities who have started to implement circularity aspects in their policies and practices. These early adopters can be seen as experimenters with the subject and could lead to a sprawl of different approaches, definitions and actions.

1.3 THE RESEARCH OBJECTIVE

The research objective should contribute to solving the research problem; the underexposed position of municipalities in the transition to the CE. As mentioned prior there are municipalities who have started to use circularity in their policies and practices. These approaches can give an insight in how municipalities currently use the CE in their policies and practices. Similarities and differences can be studied to look for the best approaches municipalities currently use and where municipalities are currently lacking. Based on these findings municipalities can alter their current approaches and become more circular. The research objective is determined as follows;

To analyse the use of circular economy principles by municipalities in their construction related policies and procurement practices.

It is expected that different municipalities have different opinions, knowledge and approaches in applying CE principles in their policies and procurement practices. The research objective should bring insight into the current use of CE principles in municipal policies and procurement practices.

1.4 THE SCOPE OF THE RESEARCH

The scope of the research is set to keep the research feasible in the time set and the results useful. Without it, the research is in danger of becoming too broad which will not be beneficial to the research objective. There are two main points of the scope which have been set.

Firstly, only constructed related activities are taken into account. Municipalities have more activities, for example household waste collection, where CE principles can be applied. However, this would make the study too broad. Policies and practices for household waste collection are different to construction related activities, mainly because construction projects have a far longer lifespan than household waste.

Secondly, the study will only include municipalities which are deemed to be 'circular frontrunners'. This is done because it is expected that smaller municipalities have less resources to make the transition towards the CE and therefore do not have circularity included in their policies and practices [Kristensen et al., 2021]. By only including circular frontrunners the data found is expected to be the most useful.

1.5 THE RESEARCH QUESTIONS

The research question made and corresponding sub-questions are set in order to achieve the research objective. The main research question is stated as follows;

To what extent do municipalities implement CE principles in their construction related policies and procurement practices?

The underlying assumption is that municipalities have made circularity part of their policies, but that this is not necessarily reflected in their procurement practices. By comparing policies and procurement practices this should become more clear. To answer the main research question the following sub research questions have been set;

1. Which CE principles can be applied by municipalities in their policies and procurement strategies?
2. How are CE principles used in municipal policies?
3. How are CE principles used in municipal procurement practices?
4. What are the similarities and differences between the use of CE principles in municipal policies and procurement practices?

The first sub question is about the CE principles. These principles are essential for the transition to the CE. There are several variations used by sources and different frameworks which could be used. This question will give a list of principles which are useful for municipalities based on the targets the CE should achieve. It will give indicators on how to 'spot' these principles in policies and procurement practices. The second question identifies which principles are used in municipal policies. This will not only provide a list, but it will also indicates the extent to which the principles are applied. This is done again for question three, but then for their corresponding tenders. Lastly, in the fourth question, the policies and procurement practices are compared to identify similarities and differences in the use of CE principles. This will shows which principles are the most and the least present.

1.6 STRUCTURE OF THE THESIS

This thesis is structured as follows; in chapter 2 the theoretical framework is explained. This contains the required knowledge for this research and proposes a framework for the explored CE principles. In chapter 3 the methodology is explained. This methodology describes how the cases are selected and how the cases are analysed. In chapter 4 the results of the case study analysis is shown. This is shown for both the policies and practices. This also contains the comparison between policies and practices. In chapter 5 the points which are open for discussion are discussed. Lastly in chapter 6 the conclusions and recommendations are made.

2 THEORETICAL FRAMEWORK

At the basis of this research is the CE. The concept of the CE can not be taken into consideration without discussing the broader topic of sustainability and sustainable development. The broader topic of sustainable development can be defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs [Keeble, 1988]. This further translates in three main 'pillars' of sustainability; Environmental, Social and Economical [Purvis et al., 2019; Hansmann et al., 2012; Momete, 2020]. The definition of the CE is not bound and determined and definitions therefore vary. In relation to sustainable development, the CE is frequently viewed as an operationalization for businesses to implement sustainable development [Kirchherr et al., 2017]. Circularity and sustainability therefore have many similarities [Geissdoerfer et al., 2017]. Sustainable development is a goal we should all try to achieve in order to sustain human life on earth. Making the transition to the CE is needed for sustainable development [Momete, 2020; Bauwens et al., 2020]. In this research the topic of sustainability is often used in the same sens as circularity because of the same nature of the two topics. For instance reusing materials for the matter of circularity (closing the loop) can also be seen as sustainable development (reducing environmental impact). Kirchherr et al also describe that environmental sustainability, economic prosperity and social equity are valid objectives of the CE and should be treated accordingly in scholarship and practices [2017].

2.1 THE CE PRINCIPLES

The CE has several targets where the CE principles are the methods in achieving these targets. These principles can be used in every decision process. Just as the concept of the CE remains eclectic and lacks a scientifically endorsed definition the CE principles are also not bound and determined [EMF, 2015a]. A renowned source regarding the CE is the Ellen MacArthur Foundation which have made the so-called 'butterfly model' with a technological cycle and a biological cycle. They firstly defined five principles [EMF, 2013];

1. *Design out waste*. This is the practice of which by design choices future waste is prevented. For instance structures are designed to be easily be deconstructed in the end of life phase;
2. *Build resilience through diversity*. This is the practice of being resilient to outer shocks. For instance by building modular to easily move structures in a future scenario where the building is not needed anymore;
3. *Rely on energy from renewable resources*. This encompasses the shift to using renewable resources like solar and wind energy instead of fossil fuels;
4. *Think in 'systems'*. This is the ability to understand how parts influence one another within a whole. For instance knowing how roads influence the response time of ambulances;
5. *Waste is food*. In the CE waste does not exist but is the input for a new process. For instance used clothing which is used for insulation material.

However, they later narrowed it down to three principles [EMF, 2015a]; *preserve and enhance capital, optimise resource yields and foster system effectiveness*. These are in effect the previous five principles, but rearranged. Based on the five 'core principles' the EMF has also developed the ReSOLVE model [EMF, 2015b]. In this model ReSOLVE stands for Regenerate, Share, Optimize, Loop, Virtualize and Exchange. All these

elements refer to actions which can be taken to make the transition towards the CE. There are also examples which take the subject broader with seven characteristics of the CE; *worth of human activity is broader than only financial*, *materials are continuously recycled at high quality*, *all energy comes from renewable resources*, *Water is extracted on a sustainable way and source restore becomes maximised*, *biodiversity becomes structurally supported and strengthened*, *society and culture are preserved* and *health and well-being of man and nature become structural supported* [Gladek, 2019]. Also commonly used is the 9-R framework [Potting et al., 2017]. This framework consists of; Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover. This framework is hierarchical where the highest strategies are better in terms of circularity than the lower ones. Variations of this framework are often used where certain R's are left out. The most used R's are Reduce, Reuse and Recycle [Kirchherr et al., 2017]. This is also comparable to Lansinks's ladder or the 'waste hierarchy' which also is a hierarchical framework from prevention (the highest), to reuse, to recycle, to recover and to dispose (the worst) [Gharfalkar et al., 2015].
When looking at comparative researches there are different sets of principles used. For instance the research of Mantalovas et al who did a case study research of the use of the CE principles at National Road Agencies [2020]. They used a set of four principles, consisting of *design out/minimise waste*, *use waste as a resource*, *prioritise regenerative resource*s and *preserve and extend what is already made*. They concluded that *design out/minimise waste* and *use waste as a resource* are the most commonly used principles in national road construction. Practices related to these principles where the removing of restriction on asphalt recycling, extending the service life of asphalt pavements and testing of waste materials for potential utilisation as resources in asphalt pavements. However, in the research they did not include all possible principles in their study but instead focused on principles which where relevant for road construction projects.
Kristensen et al. conducted a case study research of eight Danish municipalities to compare their policy towards CE with their practices through Public Procurement (PP) [2021]. Like this research they wanted to explore how policies towards the CE are translated into municipal practices. They made a relation to PP, Circular Public Procurement (CPP) and Green Public Procurement (GPP). In this comparison CPP is still perceived as new and difficult. In regards to the CE principles they state that these principles are vague and can be abstract. Awareness is needed of which principles are important through CPP [Kristensen et al., 2021]. CPP can be used as an instrument by local public authorities to construct criteria and arrangements [Ntsondé and Aggeri, 2021].
The usage and usability may also vary for different situations, depending on the processes viewed and the position of the stakeholder. This research focuses on a specific stakeholder and process; municipalities and their construction related policies and practices. Based on this specific situation principles should be reviewed which are relevant and can be used or implemented by municipalities.

2.2 CIRCULARITY IN CONSTRUCTION

Applying CE principles in the construction industry can have a large impact; According to the new Circular Economy Action Plan the European construction industry accounts for 50% of all extracted materials and over 35% of the total waste generation in Europe [European Union, 2020]. The Dutch construction sector consumes 48.9 Mt (30% of total economy) annually in raw material [PACE, 2020]. This large stream of materials consists mainly of raw materials. For concrete and steel, which are used in large quantities, using secondary material sources instead of raw material are mostly not economically feasible. Approximately 3 to 4% of all new construction materials for residential and non-residential buildings consist of secondary material [Schut et al., 2015]. Profit margins tend to be tight in the construction sector, which causes construction firms to keep costs as low as possible to compete in this very competitive sector. The implementation of CE in construction

is facing many barriers such as unproven business cases of requiring manufacturers to be responsible for their product at the end of life [Ping Tserng et al., 2021].
Platform CB'23 tries to achieve (more) circularity in construction [Platform CB'23, 2020a]. Platform CB'23 is a Dutch platform consisting of stakeholders in the Dutch construction industry in order to create and share knowledge on how to implement circularity in construction. As the name suggests they want to achieve this by 2023. They thereby agree that the CE, also in construction, is not bound and determined. Because of this current practices of circularity in construction are limited. CE thinking is currently limited to CDW minimisation and recycling [Adams et al., 2017]. Large proportion of CDW is recycled (downcycled) into foundation material for roads, residential areas and business parks. However, this is not done for buildings [Schut et al., 2015]. It is estimated that 95% of CDW is downcycled [Rijksoverheid, 2016]. Downcyling, the process of recycling material to a lower quality or function it had prior, is a better alternative than putting it into a landfill. However, this process can not be upheld without the input of raw materials into the initial process and further reuse is also not possible [Verhagen et al., 2021]. Current practices of circularity in construction tend to be experimental and exploratory.

In relation to the building process, which is still very linear, CE principles and therefore targets of the CE can be achieved throughout the building process. In figure 2.1 the building life cycle is shown in relation to policies and tenders. Policies can have a broader effect on the building process than tenders can achieve. Policies can have effect on all stages of the building process and therefore all principles can be used or applied through policies. Tenders however can only affect the design phase, the construction phase and the operating phase. It has potential to affect the demolition or deconstruction phase, however this phase is currently not included in tenders [Schut et al., 2015].

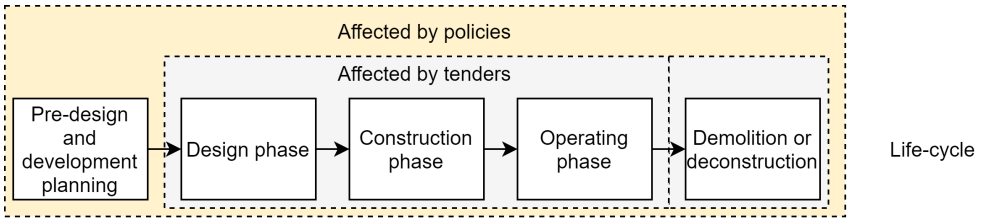

Figure 2.1: CE policies and tenders in the building process

Policies can influence the building process in several ways. For instance a municipality can facilitate circularity by creating material depots or circular hubs for second hand building materials. This would improve the use and possibility of the principle waste is food. Through policies municipalities could also state requirements which imply to all construction related activities. For instance maximum co2 emissions during construction or to state that new construction projects will not have a connection to the gas network.
Tenders can only influence a project. Parts of the project could also be redivided into multiple tenders. Circularity can be part of a tender in multiple ways. The design can require a modular design, which benefits the reusing of elements when the construction is not necessary anymore. Also it could be demanded that the construction is done with electrical equipment (from renewable energy sources) or that a certain percentage of material usage comes from secondary material sources. There are however gradations in circularity and therefore a '100% circular' construction project is almost impossible to achieve. When taking the 9-R framework [Kirchherr et al., 2017] or the butterfly diagram [EMF, 2013] the most circular options are already excluded when going to tender. Namely the option of not constructing the project but entirely refuse it.

