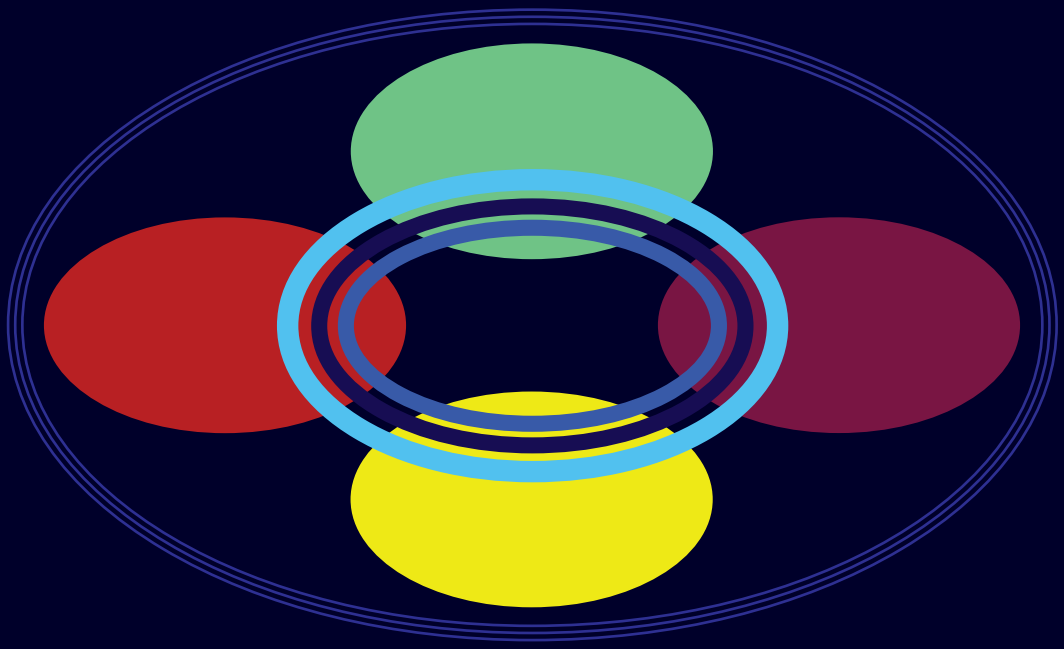
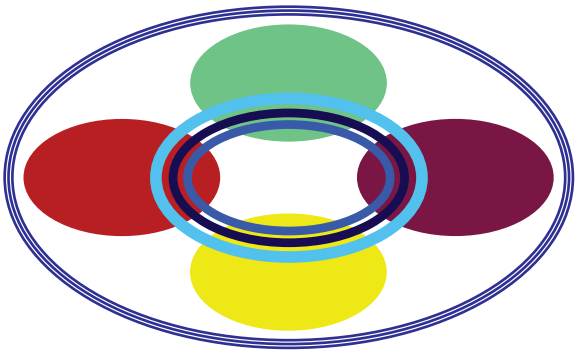


DEVELOPMENT TOWARDS CIRCULAR URBAN AREAS, A PROPOSAL FOR A HYBRID CONCEPTUAL FRAMEWORK

A casestudy at the Binckhorst, The Hague

Jolie Imme Groet



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Jolie Imme Groet

9 March 2018
Thesis Reseach Project
4413TPR30Y

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Summary

Cities today account for approximately 75% of the global Greenhouse Gas (GHG) emissions. The process of urbanization increases emissions and places an increasing pressure on resources and livability in urban areas. While challenged with the effects of climate change, governments show increasing interest in integrating sustainable development in urban policy. As a result of increasing urbanization, many cities face housing shortage and increasing rents. With a growing population and increasing wealth, resource and energy consumption tend to raise, leading to resource depletion, pollution and have a negative effect on the environment. To answer to the housing shortage in cities, a transformation of existing business areas into mixed urban areas is high on the political urban agenda. While simultaneously, increased policy space is given to incorporate sustainable development with urban planning. Circular Economy (CE) is proposed as a sustainable development strategy for policy makers. CE is a relatively new introduced concept to deal with resource depletion and efficient energy usage by adapting principles (reuse – reduce – recycle) and strategies. However, too often governments fail to operationalize CE in urban areas.

This research introduces implementation of CE in urban planning, as referred to Circular Urban Area Development (CUAD). A conceptual framework of CUAD is developed, based on a literature review of CE and sustainable urban area development. This lead to the formulation of four categories of urban planning (1) economic experience, (2) households, (3) public space and (4) infrastructure and mobility. These categories are interconnected through flows of resources and energy. Additionally, three layers (micro-, meso-, and macro-level) of CE implementation strategies and policy are incorporated in the framework. The framework is built upon findings, tools and methodologies of three research domains, namely: (1) urban metabolism, (2) stakeholder analysis and (3) future studies.

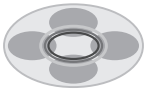
This research combines qualitative data – e.g. local regulations, stakeholders, shared visions - with quantitative data on material and energy streams to study what implementation of CE could mean on an urban level. The findings can be categorized in five stages: (1) insights from the CUAD framework, (2) participatory backcasting analysis for shared vision development, (3) involvement of current and future stakeholders, (4) baseline measurements of resources and energy, (5) circular measurement rod, and (6) monitoring and evaluation.

The CUAD conceptual framework is defined and tested on a single case-study at the Binckhorst, The Hague. The Binckhorst is an existing business area which is selected by the local government for a transition towards a circular working-living area. An analysis is done to the current state of the Binckhorst. The CUAD framework is used as leading structuring tool. Additionally, the backcasting analysis is applied to define desired scenario themes for the Binckhorst. These themes are incorporated in the CUAD framework.

Some conclusions can be made concerning the Binckhorst. With the transition of the Binckhorst, the landscape of the stakeholders as well as the flows will change drastically. The residential units will strongly increase, leading to a shift in needs from the economic experience, public space and infrastructure and mobility. The three levels provide insights in modelling the flows and stakeholders on the appropriate levels and the complexity of closing loops of resources and energy. Observing the process of the backcasting analysis for the Binckhorst, provides the suggestion that implementing CE requires a vision and ambition from the most important stakeholder: the municipality of The Hague. It is suggested the municipality first sets out its ambition and specific goals, followed by involvement and starting the dialogue with stakeholders.

A distinction is made between structural tools and process tools. The literature and the field work point out that implementing CE is a process than a state of affairs. It is concluded that future improvements of the CUAD framework can be made by emphasizing the changing nature of the urban area over time. Although the CUAD framework provides a complete and structured overview of the Binckhorst with its relevant flows and entities, the major issue with the framework is that the used methodologies for urban metabolism and stakeholder analysis create a static image of the current Binckhorst, leaving out relevant information concerning future involvement of flows and stakeholders. The traditional themes of urban planning are central to the framework. The question is whether these themes should be central point of focus for the framework. Additionally, by introducing a third categorization of the urban planning themes, besides the flows and stakeholder, integration points lack.

Suggestions are done to explore process tools for implementing CE in urban planning. A different approach can be taken from the actor-network theory, with in its core the innovation that is bound to its network of stakeholders with similar interests. Thus, the process tool, such as the backcasting analysis can be performed around a resource or energy flow with correlating stakeholders. In a later stage, additional insights in the structure of the future image can be gained by the addition of the traditional urban planning themes.



Acknowledgements

Writing the thesis for the master program Industrial Ecology has been a long journey for me. I learned a lot along the way of coming to the result. With the Binckhorst as extremely interesting as well as complex case-study, it was challenging and at the same time it kept me motivated and focused to finish my time being a student with an ambitious project.

My special appreciations and thanks go out to my first and second supervisor Jaco and Ellen. Their comments and critical questions kept me motivated to continuously work on this research. Dr. Ir. Jaco Quist, I was lucky with your extensive and fast replies to my sent versions. Additionally, the thesis circle meetings helped me to have continuous work on my thesis work as well as presentations. Dr. Ir. Ellen van Bueren, your critical questions sharpened the focus of this research. And your comments on my work at the AMS Institute helped me to dive even deeper into the literature of the Circular Economy.

A special notion deserves the work of Gerko Brouwer. Accompanying you with meetings with local organizations in the Binckhorst helped me in getting into contact with the local stakeholders in the field of research, and also to keep my work going.
I would like to thank my interviewed experts. Without your contributions and knowledge of the Binckhorst, my research would have never been as rich of information and insights. Doing the interviews was the most fun part of doing the research and made me eagerin exploring the topic further.

I could not have done this with the support of my family and friends. My sister Anna Groet, who worked to streamline my thesis. And my parents Kitty Speelman and Jandirk Groet, who continuously supported me and helped me with visualizing my frameworks. My friends Anastasia Koezjakov and Marie Krop who plodded through my texts for improvements of my English and coherence in the text. And Josefine Rook for mental support with our weekly meetings in Leiden and The Hague throughout the year.

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List of abbreviations

ANT	-	Actor-network theory
BA	-	Backcasting analysis
CBS	-	Centraal Bureau voor de Statistiek (Statistics office of The Netherlands)
CC	-	Circular City
CE	-	Circular economy
CP	-	Cleaner Production
CUAD	-	Circular urban area development
EC	-	European Commission
EIP	-	Eco-industrial park
EU	-	European Union
GHG	-	Greenhouse gas
Int.	-	Interviews
LCA	-	Life cycle assessment
MAA	-	Multi-actor analysis
MFA	-	Material flow analysis
MEFA	-	Material and energy flow analysis
PBA	-	Participatory backcasting analysis
RME	-	Raw material equivalents
RQ	-	Research question
SA	-	Stakeholder analysis
SFA	-	Substance flow analysis
SUAD	-	Sustainable urban area development
UM	-	Urban metabolism
UMF	-	Urban metabolism framework

1. Introduction

In the Netherlands, there is an increasing demand for sustainable and affordable housing in a safe, healthy and habitable environment observed for residents.Therefore, the transformation of existing urban areas is one of the priorities of the large urban municipalities (Amsterdam – The Hague – Rotterdam – Utrecht) of The Netherlands. The transformation of urban areas can accelerate sustainable growth, by making use of innovative technologies and in the end, strengthen the economic potential while meeting the housing demand (NEPROM, 2017). However, municipalities face difficulties integrating sustainability with urban developmentand no uniform consensus exist of how a truly sustainable urban area should be develop and operate. To learn more about successful implementation methods, pilot areas are appointed. One of those areas can be found in The Hague.

The municipality of The Hague pointed out the Binckhorst to be transformed from an old industrialarea to working-living area. The area, centrally located between The Hague, Voorburg and Rijswijk, is an attractive location to meet the increasing housing demand (Gemeente Den Haag, 2017).

The municipality of The Hague proposed the Circular Economy (CE) (closing resource loops by – reuse, reduce and recycle – strategies) as a promising strategy for a sustainable transformation of the Binckhorst. Thus, a resource broker, Gerko Brouwer (also third supervisor of this thesis project), was commissioned by the municipality to explore possibilities of the CE for the Binckhorst. Based on his work, the research is built around what CE means for the transformation of an existing urban area.

1.1. Problem definition

Generally, cities account for approximately 75% of Greenhouse Gas (GHG) emissions of acountry. At the same time, the construction sector accounts for 40% of all material consumption and 40% of waste creation (Ness & Xing, 2017; Icibaci& Haas, 2012; Eames, Dixon, May & Hunt., 2013), while taking up 3% of land area, leading to intensive resource and energy usage (Gladek et al., 2015). In other words, cities can be identified as pollution hotspots, contributing to global challenges, including climate change.

Simultaneously, metropolitan areas grow rapidly, with high concentrations of people, businesses and industries. In the Netherlands, between 2010 and 2015, the population of the four largest cities (Amsterdam, Rotterdam, The Hague and Utrecht) grew up to 10% (CBS.b, 2017). This led to an increased diversity and complexity that causes challenges for urban management and governmental structures (Neuvonen& Ache, 2017). Cities tend toexperience a full range of demographic change with increase and decrease of inhabitants. This creates the need for innovative approaches to generate knowledge to deal with the mentioned challenges (Ahern, Cilliers&Niemelä, 2014).

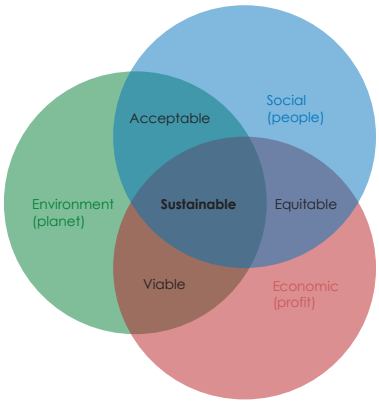


Figure 1.1. Sustainable development
Source: Tedeschi et al., 2015

As a response, sustainable development was put high on the national political agenda as a solution for environmental concerns. Sustainable development aims for an integrationof economic, environmental and social objectives as a basis for environmental policy (Gibbs, 2008). As shown in figure 1.1. sustainable development is an emerging concept in urban planning which aims to decrease environmental pressure by cities (Runhaar, Driessen &Soer, 2009). Regardless of efforts to decrease GHG emissions in urban planning and various sectors, such as the construction sector, the absolute numbers of urban emissions in the past decades have continued to rise. The distribution of emissions has remained stable since the measurements in 1990 (Pomponi&Moncaster, 2017). This indicates that so far, efforts to decouple urban growth from environmental impact have not been successful.

A promising (and relatively new) strategy to address sustainability issues is the concept of Circular Economy (CE); a practical strategy for decoupling economic growth of environmental degradation (Pomponi&Moncaster, 2017). CE has received increased attention in the past decade in policy measurements in Dutch policies (Geissdoerfer, Savaget, Bocken&Hultink, 2017; Circulaire Economie Nederland, 2016). The CE can be considered as (1) a shift in paradigm, based on a win-win philosophy for economy and environmental health as opposition to our current linear functioning of the economy (Geng, Fu, Sarkis &Xue, 2012; Murray, Skene & Haynes, 2015), (2) a strategy through tools, policies and flexible organizational structures to integrate resource and waste management (Geng et al., 2009; Ghisselini et al., 2016) and (3) as a comprehensive state policy (Yuan et al., 2008) (further elaboration in chapter 2).

At its core CE includes a system perspective on closed loops of resources and flows aimed to decrease environmental pressure of raw material usage following the three mainprinciples – reuse, reduce and recycle – (the three R's) in practice (Yuan, Bi &Moriguichi, 2008; Ghisellini, Cialani&Ulgiati, 2016; Zhijun & Nailing, 2007; Su, Heshmati, Geng& Yu, 2013). It aims for a harmonious balance between economic growth, social values and the environment (Zhijun & Nailing, 2007; Su et al., 2013; Geng, Zhu, Doberstein& Fujita, 2009), during all stages of production, distribution and consumption (Su et al., 2013; Naustdalslid, 2014). As such, CE shows significant overlap with sustainable development, which aims for a sustainable balance between people, planet and prosperity (Geissdoerfer et al., 2017).

Implementation of CE in urban planning demands for a transition in at first sight separated systems in an urban area; technical systems and socioeconomic systems. However, one cannot observe technologies separately from the system that support and sustain them (Vernay, 2013). Thus, this demands for system integration when implementing CE in urban planning.

1.2. Gaps of knowledge

Drivers of change, such as resource scarcity and climate change (Zjihun& Nailing, 2007) accelerate research and developments of CE. However, a lack of clarity on various patterns of CE in urban areas (Murray et al., 2015; Ghisselini et al., 2016; Zhijun & Nailing, 2007) and unintended consequences of this system perspective (Murray et al., 2015) lead to the absence of a unified framework for CE implementations. CE is still an emerging concept in scientific literature and policy documents. This creates a strong urgency to explore the implementation of CE in practice, proxies of CE and tools to accelerate CE. It is relevant and necessary for policy makers to gain insights in factors that influence CE development in the area and specific local elements that can be further developed in the transition path towards CE. Additionally, it provides higher incremental learning what circularity implies for transforming their municipality, based on localities and cultural background. Circular Urban Area Development (CUAD) is introduced as a concept to integrate CE with urban planning. Policy makers will be involved in the first step of planning of a CUAD for the Binckhorst by constructing a vision. The theoretical gap is the lack of insights concerning the meaning of CE in urban planning (conceptual framework) and knowledge, based on the integrated learnings from the sociopolitical context, the flow analyses, actor analyses and vision learnings. Understanding of technical solutions and the underlying social dimensions creating these solutions lacks (Vernay, 2013).

1.3. Research questions

This research will build upon existing literature on CE and implementation of CE on different levels. Additionally, practical examples of sustainability and CE in cities will be reviewed. Insights of these reviews will contribute to the development of the CUAD framework that aims to answer the following Research Question (RQ):

What is circular urban area development? How can this be applied to the Binckhorst? And what can be learned to develop the CUAD conceptual framework further?

The subquestions for this research are as follows:

- How can a CUAD framework applied using tools and methods from different research fields?
- What can be learned from the Binckhorst case-study for the CUAD framework and methodology for further development?

For this research, a case-study will be conducted in the Binckhorst, a neighborhood in The Hague. Figure 1.2 displays the Binckhorst areain transparent red. The area is a mixed industrial area, including various office buildings. In 2007, the municipality of The Hague assigned this location for transforming the area to working-living area (Gemeente Den Haag, 2011).

Figure 1.2. Area of the Binckhorst, Source: Google maps, 2017

1.4. Research aim and design

In this research, CE in urban planning is investigated in the single case-study at the Binckhorst. A conceptual framework is introduced for adopting CE in urban planning, referred to as: CUAD. It is an integration of urban planning elements with core principles of the CE and a stakeholder analysis for understanding the socioeconomic system operating in the area. To fill in the conceptual framework, multiple tools and methodologies will be applied. As mentioned in section 1.1, system integration is required. In figure 1.3, the methodological steps of this thesis project are visualized.

Figure 1.3. Methodological steps of the thesis research project.

In this thesis, the methodologies that form the basis of the conceptual framework are the Urban Metabolism/Urban Symbiosis (UM/US), a stakeholder analysis and backcasting analysis. The urban area is framed as an ecosystem. The UM study will research the resource and energy flows– the exchange processes of resources, energy water in the built environment – in an urban area (Vernay, 2013; Broto et al., 2012). Additionally, the socioeconomic perspective is analyzed, underlying these flows and technological system for understanding the roles and influences of local stakeholders. Finally, integration of visions can lead to higher and more incremental learning and dealing with long-term and complex problems that need technological innovations as well as societal changes (Neuvonen& Ache, 2017; Dreborg, 1996;Dortmans, 2005).

Since the research gap identifies the lack of an integral approach towards CE in urban planning, the choice is made for a single-case study for integrating multiple tools and methodologies in the research design for analysis of complex dynamics. Finally, the reflection of this thesis is two-folded. It provides suggestions for the case for improvements and learning gaps. Additionally, it provides a reflection on the developed and operationalization of the conceptual framework of CUAD.

1.5. Relevance

The school of thought of industrial ecology and CE depend on similar concepts and principles. Main principles of industrial ecology are (1) working to closed loop systems, (2) dematerialization of industrial output, (3) thermodynamically efficient use of energy and (4) avoiding upsetting natural cycles (Ayres & Ayres, 2001; Ehrenfeld, 1997). As the closed loop systems is in the core of CE. Dematerialization of industrial output is taken up as one of the core principles – reduce – of the CE (Yuan, Bi &Moriguichi, 2008; Ghisellini et al., 2016; Zhijun & Nailing, 2007; Su et al., 2013).

CE is a system perspective (Giurco, Cohen, Langham &Warnken, 2011; Jiao & Boons, 2014) and these systems are in their turn subsystems of the larger ecosystem which depend on the natural ecosystem. This involves an analysis of processes and flows, interdependencies and closed loops (Jiao & Boons, 2014). The point of where the material and energy flows cross the boundary of a subsystem into another system determines the sustainability of both the systems (Korhonen, 2004). The concept of CE is inspired by the field of industrial ecology, overlapping in the use of the ecosystem metaphor to research environmental burdens of current functioning of production and consumption systems. Additionally, it provides strategies of system integration with partnerships between businesses and communities for optimizing energy and resource flows (Geng et al., 2008; Naustdalslid, 2014; Ghisellini et al., 2016; Geissdoerfer et al., 2017).

Problems of urban areas are related to their socioeconomic context, and solutions can depend on the hidden 'nature' of an urban area (Vernay, 2013). This perspective serves as fundamental idea to the approach of implementing CE in urban areas. It aims for creating a conceptual framework how CE will influence an urban area. The industrial ecology ecosystem analogy and system perspective suffice for understanding flows of resources and energy in the network context in an urban area and frame the relationships and variables in a complex network (Van Bueren, 2012).

The relevance for industrial ecology (IE) is that the thesis research follows the IE pillars of (1) how an industrial system works, is regulated and interacts, (2) industrial metabolism and (3) used for sustainable development (Ghisellini et al., 2016). This is taken up for the CUAD framework, with the application of multiple methods for analyzing a socioeconomic system from a multidisciplinary viewpoint for sustainable development. The system perspective and ecosystem analogy of industrial ecology can provide understanding of sociopolitical context of complex problems in urban areas and search for synergies of industrial systems. Ecosystem analogy can lead to new insights regarding the specific flows of resources and energy, network and political dimensions in an urban area integrated in the CUAD framework. This approach needs for specific tools and methodologies to integrate transition paths, regarding the urban context.

Finally, it combines theoretical knowledge and conceptual approach of CE. It provides a structured overview of what possibly CE means for urban planning with integrating scientific literature with policy documents. This combination is considered as the theoretical and practical relevance for IE.

1.6. Structure of the report

The following chapter elaborates on the concept of CE, circularity in urban planning, and proposes a new conceptual framework, referred to as the CUAD framework. The third chapter provides an overview of tools and methodologies selected to operationalize the CUAD framework. The fourth chapter describes the methodologies for this research. The results of the baseline measurement at The Binckhorst will be described in chapter five. Chapter six includes the results of the backcasting analysis. In chapter seven, a reflection is given for the Binckhorst, including recommendations for follow-up steps. This thesis concludes with a discussion (chapter eight) on the conceptual framework and suggestions for further research and a general conclusion (both chapter nine).

2. Circularity in urban planning

To create an understanding of circularity in urban planning, the concept of CE is reviewed. The second section will elaborate on CE in urban planning and policy management. The guiding questions for this chapter are:

- What is CE?
- How is CE approached in urban planning and policy management?
- What are examples of CUAD?

2.1. The concept of CE

Since the publication of the 'limits to growth' by the Club of Rome (Meadows et al., 1972), the need arose to transform towards a more sustainable sociotechnical system. This is due to three reasons: (1) environmental raising issues, such as biodiversity loss, air pollution and climate change (Meadows et al., 2004), (2) social raising issues concerning social vulnerability, unemployment and the poverty trap (Sachs, 2015) and lastly, (3) economic raising issues concerning supply risk, financial and economic instabilities for individual companies as well as for entire economies (Jackson, 2009; Vernay, 2013). One of the approaches to answer to these sustainability issues, the concept of a circular economy (CE) was introduced.

CE can be seen as a new paradigm contrary to the linear function of the conventional economic system (Murray et al., 2015), in which an industrial symbiosis between entities stands central. It entails economic strategies for businesses (Yuan et al., 2006; Bocken, de Pauw, Bakker & van der Grinten, 2016) and policy implementation for governments (Geng et al., 2009) to move towards an economic system where waste is banned out. In this thesis project, the CE is explored as a paradigm shift. It aims to answer how CE can be implemented in policy. To create an understanding of the CE concept, the flowing logical topics are addressed: (1) origin of CE, (2) definition of CE and circular principles, (3) circular strategies, (4) CE in policy, (5) indicators of CE and (6) critique on the CE.

2.1.1. Origin of CE

The origin of the term 'Circular Economy' can be found in the article of environmental economists Pearce and Turner (1989) (Ghisellini et al., 2016; Su et al., 2013). The CE of Pearce and Turner, however, was inspired by other authors such as Boudling (1966) and Stahel and Reday (1976) who described the key principles of CE in their work (Geissdoerfer et al., 2017). In the article of Pearce and Turner, the problem of resource scarcity and environmental issues was assigned to the functioning of our current linear economic system. Pearce and Turner identified the interdependent relation between the economic and natural system, in which economic growth resulted in environmental degradation. As a solution, they proposed a closed-loop system of material flows with minimal waste and a high degree of material reuse. This would lead to a win-win balance where the economy and environment systems would both thrive (Su et al., 2013; Geng et al., 2012).

The concept of CE emerged in a variety of disciplines, such as ecological economics, industrial economics, system engineering and industrial ecology (Yuan et al., 2008; Ghisellini et al., 2016) and derived from multiple theories, such as ecological modernization theory (Geng et al., 2008). Inspired by nature, the ideal state of a system is characterized by 'complete (re)cycling of materials' (Bocken et al., 2016). Later work added the importance of closing technical and biological loops (McDonough & Braungart, 2002). The concept of CE was picked up by the private sector and includes a more practical approach from 2000s onwards. The practical approach had theoretical influences of concepts, such as: performance economy, cradle to cradle (McDonough & Braungart, 2002), biomimicry, looped and performance economy, regenerative design and industrial ecology (Geissdoerfer et al., 2017; Ghisellini et al., 2016). The work of the Ellen MacArthur Foundation is relevant for a practical implementation of the CE and identifying opportunities for businesses as well as governments. The work of Ellen MacArthur Foundation is focused on a business perspective, rather than scientific literature (Geissdoerfer et al., 2017; Ghisellini et al., 2016). In policy, the CE is adopted as an economic environmental strategy (Geng et al., 2012).

In conclusion, the CE subscribes the relevance of healthy natural ecosystems for human health. The foundation of CE perceives waste and pollution as deficits of a system, in light of limits to planetary boundaries and energy usage (Bocken et al., 2016). The CE optimizes natural resource usage with closed loop cycles of energy and resources to increase efficiency, while leading to environmental, social and ecological benefits. It observes waste as a potential resource (Ghisellini et al., 2016; Park & Chertow, 2014). The different disciplines (industrial economics, system engineering, etc.) and concepts (dematerialization, decoupling, etc.) show overlap in shared goals (decrease environmental impact, remain economic activity, etc.) and perspectives (system perspective, ecological metaphor) with the CE. Therefore, the elements of these paradigms shape the CE. This demands for an explicit definition of the CE.

2.1.2. Definition of CE and circular principles

CE is defined as a new paradigm and development model for our current linear functioning of the economy with a decoupling of economic growth, dematerialization (Stahel, 2013) and resource extraction. Decoupling aims for reduction of extraction, leading to decrease of environmental impact. This is compared with de-growth and steady state of an economy, where society aims to operate the economy within the planetary boundaries (Ghisellini et al., 2016).

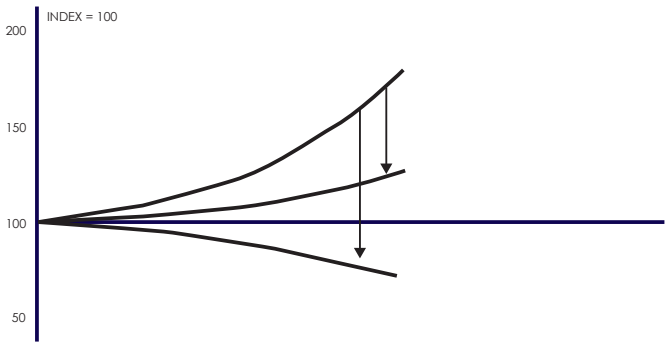


Figure 2.1. Decoupling
Source: Oxfam, 2012

As CE is a system perspective, shaped from a variety of disciplines, a great body of literature can be found. In the basis, CE is identified as an alternative model for neoliberal economics in theory and practice (Ghisellini et al., 2016). Geissdoerfer et al. (2017) define CE as "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.To remain consistent with other papers, the author of this thesis choses to use this definition for the remainder of this thesis project.

'Regenerative' is taken up as a design that aims to keep components at their highest value in the system (Geissdoerfer et al., 2017). Design, value chains and business model strategies aim for 'slowing, closing and narrowing the material loops' (Bocken et al., 2016). 'Long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling' can be taken up as principles or strategies for achieving the closed loops. Thus, the formulation of the mentioned principles of CE are reviewed by literature. The three principles mentioned mostly in literature are: **(1) reducing, (2) reusing,** and **(3) recycling** principles (Zjihun & Nailing, 2007; Yuan et al., 2008). This implies a hierarchy in these three principles, since reduce costs less energy for recovering and is more practical and effective (Sakai et al., 2011; Mentink, 2014).

Reducing resource use implies to develop objectives for production and consumption for minimizing resources and energy usage of economic activities and to keep at the lowest adequate level (Naustdalslid, 2014; Zjihun & Nailing, 2007). The correlating design strategies are: material efficiency and longer product life (Bakker et al., 2014).

Reusing is the reuse of a product after first consumption by other facilities (Zjihun & Nailing, 2007).'Reuse' and sharing economy received increased attention in literature. 'Reuse' is related to the consumer waste sector, as well as in the industrial context. Examples of 'reuse' include activities in charity shops, vintage shops, thrift shops, on-line selling, etc. (Castellani et al., 2015). The correlating design strategies are: product repair, product refurbishment and product remanufacturing (Bakker et al., 2014).

Recycling is the use of a product as far as possible in its primary state, over one-off use. The goal is to transform waste in usable resources (Naustdalslid, 2014; Zjihun & Nailing, 2007). Design strategies are: product/material recycling (Bakker et al., 2014).

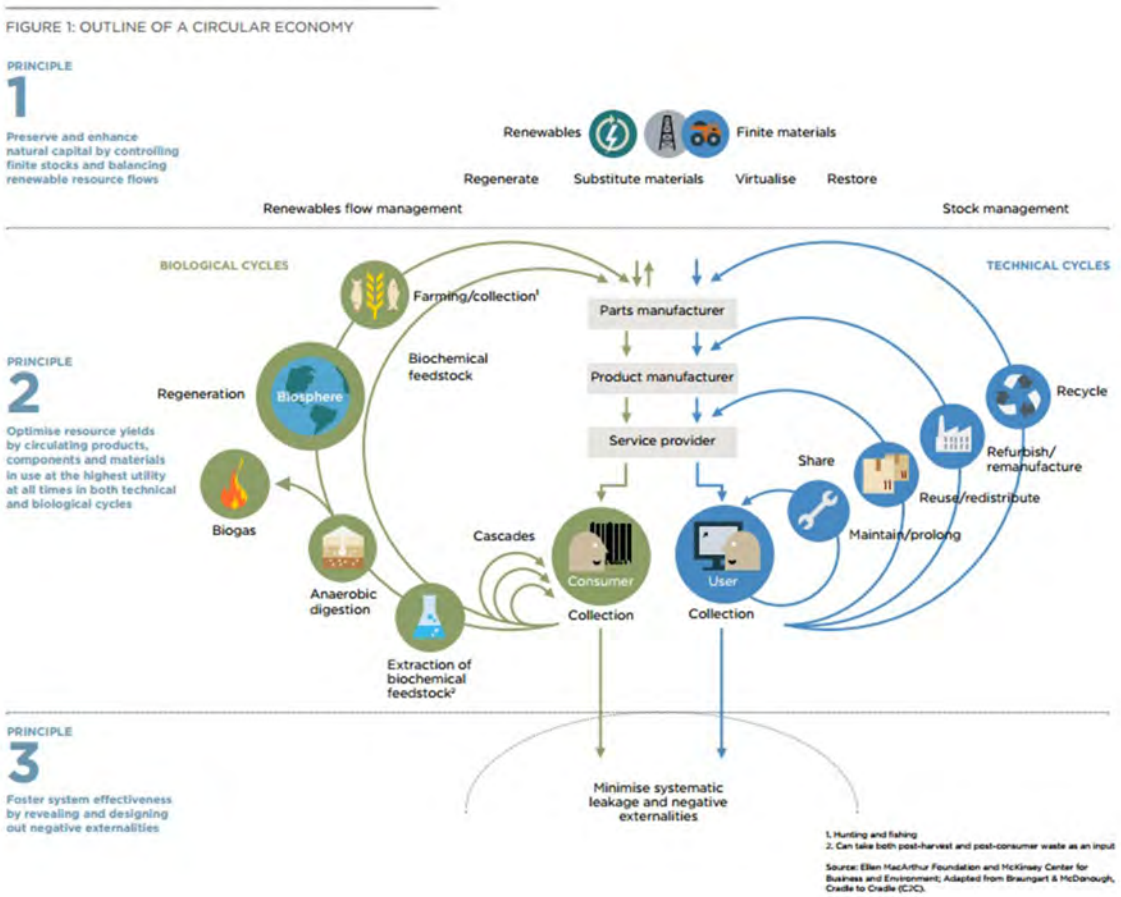


Figure 2.2. Outline of a circular economy
Source: Ellen MacArthur Foundation, 2015

Additionally, from a business perspective, Ellen McArthur foundation (2015) identified the following principles: (1) '**rethink the system',** where basis materials can be substitute, and design of products and systems can be redesigned. Central to this principle is dematerialization utility. In this principle resources and energy can be preserved and the ultimate technologies and processes can be chosen for taking a role in the design process. (2) The second principle, **two spheres** are set out: the biological sphere and the technological sphere. In the technical sphere, there is the strive for maintaining, reuse, refurbish and recycle resources while maintaining high rates of embedded energy. Biological nutrients in the biological sphere are intended to re-enter for decomposition. Cascading processes extend the life-cycle of these biological materials. Requirement for a circular system is the optimization of both the spheres. (3) The third principle is based on **limiting negative externalities** to the environment. The environment includes systems of food, mobility, shelter, education and health (Ellen MacArthur Foundation, 2015; Mentink, 2014). These additional three principles are shown in figure 2.2. As one observes, the – reduce, reuse and recycle – principles are shown in the technical cycle of figure 2.2.

Bakker et al. (2014) provides additional principles of **repair, refurbishment** and **remanufacturing.** Repair is defined as putting back a broken product in its original state. Refurbishment is repairing components that are close to failure to create a satisfactory working condition. Remanufacturing is defined as to return a product to its original performance state that is equivalent or better compared to a newly manufactured product.

While Stahel (2013) formulates the following principles: (1) **decrease the loop in scale and activity** leads to increase in profit and resource efficiency, (2) **loops are never-ending,** (3) **decrease of flow speed** increases efficiency of managing stock, (4), **continued ownership is cost-efficient** and (5) CE needs **functioning markets.**

Various reasons can be given for implementation of CE. The benefits vary from economic, environmental and social benefits. More efficient use of material and energy will be achieved, while increasing competitive capacity as an economic benefit. Competitiveness of local economies will be improved, since circulation of resources increases employment and decrease dependency of resource extraction and resource prices shocks (Stahel, 2013; Geng et al., 2012). Besides this, a reduction in costs is achieved due to less waste management (Ghisellini et al., 2016).

Environmental benefits concerning resource conservation and reduction of environmental impact through efficient energy and material usage (Geng et al., 2012). This leads directly to a reduction of emissions that come with the material and energy usage.