2.3 DUTCH MUNICIPALITIES

This research centres around the position of (Dutch) municipalities. There are in total 352 municipalities in the Netherlands. They are an administrative layer in the Dutch governmental structure. In the Netherlands there are three administrative layers; the national government, the provinces and the municipalities. On top of that the Netherlands is part of international arrangements like the UN, NATO and of course the European Union. The European Union will launch a new comprehensive strategy for a sustainable built environment in 2021, integrating CE principles in its policies [European Union, 2020]. At the national level the Dutch government has made it its target to achieve a 100% CE by 2050 [Rijksoverheid, 2016]. Because the Netherlands is very decentralised a lot of responsibilities lies with the municipalities. It is however not clearly stated who has to do what in regards to the CE. There are arguments to work downwards from EU level of government [Hartley et al., 2020], but municipalities tend to be eager in taking action to facilitate and support the transistion towards the CE [Christensen, 2021].

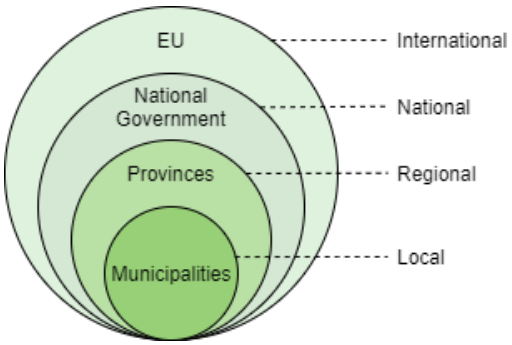

Figure 2.2: Dutch governmental levels

In regards to the implementation of the CE municipalities are not yet required to use the principles of the CE. Municipalities are still fundamentally limited by their instrumental capacity and CE-focus [Campbell-Johnston et al., 2019]. However, several municipalities are experimenting with it and state that they want to make the transition towards the CE. This is mainly because the concept of the CE is very much in line with sustainability targets which were made prior. Municipalities state these ambitions and targets through their policies. These governmental policies are required to stimulate the use of secondary material in the construction industry [Verhagen et al., 2021]. There are two main possibilities explored in this research how municipalities can work towards the CE; policies and practices.

2.3.1 Municipal policies

Municipalities have different ways to enact their policies in regard to the transition towards the CE. Within the Dutch construction laws municipalities have space to set their own targets and state their ambitions through policy documents. CE policies in regards to the construction sector can be found in a variety of policy documents such as;

- Construction specifications;
- Multi-year plans;
- Vision documents;
- Program requirements;
- Frame notes;
- Purchasing conditions.

Many municipalities want to excel in being 'sustainable', 'green', 'climate neutral' etc. Therefore most municipalities have separate policy documents solely on these

targets and ambitions in multi-year plans. Municipalities are free to make their own decisions regarding it. They can make these planes themselves or they can ask for consult from a consultation firm. These policies can have a wide range of effects of applying CE principles in their construction related activities. Municipalities can function as an important change agent to support and facilitate the transformation towards a CE [Christensen, 2021] or other forms of sustainable procurement [Grandia, 2015]. These policies can for instance apply to the design of the built environment in municipalities which provide local governments with numerous opportunities to encourage CE practices and supports a more system thinking approach to urban development [Bolger and Doyon, 2019].

2.3.2 Municipal practices

Municipalities mostly outsource their construction related activities. In this way municipalities can focus on their main responsibilities and let construction firms do their work. Through PP tenders are put to the market. Contractors can then make a bid to win the tender. Municipalities can state the selection criteria for each tender in order to select the best contractor. Only for certain values they are obliged to certain rules regarding tendering it at an European level. They make use of TenderNed to publicise their tenders. This is a Dutch platform where authorities can announce tenders and facilitate the selection process. According to the EU the procurer has to award a contract to the tender that is economically the most advantageous [European Union, 2014]. This can imply: lowest price; lowest overall cost; or the most value based on a price/quality ratio.

Municipalities have several options to include circularity or sustainability in their procurement strategies. Terms used are 'green procurement, 'green purchasing' or 'ecoprocurement', but they all describe similar phenomena in the same sens as sustainable procurement [Grandia, 2015]. The term CPP is used in this research, but it remains a collective name for all PP where circularity principles are used. This can be used as an instrument by local public authorities to construct criteria and arrangements [Ntsondé and Aggeri, 2021]. Historically procurement is mostly used to find the economically cheapest option. Public authorities need to promote performance-based approach and PP of innovation in their call for tenders linked to deconstruction projects [Bougrain, 2020]. Because this is a new approach procurement departments struggle to find suitable knowledge partners and collaborators to support the inclusion of CE into PP [Kristensen et al., 2021]. Circularity aspects of a tender can either come forward in the design specifications of the project or through the award criteria.

2.4 TARGETS OF THE CE

Just as the definition of the CE is not precisely defined, so are the targets of the CE. Definitions of what the CE encompasses can be a broad definition, where all forms of sustainability are included in circularity, a small definition, which only includes the protection of material stocks and everything in between [Platform CB'23, 2021]. Targets of what the CE should achieve are linked to what the CE includes. This research uses the three targets stated by Platfrom CB'23; protection of material stocks, protection of the environment and the protection of existing value. These three targets are selected by Platform CB'23 based on their relevance in the construction sector by consensus between multiple stakeholders in the Dutch construction sector. A more broader objective of the CE has the possible downside of including too much and therefore risk becoming ineffective, not feasible or not relevant for the situation. An objective too small, which only includes material stocks, excludes certain aspects which are deemed too important to be excluded. Namely environmental issues which are very relevant for the construction sector. Other aspects

which could be included into the CE are for instance social aspects. However, such aspects are less relevant for municipalities in their construction related policies and practices. It can be argued that what the CE encompasses is dependent on the situation it is applied to.

2.5 INDICATORS OF A CE

Measuring circularity remains one of the main obstacles of implementing the CE. However there are indicators which can indicate the use of CE principles in processes. Based on the three targets of Platform CB'23, as described in section 2.4, in the following part it is described which principles are used for each target and how these principles can be identified.

2.5.1 Protecting material stocks

An important factor of the CE is how materials are used. As mentioned previously the construction sector generates huge amounts of CDW and therefore this target of the CE is very relevant for the construction related policies and practices of municipalities. It is also one of the two main factors in the description of the 100% CE by the Dutch government [Rijksoverheid, 2016]. There are several ways how material stocks can be protected.
Firstly, waste is seen as a design flaw. This is the basis of the principle *design out waste*. For instance when beams are welded instead of bolted together it hampers the deconstruction process. There are several options and action municipalities can take in order to design out waste in their built environment. In construction projects large amount of waste is generally generated at the end of the life phase. Because elements are difficult to separate (glued together) or elements were made to only fit a specific purpose (non standardised). Buildings and objects should be deconstructed instead of being demolished [van den Berg et al., 2020]. Municipalities can contribute to this process by designing objects in the built environment to be feasible to be deconstructed. Also in other steps of the building life cycle indicators of this principles can be found; for instance penalising the waste generated by construction activities. The source of value creation *the inner circle* of the Ellen MacArthur Foundation (EMF) also applies to this target [EMF, 2013]. This sources of value creation is a 'circular setup' which have economic and comparative attractiveness. Sources of value creation can be used in order to create circular business models [PACE, 2019]. The inner circle states that how 'smaller' the circle the better. This is based on the butterfly diagram from the Ellen MacArthur Foundation [EMF, 2015a]. This diagrams consists of circle where the smaller circle is better in terms of circularity. For instance repair is a smaller circle than recycle and is therefore better in therms of circularity. Alternatively it can be used with the 9R-Framework of Kircher [2017] where the higher in the list the better it is. For municipalities this is an important factor. For instance, recycling sounds very circular, but reusing or repairing are better options in therms of circularity. Municipalities could address this in policies by stating how this works and that they prefer methods which are higher in the 9R-Framework, or variations of this framework like the 5R-Framework [Bauwens et al., 2020].
Secondly, *waste is food*. What waste is in the linear economy is food for a new process in the circular economy [Mcdonough, 1998]. This of course is challenging when this is not taken into account in the design. In the built environment there is a lot of demolition waste because it is not economically feasible to reuse it. Nonetheless this waste can become the input for new processes. This principle can be applied at the end of the building process or at the beginning of a new one. Municipalities can take a coordinating role in facilitating this principle. By setting up, for instance, material depots for materials which are feasible to be re purposed and thereby close the loop [Janik and Ryszko, 2017]. In a tender this principle can be used by demanding

that there will be built with materials from secondary material sources. Large potential for the construction industry lies in cascaded use of materials. Cascaded use is also a source of value creation and focuses on materials being reused in different processes than it was [EMF, 2013]. This is somewhat comparable with down cycling of products for different purposes. For instance clothing after use, when they are not suited anymore for clothing, could be cascaded into fibrefill for furniture, and after that it could be cascaded into insulation material. A material depot could be a method which a municipality could use in order to facilitate cascaded use. In building projects through PP this is at the moment still a challenge due to the lack of these material depots and current working methods. Suppliers are needed to transform other material streams into materials which are suitable in construction projects. Also material passports could help address this source of value creation [Platform CB'23, 2020b].

Based on the target of protecting material stocks it is expected that in a fully CE:

- *Materials used in the construction phase are from secondary material sources (waste is food)*;
- *Materials are reusable after the end of life phase through design choices (design out waste).*

2.5.2 Protecting the environment

Another target of the CE is the protection of the environment. It does not necessarily need to have a positive effect on the environment, as long as it has no negative effect on it. There are several ways how the implementation of the CE can protect the environment.
Firstly, the largest factor in environmental protection is the amount of CO_2 produced. This is produced in almost all phases of the construction life-cycle; during construction trucks who deliver materials mostly still run on diesel and during the operation phase either electricity or gas is needed for heating and lightning. Making the entire construction life-cycle run on renewable energy sources is also in line with the definition of a 100% CE of the Dutch government [Rijksoverheid, 2016]. There are many ways in order to let the construction life-cycle fully run on renewable energy sources. In construction projects municipalities can demand that the construction is done solely with electric vehicles and equipment, provided that the energy comes from renewable resources. Also during use an object or building should rely on energy from renewable resources, a practice or objective to achieve this is to make buildings gas-free. The main indicator here is the amount of CO_2 produced in the construction and usage of a building.
Secondly, in a circular construction process toxic materials are avoided. This is also a source of value creation of the EMF [EMF, 2013]. For instance asbestos but also turpentine in paint or toxic substances in coatings. These materials not only hinder the re-usability of (parts of) construction projects, but also cause environmental risks. In this regard municipalities should shift more to using biobased materials like wood. In tenders this can be demanded in the project description.

Based on the target of protecting the environment it is expected that in a fully CE:

- *During all phases of the construction life-cycle energy used comes from renewable sources*;
- *Toxic materials are avoided*;
- *Biobased materials are used*.

2.5.3 Protecting existing value

Protecting existing value is about preventing new projects and rather maintain what already is. This contributes towards the CE by preventing the need for new construction projects by focusing on maintenance. This enables high ranking circular methods of the 9-R Framework of Kirchherr like rethinking [2017]. Also the principle from the EMF of *thinking in systems* can be applied for this target [EMF, 2013]. By thinking in systems you look at the function of objects and assets in relation to others. In this principle you can look more critical to the use of objects and the need for them. Is a certain object really necessary for the needs of the client? Or maybe there are alternatives to achieve the same function. By this more critically way of thinking elements which are little to no use for the functions the client desires can be left out. An exact indicator is hard to define because it is about keeping or creating the same functions without the need for new projects.
Also the source of value creation *circling longer* of the EMF helps in achieving this target of the CE [EMF, 2013]. Circling longer is going through the same cycle multiple times. So for instance when something break you repair it, and when it breaks again you repair it again. This can be done for elements of a object or building or the entire object or building itself. For instance reusing a building even when it is economically written of is better than to built a new building. In policies municipalities can address this by stating they want to focus more on repairing and reusing existing objects instead of building new objects. In practices, especially tenders, this source of value creation is harder to determine. This is due to the fact that when a project is put out to tender this choice has already been made. A road maintenance project is an example of circling longer, building a new road is not.
When new construction projects do need to take place (more houses are needed to be built) this target can still be taken into account by *building resilience through diversity*. This principle of the EMF [EMF, 2013] focuses on being resilient for external shocks. For instance weather tend to be more extreme so rainfall drainage can be taken into the design specifications. Also modular built can be beneficial in becoming adaptive for changes. With modular built elements can be one on one reused when the building (or parts of it) are no longer necessary at that specific location.