Social benefits concerning social relations among industrial sectors, local societies and enterprises, more employment opportunities, improved public awareness and maintaining cultural heritage and natural wealth, especially among low income households (Castellani et al., 2015; Stahel, 2013; Geng et al., 2012). Besides this, a reduction of externalities for society is achieved (Ghisellini et al., 2016).

To conclude, there is no consensus of the principles of CE. However, the major part of literature mentions the three R's – reduce, reuse and recycle – as the main principles of the CE. The other principles mentioned by Ellen MacArthur (2015), Bakker et al. (2014) andStahel (2013) are complementary to the three R's. Besides this, in some scientific publications, the three R's are identified as key-principles of CE as foundation for formulating strategies (Zjihun & Nailing, 2007; Yuan et al., 2008; Bakker et al., 2014), while in other publications the three R's is described as policy measurements or conditions to stimulate CE (Sakai et al., 2011). The principles can be translated into strategies, which vary in patterns and levels of implementation.

2.1.3. Circular urban strategies

The CE is implemented on multiple levels, leading to different strategies to harmonize the connection between nature, economy and society. (Naustdalslid, 2014; Yuan et al., 2008). Traditionally, cities aim to reducing pollution and energy usage. Compared to sustainability, CE might be more ambitious for cities. However, it can be easier to implement due to the represented economic component of the CE (Geng et al., 2009).

Circular strategies can be formulated on three levels: (1) firm level (micro-level), with a focus on eco-design and Cleaner Production (CP), (2) inter-firm level (meso-level), with the development of Eco-Industrial Parks (EIP's) (Yuan et al., 2006; Geng et al., 2012) and (3) societal-level (macro-level) a recycling-oriented society with a focus on sustainable production and consumption activities (Geng et al., 2012). Strategies need to consider the characteristics of a product and business constraints. This can be done with the addition of different tools, leading to different outcomes for products, raising the question whether circular products lead to lower environmental impact (Bakker et al., 2014).

Observing circularity on firm level (micro-level), a business model of a single firm can be considered as a subcategory of a larger circular system. This means that a single firm does not need to close the material loop in its business model. Rather, it can be part of a system of businesses that closes loop combined (Mentink, 2014). The same in true for e.g. households, industries or urban areas. Entities operate in a network that combined can form a circular system. The adoption of CE for a firm can lead to improvements of circularity with other companies regarding the supply chain (Wrinkler, 2011). The three main strategies for implementing circularity in production processes are given in the table below.

Strategy at micro-level	Explanation
Eco-design	Focus for innovation is in stages of 'rethink' and 'redesign'. The early design strategy phase is most suitable for implementing highest impact on sustainability. Different tools can be adopted concerning eco-design: LCA tools, checklist tools and tools based on quality function deployment (Ramani et al., 2010).
Design for environment	Design for environment and CP are interlinked. Environmental aspects are considered throughout the lifecycle of a product. (Van Berkel et al., 1997)
Cleaner production (CP)	CP includes three connected practices: pollution prevention, toxic use reduction and design for environment. Adoption of CP leads to cleaner products, processes and services to aim for reduction of waste and emission flows while prevent use of non-renewable and harmful input flows. It is a continuous application of an environmental strategy towards products, processes and services to increase economic efficiency and decrease environmental damage. (Van Berkel et al., 1997)

Table 1. Overview of strategies on micro-level

CE strategies on meso-level refers to EIP's and industrial symbiosis districts and networks. The industrial symbiosis is a holistic approach to industrial systems to achieve dramatic reductions in environmental pressure (Gibbs, 2008). In an eco-industrial park, the aim is to mimic nature to create the circular loops of energy and resources. These industrial parks are transformed in the so-called industrial ecosystems. Industrial symbiosis differs from 'greener industry' in that the involved industries are approached as a system and not as separated entities (Boons et al., 2011). It involves exchange of flows (physical and energy) between entities in a system (Ghisellini et al., 2016). Kalundborg (Denmark) is one of the most analyzed examples of an EIP (Mathews & Tan, 2011). Benefits of an EIP is direct in forms of cost savings for waste fees, purchase of virgin materials or energy, and indirect in forms of avoidance of investments, positive reputation, supply security and increased resilience (Veleva et al., 2015).

CE strategies on macro-level demands on the redesign of four systems in an urban area: (1) industrial system, (2) infrastructure system delivering services, (3) cultural framework and the social system (Ness, 2008; Naustalslid, 2014; Zhijun & Nailing, 2007). This is further explained in section 2.2. Currently, three concepts are dominating CE strategies on macro-level: (1) eco-cities, (2) collaborative consumption and (3) innovative waste management. Multiple cities in China and Europe adopted eco-city pilot projects to research the evolution of CE in terms of resource efficiency (indicators for water, resource and energy usage per capita), municipal waste production, waste treatment and reclamation (Geng et al., 2009; Su et al., 2013). Major drivers for improvements are found in relocation of heavy industry, introduction of regulations for polluting sectors and adoption of energy efficient technologies (Geng et al., 2009; Ghisellini et al., 2016). Collaborative consumption is based on the idea of 'shared ownership' among multiple consumers (Ness, 2008; Ellen MacArthur Foundation, 2015). The most common known business model is selling services (Product as a service system – PSS) instead of selling products (Stahel, 2010). Waste production and waste management increase when society increases in wealth. In general, municipalities treat waste with landfill, incineration and recycling (Ghisellini et al., 2016). Given that raising economies leads to an increased amount of waste, together with the urbanization trend that cities become denser, waste accelerates in amounts. The transition of CE would ideally lead to a 'zero-waste' society, where waste is observed as a resource (Ghisellini et al., 2016). Therefore, different waste management programs are set-up as a strategy for enhancing waste as a resource input.

CE leans on different schools of thoughts with shared goals and ambitions, rooted in a variety of theoretical backgrounds (ecological economics, environmental economics and industrial ecology). The theoretical approach of CE as a paradigm, raises the question how to implement CE in practice. This leads to the overview of implementing circularity in policy.

2.1.4. CE in policy

Similar to adapting strategy, implementation of CE policy can refer to three different levels: micro-, meso-, and macro-level, (Su et al., 2013; Yuan et al., 2006; Geng et al., 2012). The macro level refers to implementation of CE for countries, region or provinces. The meso-level refers to implementation of CE in eco-industrial parks. Practical implementation of a CE to industrial parks can be viewed as implementing industrial symbiosis/urban symbiosis where companies exchange by-products. The microlevel is CE implemented on consumer or company level (Ghisellini et al., 2016). This is related to implementing circular business models. One can state that complexity of activities increases when the level of scale increases (Su et al., 2013).

On the political level, a variety of measurements are found to use for implementing CE on a macro-level. In scientific literature, a distinction is made between European, Japanese, USA and Chinese policy measurements concerning the CE. This is due to the Chinese implementation of CE as a national program and top-down approach for socio-economic transformation, while creating harmony between society and environment, formally accepted since 2002 (Geng et al., 2009; Ghisellini et al., 2016; Naustdalslid, 2014). The high economic growth of China (yearly approximately 9%) is facilitated with increased energy demand and material usage, leading to unacceptable amount of pollution and resource depletion (Mathews & Tan, 2011). The Chinese policy is characterized with a vertical (implementation of CE on micro-, meso-, and macro-level, further elaboration in this paragraph) dimension and horizontal (implementation of industries, urban infrastructures, cultural environment and social consumption system, further explanation in section 2.2) (Zjihun & Nailing, 2007; Yuan et al., 2006; Su et al., 2013).

The European policies are marked with their more market-based and bottom-up approach. Economic actors and commercial parties demand for greener products and adequate legislation to involve public and private parties (Naustdalslid, 2014; Ghisellini et al., 2016). The directives of the European Union can be categorized according to the hierarchy of CE principles, with reduce at the top of the hierarchy. Reuse policies are related to second-hand use of products. The concept 'sharing economy' is related to the reuse policies. Sharing economy includes 'using, instead of owning products', or products-as-a-service (Castellani et al., 2015). It has the focus on businesses and industries with (1) different categories of inputs and outputs and (2) design, production and consumption of products. The differentiation of different levels of CE as in Chinese policy, is not clearly distinguished in European/Dutch policy. Research is done to effective policy measurements on a national level. Results pointed out that taxation policies should be adjusted towards taxing use of non-renewable resources, instead of labor on renewable resources. This argument leads directly to the current large barrier for implementation of CE on a large scale (further elaborated in paragraph 7.6, the challenges) (Groothuis, 2014). Table 2 provides an overview of all large policy programs for the CE with a distinction between European and Chinese policy.

European policy	Chinese policy
Framework legislation • European Union Waste Framework Directive (EU WFD)targets policy interventions concerning the reuse, reduce and recycling principles by technical efficiencies and economics (Castel lani, Sala & Mirabella, 2015; Bakker et al., 2014) • Towards a Circular Economy: a Zero Waste Programme for Europe (Smol, Kulczycka & Avdiushchenko, 2017). • Regulation on Shipment of waste (Sakai et al., 2011)	Cleaner Production Promotion Law as the first CE law for national regulatory policy (2003). The 'Law on Pollution Prevention and control of Solid Waste' was the follow-up on this law in 2005. This is in 2008 formed in the 'Circular Economy Promotion Law' adopted. (Geng et al., 2012)
Waste treatment operation • Incineration of waste (Sakai et al., 2011) • Landfill of waste (Sakai et al., 2011)	Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid waste (Sakai et al., 2011)
European Resource Efficiency Platform (EREP) EU Circular Economy package (Ghisellini et al., 2016; Geissdoerfer et al., 2017)	National EIP standard – currently 50 industrial parks exist under this national EIP standard, promoted by the Chinese State Environmental Protection Administration (Geng et al., 2012; Ghisellini et al., 2016)
DPSIR – framework (driving force-pressure-state-impact-response), adopted by the European Environment Agency and used for analyzing environment-development interactions (Geng et al., 2012)	National Development and Reform Commission (NDRC) promotes and implements CE with national CE indicators, coordination and communication. (Geng et al., 2009; Geng et al., 2012)
Recycling obligations for specific waste streams 1. WEEE and EcoDesign directives in EU (Bakker et al., 2014) 2. Waste oils (Sakai et al., 2011) 3. Sewage sludge (Sakai et al., 2011) 4. Packaging (Sakai et al., 2011) 5. Batteries (Sakai et al., 2011) 6. End-of-life vehicles (Sakai et al., 2011)	Circular Economy Promotion Law of the People's Republic of China, with a focus on improvements in the waste sectors. (Sakai et al., 2011; Mathews & Tan, 2011)

Horizon 2020, COSME, Structural and Investment Funds, Fund for strategic investments and other EU programmes are support instruments for a more CE. Measurements are taken on: 1. Product design 2. Production process 3. Consumption 4. Secondary raw materials 5. Innovation and investments. The sectors of focus: (1) plastics, (2) food value chain, (3) critical raw materials, (4) construction and demolition, (5) biomass and bio-based products and (6) review of fertilizers legislation (European Commission, 2018)	Circular Economy Pilot Demonstration Program and Eco-industrial Park Program, as a top-down approach for regulatory requirements of implementing CE (Mathews & Tan, 2011)

Table 2. Overview of European and Chinese policy measurements for CE

Knowledge of CE best practices in China remains unknown. This is specific for the effectiveness, efficiency and appropriateness of CE best practices in the different contexts of Chinese cities (Geng et al., 2009). Besides this, Geng et al. (2009) review in their article the case of Dalian (a pioneer eco-city in China) and conclude that each city must develop its own CE strategy due to differing context and local realities. Also, since the context of cities is shaped through social, economic and political governance (Joss, 2011).

Although the context of a city or country determines the specific policy measurements and solutions, different types of instruments can be mentioned for accelerating CE. A distinction between the following governance tools are made: (1) international agreements, (2) emission trading schemes, (3) planning regulations and (4) financial instruments (Murphy, Meijer & Visscher, 2012). The table below provides an overview of economic and informational instruments. These instruments can be applied on a micro-level, as well as on meso-, and macro-level (Geng et al., 2008). Most of these instruments can be found in literature on EIPs. The context of a city/country/area determines which instrument can be applied in combination with policy.

Type of instruments	**Instruments**	**Explanation**	**Source**
Regulations	Waste regulations, targets and standards	This includes recycling targets	Murphy et al., 2012; Costa et al., 2010
	Production regulations, targets and standards	This includes criteria for production	Naustdalslid, 2014; Su et al., 2013
	Product regulations, targets and standards	This includes criteria and labelling of products	Sakai et al., 2011; Naustdalslid, 2014; Ren, 2007
	Environmental management systems, such as ISO 14001	These standards can be in forms of (1) product standards, (2) waste standards and (3) production standards	Geng et al., 2009; Sakai et al., 2011, Su et al., 2013
	Planning regulations	It includes regulation of built environment and land use	Murphy et al., 2012
Economic instruments	Environmental taxes and eco-labelling	Labelling of food and non-food items can increase awareness of products and services. Besides this, it aims for incorporating externalities. Tax instruments such as: 1. Landfill tax 2. Incineration tax 3. Pollution tax 4. Emisison tax	Geng et al., 2009 Ghisellini et al., 2016 Zhijun & Nailing, 2007 Murphy et al., 2012 Su et al., 2013; Mirata, 2004; Zhu et al., 2008
	Financial subsidies and tradable permits	Financing can be done with: 1. Subsidies 2. Loans 3. Credits 4. Funding for laggards in the region A point of critique is that these tools can change behavior as long as the subsidies remain. If this incentive drops, it will return to its original stage.	Ghisellini et al., 2016; Murphy et al., 2012; Baas & Boons, 2004; Van Berkel et al., 2009; Mathews & Tan, 2011; Naustdalslid, 2014; Mirata, 2004; Ren, 2007
	Voluntary agreements	An example of a voluntary agreement is corporate responsibility (CR). It offers a platform for collaboration and transparency. Other	Murphy et al., 2012; Taddeo et al., 2012

		agreements can be in forms of knowledge platforms, coordination programs and operational support. A point of criticism is the effectiveness of these agreements.	
Information and communication tools	Life cycle assessments and reduction, Material Flow Analysis (MFA) and reuse and recycling of waste reduction	These tools can provide additional knowledge and insights for substitution of resources or connection of flows.	Geng et al., 2009; Su et al., 2013

Table 3. Overview of instruments for stimulating CE

As shortly introduced in the first chapter, the framework will be applied to the Binckhorst. As mentioned before, the context is shaped by social, economic and political governance (Joss, 2011). Thus, this following part is an analysis of the specific CE policies in The Netherlands. The ambition of the Dutch government is a 100% CE in 2050 and a 50% CE in 2030. Resources in the economy of the Netherlands arrive through own exploitation and import (Circulaire Economie Nederland, 2016). The Netherlands aims to be front-runner for implementing CE in the European Union (European Commission, 2015). The largest urban municipalities in The Netherlands compete to become front-runner in developing and implementing the concepts of a 'Circular City' (CC). CC is proposed as a new way to use waste within city borders. CC is taken up as an ambition in policy documents. However, clear definition of a CC and examples of practical implementations are lacking (Gemeente Amsterdam, 2015). In the table, the two levels of policy implementation are added. However, the policy is not explicit formulated for a level.

Level	Policy	Explanation
Macro-level	Program 'Nederland Circulair in 2050'	In 2050, the ambition is to realize a 100% CE, with keeping natural capital and make as much as possible usage of renewable and common accessible resources. It is a sector-oriented approach. The five priority themes are biomass and nutrition, plastics, manufacturing industry, construction sector and consumption goods (Circulaire economie Nederland, 2016).
	LAP 'Landelijk Afvalbeheerplan'	This is a plan for the national waste management policy. Waste management in The Netherland is shaped around separation, collection, recycling, incineration and landfill of waste. The plan consists of eighty sector plans for waste management. The core of the plans is creating a minimum standard of processing high quality waste (LAP3, 2017).
	VANG – residential waste and commercial waste	This is the waste management policy for municipalities concerning household waste and professional waste. The main goal for household waste management is a reduction of 60% of household waste in 2020 and 50% reduction of professional waste in 2022. The program is carried by Rijkswaterstaat and the association of municipalities. It concerns waste separation, prevention and closing loops of resources in value chains (VANG, 2018)
	City Deal Roadmap Next Economy	The City Deal Roadmap Next Economy identified 5 themes: (1) smart digital delta, (2) smart energy delta, (3) CE, (4) entrepreneurial region and last (5) next society. The definition of CE in the Roadmap Next Economy document is 'renewability of allnatural resources: energy, water, biological and technical materials, air and soil'. This implies that every resource should accrue from renewable sources or they are able to be renewed. Simultaneously, negative effects on ecology, economy and society should be avoided. The aim is to achieve 100% circularity in 2050, correlating with the goals of the national government program (Metropolitan area Rotterdam and The Hague, 2016).
	Green Deals	Green deals are programs, set up by the national Dutch government in order to provide space for sustainable initiatives. It is a collaboration between private parties and public parties for innovative experiments concerning sustainability and circularity. The focus of Green deals is on legislation adjustments, creation of new markets, supply of information and optimal collaboration. Since the start of Green Deals in 2011, over 200 Green Deals are developed and signed by parties

		(Green Deals, 2018). Below the Green deals are mentioned that are functional for policy on the Binckhorst. **Cirkelstad** Municipalities of cities in The Netherlands can subscribe and commit themselves to city deals (promoted by ministries of the Dutch government). For example. the 'City Deal Circulaire Stad' is a powerful instrument for collaboration between the committed cities for realizing circularity in cities. City deals are set up by the national government, urban municipalities and societal partners for supporting system transitions to increase growth, quality of life and innovation (Agendastad, 2017). A condition of the City Deal is that every city acquires flexibility in designing and realizing the transition of a linear economy to a more CE. Additionally, cities have the opportunity to exchange knowledge and learnings. The Hague is since 2017 part of this Green deal **Circulair inkopen** This green deal is focused on circular procurement. This is done in the following sectors: construction, general and technical services, ICT, office equipment and textile. In different pilot project, experiments are executed for circular procurements. The municipality of The Hague is part of this Green deal (Green deal, 2018). **Circulaire gebouwen** This Green deal has the focus on developing material passports for buildings (Green deal, 2018).
Micro-level	European Union directive on Eco-design	This directive aims for reduction of environmental impact during the design- and development phase. This is mainly concerning commercial usage of electronics, household white goods, industrial products, air treatment, professional white goods and lightening (EUR-Lex, 2009)

Table 4. Overview of Dutch policy measurements.

Comparing the European Union directives and Dutch legislation, one can note that the Dutch policy is strongly derived from the EU directives. The main focus is on waste treatment. Strategies of prioritizing themes of flows are taken in national policy.

To conclude, with the different policies of implementing CE in Chinese policy and European policy, more specific Dutch policy, leading to the question how to monitor and evaluate CE. A first demand is a baseline measurement with correlating indicators to measure improvements over time.

2.1.5. *Indicators of CE*

The indicators of CE are taken from different literatures. Indicators found in scientific literature, are derived from studies in China. China has developed its indicator system due to implementation of CE policy since 2002. The Chinese CE evaluation indicator system contains two sets of indicators: (1) for macro-level on regional and national level and (2) for meso-level for assessing industrial parks (Geng et al., 2012; Naustdalslid, 2014). In The Netherlands, an indicator system for CE is in the form of national transition agenda's for five different sectors (Delahaye & Baldé, 2016). First, an elaboration on indicators from scientific literature will be presented. This is followed by indicators from the CBS for CE in The Netherlands.

Most indicators are derived from material flow accounting or analysis (MFA), since this methodology can be applied on different levels (macro-, meso-, and micro-level) (Bringezu et al., 2003; Geng et al., 2012).

Indicator	**Variable**	**Unit measurement**	**Of**	**Source**
Economic indicators	GDP per capita	Yearly income per capita	Macro-level	Zhijun & Nailing, 2007
	CPI	Average price increase of products	Macro-level	Zhijun & Nailing, 2007
	Ratio of investment	Percentage investment to GDP	Macro-level	Zhijun & Nailing, 2007
	Revenue in CE	% of total revenue across all companies	Macro-level	Smol et al., 2017
Social indicators	Air pollution	Parts per million by volume	Macro-level	Zhijun & Nailing, 2007
	Green space per capita	M2 per capita	Macro-level	Zhijun & Nailing, 2007
	Road space	M2 per capita	Macro-level	Zhijun & Nailing, 2007
	Unemployment rate/employment rate	% of theoretical 100% employment	Macro-level	Zhijun & Nailing, 2007 Smol et al., 2017
	Engel coefficient	% of income per person to food	Macro-level	Zhijun & Nailing, 2007
Resource: output rate	Land output	M2 land use for production	Macro-level and meso-level	Zhijun & Nailing, 2007
	Resource output	Tons per year or GDP/total consumption of resource Regional GDP/domestic material consumption	Macro-level and meso-level	Zhijun & Nailing, 2007 Geng et al., 2012 Smol et al., 2017

		of region		
	Energy output	GDP/energy consumption	Macro-level and meso-level	Geng et al., 2012
Resource: consumption rate	Energy consumption per GDP	Tons/10^4*€ Energy productivity GDP/gross inland energy consumption	Macro-level	Geng et al., 2009 Geng et al., 2012 Smol et al., 2017
	Energy consumption per industrial value added	Tons/10^4*€	Macro-level and meso-level	Geng et al., 2009 Geng et al., 2012
	Per capita energy consumption	Tons/year	Macro-level	Geng et al., 2009
	Energy consumption of per unit product in key industrial sectors	e.g. Energy consumption of steel/steel production	Macro-level	Geng et al., 2012
	Water consumption per capita	M^3/year		Geng et al., 2009
	Water consumption per industrial value added	Tons/10^4RMB	Macro-level and meso-level	Geng et al., 2009 Geng et al., 2012
	Water withdrawal per unit of GDP	Total amount of water withdrawal/GDP GDP/water footprint of urban area	Macro-level	Geng et al., 2012 Smol et al., 2017
	Water withdrawal per added industrial value	Amount of industrial water withdrawal/AVI	Macro-level	Geng et al., 2012
	Coefficient of irrigation water utilization	Actual amount of irrigation water consumption/total amount of irrigation water consumption	Macro-level	Geng et al., 2012
	Energy consumption per business	Energy consumption/unit	Micro-level	Golinska et al., 2015
	Water consumption	Liters/capita	Micro-level	Golinska et al., 2015
	General waste		Micro-level	Golinska et al., 2015
	GHG emissions	GHG emissions intensity: CO2 per GDP	Micro-level /macro-level	Golinska et al., 2015 Smol et al., 2017
	CO2 equivalent		Micro-level	Golinska et al., 2015
	LCA		Micro-level	Golinska et al., 2015

Resource: utilization rate	Per capita municipal waste generation	Kg/year	Macro-level	Geng et al., 2009
	Recycling rate of industrial solid waste	Industrial solid waste integrated utilization/industrial solid waste generation	Macro-level and meso-level	Geng et al., 2009 Geng et al., 2012
	Recycling rate of municipal waste water treatment	Treated wastewater reuse/total treated wastewater	Macro-level	Geng et al., 2009 Geng et al., 2012
	Rate of safe disposal of municipal solid wastes	Total amount of safely treated domestic waste/total amount of domestic waste	Macro-level	Geng et al., 2009 Geng et al., 2012
	Industrial water reuse ratio	Industrial repetitive water use/industrial water consumption	Macro-level and meso-level	Geng et al., 2012
Resource: waste disposal and pollutant emissions	Total amount of industrial solid waste for final disposal	Ton	Macro-level and meso-level	Geng et al., 2012
	Total amount of industrial wastewater discharge	Ton	Macro-level and meso-level	Geng et al., 2012
	Total amount of SO2 emissions	Kg	Macro-level and meso-level	Geng et al., 2012
	Total amount of COD discharge	Kg	Macro-level and meso-level	Geng et al., 2012

Table 5. Indicators for CE from literature

The indicators are derived directly from MFA and CE literature. However, it lacks indicators concerning direct social indicators, indicators for businesses, lack of prevented-oriented indicators and lack of measurable criteria and barriers on implementation (Geng et al., 2012). The indicator system based on MFA, developed by the Statistical Office of the European Commission consists of input indicators, consumption indicators and output and balance indicators (EEA, 1999). The indicators link the environmental pressure to human activities. However, the indicators have some limitations concerning data collection, material quality and level of detail. Most MFA indicators are applied at macro-level for macro-level policy measurements. However, material production and consumption patterns require data on meso-, micro-level in combination with other tools, such as life cycle analyses (LCA), supply chain analyses and substance flow analyses (SFA) (Geng et al., 2012).

In specific, the Dutch policy is reviewed with the different programs and initiatives. With the set ambitions of a 100% CE in The Netherlands in 2050 and 50% CE in 2030, the statistical office of The Netherlands (CBS) wrote a report on the definition of CE, indicators to measure CE and a baseline measurement of the current situation of CE in The Netherlands. A review of the report provides the following conclusions; Dutch policy has specified the CE to 'a reduction of raw input of resources in forms of metals, non-metal minerals and fossil fuel carriers. It remains unclear which measuring year the 50% reduction is accounting for. Additionally, it is unclear whether the resources in foreign countries that are used to produce our products need to be taken into consideration. Finally, it is unclear if biomass is part of the 50% reduction (Delahaye & Baldé, 2016).

The economy of The Netherlands changes and becomes a more service-based economy. This leads to import more end-products. The Dutch consumption is therefore not directly linked on the total amount of resources needed for producing all products. The introduction of raw material equivalents (RME) takes into account the materials that are needed for production for a product. These materials include energy carriers, e.g. fossil fuels. The RME of The Netherlands in 2014 was 33% higher compared to the total weight of actual used products (Delahaye & Baldé, 2016). Indicators are developed in order to measure the CE in The Netherlands. The following table includes these indicators.

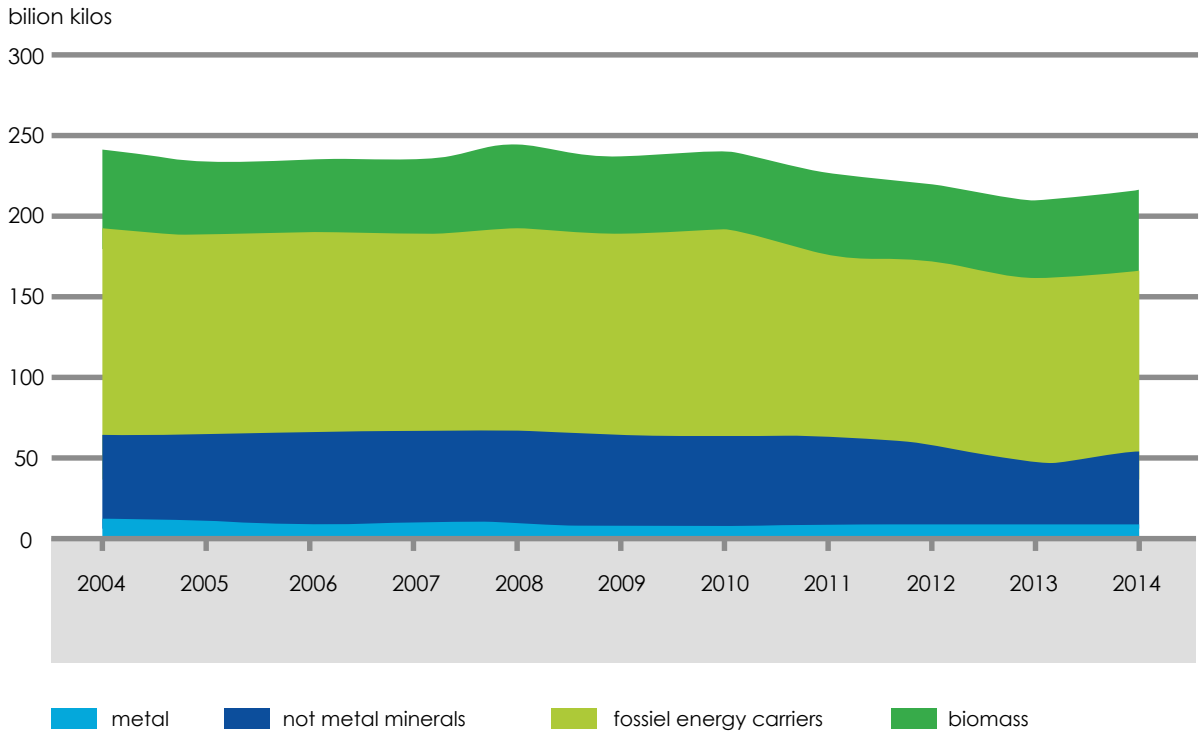


Figure 2.3. Raw material usage The Netherlands,
Source: Delahaye & Baldé, 2016

Indicator	Explanation	Source
Leakage streams		
Percentage waste production per kg produced product	This indicator is calculated for the following categories: (1) Transport industry, (2) Machine industry, (3) Electronic appliances, (4) Computers, (5) Metal production industry, (6) Metal industry, (7) Construction product industry, (8) Rubber and plastic industry, (9) Chemical industry, (10) Wood and paper industry, (11) Textile industry, (12) Nutrition and natural stimulants industry and (13) Agriculture. The unit is percentage per category. The more efficient production process, the less waste production	Delahaye & Baldé, 2016
Raw material equivalents per material	Another commonly used word is resource footprint. This is calculated in the following categories: (1) Biomass, (2) Fossil energy carriers, (3) Non-metal minerals and (4) Metals	
Raw material equivalents per inhabitant	This is calculated in resource usage per inhabitant.	
Percentage of type of waste management	This variable is categorized in the commonly used methods for waste management: recycling, incineration and landfill	
Weight and value of raw resources from electronic appliances in incineration of waste	Electronic appliances end up in the incineration oven in The Netherlands. This indicator is calculated in kilograms of wasted materials and monetary loss	
Percentage of food waste	This indicator is calculated according to the wasted food that can be avoided.	
Technical materials		
Expenses households for reparation	This indicator is calculated according to the amount of money spend per average household on reparation	Delahaye & Baldé, 2016
Part secondary resources per sector	The sectors taken up in this indicator are: metal industry and construction industry. The part 'secondary resources' is a percentage.	
Biological materials		
Part secondary resources per sector for biomass	The following sectors are taken into account: (1) electricity companies, (2) nutrition industry and (3) agriculture. The part 'secondary resources' is a percentage.	

Usage of biological and technical resources in chemistry	This is categorized according to: (1) chemical products, (2) energy carriers, (3) minerals, (4) biomass and (5) waste	Delahaye & Baldé, 2016
Phosphor from natural closed loop	This is a percentage of the total added phosphor amount.	
Consumers		
Possession cars in the Netherlands	This indicator is given in the number of cars per 1000 inhabitants.	Delahaye & Baldé, 2016
Supply electronic appliances in the Netherlands	This indicator is given in kilograms per inhabitant	

Table 6. Dutch indicators for measuring CE in The Netherlands

By taking up the fossil energy carriers as a resource, the energy sector is taken into account when implementing CE in The Netherlands. Finally, a point is made in the report of Delahaye & Baldé (2016) that national as well as international, no common proposal is made for monitoring the CE. Another point is that these indicators are calculated and used for the situation of CE in the Netherlands, on a national level. These indicators cannot be one-to-one applied to urban planning policies of local governments.

2.1.6. Critique on the CE

An extensive review is done of the theoretical definition of CE, its principles and strategies, and how CE is implemented in policy with correlating instruments and indicators. Although CE is a promising approach to efficient energy and resource usage, critique towards CE is expressed in theoretical approaches and implementation of CE in practice.

The CE principles are mainly based on physical flows (such as energy and material flows) over other aspects of the economic and social dimension (Murray et al., 2015). For example, the monetary flows of the economic dimension have significant lower attention compared to other flows. The monetary flows are underexposed in analyses, while this factor is key for failing or succeeding a transition to a circular model. This factor is crucial to keep in mind with implementing the CE into practice (Ghisellini et al., 2016). The social dimension in terms of human rights and human well-being are as well underexposed in the CE. It is unclear what the effects of the CE concept will be on social factors such as social equality and human health (Murray et al., 2015).

Another point is that a hundred percent closed loop of material and energy usage cannot be achieved. This is due to the entropy law and material complexity. A 100% CE can theoretically not be achieved, due to entropy law (Ghisellini et al., 2016). Material complexity refers to recycling of for example paper, which is limited for reuse cycles due to cascading, while metals (in pure form, not mixed with other elements) can be recycled without decreasing in quality. Some plastics are mixed with metals and therefore limited in recycling options (Ghisellini et al., 2016).

A major gap is found with implementation of CE in practice (Su et al., 2013; Vernay, 2013). CE is found in its initial phase of development (Ghisellini et al., 2016). Due to a number of limitations varying from different causes, such as information distribution, public awareness, poor leadership and weak economic incentives and different levels, implementation of CE hampers (Su et al., 2013).

A critical note should be made concerning eco-cities, since eco-cities refer to sustainable strategies of cities, with a specific focus on GHG emission reductions. These centrally organized sustainable strategies incorporate conceptual notions of innovation regarding business development, cultural branding and socio-technological innovation (Joss, 2011). Although notions of circularity and sustainability are used in similar contexts, the goals, motivations and commitments differ (Geissdoerfer et al., 2017). To conclude, one should keep in mind that eco-cities do not completely refer to implementation of CE on macro-level.

The last point of critique is the unintended negative environmental consequences of sustainable activities. For example, certain types of green technology (generation of renewable energy) can depend on rare metals that are mined with a significant environmental burden. Besides this, high quality products that last longer can have a negative impact on increase of energy usage and release more entropy when produced, compared to products with a shorter lifetime (Murray et al., 2015).

2.2. CE in urban planning

As stated in the introduction, this thesis develops the framework CUAD and applies this to a single case-study in the Netherlands. As literature points out, CE strategies need to be developed in the context shaped by the city (Geng et al., 2009; Joss, 2011). This section elaborates on urban planning in the Netherlands and creates a conceptual framework that integrating circularity in urban planning in the Netherlands.

In the past decades, urban planning changed in The Netherlands from sectoral and generic planning to more decentralized and integrated. Parallel to this, urban planners received more freedom in formulating area-specific ambitions for sustainability, based on the existing functions and characteristics of urban areas. Additionally, the Dutch government aims for more integration between the spatial planning discipline and environmental discipline in urban planning, although these two disciplines in policies have shown often conflicts in the past. It is suggested that integration of these two policy domains has to be facilitated by local authorities in determining area-based environmental ambitions. An important note is that integration of policies does not always lead to more environmentally oriented urban planning (Runhaar et al., 2009). Also, should be stated that integration of sustainability in urban planning differs from CE in urban planning.

This review indicates the importance of considering technical, social and institutional aspects of industrial ecologists and urban planners (Vernay, 2013). As indicated in the previous section, Chinese policies are more familiar with implementing CE in cities. Therefore, their approach is reviewed and used as a source of inspiration for defining CUAD and develop a conceptual framework.