Based on the target of protecting of existing value it is expected that in a fully CE:

- *Maintaining is prioritised above new construction*;
- *Resilience is taken into account in the design phase*.

Summarising the above mentioned targets and corresponding principles results in table 2.1.

Table 2.1: Targets and principles of a CE

CE target	Principle
Protecting material stocks	- *Waste is food* - *Design out waste*
Protecting the environment	- *Energy from renewable sources* - *No toxic materials used* - *Use of biobased materials*
Protecting existing value	- *Maintaining prioritised above new construction* - *Design resilient*

3 METHODOLOGY: A CASE STUDY ANALYSIS

The method/research strategy is chosen in order to achieve the research objective; *to analyse the use of CE principles by municipalities in their construction related policies and procurement practices*. As described in chapter 1, the real point of focus is the relation between policies and procurement practices. On one hand what municipalities want to do (policies) and on the other hand what they actually do (practices). There are several methods which could be used in order to achieve the objective. For instance a solely literature study could be conducted to combine studies who have delved into this specific subject. There is however chosen for a case study analysis. This choice has been made for the following reasons;

Firstly the implementation of the CE in policies and practices is relatively new. The concept of the CE has been gaining momentum since the 1970's [EMF, 2013], but it has been made a Dutch ambition for 2050 only in 2016 [Rijksoverheid, 2016]. Companies and institutions are still experimenting and looking for best practices. As mentioned prior the concept of the CE and what to in- and exclude is still open to debate. Platform CB'23 is a Dutch platform for construction to better define the concept for the built environment for 2023 [Platform CB'23, 2020a]. By working together with institutions and other stakeholders they want to reach a common basis by 2023 to work from and gain a profound base to built upon in the Dutch construction sector.

Secondly, at an international level the Netherlands is preforming relatively well in the implementation of the CE (24,5% circular national to 9% international [PACE, 2020, 2019]). Therefore looking abroad at large scale practices is not deemed as feasible. It is expected that there are examples of circularity in municipalities abroad, but that this is currently still limited. This limitation is also expected in the Netherlands; especially smaller municipalities tend to have fewer resources to allocate to CPP projects [Kristensen et al., 2021]. By selecting cases which are expected to use or experiment with the concept of the CE lessons can be learned for municipalities which have little to none experience with the concept and corresponding procurement practices.

Lastly, a case study is a good method to study a real-life phenomenon. The phenomenon studied in this research is the way municipalities cope with the transition to the CE. According to Yin a case study is a good method to understand how or why a phenomenon works [2014].

Using a case study analysis also has its limitations. Because of the limited sample size it is difficult to make conclusions for all Dutch municipalities in regard to CE policies and procurement practices. A case study analysis can not conclude how circular Dutch municipalities currently are. Only trends can be identified for the chosen cases. For this research however a case study analysis is deemed as the best research method. The case study procedure is based on the work of Yin [2014].

3.1 CASE STUDY PROCEDURE

The case study analysis is structured through the case study procedure. The case study procedure is based on the work of Yin [2014]. The case study will analyse two aspects of the selected cases; their policies and their procurment practices. The case study procedure used is shown in figure 3.1 and is further explained below.

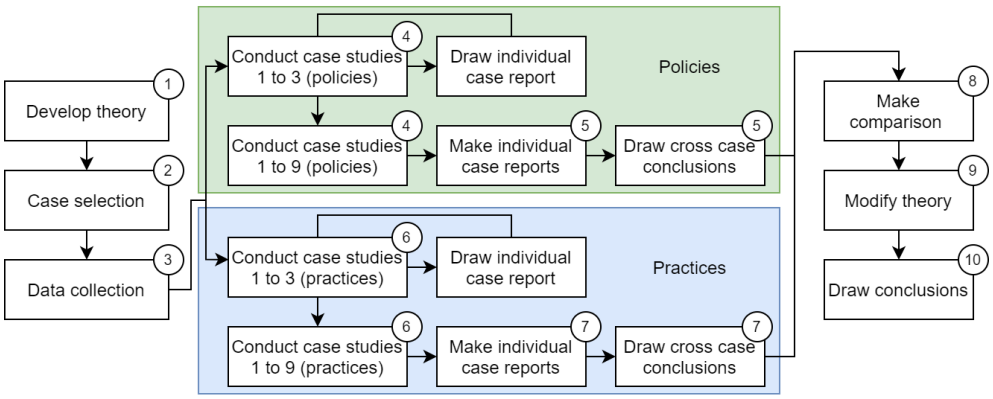

Figure 3.1: Case study procedure (derived from Yin [2014])

1. Develop theory

The first step is to develop a theory which lies central in the research. This theory is described in chapter 2 and is developed through existing literature regarding the CE. Most noticeable is that the exact definition varies of the CE and its corresponding principles. The general idea is that municipalities want to be circular, however do not know what this exactly means (the definition of the CE is not bound and determined) and therefore their current procurement practices remain mostly linear. This theory is further described in chapter 2 and the main result is the format in table 2.1.

2. Case selection

For the case study analysis municipalities are selected which state or are expected to use the CE principles in their processes. Smaller municipalities are expected to have fewer resources available for the transition towards the CE [Kristensen et al., 2021]. Therefore the cases which are selected will only include the larger (in population) municipalities which are expected to work with the concept of the CE. In the Netherlands there are nine municipalities which have joint forces in creating circular cities by the year 2050. They have stated this in the 'City Deal Circulaire Stad' [Agenda Stad, 2016]. The cases were all examined on two main points; policies and procurment practices. On the one hand how they want to imply CE principles in their municipality and on the other hand how this impacts their practices in their procurement strategies. These municipalities are expected to have specific policies in making the transition towards the CE. However during the data collection there was insufficient data available for the municipality of Apeldoorn for both policy documents as well as tenders. Therefore Apeldoorn was left out of the study. The eight municipalities which are used as cases in the case study analysis are;

1. Almere
2. Amsterdam
3. The Hague
4. Dordrecht
5. Haarlemmermeer
6. Rotterdam
7. Utrecht
8. Venlo

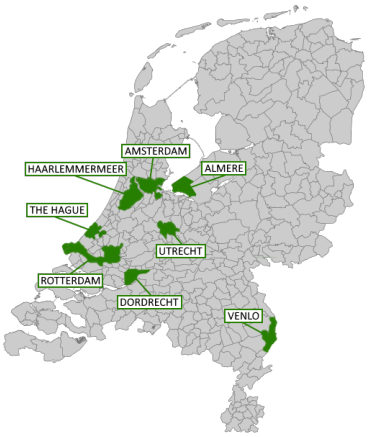

Figure 3.2: Municipalities used in case study analysis

3. Data collection

This data collection protocol has two parts; data collection of policy documents and data collection of tender documents.
Policy documents are acquired as follows; municipal websites are searched via their search engine for documents regarding circularity and sustainability. Sustainability is also taken into account because of the overlap it has with the concept of the CE. The found policy documents are put into a folder to be analysed later. When there are no policy documents regarding the implementation of the CE there will be looked further. For instance when a municipality is working together in a cooperation for their circularity ambitions these documents will be taken into account.
Tender documents are acquired through TenderNed. This website consist all tenders from Dutch institutions. The data sets are acquired for the period 2017 till 2020. This period is chosen because the ambition for the 100% CE by the Dutch government dates from 2016 [Rijksoverheid, 2016]. The data is then further filtered to only include construction related activities. In TenderNed tenders are given a code based on their activities. For each case a separate data sheet is created. Some projects have multiple entries or 'announcements' because of extra information provided through TenderNed in a later stadium. These extra entries are filtered out to be left only with unique tenders/projects.

4. Case studies policies

The found policy documents are analysed to see which CE principles are used and how they are used. This is done by noting all ambitions, actions or other indicators which indicate to the use of one of the principles as stated in chapter 2.5 and are also shown in table 3.1. There are examples mentioned, but more can be found in the policy documents. Each found indicator to a principle is coded according the codes in table 3.1.

Table 3.1: Codes and examples principles in policies

CE target	Principle	Example of indicator	Code
Protecting material stocks	- Waste is food	*"Buildings and objects are constructed with material from secondary material sources"*	[1.1]
	- Design out waste	*"Penalties for amount of waste generated by construction projects"*	[1.2]
Protecting the environment	- Energy from renewable sources	*"New projects are constructed without natural gas connection"*	[2.1]
	- No toxic materials used	*"Only made use of materials which are not harmful to the environment"*	[2.2]
	- Use of biobased materials	*"Where possible there is made use of wood"*	[2.3]
Protecting existing value	- Maintaining prioritised above new construction	*"Focus on conserving present infrastructure"*	[3.1]
	- Design resilient	*"New construction projects can sustain a rainwater drainage of ..."*	[3.2]

5. Individual case reports and cross case conclusions policies

For each case an individual case report is made. This report is the result of the analysis on how well certain principles occur in the policy of the case. Measuring circularity remains one of the main obstacles of the CE. Therefore there will be made use of *pattern matching*. Pattern matching is comparing two patterns in order to determine whether they match or do not match [Hak and Dul, 2009]. The observed pattern found in the policy documents is compared with the expected pattern and it is decided whether the pattern match. The found indicators for each principle are matched according;

- No match	There are no indicators indicating the use of this principle in policy.
- Partly match	There are indicators for this principle, however there is room for improvement.
- Fully match	The indicators found indicate this principle is fully implemented in policy.

There is chosen for this division because stating it is used or not used would make it too binary. Going into more scales would not be feasible because how well a principle is used is very subjective to interpretation of the researcher. This results in a table consisting of all principles and the found matches. For each case an individual case report is made based on this. After the individual case report the cross case analysis is done for the CE principles in policies. This is done by analysing the use of each principle across all cases regarding their policies. This results in a hierarchical list of principles which are used often to principles which are used less.

6. Case studies practices

The tender data is further narrowed down by highlighting 'circular tenders'. These are tenders which are deemed to have circularity aspects in either their project description, design criteria or award criteria. These tenders are selected by looking for 'circular', 'sustainable' and abbreviations of these words in tender name, ten-

der description and key words. The found tenders are then further analysed and indicators for circularity are coded according the codes in table 3.2.

Table 3.2: Codes and examples principles in practices

CE target	Principle	Example of indicator	Code
Protecting material stocks	- Waste is food	*"The project is constructed with 50% material from secondary material sources"*	[1.1]
	- Design out waste	*"All components are designed to be reusable after use"*	[1.2]
Protecting the environment	- Energy from renewable sources	*"Construction is done solely with electric equipment using electricity from a renewable energy resource"*	[2.1]
	- No toxic materials used	*"Paint or other coatings are water based"*	[2.2]
	- Use of biobased materials	*"The construction is entirely made of wood"*	[2.3]
Protecting existing value	- Maintaining prioritised above new construction	*"Shift from new construction to life extension"*	[3.1]
	- Design resilient	*"The project can sustain a rainwater drainage of ..."*	[3.2]

7. Individual case reports and cross case conclusions practices

For each case an individual case report is made in regard to the found tenders. This consists of an analysis of the found tenders of the previous step. The use of CE principles is checked through pattern matching as is described in step 5. The found indicators for each principle are matched according;

- No match — There are no indicators indicating the use of this principle in their tenders.
- Partly match — There are indicators for this principle, however there is room for improvement.
- Fully match — The indicators found indicate this principle is fully implemented in their tenders.

This results in a table per case consisting of all principles and the found matches. For each case the individual case report is based around this result. After the individual case reports the cross case analysis is done for the principles in tenders. This is done by analysing the use of each principle across all cases regarding their tenders. This results in a hierarchical list of principles which are used often to principles which are used less.

8. Make comparison

The comparison is made between the use of CE principles in policies and procurement practices. The results of both cross case analyses of CE principles used in policies and procurement practices are compared. This comparison will highlight if and how policies are translated into practices. The underlying idea is that municipalities can be ambitious in their policies but that this does not necessarily show in their procurement strategies.

9. Modify theory

Based on the comparison the theory is modified. This is done by checking if the results are in line with the expectations. If the theory does not match the results the theory has to be modified. However, in this case study the theory is backed through a literature study and is not expected to have to be modified. This step by Yin is more for case studies where a 'new' theory is tested in practice [2014].

10. Draw conclusion

Lastly the conclusions are drawn. This conclusion will have to answer the main research question: *'To what extent do municipalities implement CE principles in their construction related policies and procurement practices?'*. This conclusion will also include a discussion on which assumptions are made. It will also consists of recommendations for municipalities and further research.