A great body of literature and analytical frameworks can be found concerning Sustainable Urban Area Development (SUAD). This research identifies the differences between SUAD and CUAD. Since circular cities are not extensively discussed in scientific literature, the choice is made to first analyze three examples in practice of (1) SUAD in an urban area, (2) CUAD in an urban area and (3) CE in a building. This is followed by a definition of CUAD, derived from the scientific literature of CE and the examples in practice. Then, a distinction is made between SUAD and CUAD. Finally, the conceptual framework of CUAD is presented.

2.2.1. Review of SUAD and CUAD in urban areas

This section elaborates on three examples of SUAD and CUAD in urban areas. The examples are chosen, based on their geographical location (Europe and in specific The Netherlands) and the process of transformation of existing business areas with the ambition to implement sustainable development (in the case of the Stockholm Royal Seaport) or circularity (in the case of the Buiksloterham and Park2020). A review of implementing CE in a Chinese city is out of scope for this thesis research. Besides this, as indicated in the review, the implementation and execution of Chinese policy is done differently, compared to Europe. Additionally, the transformation of existing business areas to living-working areas is lower on the agenda of Chinese policy.

An international example of SUAD is the Royal Seaport area in Stockholm (Sweden). In 2007, the city council of Stockholm started an environmental improvement program to transform the district into the first environmental urban district of the city. The main aim of the redevelopment of the Stockholm Royal Seaport is to become an environmentally and sustainable sound district, taking the three pillars of sustainability (ecological, environmental and social, fig. 1.1) into account. To operationalize this, the program was divided into eight focus themes: climate-adapted and green outdoor sustainable recovery systems, sustainable water and wastewater systems, sustainable transport,environmentally adapted residential and commercialpremises, sustainable lifestyles and sustainable business. For eachof these focus them es a vision, strategy and goals are formulated (Holmstedt et al., 2017).

Figure 2.4. Stockholm Royal Seaport
Source: AIVP, 2017

The municipality of Stockholm involved different departments of the municipality itself and other stakeholders (such as developers, construction companies, academia and utility providers) in composing the Stockholm Royal Seaport environmental and sustainability program. Next to the usual planning and involved departments of the municipality, additional representatives of other departments are hold responsible for the sustainability and environmental program (Holmstedt et al., 2017).

For this district, a monitoring and feedback plan is developed in order to measure the progress of the transformation and to measure whether the area achieve itsset goals. Measurements are performed on three levels: household level, property level and district level (Shahrokni et al., 2015). Research has pointed out that there is a gap between the theory and practical implementation of sustainability at the Stockholm Royal Seaport. The main reason for this can be pointed out in specific definition of sustainability and why certain requirements should be met and others not. Furthermore, there is a lack of common practical understanding of sustainability and sustainability measurements. Involvement, willingness and collaboration of all stakeholders is needed in the larger system perspective. Stakeholders need to be aware of their influence, role and holistic goals to avoid lock-ins, sub-optimization and counterproductive decisions and investments (Holmstedt et al., 2017). The learnings from the Stockholm Royal Seaport will be compared with learnings from the Binckhorst.

Another example will be on CUAD in The Netherlands. Although CUAD appeared recently on political agendas, there is still a lack of examples of CUAD. Lately, municipalities pointed out areas for CUAD, for example the municipality of Utrecht assigned the business area 'Werkspoorkwartier' as CUAD (Gemeente Utrecht, 2017).The policy document 'Wereldstad aan Zee' hasassigned nine development areas to transform these existing business areas to living-working areas with special attention to CE (Gemeente Den Haag, 2011).

Municipalities (such as the municipality of Amsterdam) addressed different existing urban areas for transformation to CUAD, characterizing the CE with the following notions for area development:

- Materials and products will be applied in the economy in a manner that the materials can be infinitely recycled without decreasing in quality.
- All energy supply is generated from renewable resources.
- Nutrient from water will be applied and the Buiksloterham is rainproof.
- Biodiversity and the local ecosystem will be supported and strengthened by human activity.
- Culture and society will be strengthened by human activity.
- Infrastructure and mobility is zero-emission
- Health and wellbeing of humans and animals will be structural supported
- Value will be created, broader than solely financial value, while contributing to a strong local economy (Gemeente Amsterdam, 2015; Gladek et al., 2015).

The Buiksloterham is an example of the most elaborated plan of CUAD in The Netherlands. The Buiksloterham is an old industrial area in the north part of Amsterdam. Buiksloterham is a city lab where new forms of living and working are combinedwith sustainable experiments (Buiksloterham, 2017). Similar to the Binckhorst, 700 000 square meters is usable space for residential units and office functions. It is expected the number of residents will become approximately 6500 residents in 2034 (Gladek et al., 2015).

Figure 2.5. Buiksloterham
Source: Zondag CS Architects, 2009

The development of the Buiksloterham consist of three main pillars: circular, bio based andsmart. These pillars are translated into practice and local activities. The local activities can be utilized as drivers for the economy of the area and strengthening of the social network since the adoption requires collaboration among the residents and businesses. Furthermore, smart IT-applications are applied to achieve resource and energy efficiency. To increase the local

resilience of the area, climate adaptation measures will be incorporated. The municipality considers this area as a living lob of howexisting areas can be transformed in adopting sustainable development. Characteristics of the policies of Buiksloterham is that there is no central authority, directive or sustainability plan (Gemeente Amsterdam, Waternet, De Alliantie, 2015). The five systemic preconditions for the Binckhorst are:

1. Attribute the Buiksloterham as a living-lab status. A living-lab status can be assigned to an area as an experimental zone. Thus, regulations are less strict in such area. Authorities support this area, while safety and health are secured.
2. Build a regulating structure for the Buiksloterham, supported by the municipality of Amsterdam. Since the residents and other important stakeholder will contribute a significant part to the development of the Buiksloterham, a certain regulation structure is needed.
3. Build new financial structures. Large investments are needed for the development and in the long term, return on investments will occur.
4. Compose an action plan for the circular urban area. The high ambitions of the Buiksloterham have to be translated in daily life of the inhabitants and users of the Buiksloterham.
5. Building monitoring systems and open data structures in order to measure progress (Gladek et al., 2016).

Closing loops of resources and energy will be realized in the Buiksloterham with several measurements. Important point is that not all resources loops can be closed on site. In specific cases, it can be more beneficial to close loops on a more regional level since this creates more efficiency or there is a different demand-supply mechanism. Considering management of local resources, the following strategies are applied in the Buiksloterham:

- Reducing the volume of local flows
- Finding local supply synergies
- Supply local flows in a renewable manner

The following flows have the focus: energy, water and resources (Gemeente Amsterdam, Waternet, De Alliantie, 2015). The Buiksloterham report introduces the CC model (figure 2.5) to deal with the different levels for closing the loop systems. Per resource one can determine which level of closing the loops is most suitable.

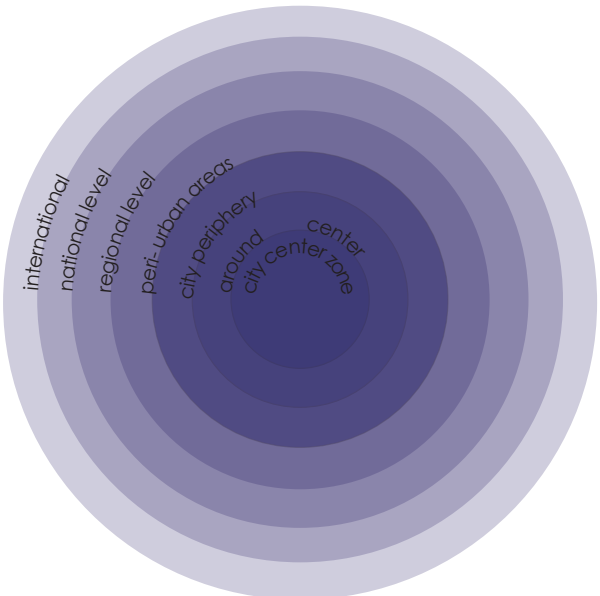


Figure 2.6. Circular city model
Source: Gemeente Amsterdam, Waternet, De Alliantie, 2015

Current results of development of the Buiksloterham is (1) UM scan of the Buiksloterham, (2) vision and goals for a circular Buiksloterham, (3) action plan and roadmaps, (4) detailed list of possible interventions and (5) a detailed list of share- and stakeholders (Gladek et al., 2015).

The Buiksloterham deals with a number of challenges. A few identified challenges are: (1) scattered ownership of the buildings and property, (2) a large amount of the parcels is highly polluted from old port industries: 15% (Gladek et al., 2015). Besides this, the municipality of Amsterdam does not have a broad carried plan for transformation of the area and only facilitates circularity in the area. This aspect is relevant for the case-study of the Binckhorst since the municipality of The Hague has adopted a similar role in the CUAD (Gemeente Amsterdam, Waternet, De Alliantie, 2015).

The last example is Park 2020, a cradle-to-cradle (McDonough & Braungart, 2002) inspired business park. This park is located close to Hoofddorp in The Netherlands. The office areas include closed loops of water, waste and energy. Innovative technologies are added, concerning thermal energy for heating and cooling the buildings. Solar PV panels and windmills provide electricity. green roofs and walls are installed for water storage and air purification. Additionally, this office building is constructed with material passports, whereas the composition of elements in the office can be traced down to its basic elements, allowing reuse of materials (Leising, 2016). This example can be useful for inspiration of other business buildings in the Binckhorst, since business activities remains at its core.

Reflection on ambitions of CUAD, defined by the municipality of Amsterdam gives the insight that these ambitions are more similar to sustainable development, rather than circular development, since it is not clear how an inclusive society contributes to circularity. Additionally, measurements and operationalization of the elements 'value creation', 'supporting biodiversity' and 'strengthening of culture and society' lacks.

Reflection of the CC model, compared to the three levels introduced in the CUAD framework is that the differentiation of the levels does not have significant additional value to the other introduced levels. The CC model lacks the individual level, as well the level of exchange among a group of individuals or firms. Moreover, the differentiation between city periphery and regional level is not clearly defined and does not provide additional relevance for closing the loop systems. These levels are captured in the macro-level.

2.2.2 *Definition of CUAD*

CUAD is introduced as a state of a neighborhood that can be reached when CE is implemented as an answer to the linear paradigm of functioning of our current economic system. The definition of CUAD for this thesis project is: 'the area that operates as a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling' (Geissdoerfer et al, 2017). An addition to the definition for CUAD is the implementation of CE on different levels: micro-, meso-, and macro-level (Yuan et al., 2006; Geng et al., 2012).

This definition refers to the area that operates as a regenerative system. An important notion concerning this is that it is bound to the geographical area of a city to aim for the principles of the CE, as policy documents refer to as CC. This decreases transport since the exchange is bound to a geographical area. The definition of CE in paragraph 2.1 commonly is taken up as increasing efficiencies in the value chain, as observed in policy documents from the national Dutch government (Green deal, 2018). This demands for a third notion of circularity referring to circularity in value chains as well as in geographical areas, opening opportunities for exploration of possibilities for high-quality re-utilization of resource flows as well as energy flows. The addition of the three levels refers to the levels of operating stakeholders as well as the level of closing the loops of resources and energy. With the definition of CUAD, the question rises of how exactly CUAD differs from SUAD overlapping elements.

2.2.3. *Comparison with SUAD*

As mentioned in the introduction of this paragraph, different trends have influence in urban planning. The combination of sustainable development and urban planning is an emerging integration of two commonly conflicting policy domains. This section elaborates on how SUAD differs from CUAD and specifies the focus of both concepts.

It is acknowledged that a public actor is not the only controlling actor in urban planning. Governance and policy should be formed in a debate with different stakeholders, including the state, the market and civil society. Governance is taken up as interaction between actors (stakeholders, institutions) responding to particular institutional features (Driessen, Dieperink, Laerhoven, Runhaar & Vermeulen, 2012). In specific, environmental governance is further elaborated in the perspective of SUAD. A distinction is made between three types of environmental governance: (1) hierarchical governance, (2) interactive governance and (3) self-governance. There is overlap between SUAD and CUAD concerning integrating environmental policy and indicators in urban planning, as how CUAD is defined in this thesis project.

The similarities are found in the multidisciplinary perspective for integration of non-economic aspects in development. System dynamics and innovations are the main drivers for integrating the non-economic aspects and achieve set goals for sustainability. The integration of stakeholders and stakeholder dialogue is in both approaches aligned by regulation and deliberate design of incentive structures (Geissdoerfer et al., 2017).

The main difference that CUAD has in its core the focus on closed loops for resource and energy flows, eliminating leakages in the system. Resources could be better used, and waste and emissions can be reduced, compared to a linear functioning system. The benefits of implementing CE are for the economic stakeholders of the system, while the environment benefit through less pollution and resource depletion. The society benefits from economic opportunities and environmental improvements, which is not explicit and less prioritized compared to the economic and environmental dimension (Geissdoerfer et al., 2017; Murray et al., 2015). As implied in the literature of CE, social improvements are secondary, compared to economic and environmental benefits. The key stakeholders are therefore private companies and governments. SUAD is considered more open-end with multiple goals, leading to a shift in considered stakeholders and interests. The goals of sustainability in urban planning are more diverse, leading to adaptivity and reflexivity in different context. The benefits of implementing sustainability are concerning the society as a whole, the economic system and the environment (Geissdoerfer et al., 2017). With sustainability, the key stakeholders are diffuse, since all should take responsibility in system change (Bocken et al., 2015).

Different tools and frameworks are used to assist urban planners with implementing urban planning tasks. The tools and frameworks vary in assisting in identifying spatial functions as well as decision making in a multi stakeholder context. The associated tools can be data analysis with for example GIS (Geo-Information System) and analyzing spatial plans to checklists. In the past decennia, tools for environmental assessment in urban planning came up. Examples of this is the PETUS project and 2000 Environmental Impact Assessment Review (Runhaar et al., 2009). Substance-oriented tools are focused on indicators of environmental planning in forms of indicators, GIS and other effects of spatial developments (Runhaar et al., 2009). Process-oriented tools have the focus on facilitating dialogues, creating consensus and negotiation around action plans (Runhaar et al., 2009). A third category can be added as a hybrid form of substance and process tools.

These tools take a phased plan, including the following six steps:

1. **Analysis of the current situation.** This includes a description of spatial functions, the condition of the area, analysis of the relations and dependencies between the functions and conditions and an analysis of the planned developments.
2. **Determination of the desired area types.** This step includes a focus on the desired functions or qualities.
3. **Selection and prioritize.** The key focus on desired functions or qualities is chosen. In order to prioritize, tools such as multicriteria analyses, environmental input-out put analyses etc. can be used.
4. **Formulation of environmental ambition.** In this step, the ambitions and goals are formulated per prioritized function or quality.
5. **Development of action plans.** This step includes implementation plans to achieve the set ambitions. A checklist can be used with measurements of best practices.
6. **Monitoring, evaluation and feedback.** Operationalized indicators for environ mental ambitions can support this step to overview the process and observe whether environmental ambitions will be achieved (Runhaar et al., 2009).

As CUAD is in an early stage, substance-oriented tools and process-oriented tools specific for urban areas are not clearly defined yet, as reviewed in examples and literature. With the overlapping system approach, involvement of non-economic elements and achieve goals for sustainability, these steps for implementing SUAD are taken as steps for CUAD. The specific tools per step will be specified for CUAD. This leads to the question how CUAD framework can be developed and implemented.

2.2.4. Framework and implementation of CUAD

The aim of CUAD is to close the material loops and energy loops as much as possible in a defined urban area. In order to develop the CUAD framework, SUAD and scientific literature on implementing CE on macro-levelare reviewed. This knowledge is combined with the review of CE in paragraph 2.1. The framework will be presented by the end of this section.

Main themes of sustainable urban planning can be found in the Tienkamp model. The TU Delft introduced the Tienkamp model for sustainable urban planning. The general idea is that urban areas can 'score' on 10 different disciplines described in 13 themes. E.g. an urban area can score high on renewable energy supply, however, if the soil is heavily polluted, the high mark of the energy theme is levelled with the low mark of the soil and soil contamination theme. In this way, the overall mark of the urban area includes all themes related to sustainable urban planning (Puylaert & Werksma, 2011). Based on the Green Score Card from Bouwfonds Ontwikkeling (2009) the following themes are identified that generally take a part in an urban area:

1. Soil and soil decontamination
2. Water storage and water safety
3. Urban green areas
4. Nature and landscape
5. Energy and energy usage
6. Mobility and transport
7. Health and safety
8. Urban history and identity
9. Transformation and space utilization
10. Economic vitality
11. Flexibility and resilience
12. Social vitality
13. Maintenance and evaluation (Puylaert & Werksma, 2011)

The CUAD is formed from these themes, based on the relevance of the previous topics. As indicated by literature, there is overlap in perspective of CE and sustainability. However, the goals and prioritizing of CE and sustainability diverge, leading to significant differences in implementation and focus (Geissdoerfer et al., 2017). E.g. urban history and identity is relevant for SUAD, since it contributes to social values of the three pillars. However, since CUAD has in its core closed loop systems, these items are not taken up in the adjusted CUAD framework. Additionally, observing the categories of the Circulair Buiksloterham report, the categories 'culture and society', 'biodiversity and local

ecosystem' and 'health and wellbeing' (Gladek et al., 2015) are left out of the CUAD framework since the direct link with circularity is lacking. A disadvantage of this is that social factors in CUAD are lacking, although this is a point of critique towards the CE in general. As mentioned before, the CUAD framework is an integration of urban planning categories with categories especially relevant for CE.