4 CASE STUDY ANALYSIS

In total eight municipalities are analysed. This is done by comparing their policies regarding the implementation of the CE and the award/design criteria of their tenders regarding construction related activities. The first mayor subject which is researched are the policies of municipalities in regard to circularity and sustainability targets. This is done by reviewing publicly available policy documents acquired from municipal websites.

4.1 WITHIN CASE ANALYSIS – POLICIES

The within case analysis is conducted by a document review of the found policy documents. The documents which where analysed in the research are shown in table 4.1. The documents were reviewed on; their targets regarding the CE and sustainability in time and factors which are beneficial to one of the three targets of the CE. Based on these factors found it is determined if there is a fully, partly or no match with the specific CE target.

Table 4.1: Researched policy documents

Municipality	Document name	Number
1- Almere	- *Uitvoeringsprogramma 2020 duurzaamheidsagenda een groene, gezonde stad Almere*	[1.1]
2 - Amsterdam	- *Amsterdam Circulair Monitor*	[2.1]
	- *De Stadsdonut voor Amsterdam*	[2.2]
	- *Amsterdam Circulair 2020-2025 strategie*	[2.3]
	- *Amsterdam Circulair 2020-2025 innovatie- en uitvoeringsprogramma 2020-2021*	[2.4]
3 - The Hague	- *Circulair Den Haag, kansen in de circulaire economie*	[4.1]
	- *Stand van zaken Circulaire Economie in Den Haag*	[4.2]
4 - Dordrecht	- *Gebiedsvisie Spuiboulevard e.o. Dordrecht*	[5.1]
	- *Goed wonen in Dordrecht 2019 - 2031*	[5.2]
	- *Dordrecht Circulair*	[5.3]
5 - Haarlemmermeer	- *Haarlemmermeer naar een circulaire samenleving Duurzaam 2015-2018*	[6.1]
	- *Lincolnpark circulair*	[6.2]
6 - Rotterdam	- *Van zooi naar mooi, programma Rotterdam Circulair 2019 - 2023*	[7.1]
	- *Actieplan Maatschappelijk Verantwoord Inkopen*	[7.2]
7 - Utrecht	- *Utrecht Circulair 2020-2023*	[8.1]
8 - Venlo	- *Kadernota 2020*	[9.1]
	- *Strategische visie 2030*	[9.2]
	- *Venlo Circulaire en duurzame hoofdstad - uitvoeringsprogramma 2019 - 2022*	[9.3]

Almere - policies

Almere has one policy document in regards to sustainability in the form of an implementation program. Besides this policy document they have multiple websites (groengezond.almere.nl and price-circulairalmere.nl) dedicated to sustainability and circularity in their municipality. These sites are mostly for interested inhabitants who are interested in the subject for their municipality. They have stated their definition of the CE as;

*'Develop and maintain circular and **tender circular** (know which materials are present in public spaces, the built environment and our own assets)'* [Gemeente Almere, 2019].

The principles regarding protecting material stocks are shown in table 4.2. Almere sees opportunities for a material depot to keep materials in circulation. There is however no found policy towards the prevention of waste. Regarding the target of protecting the environment (table 4.4) there is only a policy for stimulating residents in shifting from natural to gas to alternatives. For new construction there is no policy of using renewable resources. Also no policy is towards avoiding toxic materials and using biobased materials where possible. Regarding the target of protecting existing value (table 4.3) no policy is found regarding prioritising maintenance above new construction. Regarding resilience there is a clear policy of taking heat stress and flooding into design.

Table 4.2: Circularity in policies Almere - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	Less use of primary material sources (thus more use of secondary material sources).	*'In order to use 50% less primary raw materials by 2030, it is necessary to scale up the pilots of recent years, and to allow the circular economy to mature.'* [1.1]	Yes
	Stating the need for a material depot to facilitate reuse.	*'There is need for a material depot'*[1.1]	
Construction related activities do not generate waste. *(Design out waste)*	No mentioning of the prevention of waste generation of construction related activities.		No

Table 4.3: Circularity in policies Almere - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	No policy found regarding prioritising maintenance above new construction.		No
Resilience taking into design *(Design resilient)*	Reduction of heat stress and flooding.	*'We limit the effects of heat stress and flooding in the city. This means that after all projects have been completed, the public space can withstand rain showers of 70 mm and that urban area is not much warmer than the green outskirts of the city. In addition, we are taking measures to limit subsidence.'* [1.1]	Yes

Table 4.4: Circularity in policies Almere - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Stimulating energy reduction by residents and informing them about alternatives of gas.	*'There is a strong focus on clear communication with the aim of informing residents about the alternatives to natural gas and their role in them'*. [1.1]	Partly
No toxic materials are used in construction related activities. *(no toxic materials)*	No policy regarding avoiding toxic materials.		No
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	No policy found regarding using biobased materials		No

Amsterdam - policies

Amsterdam has in total 4 policy documents regarding the transition to the CE for the period 2020-2025. They are basing their strategy on the work of K. Raworth [Raworth, 2018] for a 'doughnut Economy'. This concept is more focused on a global level (strive to feed the needs of the people within the possibilities of the earth [Gemeente Amsterdam, 2019]). The policies regarding the protection of material stocks are shown in table 4.5. Amsterdam has a clear focus regarding the reducing of the use of primary material sources with a target of 2050 to be using solely materials from secondary material sources. There is however no policy regarding waste prevention. Regarding the target of protecting the environment (table 4.6) Amsterdam checks all boxes by reducing the amount of CO_2 emissions with 95% by 2050, by gas free by 2040, avoiding toxic materials and using biobased materials where possible. Regarding the protection of existing value Amsterdam uses the 9R framework for prioritising maintenance. Climate adaptive design is mentioned as a possibility (design resilient) however there is no elaborated plan of action regarding it.

Table 4.5: Circularity in policies Amsterdam - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	Reduction of use primary material sources.	*Amsterdam wants to use 50% less primary raw materials (that have never been used or recycled before) by 2030, and be 100% circular by 2050 at the latest.* [2.3]	Yes
Construction related activities do not generate waste. *(Design out waste)*	No mentioning of the prevention of waste generation of construction related activities.		No

Table 4.6: Circularity in policies Amsterdam - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Reducing CO_2 emissions and be gas free.	*'In 2030 we want to emit 55% less CO_2 compared to 1990. By 2050 that should be 95%. On the way there, we want to be natural gas-free by 2040.'.* [2.3]	Yes
No toxic materials are used in construction related activities. *(no toxic materials)*	Toxic materials are avoided.	*'..., avoiding the use of toxic substances and a product passport are examples of this.'* [2.3]	Yes
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	More use of biobased materials	*'In the short and medium term, the focus for area development is on increased use of recycled and biobased materials.'* [2.3]	Yes

Table 4.7: Circularity in policies Amsterdam - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	Using the 9R-framework	*'In a circular economy, the value of raw materials is preserved as much as possible during the entire life cycle of a product: from design to disposal.'* [2.3]	Yes
Resilience taking into design *(Design resilient)*	Climate adaptive design mentioned as possible without stating how.	*'Moreover, we can design the city in a climate-adaptive way, so that Amsterdammers breathe cleaner air and are less affected by increasing heat and rainfall.'* [2.3]	Partly

The Hague

The Hague has a rather limited policy towards the CE. They have focused on material streams to indicate the scale of the problem and the potential of the CE. They however have not made clear actions on how they are going to make the transition towards the CE and what their vision is of a 100% circular The Hague. Regarding protecting material stocks (table 4.8) there is a lot of focus on material streams and on which sectors produce the most waste. However it is not clear in their policy what The Hague will do about it. They have only stated that reuse is more preferable than incinerating or landfill. Regarding protecting the environment (table 4.9) they want to be climate neatral by 2040, but lack policy towards avoiding toxic materials or using more biobased materials in their construction related activities. Regarding the target of protecting existing value there is no found policy.

Table 4.8: Circularity in policies The Hague - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	Reusing of materials more desirable than incineration and landfill.	*'Waste processing has been worked out per sector in five scenarios: reuse, recycling, power generation, incineration and landfill. Reuse is here the most and deposit the least desired scenario.'* [4.1]	Partly
Construction related activities do not generate waste. *(Design out waste)*	No mentioning of the prevention of waste generation of construction related activities.		No

Table 4.9: Circularity in policies The Hague - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Stimulating energy reduction by residents and informing them about alternatives of gas.	*'The national government aims to be 100% circular by 2050 and in addition, the municipality has the ambition to reduce CO2 emissions by 2040. to be neutral.'*. [4.1]	Yes
No toxic materials are used in construction related activities. *(no toxic materials)*	No policy towards avoiding toxic materials.		No
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	No policy towards use of biobased materials.		No

Table 4.10: Circularity in policies The Hague - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	No policy towards maintenance above new construction.		No
Resilience taking into design *(Design resilient)*	No policy found towards resilience in design		No

Dordrecht – policies

Dordrecht has one main policy document (Dordrecht Circular) besides two smaller policy documents which also includes policies towards the CE. They have a broad definition of the CE with seven characteristics;

- The worth of human activities is expressed broader than only financially
- Materials become continuous on a high quality recycled way
- All energy comes from renewable resources
- Water is extracted on a sustainable way and source recovery is maximised
- Biodiversity becomes structurally supported and strengthened
- Society and culture are preserved
- Health and wellbeing of people and nature become structural supported

Regarding the target of protecting material stocks (table 4.11) there are both fully matches for the principles of *waste is food* and *design out waste*. Also regarding the target of protecting the environment (table 4.13) all principles are stated through policy. For the target of protecting existing value (table 4.12) there is yet room for improvement regarding resilience through design. Here there is mentioning about climate adaptive development, but it misses how they are going to implement this.

Table 4.11: Circularity in policies Dordrecht - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	As much as possible material use from secondary material sources.	*'The materials required for construction, such as concrete, brick, sand, glass and steel have a low environmental impact in accordance with the legal MPG requirement and are sourced as much as possible from secondary or biobased raw materials.'* [5.2]	Yes
Construction related activities do not generate waste. *(Design out waste)*	Responsibility to wrecking company to deliver clean CDW.	*'Demolished buildings play an important role in delivering clean construction and demolition waste that is further separated can be used to form a raw material for new, high-quality recycled concrete.'* [5.3]	Yes

Table 4.12: Circularity in policies Dordrecht - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	Variation on the 9R-framework used.	*'... a decision hierarchy of 6 'R's' (also known as the 'R-ladder'), in order from highest to lowest: Refuse/Rethink, Reduce, Reuse, Repair/Remanufacture, Recycle and Recover.'* [5.3]	Yes
Resilience taking into design *(Design resilient)*	Climate adaptive development mentioned without clear measures.	*'In addition, the Spuiboulevard and the surrounding area will be designed to be future-proof by taking the changing climate into account in the design, i.e. climate-adaptive development.'* [5.1]	Partly

Table 4.13: Circularity in policies Dordrecht - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Become energy neutral.	*'For the built environment, we are aiming for energy neutrality by 2035.'*. [5.1]	Yes
No toxic materials are used in construction related activities. *(no toxic materials)*	Toxic materials are avoided.	*'Scarce and toxic materials/raw materials are avoided.'* [5.1]	Yes
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	Using more biobased materials.	*'The materials to be used, such as concrete, wood or metals, have a low environmental impact in accordance with the legal MPG standard and come as much as possible from secondary or biobased raw materials'* [5.1]	Yes

Haarlemmermeer - policies

Haarlemmermeer has one main policy document in regards to the CE where they see the achievement of a 'circular society' as a way to reach sustainability. Their definition of a Circular Society is as follows;

> *"A society in which all aspects of the use of water, energy and raw materials are tackled from new social and innovative (economic) perspectives. This creates a new economy."* [Gemeente Haarlemmermeer, 2015]

Compared to the other cases this policy document is rather 'old', dating from 2015, however it remains very close to the basics of the CE with two of their three main themes being Energy and Materials. They also acknowledge the main difficulties; mainly which indicators to use to monitor the progress. Regarding the target of protecting material stocks (table 4.14) the policy matches the principle of *waste is food*, Regarding *designing out waste* they want to reduce residual waste, but not outlaw it completely. Regarding the target of protecting the environment (table 4.16) they are fully matching the principle of *energy from renewable resources*. There is no mentioning of avoiding toxic materials and using biobased materials is only further researched. Regarding the target of protecting existing value (table 4.15) There is only a small discussion found regarding the need for climate adaptation, but without measures. A maintenance prioritising is not mentioned.

Table 4.14: Circularity in policies Haarlemmermeer - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	Gaining new materials from waste streams.	*'By recovering raw materials from residual products, waste processing costs are saved and income can even be generated.'* [6.1]	Yes
Construction related activities do not generate waste. *(Design out waste)*	Reducing waste.	*'Targets waste: less residual waste'* [6.1]	Partly

Table 4.15: Circularity in policies Haarlemmermeer - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	No policy found regarding prioritising maintenance.		No
Resilience taking into design *(Design resilient)*	Mentioning the need for climate adaptation without clear measures.	*'the decline in the absorbing capacity of the soil due to ongoing urbanisation, the construction of major infrastructure works and more extreme rainfall events as a result of climate change;'* [6.1]	Partly

Table 4.16: Circularity in policies Haarlemmermeer - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Become energy neutral.	*'The Amsterdam Metropolitan Area (MRA) has the ambition to be energy neutral by 2040. ... Our ambition on the theme of energy is: Haarlemmermeer becomes energy-supplying.'*. [6.1]	Yes
No toxic materials are used in construction related activities. *(no toxic materials)*	No policy toward avoiding toxic materials.		No
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	Researching the use of biobased composites. No large scale implementation.	*'Investigates the possibilities of applying biocomposite'* [6.1]	Partly

Rotterdam - policies

Rotterdam has an ambitious circularity policy named *'van zooi naar mooi'* (from junk to beautiful). In 2020 they already want to buy 25% circular where the most can be gained in regards to circularity [Gemeente Rotterdam, 2018]. Regarding the target of protecting material stocks (table 4.17) they partly match both principles. The principle of *waste is food* is not fully matched because they only want to reduce the use of primary resources (thus increasing the use of secondary material sources), but not to the full extent. Also with the principle of *design out waste* they want to reduce the waste but state that waste still will be present. Regarding the target of protecting the environment (table 4.18) they want to make the switch to fully run on renewable energy sources. There is however no mentioning of the avoidance of toxic materials or making more use of biobased materials. Regarding the target of protecting existing value (table 4.19) they have a very clear target of prioritising maintenance by extending the lifespan of existing buildings. Climate adaptation is mentioned to be an important theme, however measures lack.

Table 4.17: Circularity in policies Rotterdam - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	Reducing the use of primary resources, not outlawing completely.	*'halving the use of primary raw materials by 2030.'* [7.1]	Partly
Construction related activities do not generate waste. *(Design out waste)*	Reducing waste by deconstructing.	*'The demolition is not done with the wrecking ball, but in such a way that as little waste as possible is created.'* [7.1]	Partly

Table 4.18: Circularity in policies Rotterdam - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Running solely on renewable energy sources.	*'... and has made a switch to renewable energy sources.'* [7.1]	Yes
No toxic materials are used in construction related activities. *(no toxic materials)*	No policy toward avoiding toxic materials.		No
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	No policy toward using biobased materials.		No

Table 4.19: Circularity in policies Rotterdam - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	Using variation of the 9R-framework	*'We use this model (value hill) as the basis for our approach to circular construction and circular material flows in Rotterdam.'* [7.1]	Yes
	Extending lifespan of existing buildings.	*'Goal: Extend the life of existing buildings.'* [7.1]	
Resilience taking into design *(Design resilient)*	Mentioning the need for climate adaptation without clear measures.	*'Important themes from the Vision for the Rotterdam Style are: climate adaptation, mobility, energy transition and densification.'* [7.1]	Partly

Utrecht - policies

Utrecht has a single policy document called 'Utrecht Circulair 2020-2023'. In the period 2020 till 2023 they want to experiment with circularity and want to reach 'circular basecamp' in 2023 [Gemeente Utrecht, 2019]. They are defining circular construction as follows;

> *'Circular construction means developing, using and reusing buildings, areas and infrastructure, without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems.'* [Gemeente Utrecht, 2019]

Regarding the target of protecting material stocks (table 4.22) both principles are fully matched. Several policies or measures are indicators for these principles, like the setting up of a 'circular hub' to facilitate the reuse of materials. Regarding the target of protecting the environment (table 4.20) also all principles are matched. With the target of protecting existing value (table 4.21) there are no indicators towards the principle of prioritising maintaining. Also resilience in design is partly met; climate adaptation is mentioned, but without corresponding measures.

Table 4.20: Circularity in policies Utrecht - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Making new constructions energy neutral or energy-producing.	*'There are also examples where circular new construction is immediately energy neutral or even energy-producing.'* [8.1]	Yes
	Energy comes from renewable sources	*"Waste' is a raw material and energy comes from sustainable sources.'* [8.1]	
No toxic materials are used in construction related activities. *(no toxic materials)*	Use materials which are free of toxics	*'Use as many (new) materials that are environmentally friendly and free of toxic substances.'* [8.1]	Yes
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	Making a shift to a biobased economy.	*'The Biobased Economy is an economy that uses crops and residual flows from the agriculture and food industry for non-food applications.'* [8.1]	Yes

Table 4.21: Circularity in policies Utrecht - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	No policy toward this principle found.		No
Resilience taking into design *(Design resilient)*	Mentioning the need for climate adaptation without clear measures.	*'... focuses on energy-efficient, circular and climate-adaptive building.'* [8.1]	Partly

Table 4.22: Circularity in policies Utrecht - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	Creating value by reuse.	*'The aim is to create value by reusing raw materials.'* [8.1]	Yes
	Waste becomes a raw material	*"Waste' is a raw material and energy comes from sustainable sources.'* [8.1]	
Construction related activities do not generate waste. *(Design out waste)*	Creating zero waste building sites.	*'If the construction site is actively directed towards the zero waste (waste-free construction site) concept, additional results can be achieved. The next step is to include circular disassembly and upcycling in this process, so instead of demolition and low-grade reuse, focus on making construction components suitable for high-value reuse, for example using social return.'* [8.1]	Yes
	Creating a circular hub	*'A hub on the outskirts of the city, where the total logistics process of the construction chain (from supplier to construction site) is monitored and coordinated.'* [8.1]	

Venlo - policies

Venlo has one main policy document in which they discuss their policies in regards to the implementation of the CE. They also have a website c2cvenlo.nl where they provide information for inhabitants of what they are doing. The city office of Venlo, which is in use since 2016, is priced as a circular building in the cradle to cradle principle [Gemeente Venlo, 2018]. They have stated seven principles in relation to the C2C philosophy; keep innovating, connect place and context, manage and value food, enjoy mobility, enjoy the sun, create clean air, water and soil and design with an eye for future generations [Gemeente Venlo, 2019]. They have determined circular construction as;

> *Closing material and raw material cycles within the demolition, renovation and new construction phase as well as the infrastructure sector in the built environment.*

The detail of their policy in regard to their construction related activities however remains limited. Regarding the target of protecting material stocks (table 4.23) they only fully match the principle of *design out waste*. In the target of protecting the environment (table 4.25) the only partly match the principle of *energy from renewable resources* by discussing the need of local energy generation. Regarding the target of protecting existing value (table 4.24) they only partly match the principle of *design resilient* by stating the need to be climate-proof, but without taking measures to become climate-proof.

Table 4.23: Circularity in policies Venlo - protecting material stocks

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Only made use of material from secondary material sources. *(waste is food)*	No policy towards this principle found.	*'The aim is to create value by reusing raw materials.'* [8.1]	No
Construction related activities do not generate waste. *(Design out waste)*	Closing of the loop.	*'closing material and raw material cycles within the demolition, renovation and new construction phase as well as the infrastructure sector in the built environment'* [9.3]	Yes

Table 4.24: Circularity in policies Venlo - protecting existing value

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
A focus on maintenance *(Maintaining prioritised above new construction)*	No policy toward this principle found.		No
Resilience taking into design *(Design resilient)*	Climate adaptation as a main target without corresponding measures.	*'As the city of the future, we want Venlo to become climate-proof in order to be able to cope with heavy peak rainfall and increasing heat and drought.'* [9.3]	Partly

Table 4.25: Circularity in policies Venlo - protecting the environment

Theoretical pattern	Empirical pattern	Exemplary evidence	Match
Construction related activities run solely on energy from renewable resources *(Energy from renewable resources)*	Produce energy local as a theme (solar panels on roofs).	*'Joint local energy generation'* [9.3]	Partly
No toxic materials are used in construction related activities. *(no toxic materials)*	No policy found regarding this principle		No
Construction related activities make use of biobased materials as much as possible. *(biobased materials)*	No policy found regarding this principle		No

4.2 CROSS CASE ANALYSIS – CE PRINCIPLES IN POLICIES

It first has to be noted that due to the limited number of cases results are not necessary the same if all Dutch municipalities were analysed [Yin, 2014]. However the case study gives an insight in the trends of the cases where other municipalities can learn from. The results, which are shown in table 4.26, shows that the most used principle is the use of *energy from renewable resources* (7). There are differences in how explicitly the use can be directed to construction related activities. It is however interpreted that when a municipality has stated the ambition and/or target of running the whole municipality on energy from renewable resources that this also implies to their construction related activities.
Also the principle of *waste is food* (6) is present in most of the policies. This mostly comes from policies towards the shift from primary to secondary material sources. Where there is a partly match the use of primary sources is reduced to 50% but has not completely disappeared.
The principles of *design out waste* (4) and *design resilient* (4) are matched half of the time. Designing out waste can be done by setting up a material depot (waste processing) or lay full responsibility by the contractor (waste prevention). With resilience it is most of the time related to rainfall and water drainage. This principles is most of the time partly matched because there are talks of climate adaptation (with regard to extreme weather) but without corresponding actions or policies.
Making *use of biobased materials* (3.5), *avoiding toxic materials* (3) and *prioritising maintaining above new construction* (3) are not found often. This can have different causes. For instance the avoiding of toxic materials are largely already in rules and regulations nationally, so there is no need to specify it in policy. A maintenance prioritising strategy can be less desirable for municipalities who want to create a modern looking municipality with new buildings and structures. The causes however remain guesswork.

Between the cases there are also differences. From Dordrecht who almost matches all principles to the full extend to the Hague who only fully matches one. All these municipalities were expected to be circular frontrunners, but some seem to me lacking in this perspective based on their policies. As stated prior, the concept of the CE is not bound and therefore municipalities are free to give their own interpretation to the subject. So it may be that the municipalities who are deemed to be lacking in their circular ambitions have other focus points in regards to the CE.

Table 4.26: Circularity principles in policies

Principle	Alm.	Ams.	TH.	Dor.	Haa.	Rot.	Utr.	Ven.	sum
Waste is food	Yes	Yes	Partly	Yes	Yes	Partly	Yes	No	6
Design out waste	No	No	No	Yes	Partly	Partly	Yes	Yes	4
Energy from renewable resources	Partly	Yes	Yes	Yes	Yes	Yes	Yes	Partly	7
No toxic materials	No	Yes	No	Yes	No	No	Yes	No	3
Biobased materials	No	Yes	No	Yes	Partly	No	Yes	No	3.5
Maintaining prioritised above new construction	No	Yes	No	Yes	No	Yes	No	No	3
Design resilient	Yes	Partly	No	Partly	Partly	Partly	Partly	Partly	4
Sum	2.5	5.5	1.5	6.5	3.5	3.5	5.5	2	

4.3 WITHIN CASE ANALYSIS – TENDERS

Most of the construction related activities from municipalities are procured through tenders to the market. In the Netherlands the platform TenderNed is used to facilitate this process [TenderNed, 2021]. This platform coordinates communication between municipalities, regional water authorities and other institutions which can procure projects via this platform. Contractors can then make a bid based on the award criteria. This process stimulates competition between contractors which ultimately drives prices down.

4.3.1 Tender selection

Through TenderNed datasets were acquired from the period 2017 till 2020 for each municipality. These datasets also contain tenders which are not related to construction activities, for instance the purchase of medical equipment or financial services. Therefore the tenders were filtered to only include construction activities. In TenderNed this includes the following sub-categories;

- Preparing sites for construction;
- Complete or partial construction and civil engineering work;
- Installation work in construction;
- Finishing of buildings;
- Rental of construction and civil engineering installations and equipment with operating personnel.

The tenders were also filtered to be unique. Many tenders have multiple entries because of the nature of the announcement on TenderNed. TenderNed makes a distinction between (pre-) announcements, additional information and rectifications. However the online reference always links to the most relevant version. The amount of tenders selected for the analysis are shown in table 4.27. In the selected tenders there were also market consultations present which are not feasible in the tender analysis, but indicate the need for knowledge regarding circularity in construction projects.