A review of literature points out that implementing CE strategy (on a macro-level) in a city involves integration and redesign of four systems: (1) industrial system, (2) infrastructure system delivering services, (3) cultural environment and (4) social consumption (Ghisellini et al., 2016; Zhijun & Nailing, 2007; Ness, 2008; Naustalslid, 2014). Implementation of CC models include the following steps. First, an industrial system should be build including implementation of synergies and connections of material and energy flows. This forms the basis for the other three systems, together part of a larger system. The industrial system includes UM and industrial symbiosis. Secondly, infrastructure needs to be set up to facilitate recycling activities,energy distributions and water recycling systems. Infrastructure accounts as well for knowledge exchange of integration clean production and formulation of strategies. Thirdly, an inclusion of green area is required in order to restore ecosystems in cities and increase quality of life for the inhabitants. Lastly, green consumption should be encouraged and practiced through authorities. With this, human health, ecological quality and demand for materials can be satisfied, while establishing cycles of social consumption (Zhijun & Nailing, 2007). As explained in the previous section, Chinese governance of implementing CE is characterized by vertical and horizontal integration. This is done according to these vertical and horizontal integration. Governance of implementation of CC is done in a process of horizontal integration: including institutions, private organizations and policy fields. Vertical integration links to implementing the four systems, mentioned above, with suitable tools and institutions at different scales (Murphy et al., 2012).

The introduced concepts by Chinese literature provides some grip on implementing CE in cities. However, questions remain what an industrial system entails and how such industrial systems should be organized. Similar notions can be made concerning infrastructure, cultural environments and social consumption. The formulated CE strategies with the different implementation levels (micro-, meso-, and macro-level) (Geng et al., 2012; Yuan et al., 2006) are taken up in the framework. This is since all the levels are present and operating in an urban area; micro-level is single firm or individual, meso-level is exchange among firms and households, and macro-level is recycling oriented society including governmental institutions. These three levels concern closing the loops of resources and energy, as well as the operating social system with correlating stakeholders.

In the CUAD framework, energy and resources are taken up as flows coming in and going out of the system. Four elements from urban planning are taken up in the framework, since the flows will be mostly present in these four categories and it is logic to categorize these separate elements for the energy and resource flows.

1. **Resources.** Since flows and closing the loops are the core of CE, this is taken as a separate theme. This is the importance of the outflows excreted from economic experience as well as households. Exchange of these flows can occur on plot. The resources for the Binckhorst will be elaborated with an analysis of the metabolic analysis (Superuse Studios, gemeente Den Haag, 2016). As with the circular Buiksloterham, a metabolic analysis of energy and resources is executed to determine the current situation and visualize an image of the future of the Buiksloterham (Gladek et al., 2015).
2. **Energy**. An urban area has generally a high import of energy. It is almost impossible to generate all energy on plot. However, there are possibilities of collaboration in energy usage. Within the light of CE, energy can be considered as an 'inflow' and 'outflow' of a resource. Rethink of the energy system and infrastructure can lead to benefits for the environment (usage of renewable sources, without extraction in other places) and economic (smarter usage of energy leads to reduction in cost) (Puylaert & Werksma, 2011).

Since CUAD will have consequences for public space, construction and other themes than economic activities and waste management, the themes from sustainable urban planning will be picked for CUAD. These themes will be aligned with the themes, identified by the municipality of The Hague for their workshop on the second of October 2017. The municipality of The Hague initiated a workshop for involvement of stakeholders of the Binckhorst for contribution to plan formation. The themes are traditional urban planning themes, such as: (1) residents, (2) working, (3) identity, (4) mobility, (5) nature, (6) waste and (7) energy. The single case-study is an area in the municipality of The Hague. By formulating and aligning the CUAD entities around these themes, the workshop results become partly useful for this research.

3. **Households.** The households theme includes the construction and usage of the residential units and the (future) residents of these residential units. Health and safety of the residents are essential elements and need to be taken into account throughout the lifetime of the residential units. Furthermore, the flows correlating with construction and during usage phase are part of this theme.
4. **Public space.** The public space includes the parks and water in an urban plot. Water refers to ports, waterways and canals.
5. **Economic experience.** The economic experience of an urban area includes the businesses, industries and facilities of an urban area. These businesses, industries and facilities produce and consume flows.
6. **Mobility and infrastructure.** This theme refers to all types of transport of humans in an urban area, such as public transportation, cars, bicycles etc. Including the infrastructure needed for the types of transport. Important note: water is part of the public space; however, it can also be part of infrastructure for boats. Additionally, telecommunication infrastructure is out of the scope of this theme.

CIRCULAR URBAN AREA DEVELOPMENT CONCEPTUAL FRAMEWORK

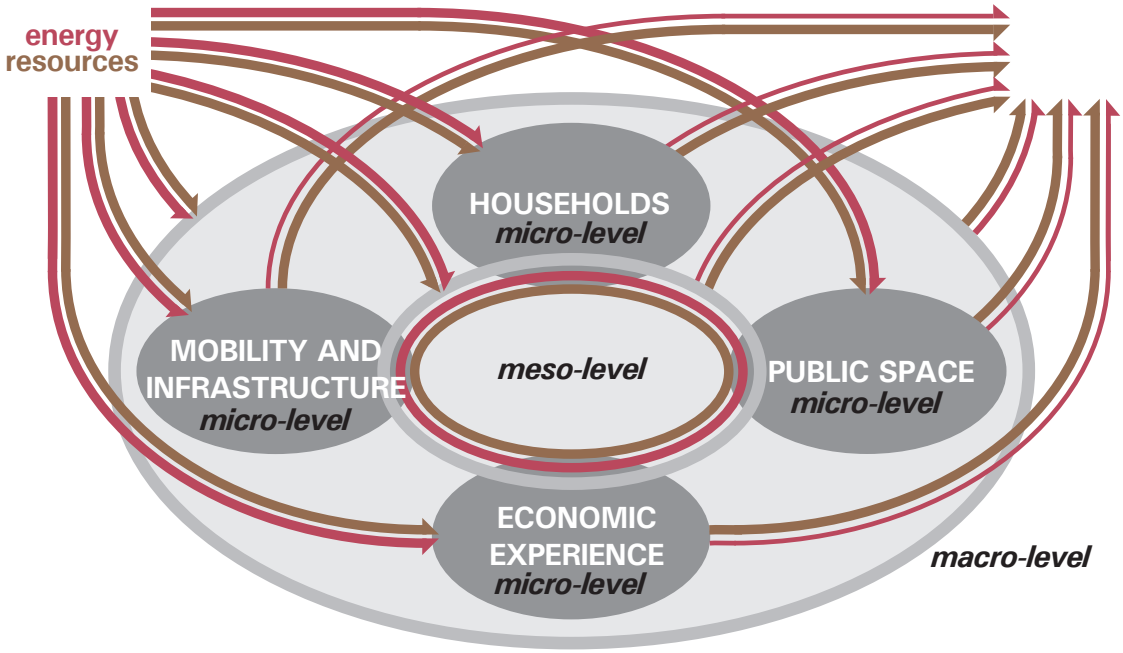


Figure 2.7. Conceptual framework of CUAD

The framework leads to the following questions:

What are the variables of these elements?	Answers will be provided in chapter 3 and 4
What is the operationalization of the framework?	Answers will be provided in chapter 5 and 6
Which factors and trends drive the system?	Answers will be provided in chapter 6.1
How to monitor and evaluate?	Answers will be given in chapter 7.5
What are the indicators?	Answers will be given in chapter 7.5
Which factors and trends put up barriers for the system?	Answers will be given in chapter 7.6
For who is this framework useful?	Answers will be given in chapter 9.1
What are the following-up steps concerning this framework?	Answers will be given in chapter 9.2

In order to provide answers to these questions, different methodologies will be applied to operationalize the framework. It will be applied to a single case-study. As mentioned in the introduction, implementing CE is a system integration of technologies and underlying social systems. The chosen methodologies will be related to analyzing social systems and physical flows of resources and energy as core of the CE. The discussion will provide suggestions for improvement of the conceptual framework.

Figure 2.8. Methodological steps of the thesis research project

The following step will lead to application of the CUAD framework to a single-case study for further operationalization of the framework. The four main categories (1) households, (2) economic experience, (3) public space and (4) mobility and infrastructure will be further defined and variables will be defined for the flows (1) energy and (2) resources. Follow-up questions on the framework demands for an identification of the (1)types of flows and (2) stakeholders. UM will be further explored to define flows of resources and energy in an area (Bocken et al., 2016; Ness & Xing, 2017). The stakeholder analysis will be performed in order to determine the socioeconomic system underlying CE (Vernay, 2013; Murray et al., 2015). Additionally, integration of these two methodologies will be elaborated with a third methodology: the backcasting analysis. The CUAD conceptual framework is a static image of an urban area. However, since implementing CE is rather a process than a state of affairs and demands for system integration and a transition, addition of a temporal scale is necessary (Boons et al., 2011). The phased steps of SUAD will be used as a process framework. Step 2, the desired elements will be conducted with the backcasting methodology. The backcasting analysis aims to shape a desired scenario for the future of an area or artefact. Based on this desired scenario on the long-term, smaller steps in the short-term can be formulated.

3. Integrating UM, multi-stakeholder systems and back-casting analysis in urban system transitions

The steps of SUAD will be applied for the sequence and choice of methodologies. The first step is the analysis of the current situation. The CUAD framework determines the focus of the analysis of the spatial functions and conditions of the area. Methodologies will be elaborated that focus on the urban planning themes, as well as the flows. The second step is the determination of the desired area types. This step will have the focus on desired functions or qualities of an urban area (Runhaar et al., 2009).

CE contributes to a system change, including all entities, processes and products. This chapter discusses UM as methodology to identify urban flows of energy and resources. In order to apply the framework, understanding and information on background conditions, local policies, multiple levels of application, networks of stakeholders and sectors and fields that should be collaborating are required (Geng et al., 2009; Yuan et al., 2006). The stakeholder analysis will be discussed to identify stakeholder groups operating in an urban area, including their dynamics. For the second step, the backcasting analysis will be discussed for developing a transition path for an urban area.

3.1. UM framework and MFA

The increased urbanization trend (CBS, 2017) causes increased concentration and consumption of resources and energy by cities. As a respond in the research field, academics advocate to initiate a transition of linear production and consumption systems towards circular system. Related concepts of the CE with the main focus on the flows coming in and going out an urban system are known as Urban Symbiosis (US) (Van Berkel, Fujita, Hashimoto & Geng, 2009), UM (Pincetl et al., 2012; Kennedy et al., 2011), and designing for zero-wastes (Lehmann, 2011). The overlapping idea of these concepts is that connection among different resource and energy flows lead to increase in efficiency and reduction in waste flows or leakages. In this section, the UM/US concept is chosen for further analysis.

As mentioned in chapter 2, closed loop systems is in the core of CE (Geissdoerfer et al., 2017; Murray et al., 2015). Increase in complexity leads to greater dependence on its surrounding environment, increasing infrastructure and vulnerability for change around them (Timmeren, 2012). The look at UM can create new insights in the flows of an urban area.

3.1.1. Introduction to UM

UM was first mentioned in 1965 as a fundamental starting point to develop sustainable cities. The definition of UM which will be used in this thesis project is: "the total sum of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy and elimination of waste" (Pincetl et al., 2012; Kennedy et al., 2011).

The UMconcept is a sociotechnical perspective on processes in the city. This implies that processes are not solely technical, nor completely social (Wallsten, 2013). UM emerged from disciplines such as ecology, industrial ecology, chemistry, political ecology, ecological economics and urban planning and includes concepts from the variety of disciplines (Broto et al., 2012; Kennedy et al., 2011). UM perspective is to bring urban society resource and energy demand in balance with the finite supply of the earth. The UM sets the resource and energy demand of an urban city in context of political, economic and ecologic dimensions (Pincetl et al., 2012). Correlating concepts is US as an extension of Industrial Symbiosis (IS) and refers to exchange of by-products from cities as alternative inputs of resources and energy in business and industrial operations (Gibbs, 2008; Van Berkel et al., 2009). IS is commonly seen as the main application of industrial ecology as closing the loop resource cycles by using 'waste products' of one industrial unit as input for another industrial unit (Van Berkel et al., 2009).

The UM distinguishes six themes for creating understanding of (1) the city as an ecosystem, (2) material and energy flows in a city, (3) economic-material relations within the city, (4) economic drivers of rural-urban relationships, (5) the reproduction of urban inequality and (6) attempts at signifying the city through new visions of socioecological relationships (Broto et al., 2012). In this context, UM can be viewed as an approach that detects resource and energy relationships between society and nature (Kennedy et al., 2011). UM is embedded in a system that is interconnected with subsystems, interactive and interdependent between other systems and therefore, system thinking is one of the key factor required for an UM approach. The additional value of these themes will be for decision makers involved in the process of a sustainability transformation. The themes aim to create a deeper understanding of an UM and provide insights in possible changes to reduce pressure on the environment, while increasing quality of life (Pincetl et al., 2012).

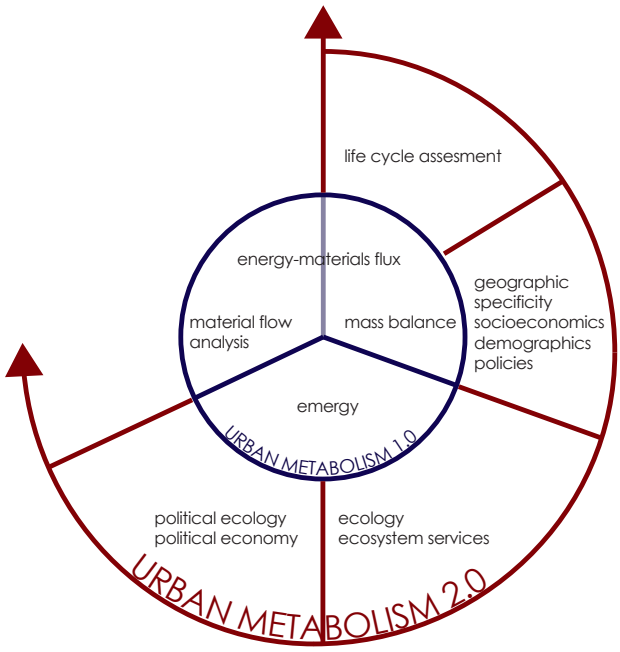


Figure 3.1. Urban Metabolism 2.0 framework
Source: Pincetl et al., 2012

Application of the UM for urban planners and designers can provide (1) sustainability indicators, (2) inputs to urban GHG accounting, (3) mathematical modelling for policy analysis and (4) urban design. Sustainability indicators are related to numbers of energy efficiency, material cycling, waste management and infrastructure. GHG accounting refers to quantification of actual urban GHG emissions and indirect GHG emissions (e.g. GHG emissions produced through production of materials for cities). Modelling for policy analysis is related to future changes to UM as a result of

technological innovation or policy measurements. Design tools refer to tracking down flows that can be redesigned for reduction of input of resources and waste. The four principles for redesigning the city are: (1) shapability, (2) sustainability, (3) reconstruction and (4) responsibility (Kennedy et al., 2011).

The most common tool of the UM is the Material and Energy Flow Analysis (MEFA) for assessment of resource and energy flows through an urban system (Pincetl et al., 2012). The framework of Pincetl et al. (2012) for UM is expanded with human, social, policy, economic and related systems in order to create a deeper understanding of the functioning of the urban material and energy flows and the context of these flows. An outline of this framework is shown in figure 3.1.

An advantage of applying UM is that it has precise system boundaries for the analysis. The inputs and outputs of such a defined area are quantified. Additionally, the UM is a suitable analysis for policy and technology outcomes concerning sustainability goals. And lastly, the UM integrates social dimensions with technological systems. This is due to the fact that UM is inherently linked with social factors. E.g. increased consumption of gasoline and high levels of obesity are related to a car dependent lifestyle (Kennedy et al., 2011). The UM is considered as the focus on the closed loop principle as core of the CE and addresses the current excessive urban resource consumption (Ness & Xing, 2017).

3.1.2. Critique on UM

UM studies have been effective in addressing imbalance of resource and energy usage of cities and the earth's capacity to provide these services. However, the UM (1.0) fails to deliver concrete policy and legislation solutions for these insufficiencies. The UM should be connected to lifestyles and other social factors. Therefore, there is a need for enrichment of the UM with urban driver factors, environmental quality, lifestyles and other socio-economic factors (Broto et al., 2012).

This expansion is shown in figure 3.1 with the additional socio-economic factors. However, as Pincetl et al. (2012) argued in their article these additional indicators imply generation of more data. This data generation and including more disciplines lead to potential of reducing unwanted side-effects and improving the basic knowledge of policy making. Additionally, the application of the additional indicators is not specified and the relation among all factors remain unclear. Further integration of the indicators of other disciplines is suggested.

3.1.3. Tools of UM

The UM theme 'material and energy flows in a city' (Broto et al., 2012) is further discussed in this section with the MEFA. The MEFA originate from 1925 as a central tool in the discipline 'ecology'. In 1970, energy and material flows were introduced in a network structure, originating from the input-output economics. This approach researches the structure of energy and material utilization in an ecosystem (Suh, 2005).

The MEFA consist of the basic formula with mass conservation: mass in = mass out + stock changes (Pincetl et al., 2012). The MEFA provide basic answers to the following questions regarding society-nature interactions: (1) which changes are caused by socio-economic activities in natural systems and (2) which socio-economic forces drive these changes and how they can be influenced (Haberl et al., 2004). In this context, the industrial system, the natural system and the societal interactions (as dimensions of an urban area) are constructed as an ecosystem with metabolism material and energy exchange. Materials and energy are absorbed, transformed, stored, recycled and excreted from nature in the industrial ecosystem (Bringezu et al., 2003). MEFA can be used as (1) a basic data structure of a specific material flow and stock in an ecosystem (as shown in figure 3.2), (2) the importance and relevance of these flows and stocks and (3) manage flows for achieving goals, such as sustainable development (Suh, 2005; Hendriks et al., 2000).

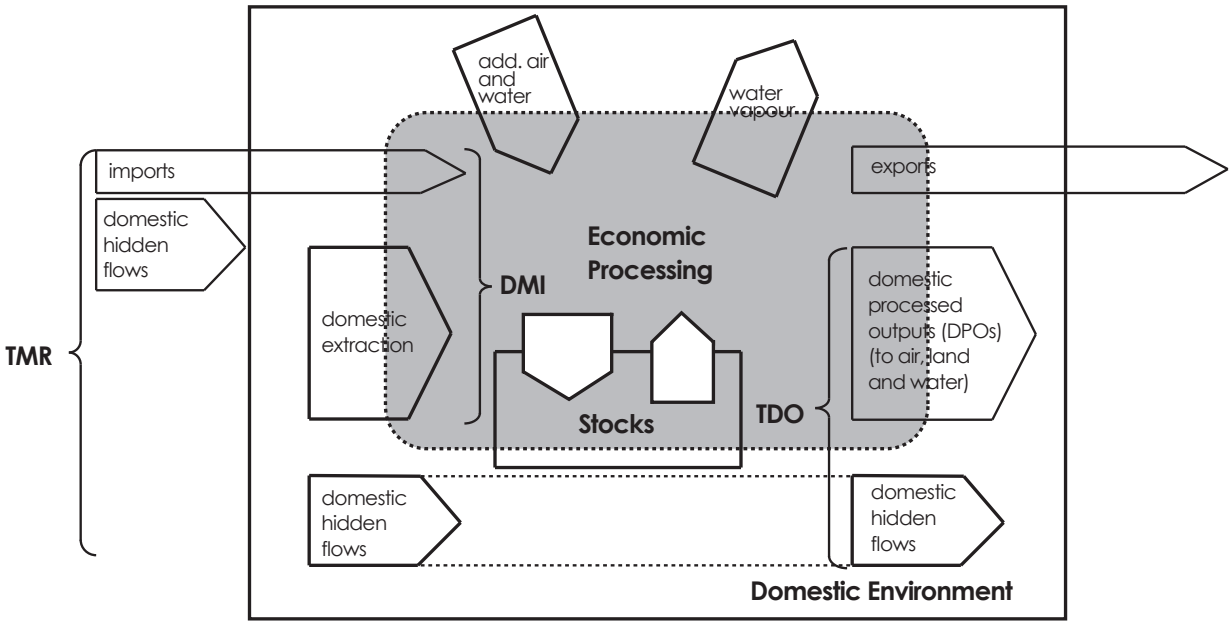


Figure 3.2. Material flow analysis
Source: Bringezu et al., 2003

Voskamp et al. (2016) developed the SIRUP tool (space-time information analysis for resource-conscious urban planning) for analyzing whether resource flows contain the desired level of detail. The theoretical potential of MEFA's is widely addressed in scientific literature, howeverpractical implementation of detected synergies remains limited. Implementing the SIRUP tool leads to the following conclusion. The scale and time level for MEFA's depends on the intentions of the stakeholder and the targeted resource flow. Current MEFA's on city level and on a yearly basis are not suitable for urban planners and designers (Voskamp et al., 2016). Additionally, resources in some sectors have a different life-span, compared to other sectors. For example, a building in the construction sector has an average lifespan of 50 years (Icibaci & Haas, 2012), while nutrition products have a shorter lifespan.

The procedure of a MEFA consists of the following steps: (1) goal and systems definition, (2) process chain analysis, (3) accounting and balancing and (4) modeling and evaluation. The goal and systems definition comprise establishment of the main question, the system boundaries and the scope of the analysis. The second step, the process chain analysis is the accounting and balancing of the material inflows and outflows. The material low analysis functions according to the principle of mass conservation. The checks and balances (step three) is executed to detect gaps in data. The fourth step: modeling can be applied as 'bookkeeping'. The evaluation phase tests whether the results correlate with the primary interests and basic assumptions (Bringezu & Moriguchi, 2002; Sendra et al., 2007).

The advantages of a MEFA are the visualization of a network structure. The analysis provides basic data of a network. This data can function in a later stage for sophistication of the process (Suh, 2005). A MEFA can be combined with other industrial ecology tools, such as a Life Cycle Assessment (LCA) to address the impact of certain utilized materials or energy. As described in the introduction, most of the indicators of implementing CE are derived from the MEFA. The advantages of these indicators are that they are credible, transparent, relevant, accurate, measurable, comparable, adaptable and able to show changes (Sendra, Gabarell & Vicent, 2007).

3.1.4. Critique on MEFA

Critique on the MEFA is that the outcome of this tool is linear and fixed. However, in an urban system, the relationships between the entities are not characterized as linear and fixed. This factor is crucial if the outcomes of the MEFA are used for predictions. Systems as object of analysis will change over time due to network dynamics and trends influencing the systems. Predictions will be done for a set time, based on linear information from the analysis. Prediction require reflection and monitoring (Suh, 2005). Moreover, the MEFA does not incorporate possible substitution materials for transition processes (Pincetl et al., 2012).

The MEFA discusses two aspects of sustainability: the energy and material flows. Other dimensions of sustainability such as political, legal, social and economic factors are not taken into account, although resource and energy flows can be results of social factors. These factors are not part of the modelling. In this research, the material and energy flows form the basis of increasing sustainability, other factors will follow these flows (Haberl et al., 2004). A critical note is: questions rise around the basis (flows) and following factors (causality).

3.1.5. Conclusion on UM

The UM observes all flows coming in and leaving an urban area as a result of socio-economic processes. This fits the CE approach with the closed loop systems. In order to create these closed loop systems, insights are needed of the flows on different scales. The theme of the UM for this research is 'material and energy flows in a city'. Additional tools can be applied to this framework in order to create a more holistic view. However, the application of other tools from the UM 2.0 framework, such as the LCA are out of scope of this thesis project.

The basic formula of mass in = mass out + stock changesis central to this analysis (Pincetl et al., 2012). The MEFA can be applied on different levels of scale (micro-, meso-, and macro-level), depending on the (1) resource targeted and the (2) intended goal (Voskamp et al., 2016). The MEFA include the following steps: (1) goal and system definition, (2) process chain analysis, (3) accounting and balancing and (4) monitoring and evaluation (Bringezu & Moriguchi, 2002). Relevant for policymaking, are insights in energy and resource flow on all the three levels: micro-, meso-, and macro-level.

3.2. Stakeholder analysis and dynamics

Stakeholders and their networks are key for insights in analyzing complex issues. Currently, there is limited knowledge of role and influences of local stakeholders (Vernay, 2013). Implementing CUAD in governance demands for horizontal integration of institutions, organizations, private and public sector on all three levels (micro-, meso-, and macro-level) (Murphy et al., 2012; Geng et al., 2012). This demands for insights in the stakeholders and their network dynamics.

3.2.1. Introduction in stakeholder analysis

A stakeholder analysis is needed for analyzing complex issues where different organizations and individuals are involved with their various interests (Reed et al., 2009). Stakeholder analyses are mentioned in different disciplines. Table 7 provides an overview of these disciplines.

Dicipline	**Used for**	**Source**
Governance and policy makers	Create understanding who will be affected by decisions and actions	Reed et al., 2009
Research and development management	Participation of multiple stakeholders leads to learning beyond a single organization and integrates the potential of partners and consumers in research activity	Elias, Cavana & Jackson, 2002
Businesses	Understanding the dynamics of a stakeholder's influence creates insights in potential opportunities and market developments	Bunn, Savage & Holloway, 2002
Media	Stakeholder analysis and management can be an effective tool for determining target groups for news and marketing strategies	Merrilees, Getz & O'Brien, 2005

Table 7. Overview of disciplines for stakeholder analyses

With the increased complexity and interconnectedness, stakeholder analyses are essential for determine information held by key stakeholders and paying attention towards stakeholders. Besides this, no single-organization has ownership of complex issues. In complex issues, many stakeholders are involved, contribute and are affected by it. Multiple frameworks exist for identifying stakeholders and analyzing their influences and dynamics (Ackermann & Eden, 2011; Bryson, 2004; Bryson et al., 2011). Arguably, stakeholder analyses of networks of stakeholders become increasingly important compared to markets and hierarchies (Bryson, 2004). The definition of a stakeholder for this thesis is: 'individuals, groups, or organizations that can affect or are affected by an evaluation process and/or its findings (Bryson et al., 2011). These stakeholders have attributes and interdependent relationships with other stakeholders, consisting of formal and informal networks. History learned consequences of inadequate stakeholder involvement in transitions (Bryson et al., 2011). The stakeholder analysis aims to answer the 'why, when, where, how and with whom' questions for situations where a change of direction is needed (Bryson et al., 2011).

A distinction can be made between three stakeholder analysis approaches: the normative, instrumental and the descriptive approach. The normative approach is commonly used in policy, natural resource management and development. The stakeholder analysis is used for legitimizing and empowerment of decision-making processes. Additionally, it is used for identifying stakeholders in the legal and institutional context and who is affected by these contexts (Reed et al., 2009). Instrumental approach is more pragmatic for researching how organizations and policymakers can be managed for achieving desired outcomes. The instrumental approach is applied in natural resource management as well in order to overcome barriers for adoption of technologies and innovations (Reed et al., 2009). The descriptive approach is not commonly used due to the fact that it solely describes relationships among stakeholders, without a specific goal (Reed et al, 2009).

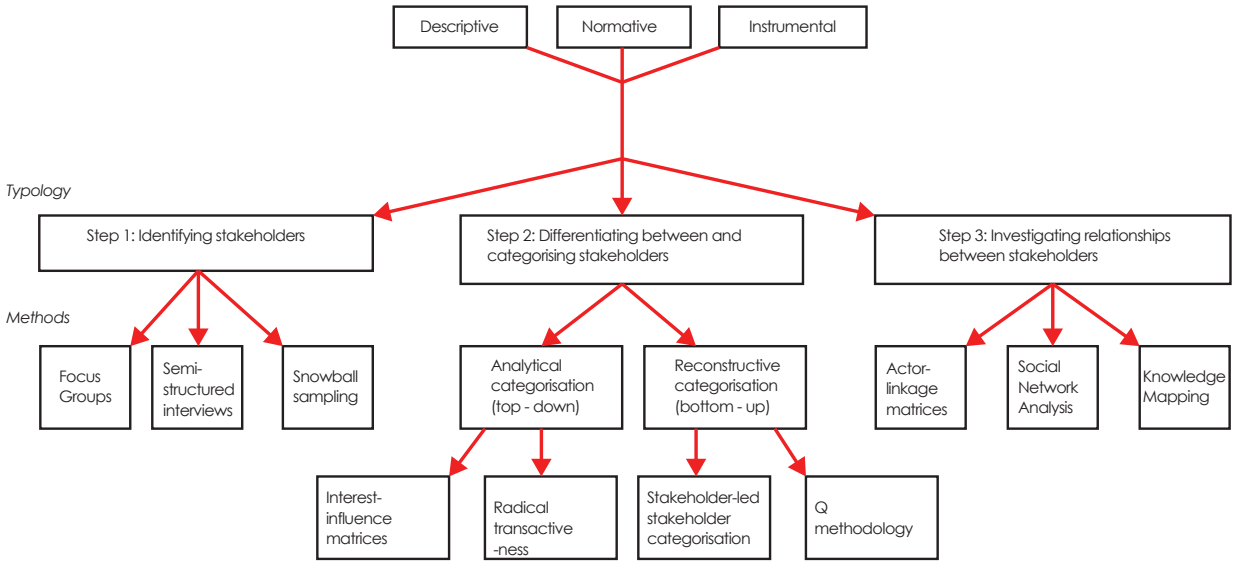


Figure 3.3. Rationale of stakeholder analysis
Source: Reed et al., 2009.

The rationale of a stakeholder analysis is displayed in figure 3.3. It includes the three phases: the rationale, as described above, the typology with the three steps and lastly the methods of the correlating typologies. The stakeholder analysis consists of different methods for: (1) identifying stakeholders, (2) differentiating between and categorizing stakeholders and (3) investigate relationships between stakeholders (Reed et al., 2009; Ackermann & Eden, 2011). A combination of these methods can strengthen a stakeholder analysis for understanding the different categories of stakeholders and their inter-relationships (Reed et al., 2009). A stakeholder analysis is not a static process. Unexpected events can change the stakeholder landscape and power dynamics. Additionally, changes in political administrations can lead to large variations in the stakeholder landscape (Bryson & Patton, 2010).

A disadvantage of the stakeholder analysis is that a level of disaggregation has to be chosen, leading to a generic or abstract level of stakeholders. The abstract level can lose the representation of the reality. Stakeholders of a stakeholder group can differ in influence and dynamics in reality, then is reflected in an abstract level of stakeholder groups. Nuance in the overview of stakeholder group can be missed (Ackermann & Eden, 2011).

Another point for discussion is the distinction between formal and informal relations between stakeholders. Informal networks are more complex, since this is based on human interaction and relations, leaving out formal procedures. Informal networks are taken for granted by stakeholders and these are not managed in a structured way. However, dynamics of informal networks can strongly influence formal networks and dynamics (Ackermann & Eden, 2011).

3.2.2. Conclusion on stakeholder analysis

With the introduction of the CUAD conceptual framework, it is especially relevant to gain knowledge concerning the dynamics and relations of stakeholders. Since the entities are connected through flows of energy and materials, knowledge of the different stakeholders, their role and dynamics is therefore essential. Implementing CE demands for a stakeholder analysis to identify the field of involved stakeholder groups, specific responsibilities and power of these stakeholder groups. Additionally, stakeholder groups can operate on different levels and in different time scales.

3.3. Backcasting analysis

As indicated in chapter 2, implementing CE in urban planning is seen as a process, rather than a state of affairs (Boons et al., 2011). This section elaborates on the second step of SUAD: defining desired elements for an urban area. By formulating desired element, a backcasting analysis is further explored as an addition to the framework. The backcasting analysis is a commonly used approach for transition to sustainability (Quist & Vergragt, 2006). Since CE and sustainability are strongly related, the backcasting is found as an effective methodology for the CUAD framework.

Visions and in specific the backcasting analysis can be an important element for outlining system transitions towards sustainability (Quist & Vergragt, 2006). Visions are part of future studies; a research field including theoretical and methodological approaches. The common future oriented studies are forecasting analysis, scenario studies and the backcasting analysis (Dreborg, 1996). Traditional forecasting analysis is a method including polarize current trends to predict the future scenario. The forecasting analysis tends to exclude large changes since it magnifies current trends (Dreborg, 1996).

The backcasting analysis was introduced in 1970s as a different perspective of foresight and forecasting as normative forecasting in the energy sector (Vergragt & Quist, 2011; Anderson, 2001). Lovins suggested to construct a desired future instead of predicting complexities and uncertainties in forecasting (Anderson, 2001). The backcasting analysis was mentioned by Robinson in the 1980's as a separate method to investigate future options in the energy sector. Since the 1990s, the backcasting analysis is related to sustainable development. Sociotechnical system transitions are needed to deal with environmental challenges in the long-term. The backcasting analysis addresses these issues with long term perspective and the broad notion of sustainability (Vergragt & Quist, 2011; Robinson et al., 2011).Backcasting analysis can create strategic governance capacity in order to outline city visions (Healey, 2002).

3.3.1. Features and concepts of the backcasting analysis

Three types of demands are distinguished in a backcasting analysis: (1) normative demands, (2) process demands and (3) knowledge demands. Normative demands refer to the definition of sustainability, goal-related requirements of the analysis and how these are translated into principles or criteria for the results of the backcasting. Process demands includes stakeholder participation and their relationship and level of influence in the identified problems and solutions of the backcasting analysis. The knowledge demand sets the requirements for knowledge and how these sources of knowledge are valued (Quist et al., 2011). Results can be divided in three categories (1) network formation, (2) future visions and (3) institutionalization (Neuvonen & Ache, 2017; Quist et al., 2011).

Different types of backcasting analysis can be distinguished. Target-oriented backcasting analysis is focused on technical systems that can answer the question 'what can change?' Pathway-oriented backcasting sets the relations of current technical systems with planned actions in the future, answering the question 'how can change take place?'. And lastly action-oriented backcasting stakeholders are identified to answer the question 'who could make the change happen?' (Wangel, 2011; Neuvonen & Ache, 2017).

To determine whether a backcasting analysis is suitable to be applied for decision making and policy development, there are requirement points:

1. The problem is complex.
2. There is a need for major change.
3. Dominant trends are part of the problem.
4. Externalities are important.
5. The time horizon is long enough to allow deliberate choice (Giurco et al., 2011; Dreborg, 1996).

According to Dreborg (1996) the core features of a backcasting analysis are: (1) the product (the future desired image or better known as the normative scenario) containing the feasibility, consequences and strategic choices. (2)A stakeholder identification with all involved parties from stakeholder groups, purpose of the backcasting analysis and how this future image should be reached in the context of the case-study. And (3) incorporating creativity to deal with current dominant perspectives and paradigms (Dreborg, 1996). The normative scenario sketches a desired future with a basis in solution, core decisions and problem-solving principles. A normative scenario aims for a future image that develops apart of current trends or dominant perspectives (Vergragt & Quist, 2011). Stakeholders are relevant for two main aspects: the knowledge that the stakeholders bring into the process towards achieving sustainability and contribution to achieve set goals required for realizing created normative scenario (Quist & Vergragt, 2006). Involving stakeholders in the backcasting process leads to insights for the stakeholders in the variety of choices and its correlating tradeoffs and consequences (Robinson et al., 2011).