Table 4.27: Tender selection

Municipality	Total tenders	Containing 'circularity'	Percentage
1- Almere	50	5	10.0%
2- Amsterdam	193	3	1.6%
3 - The Hague	103	5	4.9%
4 - Dordrecht	15	0	0.0%
5 - Haarlemmermeer	31	3	9.7%
6 - Rotterdam	99	1	1.0%
7 - Utrecht	61	5	8.2%
8 - Venlo	14	2	14.3%
Sum	**566**	**24**	**4.2%**

4.3.2 Tender analysis

To understand the use of CE principles in tenders the selected tenders are further analysed. This was done by further selecting tenders which contain circular aspects in their project. This is done by searching for terms circularity, sustainability or variations of these words in the name, description or keywords of the tender. Sustainability is included in this search because of the overlap it has with circularity which can be seen as a method to achieve sustainability or sustainable development

as described by the UN [United Nations, 2019]. It can therefore be expected that circularity aspects can be found in sustainability factors. In the following part per case the within case analysis is held based on the found tenders. The found tenders are also shown in time per quartile in figure 4.1. As can be seen the amount of 'circular' tenders is very little in comparison to the 'regular' tenders. There is a small increase noticeable of these circular tenders in time, but it remains rather limited.

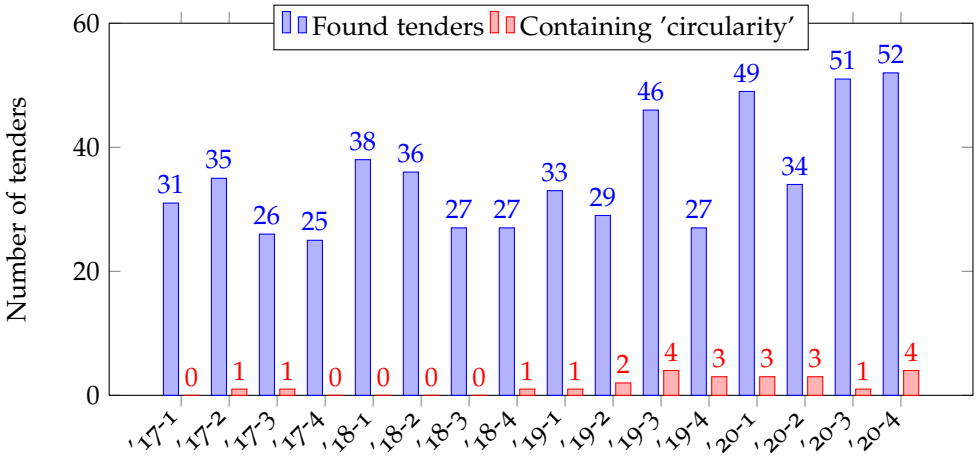

Figure 4.1: Number of tenders in time

Almere - tenders

For Almere in total of four tenders were selected which contains sustainable or circular elements. However, for one the data was unavailable and one contained a market consultation regarding sustainable road construction and were therefore left out.

1 - GON-10-19-064-B01 Framework agreement Construction preparation Stichtsekant in Almere Harbour

Description: *The aim is to take **sustainability**, **circularity**, flexibility, communication, engineering and geotechnical risk management to a higher level when preparing Stichtsekant for construction. The construction preparation work will consist of: carrying out clearing work, picking up and applying foundation layers, picking up and installing asphalt pavements, picking up and installing element pavements, picking up and applying edge closures, excavating, processing clay and sand (Earth moving) , installing drainage, installing pressure and vacuum sewerage, performing additional work.*

For the selection process the contractor could score points in regards to sustainability and circularity by;

- The candidate scores 20 points (out of 100) if the candidate complies with: One civil engineering project, with a size of 20,000 m2, where the asphalt work has been carried out with a reduction of CO_2 emissions.
- Required: The candidate must be in possession of the CO_2 awareness certificate or equivalent.

2 - Construction team assignment "Major Maintenance and Replacement of bicycle and pedestrian bridges" in Almere

Description: *The nature and scope of the assignment concerns:*

- *Designing bridges;*
- *Demolish wooden bridges;*
- *Renovating wooden bridges;*
- *Replacing wooden bridges with a **durable alternative** such as concrete or steel and composite/plastic.*

This particular tender was selected because the Dutch translation of sustainable and durable are the same. The bidder can score points if he has a 'CO2-bewust' certificate.

In the tenders there is only the indicator of CO_2 reduction found which indicates to the use of energy from renewable resources. There are also hints to the extending of lifespan, but for the new construction which are made. This however consists of the replacement of wood by more durable materials.

Table 4.28: Circularity in tenders - Almere

Principle	Empirical pattern	Match
Waste is food	Not found	No
Design out waste	Not found	No
Energy from renewable resources	CO_2 reduction part of the award criteria through proof of past projects or certificates.	Yes
No toxic materials	Not found	No
Biobased materials	Opposite found	No
Maintaining prioritised above new construction	In the second project there is a shift to materials with a longer lifespan.	Partly
Design resilient	Not found	No

Amsterdam - tenders

Amsterdam has three tenders which state that circularity and/or sustainability are part of the tender. However two are market consultations regarding the subject of sustainability, so only one tender remains to be included in the analysis.

1 - AI 2019-0329 Demolition remediation and preparation for construction of lots 18 & 19

Description: *Buiksloterham is part of the Northern IJ bank and is transforming into an area where living and working naturally take place sustainably. The municipality of Amsterdam shapes the growth and development of the city. The present contract concerns the preparation of the former AVI/GEB site (lot 18, 18a and 19) in the Buiksloterham area. Project goal / goals:*

- *Circular reuse*
- *Sustainability (as described on: Duurzaam Amsterdam)*

The tender is awarded based on the following points;

- Plan of approach;
- CO_2 emissions;
- Risk management;
- Registration fee.

Besides the following award criteria the contractor needs to have a System Certificate Safe and Environmental Demolition BRL SVMS-007. The projects goals (circular reuse and sustainability) can come forward in the plan of approach. Also CO_2 emissions can also be regarded as a sustainability / circularity indicator.

To conclude for Amsterdam; they have relatively a lot of tenders, but only one where they state they have sustainability and circularity goals. The results are shown in table 4.29. They clearly state that they want materials which come from the site are prepared to be reusable. CO_2 emissions are also part of the award criteria which can be achieved by a CO_2 reduction calculation. The nature of the works (demolition project) however is contradictory to the target of protecting existing worth. Asbestos sanitation is also part of the work which could be a reason that demolition is necessary and reuse what is already there is not possible. But Amsterdam, which does have 193 tenders for the period analysed, has only one construction project which clearly states that circularity and sustainability is part of the assignment. This remains a very low percentage.

Table 4.29: Circularity in tenders - Amsterdam

Principle	Empirical pattern	Match
Waste is food	Not found	No
Design out waste	*'Material from demolition needs to be made ready for circular reuse as much as possible.'*	Yes
Energy from renewable resources	*'In a CO_2 calculation, the Tenderer must indicate the degree of CO_2 reduction achieved in the realisation of the work'*	Yes
No toxic materials	Asbestos sanitation part of the works.	Partly
Biobased materials	Not found	No
Maintaining prioritised above new construction	Opposite found	No
Design resilient	Not found	No

The Hague - tenders

The Hague has three tenders where sustainability and/or circularity is part of the tender;

1- Replacement quayside with stone slope Suezkade

Description: *A visual inspection has shown that the wooden toe board of the stone slope along the Suezkade has been seriously affected and therefore needs to be replaced. This concerns both the sidewalk between Newtonstraat and Weimarstraat and the sidewalk between Weimarstraat and Laan van Meerdervoort. The aim is to replace the existing quayside with a construction with a visually similar appearance to the current situation that is safe and* ***sustainable****. This is based on the idea of providing the sidewalk with a green appearance and preserving the trees.*

In this tender the contractor needs to show his environmental actions by; an ISO 14001 certificate or, if the Tenderer does not have one, by enclosing a current environmental policy statement signed by the management or an environmental program or action plan indicating which steps the organisation is taking or will take to reduce the environmental impact or an environmental report or other (management) report reporting on the environmental measures taken and the results achieved and the name and job content of an officer appointed to coordinate the environmental measures of the organisation. However the contractor is selected by the lowest price.

2 - Sustainable replacement of the Hooigracht quay wall

Description: *An inspection has shown that the timber foundation of the Hooigracht is no longer adequate. The quay has become skewed towards the water due to the poor foundation. It was decided to replace the quay wall. The quay wall to be replaced has a length of 190 meters and the project runs from the Houtweg bridge to the expansion joint next to the building on the corner of the street in the direction of Laan van Roos en Doorn. The existing quay wall must be replaced by a construction that is safe and durable, without causing damage to objects belonging to third parties and in good relationship with the environment. The replacement of the Hooigracht quay wall is a pilot in the field of* ***sustainability*** *in quay replacement. A secondary objective is, among other things,* ***sustainable purchasing****. This is understood to mean:*

- *Stimulate the use of electrical construction equipment;*
- *Demonstrable environmental performance (Dubomat/CO2 reduction);*
- ***Sustainable*** *construction logistics.*

This tender was awarded based on the best price / quality, where quality is defined by the three previous mentioned under sustainable purchasing.

3 - Maintenance of element pavements - Minor maintenance (up to 200 m2)

Description: *The Municipality of The Hague wants to make 'Public Space Sustainably Better' and thus contribute to a satisfied citizen, entrepreneur and visitor to the city of The Hague. We do this, among other things, by carrying out continuous maintenance on the road network in The Hague, including element surfacing (also called paving, street work, paving, 'open' surfacing). In contrast to a closed pavement (asphalt), this pavement is made up of separate elements that are (loosely) connected to each other to a greater or lesser extent. In addition, the Municipality of The Hague has ambitions in the areas of: Sustainability, Social Return, Innovation and SMEs. The Contracting Authority will enter into a RAW Framework Agreement for several years. During the execution of the work, tenderers must be able to make progress (growth) together with the municipality of The Hague in order to do better and better.*

This tender was awarded based on the best price / quality. Sustainability targets were defined as the use of electrical equipment, the plan of the contractor to achieve sustainability (in their company) and a CO2 performance ladder.

To conclude for The Hague the main focus lies on CO2 emissions which indicates the principle of *energy from renewable resources*. There is also the possibility to indicate a low environmental impact by the contractor by stating they avoid toxic materials and make use of biobased materials. This however is not specifically asked for and in this tender the contract goes to the lowest bid. The results are shown in table 4.30.

Table 4.30: Circularity in tenders - The Hague

Principle	Empirical pattern	Match
Waste is food	Not found	No
Design out waste	Not found	No
Energy from renewable resources	Use of electrical equipment part of the award criteria. CO2 reduction in calculation	Yes
No toxic materials	Avoiding toxic materials could be used by the tenderer to indicate their actions to reduce their environmental impact.	Partly
Biobased materials	Avoiding toxic materials could be used by the tenderer to indicate their actions to reduce their environmental impact.	Partly
Maintaining prioritised above new construction	Not found	No
Design resilient	Not found	No

Dordrecht - tenders

Dordrecht has no tenders where they state sustainability or circularity as their target.

Haarlemmermeer - tenders

1 - designing and realising a soundproof construction in Hoofddorp

Description: *The client has the ambition to develop **sustainable**, multifunctional soundproofing that contributes to the **circular Economy**. With this request, a party is sought for the design and realization of the Work and optional Long-Term Maintenance of this **sustainable** soundproofing.*

This tender was awarded by price / quality (50/50) where the quality is defined by design (25) and a sustainability file (25). This sustainability file consists of the following categories which can earn points;

- Cat 1: Green and ecology
- Cat 2: **Circular design**:
  - Keep materials circling longer
  - Reduce demand of raw materials (by reusing of existing materials, by reducing material usage by design, make it demountable for the future or make use of a material passport)
- Cat 3: **Sustainable energy** (generate energy or store energy by design)
- Cat 4: Opportunities:
  - Participation of residents
  - Collaboration with a housing developer
  - Cooperation with educational institutions
  - Environmental impact during implementation

Haarlemmermeer has three tenders in which they clearly state circularity, however two are market consultations and cannot be reviewed. The tender which is included is very thorough regarding its circular aspects. Regarding the target of protecting material stocks it matches both principles fully. The principle of *waste is food* is met by demanding the reduction of raw materials used. The principle of *design out waste* is met through the demand of keeping materials circling longer. Regarding the target of protecting the environment the principle of *energy from renewable resources* is fully matched because there is a demand that energy is (sustainable) generated or stored by design. There are possibilities to include the principles of *avoiding toxic materials* or *making use of biobased materials* in the award criteria to make a better offer, but this is up to the contractor to include. Regarding the target of protecting existing value no matches where found.

Table 4.31: Circularity in tenders - Haarlemmermeer

Principle	Empirical pattern	Match
Waste is food	Reduce amount of raw materials used	Yes
Design out waste	Keep materials circling longer	Yes
Energy from renewable resources	Generate energy or store energy by design.	Yes
No toxic materials	Avoiding toxic materials could be used by the tenderer to indicate their actions to reduce their environmental impact during implementation.	Partly
Biobased materials	Avoiding toxic materials could be used by the tenderer to indicate their actions to reduce their environmental impact during implementation.	Partly
Maintaining prioritised above new construction	Not found	No
Design resilient	Not found	No

Rotterdam - tenders

Rotterdam has only one tender which includes circularity. However, this is a market consultation and can therefore not be reviewed.

Utrecht - tenders

Utrecht has a total of five tenders in which they state circularity and/or sustainability, but three tenders are market consultations and can therefore not be reviewed.

1 - Sports floors and wall coverings

Description: *This tender includes the maintenance of sports floors and the supply and installation of acoustic wall coverings within the municipality of Utrecht. The municipality wishes to enter into a longer collaboration with a party, with special attention to the themes of **circularity**, flexibility and innovation. In addition to maintenance, the installation of new floors on new accommodations is also part of the assignment.*

This tender selects on lowest price, but has demands in regards to sustainability / circularity:

- *You ensure that new sports floors are made of at least **70% recycled raw materials**;*
- *You guarantee and demonstrate that the products, parts or raw materials are **recycled at the end of their technical lifespan** or use phase for a new sports floor and (any) residual products **are recycled for processing in other applications**;*
- *You are responsible for **minimising waste** and residual products in the recycling and application process.*
- *You guarantee that all raw materials and residual materials can be traced before and during the recycling process with available documents at national and European level;*
- *With regard to the preservation of the value of raw materials, you always supply the raw materials passport per delivered sports floor. To do this, you must include a list of origin of the raw materials used for the manufacture of the sports floor(s);*
- *You demonstrate with the help of LCAs (Life Cycle Analyses) that the materials/products used are **climate neutral and the environmental impact is minimised** (for example, through water-based top coatings and solvent-free adhesives);*
- *During the recycling and implementation process, you monitor and report **a CO_2 footprint** based on SCOPE 3 emissions;*
- *You guarantee a technical lifespan of at least 15 years for a top layer on a sports floor and at least 30 years for a complete sports floor;*
- *The municipality receives a recycling discount on the recyclable raw materials, materials and components of existing sports floors from the objects in recognition of the residual value and value retention of these materials. It therefore concerns a discount on the unit prices for the parts where recycling is applicable (when revitalising, replacing or supplying a new sports floor). This discount therefore does not apply to the other parts such as inspections and tests.*

2 - Renovation and sustainability of the Sports Campus education building (Utrecht Municipality)

Description: *In addition to spatial changes, the renovation also involves structural and technical (upgrade ventilation fresh schools class B) adjustments. In addition to these activities, the entire building (17,408 m² GLA) will be made ENG (energy neutral). This renovation will take place in which education should experience little or no hindrance from the renovation. The contracted party will take place in a construction team.*

In this tender points (15/100) are awarded if the contractor has engineered a energy neutral building in the past.

Especially the first tender has detailed aspects indicating to circularity. In regards to the target of protecting material stocks they fully match both principles. The principle of *waste is food* is matched by demands regarding the percentage of recycled materials used and regarding the usability of these materials after use. The principle of *design out waste* is fully matched by several indicators. There is a demand to minimise waste, a demand that materials are recycled at the end of their technical lifespan and a material passport is required which stimulates the reusability of materials. Regarding the target of protecting the environment the principle of *energy from renewable resources* is fully matched by needing to provide proof of having engineered an energy neutral building in the past and requiring a report on the CO2 footprint of the project. The principle of *avoiding toxic materials* is also fully matched by the requirement of using materials which are climate neutral. For making *use of biobased materials* there is a possibility for using this in the LCA, but is not a specific requirement. For the target of protecting existing value there are clear requirements towards the lifespan of certain elements, which forces the contractor to deliver this quality. However this can be seen as an logical requirement which is applicable on all projects, even when not stated directly. Therefore it is partly matched. The results for Utrecht are shown in table 4.32.

Table 4.32: Circularity in tenders - Utrecht

Principle	Empirical pattern	Match
Waste is food	Demand of using at least 70% recycled materials. Demand that materials are feasible to be recycled in processing in other applications.	Yes
Design out waste	Demand of minimising waste. Demand that materials are recycled at the en of their technical lifespan. Demand that materials are traceable and documented (material passport).	Yes
Energy from renewable resources	Provide proof that the contractor has engineered a energy neutral building in the past. CO2 footprint report required	Yes
No toxic materials	Materials/products are climate neutral and have a minimal environmental impact.	Yes
Biobased materials	Biobased materials is a usable principle for the LCA, but is not required.	Partly
Maintaining prioritised above new construction	Clear requirements regarding lifespan.	Partly
Design resilient	Not found	No

Venlo - tenders

1 - Redevelopment of Blok van Gendt . location

Description: *At the Blok van Gendt location within the municipality of Venlo, there is a redevelopment assignment, which consists of developing, realising and operating a parking facility. In addition to the schedule of requirements, the tenderer has the option of adding additional residential uses or additional parking facilities. Other functions are not allowed. The municipality intends to sell the Blok van Gendt plot to a market party, on the condition that this party realises and operates the redevelopment assignment at its own expense and risk. For a detailed description of the assignment, reference is made to appendix 2a "Bloc van Gendt development assignment" (incl. appendices 2b to 2d) of these tender guidelines.*

The tender is awarded based on price / quality where sustainability is worth 40%. Sustainability is further defined as:

- Energy (based on % of renewable energy in development of the project);
- Climate adaptable, biodiversity, green and water;
- Raw materials and circular construction:
  - Make a 'green demolition';
  - C2C certified materials are used, or materials that would be certifiable on the basis of available information;
  - Use of 'healthy' materials which are part of a circular cycle;
  - Use of a material passport.

Venlo has two tenders containing circularity or sustainability aspects, however one contains a market consultation and is therefore left out. The one tender left contains indicators to certain circular principles. Regarding the target of protecting material stocks both principles are fully matched. The principle of *waste is food* is matched by the requirement of using C2C certified materials. The principle of *design out waste* is fully matched by the requirement of using material passports. Regarding the target of protecting the environment the principle of *using energy from renewable resources* is fully matched by points being awarded for the percentage of renewable energy used in the development of the project. Also the principle of *avoiding toxic materials* is matched partly by the requirement of using healthy materials. This because it can be understood in being non toxic materials. Regarding the target of protecting existing value only the principle of *design resilient* is matched by climate adaptability being part of the award criteria. The results for Venlo are shown in table 4.33.

Table 4.33: Circularity in tenders - Venlo

Principle	Empirical pattern	Match
Waste is food	Making use of C2C certified materials.	Yes
Design out waste	Making use of a material passport.	Yes
Energy from renewable resources	Points awarded for percentage of renewable energy used in development of the project.	Yes
No toxic materials	Points awarded for healthy materials.	Partly
Biobased materials	Not found	No
Maintaining prioritised above new construction	Not found	No
Design resilient	Climate adaptability part of award criteria.	Yes

4.4 CROSS CASE ANALYSIS – TENDERS

As can be seen in table 4.34 the most commonly found principle is the principle of using *energy from renewable resources* (6). This is mostly due to the fact that CO2 emissions are widely adopted in policies and are one of the (if not the) main sources of global warming. Also CO2 emissions can be calculated or estimated. In this principle several sources where found, ranging from using electric equipment (using a renewable energy source) to projects which had to generate or store energy in a sustainable way. The principle of *design out waste* is also found often. This was either through methods to prevent materials in becoming waste (material passport) to demands regarding minimising waste generation in general within the tender. The principle of *avoiding toxic materials* (3) was also present within the analysed tenders. This principle was largely partly present where as it could be used in winning a tender, but was not specified enough. Only in one case it was made clear which they meant by non toxic material, giving examples like using water-based top coatings. The principle of *waste is food* (3) is not found as much as expected. This principle was found in criteria regarding the percentage of material from secondary material sources required. With half of the cases with sufficient data this was not present. The principle of *using biobased materials* (1.5) was only matched partly in three cases where it could be used in the award criteria to win the tender, but was not specified. For instance the term 'healthy material' could be interpreted as being biobased. Both principles regarding the target of protecting existing value, and *design resilient* (1), are both matched very little. Regarding the principle of *maintaining prioritised above new construction* (1) it can be argued if tenders themselves are the opposite for this principle. This because tenders tend to develop a project instead of keeping it as it is. The principle of *design resilient* was only matched once through climate adaptability being part of the tender. This principle however has the potential to gain track in future tenders due to the more extreme weather conditions occurring.

Between the cases there are differences ranging from the least principles found in Almere (1.5) to the most found in Utrecht (5). However, due to the limited tenders which clearly state to be 'circular' or 'sustainable' it can not be stated that one municipality is less circular in their practices than others. For instance indicators for principles can be present in other tenders which do not state to be a circular of sustainable tender.

Table 4.34: Circularity principles in tenders

Principle	Alm.	Ams.	TH.	Dor.	Haa.	Rot.	Utr.	Ven.	sum
Waste is food	No	No	No	No	Yes	No	Yes	Yes	3
Design out waste	No	Yes	No	No	Yes	No	Yes	Yes	4
Energy from renewable resources	Yes	Yes	Yes	No	Yes	No	Yes	Yes	6
No toxic materials	No	Partly	Partly	No	Partly	No	Yes	Partly	3
Biobased materials	No	No	Partly	No	Partly	No	Partly	No	1.5
Maintaining prioritised above new construction	Partly	No	No	No	No	No	Partly	No	1
Design resilient	No	No	No	No	No	No	No	Yes	1
Sum	1.5	2.5	2	No	4	No	5	4.5	

4.5 POLICIES TO PROCUREMENT PRACTICES

In the following part an analysis is held between the policies and procurement practices. This relates to sub research question 4; what are the similarities and differences between the use of CE principles in policies and procurement practices? In general, there are four possibilities per case; the case states in their policies they are or will be using certain principles and this is also shown in their tenders (perform well as expected). The case states in their policies they are or will be using certain principles, but this does not show in their tenders (perform worse than expected). They do not state they are using certain principles, but are using them in their tenders (perform better than expected). Or they do not state certain principles in their policies and this also shows in their tenders (perform poorly as expected). To analyse the similarities of how principles are translated from policies into tenders and how cases preform in relation to one another the following is used; a fully match is stated as A, a partly match as B and no match as C. To compare the results A is given 1 point, B 0.5 point and C 0 point. It has to be stated that this grading is only used to better compare the use of principle with one another and that this is not a 'score' on how well it performs. This gives the following tables for policies (table 4.35) and tenders (table 4.36). As can be seen table 4.35 is a lot greener than table 4.36. This already indicates that circularity principles occur more often in policies than in procurement practices.

Table 4.35: Circularity principles in policies scored

Principle	Alm.	Ams.	TH.	Dor.	Haa.	Rot.	Utr.	Ven.	sum
Waste is food	A	A	B	A	A	B	A	C	6
Design out waste	C	C	C	A	B	B	A	A	4
Energy from renewable resources	B	A	A	A	A	A	A	B	7
No toxic materials	C	A	C	A	C	C	A	C	3
Biobased materials	C	A	C	A	B	C	A	C	3.5
Maintaining prioritised above new construction	C	B	C	A	C	A	C	C	3
Design resilient	A	B	C	B	B	B	B	B	4
Sum	2.5	5.5	1.5	6.5	3.5	3.5	5.5	2	

Table 4.36: Circularity principles in tenders scored

Principle	Alm.	Ams.	TH.	Dor.	Haa.	Rot.	Utr.	Ven.	sum
Waste is food	C	C	C	C	A	C	A	A	3
Design out waste	C	A	C	C	A	C	A	A	4
Energy from renewable resources	A	A	A	C	A	C	A	A	6
No toxic materials	C	B	B	C	B	C	A	B	3
Biobased materials	C	C	B	C	B	C	B	C	1.5
Maintaining prioritised above new construction	B	C	C	C	C	C	B	C	1
Design resilient	C	C	C	C	C	C	C	A	1
Sum	1.5	2.5	2	0	4	0	5	4.5	

4.5.1 Policies to practices - principles

To analyse the use of different principles from policy to practice the difference (Δ) is calculated. These results are shown in table 4.38. As can be seen there is a downward trend of the use of circularity principles in policy to practice. The largest difference (-3) is found in the principles of *waste is food* and *design resilient*. The main indicator for the principle of *waste is food* is the use of secondary material sources. This indicator is found much less in the tenders where it appears to be less important. The main indicator of *design resilient* is climate adaptability. This topic has gained track in policies and is expected to gain more track due to the increase of extreme weather. However in tenders it is only found in one case. This is most likely because climate adaptive projects are more likely to be self standing projects and therefore tenders. For instance the construction of retention basins are more likely to be a separate project. This however does not take away that the construction projects of today need to be ready for the changing weather patterns of tomorrow, for which resilient design is vital.
There are no principles which score better than expected, only the principles of *design out waste* (0) and *no toxic materials* (0) which score as expected in the tenders as in the policies. Interestingly regarding the principle of design out waste there are policies which are not applicable in tenders. For instance the setting up of a material depot or 'circular hub' to transform CDW into a new useful function can not be part of a tender. The principle of avoiding toxic materials is evenly spread between policy and practice but with no clear cause.

Table 4.37: Circularity principles from policy to practice

Principle	Policy	Practice	Δ
Waste is food	6	3	-3
Design out waste	4	4	0
Energy from renewable resources	7	6	-1
No toxic materials	3	3	0
Biobased materials	3.5	1.5	-2
Maintaining prioritised above new construction	2.5	1	-1.5
Design resilient	4	1	-3
Average	4.3	2.8	-1.5

4.5.2 Policies to practices - cases

Between the cases there is a larger divide than between the principles. There are also cases which have an increase of circularity principles used between policy and practice and who perform better. The most obvious under performers are Dordrecht (-6.5) and Rotterdam (-3.5) which did not have tenders in which they stated to be circular or sustainable. This is most remarkable for Dordrecht which had the most principles present in their policies. There are also cases which have more principles present in their practices than in their policies, being The Hague (+0.5), Haarlemmermeer (+0.5) and Venlo (+2.5). There is no clear cause for this increase. It can be stated that an detailed and ambitious circularity policy does not necessarily reflect in the use of these principles in procurement practices.

Table 4.38: Case performance from policy to practice

Case	Policy	Practice	Δ
1 - Almere	2.5	1.5	-1
2 - Amsterdam	5	2.5	-2.5
3 - The Hague	1.5	2	+0.5
4 - Dordrecht	6.5	0	-6.5
5 - Haarlemmermeer	3.5	4	+0.5
6 - Rotterdam	3.5	0	-3.5
7 - Utrecht	5.5	5	-0.5
8 - Venlo	2	4.5	+2.5
Average	3.8	2.4	-1.4

4.5.3 Targets of the CE

The selection of principles is based on the targets of the CE as determined by Platform CB'23 [2020a]. As stated prior the concept of the CE is not bound and municipalities are free to determine what they perceive as the CE. Based on the findings it can be determined which targets are more important in the cases. Between the targets of protecting material stocks and protecting the environment there is a very limited difference. The target of protecting material stocks is also at the core of the CE where the use of materials are the most important. Reusing and recycling are popular terms in policy and in practice (although a bit less). This idea of how to deal with material is well established in literature and studies like the 9R-framework [Kirchherr et al., 2017] or the butterfly diagram [EMF, 2013]. The target of protecting the environment is also present in most policies where especially the emission of greenhouse gasses is a global concern. Also laws regarding emission of greenhouse gasses are present which force municipalities to adopt this subject in policies and practices. Less present is the target of protecting existing value. This target is about preserving of what already is instead of building more. The question is how realistic that is with for example the current Dutch housing crisis where the construction of 845.000 homes is needed by 2030 [Rijksoverheid, 2020]. This target also includes climate adaptation, which becomes more important due to more frequent extreme weather. So when there is a need (for housing) which can not be achieved by using what is already there, this target can still be achieved. When a project has been realised (and it exists) it should be resilient. This part however is also lacking particularly in municipal practices.

Table 4.39: Circularity principles from policy to practice

Target	Policy	Practice	Δ
Protecting material stocks	5	3.5	-1.5
Protecting the environment	4.5	3.5	-1
Protecting existing value	3.3	1	-2.3
Average	4.3	2.7	-1.6

5 DISCUSSION

This research has given an useful insight in the relation between circularity in policy and in procurement practices of municipalities. This section will discuss the results and explain the limitations of the research.

5.1 DISCUSSION OF THE RESULTS

The results are firstly formed by which principles are in- and excluded. There is no precise definition of what a fully circular municipality encompasses. There is made use of the findings of Platform CB'23, but municipalities are free to determine what their vision of a circular municipality is. The results are limited and can not say which municipal is more circular in either policy or practice. It only states which principles they use in either policy or practice.

Because definitions are loosely defined in policies, but also in tenders, there is a lot of room for interpretation by the researcher. There is an argumentation of how every choice (fully match, partly match or no match) was made. Every choice is however still open to debate. What one may perceive as a fully match is possible a partly match by another.

There are also matches in policies based on actions which are not applicable in tenders. For instance the setting up of a circular hub can not be part of a tender. However every match from a tender can be present in policies. Therefore the policies have more options to include circularity than the tenders. So the outcome that there are more principles present in policies is more likely, however it was still possible to gain a fully match for each principle through their tenders. Also specifically the principle of prioritising maintenance above new construction was not well to detect in the circular tenders. This is mostly because this principle really comes into effect before the tenders is put out to the market and other choices would have been made. This principle could be described as the principle of not doing anything (refuse). An analysis on tenders, where things do happen, may not be the best approach in detecting this principle.

The way the tenders were selected left out most of the 'regular' tenders. These tenders however could still have circularity aspects without the tender stating to be circular or sustainable. This has the most effect on municipalities where no circular tenders were found. It can be argued that in the tenders of Dordrecht (15) and Rotterdam (99), which were excluded, there are most likely some indicators to one or more principles present.

5.2 LIMITATIONS

The research does have certain limitations. It has answered the research question, but the results should be interpreted with caution. Firstly it can not be stated which municipality performs the best in terms of circularity, only which principles they are focusing on. The topic of the CE is not bound and when taking other aspects into account and leaving others out this outcome could change.

Furthermore the results are time dependent. Because the CE is likely to gain more track as time evolves when this study is redone in 10 years the results are likely to change. The target of the Dutch government to be 100% circular by 2050 is also only a target since 2016 [Rijksoverheid, 2016]. Therefore circularity may has gained traction in policies, but it may have been too early to see the effects in tenders. This because time is needed for measures to be adopted from policies into procurement practices.

Finally, as is also stated in section 5.2, the method of tender selection resulted in a very limited amount of tenders. The other option was to analyse all tenders, but this was not feasible for the duration of the research. The research objective however, knowing which principles are used, could be achieved with this limited amount of circular tenders.

6 CONCLUSION AND RECOMMENDATIONS

This study has shown the difference between policy and procurement practice by analysing eight different municipalities through a case study analysis. The answers to the separate sub-research questions lead to the answer to the main research question and therefore the research objective. The conclusions of the research are presented in this chapter as well as recommendations which are useful for better adopting CE principles in municipal policies and procurement practices. Lastly it will give suggestions for future research.

6.1 CONCLUSION

The research objective of this study was to analyse the use of circular economy principles by municipalities in their construction related policies and practices. This has been done by a case study of eight Dutch municipalities which are deemed to be circular frontrunners.

The first sub-question was about which CE principles can be applied by municipalities in their policies and procurement practices. Because the CE remains unbound different definitions, targets and principles can be found throughout literature. The principles used in this research are selected by their usefulness to the targets as stated by Platform CB'23 which is centred around the implementation of the CE in the construction industry. Each industry has their own characteristics on where to improve the most in terms of circularity. By using the targets as set by Platform '23 principles are selected to be the most beneficial to construction related activities.
The second and third sub-questions were about how these principles were used in either policies or procurement practices. In policies the most focus was towards principles which were about protecting material stocks and protecting the environment. Less use was made of CE principles regarding protecting existing value. In the procurement practices a similar trend is found, however a less overall use of the CE principles.
The fourth and last sub-question was about the similarities and differences between the use of CE principles between policies and procurement practices. As was expected there was an overall downward trend between the use of CE principles in policies and procurement practices. However this was not the case for all cases. There were municipalities who made more use of more CE principles in their procurement practices as in their policies.

The research objective was to analyse the use of CE principles by municipalities in their construction related policies and procurement practices. This usage is still limited, even when only looking at the 'circular frontrunners'. The usage of circularity in procurement practices is still limited. The 100% CE by 2050 as is the target by the Dutch government is still far away, however big steps needs to be taken in order to achieve this.

6.2 RECOMMENDATIONS

Municipalities are in the position to be the initiator and facilitator of the CE. They do not have a profit motive for their projects and can therefore make the CE and its principles leading in their municipality. In regards to their construction related activities there are measures municipalities can take in order to accelerate the transition towards the CE. Municipalities can take measures outside and inside of tenders.

6.2.1 Cross project measures

Municipalities can be a facilitator of the CE by creating a material depot or 'circular hub'. This measure is also present in several policies of cases. Currently the process of reusing materials for either the input of a project or make it reusable after deconstruction is economically not appealing. Municipalities can take here a leading role by creating these 'circular hubs'. These hubs, in comparison to second hand shops, need to be large scale and solely for building materials. Also before a new project is started alternatives to create the same function without this new project should be analysed. For instance the transformation of a office building to a residential building instead of the construction of a new building. This preserving strategy should result in less tenders in total and therefore the need of material use.

In the way how Dutch municipalities are managing their construction related activities, by mostly outsourcing their projects through tenders, a lot of responsibility lies with the contractor. It is however common to have different tenders for different stages of the building life cycle. The more stages are combined into one contract the better the contractor can manage its circularity. For instance the design is important in keeping materials (easily) reusable after use. When deconstruction is not taken into the design this will result in waste in the end of life phase. By making one party responsible for the design and deconstruction the generation of CDW can be better managed and/or prevented.

6.2.2 Tender specifications

In tenders it is recommended to have 'hard' criteria in the design of the project based on the targets of the CE. It however depends on the nature of the tender, being the construction of a building or the demolition of a bridge, which measures are usable. Per target of the CE the following is recommended;

Protecting material stocks

This target is determined by the input and output of the tender in terms of material use. In regards to the input it should be demanded that a certain percentage of material used is from a secondary material source, possible from a 'circular hub'. The nature of the project however should determine what is a feasible percentage. In the output of the project the 'worst' option is to recycle, where for instance reusing is much better. In all stages of the project waste has to be absent. For produced waste the contractor could be penalised monetary. Also in projects the builder is mostly not the party which is responsible for deconstruction after use. Therefore in the design of the project deconstruction has to be taken into account. This deconstruction design should be apart of every tender. Which also should be more implemented is the use of a material passport [Platform CB'23, 2020b]. This option is already present in multiple policies but in none of the analysed tenders.

Protecting the environment

Greenhouse gas emissions should be outlawed in all stages of the project. The construction, operating and deconstruction has to run solely on renewable energy sources. This has to be made clear in the project description by demanding the use of electric vehicles and equipment during construction and built gasfree and if possible generate (solar) energy. Toxic materials have to be avoided and a lot are already outlawed. However municipalities can go further than what is already outlawed; by demanding water-based coatings and solvent-free adhesives for instance. Also where possible biobased materials like wood should be used. This is not possible everywhere, but by new techniques the possibilities are growing.

Protecting existing value

Maintain what already is, but when projects are needed design them in such way that they are resilient to last a long time. A profound maintenance strategy can not be implemented into tender criteria, however new projects can still take a long lifespan into account. This has to be done by either making demands regarding the lifespan of objects or by including the maintenance of the project in the tender. In this way the contractor has a motive to realise the project durable. This can be taken even further by the concept of Product As A Service (PAAS). This concept changes for instance the realisation of street lightning to the function of providing light. If this necessarily helps in the transition towards the CE is however unknown. In this target is resilience in design a large factor. This factor is present in policies, but not necessarily in tenders. New projects should have requirements in regards to more extreme weather conditions. A certain rainwater drainage could be present in the design criteria.

6.3 FUTURE RESEARCH

This research has shown that municipalities are willing to adopt circularity in their construction related activities, but that this is not necessarily the case in their practices. Because the CE is not bound their practices (tenders) lack structure, even when they are stating that these tenders are circular. Further research can go further into the question of what is the CE or more specific, what is a circular municipality? Also further research can explore the concept of CPP and design a circular format for municipal procurement strategies.

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