Develop long term vision

1. Review of drivers for change
2. Analysis of Industrial Ecology principles
3. Development of regional goal and scenario themes
4. Detailed scenario development
5. Scenario validation

Develop short term actions

1. Explore solution options
2. Select among options: set up action plan

Implementation

1. Set up cooperation agreement - define roles
2. Implement research agenda

These steps come with a toolkit with a distinction of four groups of tools and methods. The first group is participatory tools and methods, suitable for involving stakeholders in a participatory backcasting analysis. The second group is the design tools and methods, suitable for constructing normative scenarios and system and process design tools. The third group is analytical tools and methods suitable for assessments of scenarios and designs. The last group is the management, coordination and communication tools and methods relevant for communication and designing stakeholder networks (Quist & Vergragt, 2006; Quist et al., 2011).

A few comments on these five stages can be given. Although these five steps imply a linear process, iteration cycles influence these five stages. Furthermore, stakeholders can enter and leave in the five different steps. Quist & Vergragt (2006) define five main groups of involved stakeholders: companies, research bodies, government, public interest groups and the public.

Various advantages of the backcasting analysis can be mentioned. The greatest benefit is the strategic learning or higher order learning by the stakeholders (Quist et al., 2011; Neuvonen & Ache, 2017). Policy can be shaped around the desired normative scenario instead of policy following 'predicted future' of extra polarizing current trends in supply and demand. Therefore, the policy is shaped around value driven scenarios and goals (Anderson, 2001). Since the future can depend on current policy measurements and decisions, creating a normative scenario can be beneficial in shaping current policy (Anderson, 2001). Therefore, a backcasting analysis can be considered suitable for addressing long-term sustainability solutions since it proposes novel ideas to problems at stake (Quist & Vergragt, 2006; Dreborg, 1996). And it can provide a strategic structure for sustainable development (Anderson, 2001; Partidario & Vergragt, 2002).

3.3.2. *Critique on the backcasting analysis*

Several points of critique on the backcasting analysis can be made. A point of critique is that the normative scenario tends to be filled in by dominant perspectives of the current time. Additionally, participants of the normative scenario workshop tend to extra polarize the current trends to the future. However, the aim of normative scenarios is to create a desired future disregarding current trend (Quist & Vergragt, 2006). This demands creativity and out-of-the-box thinking which the participants or the facilitator can lack.

Furthermore, participants of the participatory backcasting analysis should represent a variety group of stakeholders and this selected group of stakeholders should own a common understanding of definitions of sustainability, set goals and technical knowledge. Sharing a common understanding can be a challenge for creating a normative scenario with involvement of all stakeholders (Robinson et al., 2011). Stakeholders involved for the normative scenario is mostly a group representing the wider public. This can imply that the represented stakeholders do not reflect the involvement of the wider public (Neuvonen & Ache, 2017).

Another challenge is to connect the analysis with the complexity of reality. Creating a normative scenario is a simplification of current and future reality. Implementing the results from the backcasting analysis requires a translation to the real-life complexity and creates tension. The introduced simplification is necessary since the method is resource and time intensive. However, created normative scenarios can be unrealistic in reality (Dreborg, 1996) (Robinson et al., 2011).

Lastly, organizations and businesses are restricted to sunk-costs in terms of equipment, expertise and involved people. All the involved organizations in forming a normative scenario must remain relevant (or for businesses profitable). Therefore, this creates limitations for implementing radical changes for these organizations. Although a normative scenario can be radically different from the current situation, the normative scenario is still required to involve all organizations (Dortmans, 2005).

3.3.3. Conclusion on the backcasting analysis

The backcasting analysis is applied in this thesis project, since it is suitable for creating shared ground for adopting directions for policy, it proposes drastic sustainable images and problem-solving principles (Vergragt & Quist, 2011; Dreborg, 1996). Additionally, it provides a long-term timeline. The long-term perspective of the backcasting analysis fits in the ambitions of EU policies of GHG target reductions (80% reduction by 2050). This stretched up the local political debate to incorporate these long-term targets in urban planning and city policies. By applying the backcasting methodology, a drastic desired scenario in the long term can be created, while fulfilling the long-term goals of the EU (Neuvonen & Ache, 2017).

Creating a future perspective on a specific area makes a complex urban area manageable. On different governance levels, a variety of stakeholders' dynamics and different flows of resources and energy are intertwined in a complex socioeconomic system. In order to create common ground and a management plan for a complex urban area, a vision can be a suitable tool (Neuvonen & Ache, 2017). The backcasting analysis is a methodology that integrates the UM with the complex flows and stakeholder's dynamics from the stakeholder analysis and is the methodology of the second step of the implementation of SUAD, as explained in chapter 2 (Runhaar et al., 2009).

4. Framework methodologies

The research methodologies are formed around the three pillars of industrial ecology: (1) how industrials systems work, interact and regulate, (2) industrial metabolism and (3) how it is used for sustainable development (Ghisellini et al., 2016), as pointed out in the relevance for industrial ecology (1.5). The developed conceptual framework will be applied to the case-study for a structured overview and operationalization.

4.1 CUAD framework

4.1.1. CUAD in conceptual framework

As from literature, CE can be implemented in three levels. All three levels can be taken into account when adopting CUAD, since CUAD operates on the large scale as well as on the small scale. These levels are incorporated in each step that is described below.

To reach CUAD, a few proposed steps need to be taken. These steps are formulated on the extensive literature review and theoretical framework of this thesis.

1. **Analysis of the current situation.** Founded knowledge of the context is needed. This defines the baseline of the urban area and provides insight in the possibilities and strength of the area. This includes a description of spatial functions, the condition of the area and an analysis of relations and dependencies between the functions and conditions (Boons & Baas, 2004; Gibbs & Deutz, 2007; Runhaar et al., 2009). A relevant goal and scope should be defined (Ahern et al., 2014). The following two methodologies are chosen for this step, regarding the definition and framework of CUAD.
    a. A MEFA is needed for insights in flows coming in and going out of an urban area on different level. Additionally, the level of detail is researched what is needed for implementation of closed loop possibilities (Timmeren van, 2012).
    b. A stakeholder analysis is required to gain insight in an identification of involved stakeholder groups and the dynamics and interactions among these stakeholder groups.
2. **Determination of the desired area types.** Since implementation of CE demands for a transition of a socio-technical system, a time scale provides additional insights in the different steps that needs to be taken. Since there is no existing CUAD realized, the ideal Binckhorst should be described, based on the CUAD conceptual framework. The backcasting analysis will be used in order to form normative scenarios for the Binckhorst and determine the desired types for the urban area (Runhaar et al., 2009).
3. **Selection and prioritize.** Prioritize goals and flows. Consider principles, strategies, tradeoffs and alternatives. This step includes putting emphasis on the desired themes from the previous step (Ahern et al., 2014; Runhaar et al., 2009).
4. **Formulation of environmental ambition.** For each desired theme, an ambition and goals has to be formulated. This can be done by governmental institutions as well as a participatory process of stakeholder groups (Runhaar et al., 2009)

5. **Development of action plans.** This includes all ambitions translated into action plans. A checklist with best practices can support this step (Runhaar et al., 2009). A baseline measurement should be set, including a list of indicators to measure CUAD.
6. **Monitoring, evaluation and feedback.** Monitoring and evaluation needs to be set up to test whether the goals and ambitions will be reached (Ahern et al., 2014). Evaluation should be executed with testing the indicators on each theme of the CUAD framework.

4.1.2. MEFA in conceptual framework

The flows occur on three levels in an urban area. The scope of the flows for this framework is narrowed to the micro-level. The motivations for this are: (1) it is time consuming to research all flows occurring on macro-, meso-, and micro-level. (2) the motivation of this research is built on the work of the resource-broker. He is involved in networking for companies to collaborate and implement CE. This level can provide insights for firms.

The following materials and energy will be measured on a company level.

Category	**Type**	**Product**
Material	Natural resources	All resources and products
	Adjuvant	All adjuvants
	Packaging	Packaging of natural resources and adjuvants
Water	Water usage	Liters per month
Waste	Solid waste	Types of waste
Energy	Types of energy	

Table 8. MEFA indicators

A final note is made concerning the MEFA. The flows will be researched on micro-level. However, different flows on different levels occur in an urban area. For example, hydrological cycles for drinking water, wastewater and rainwater occur on meso- and macro-level (van Timmeren, 2012). Although modelling the flows on the meso-, and macro-scale are out of scope of this thesis project, an important note is that interconnectedness of the flows on micro-level with the other levels should not be neglected.

4.1.3. Stakeholders in conceptual framework

The methodological steps of the stakeholder analysis will be used for applying the stakeholder analysis in the CUAD framework. The methodological steps are displayed in figure 4.1.

The stakeholder analysis described the normative, instrumental and descriptive approach. The goal of the stakeholder analysis is (1) to identify the relevant stakeholders for policy measurements, (2) research their dynamics to gain insights in their behavior and (3) discover how they can be moved to achieve the desired ambition (identify focus). Instrumental stakeholder analysis is considered more suitable since this requires a more pragmatic approach (Reed et al., 2009).

Identify system boundaries

The first part is context formulation. This includes users of the area, policy makers that are responsible for regulation and execution of plans and development activities of the area.

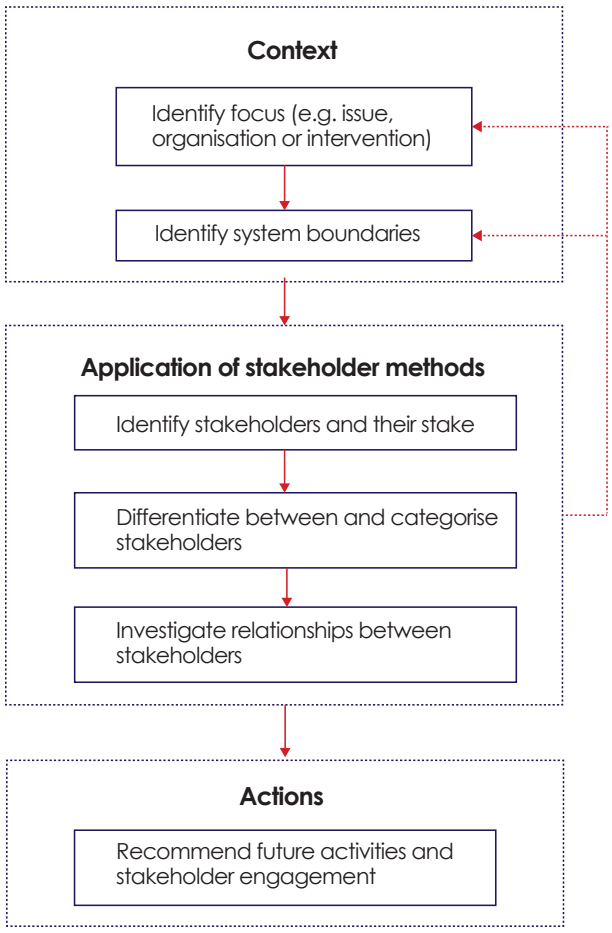


Figure 4.1. Methodological steps stakeholders
Source: Reed et al., 2009

Identifying stakeholders

This method is useful for in-depth insights of stakeholders and stakeholders' relationships. The negative point is that this method is time-consuming (Reed et al., 2009). These stakeholders will be checked with stakeholders mentioned in policy literature. Due to the size of the Binckhorst and the development stage, that includes a large number of stakeholders, stakeholder groups will be identified. Some specific organizations will be mentioned due to their participation in expert interviews, however, this list of organizations is not complete since the focus will be on dynamics and groups of stakeholders rather than providing a complete list of all stakeholders.

Bryson (2004)		
Public sector Ministries Political parties Advisory body Regulator Political decision-making bodies Executive services and agencies and bodies	**Economic sector** Sectoral umbrella organizations Lobby clubs Professional trade unions Labor unions Consumers organizations Financial institutes Companies	**Interest organizations** Nature and environmental organizations Safety and health organizations Specific interest groups
International players European Union and European Commission Multilateral institutions like UN, IMF, WTO, NAVO Governments from other countries and trade partners	**Knowledge, science and technology** Universities Knowledge centers Technology developers Think tanks Scientific associations	**Public domain** Tax payers Future generations Residents Users of public services Opinion leaders

Table 9. Typical stakeholder categories (source: Bryson, 2004)

Differentiating between and categorizing stakeholders
This step creates priorities to certain stakeholders and makes the power dynamics more explicit. The disadvantage of this method is that there is the assumption that stakeholders low on the interest-influence matrix are irrelevant and high in the matrix more relevant (Reed et al., 2009; Bryson et al., 2011). However, this can be more nuanced, as described in the review of the existence of formal and informal networks of stakeholders.

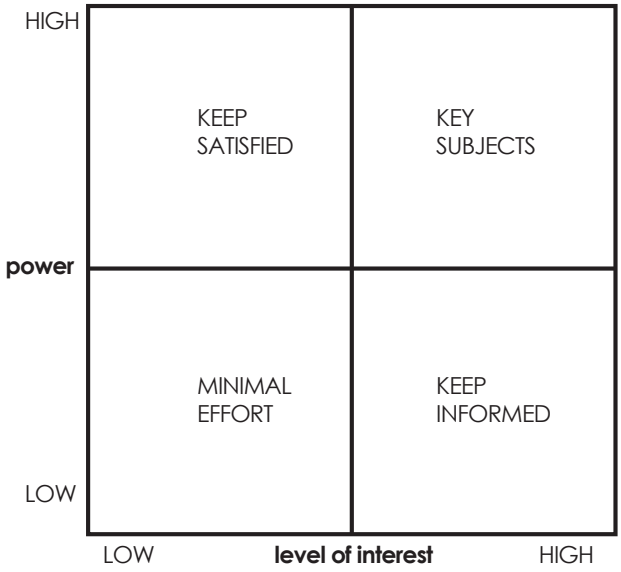


Figure 4.2. Power-interest diagram
Source: Caputo, 2013

Investigate relationships between stakeholders
It can provide information concerning the stakeholder that work well together and others with power. The disadvantage of this method is that the information conducted is limited to the knowledge gained from the experts (Reed et al., 2009).

Recommendation future activities and stakeholder engagement
Since this is an instrumental approach to the stakeholder analysis, suggestions will be done to involve relevant stakeholders for achieving shared ambitions. These recommendations will be done in the suggestions for follow-up on the case-study.

4.1.4. Backcasting analysis in conceptual framework

In this paragraph, there is an elaboration per step of the backcasting analysis on the methodologies that will be used for this step.

Develop long term vision

Review of drivers for change

Processes of change became increasingly complex in the past decennia, due to globalization. Operating businesses and governments deal with influences outside of their national political geographies. The macro changes affect structure, decision-making, business models of companies and governments. Therefore, awareness of the environment of a system and its dynamics is increasingly important (Yüksel, 2012).

Additionally, applying CE demands for knowledge of the specific local context of an area. The current and expected drivers of change will be especially relevant for the local area. Historical developments in the region can have a role in this analysis as well. This stage can be seen as the foundation of the research (Giurco et al., 2011). According to Partidario & Vergragt (2002) can lifecycle thinking be useful in the problem orientation of the backcasting analysis.

The PESTEL-methodology (Political, Economic, Social, Technology, Ecological and Legal) is applied to identify the external environment for the Binckhorst. This has two functions:

1. It identifies the external drivers of the system
2. It enables prediction of the context in the future (Yüksel, 2012)
   Since implementing CE refers to a socio-technical transition, all factors of the PESTEL-analysis are relevant to take into consideration. Important note is that these factors show interdependence and can have causal relations with each other.

Circularity principles and potential

The circularity success factors should be assessed for potential use in the normative scenario. The circularity principles can lead to possible sociotechnical linkages as well as learnings of failures in other cases. This step can be done with literature review (Giurco et al., 2011) and a combination with expert interviews to test knowledge of involved stakeholders.

Development of regional goal and scenario themes

This is an identification of individual core elements such as technologies or processes. This can be done in for example workshops or interviews with relevant stakeholders such as local active stakeholders, policy makers, etc. (Giurco et al., 2011). Outlines of the following step: creating the normative scenario can be given as a conclusion, based on the findings of the scenario themes.

4.2. Methodology

4.2.1. Purpose and rationale for case-study

This thesis defines a conceptual framework for integrating circularity – closing loops of energy and resources - in urban planning. Practices of circularity are researched in the urban context. The integration of these two fields (CE and urban planning) is emerging.

A single case-study is taken up for this thesis project. The definition of a case-study is 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident'. The five main characteristicsof a case-study: (1) case-study in context, (2) explanation of causal links, (3) theory development, (4) multiple sources of evidence and (5) generalize theory, will be further discussed below (Groat, 2013).

(1) The essence of a case-study is the focus of phenomenon(s) in the context. (2) The case is in complex dynamic relations with its context and are not isolated elements. In the research design, the case-study comes out as an explorative case, explanatory or descriptive. Each of the type of cases leads to a different structure of a research. (3) The theory development is specifically relevant for testing the case-study. The theory should embody the question of what is being studied. In this case, the theory development is done in the literature review with the CE a new paradigm as an answer to the current linear functioning of the economy. (4) The fourth characterization is the multiple sources of evidence. This is reflected in the data collection for the research. The last point is generalizing theory. This is a difficult point in a single case-study due to the context related component. However, it can clarify some points explored in the case-study (Groat, 2013).

The case-study of the Binckhorst is categorized as an explanatory as well as an exploratory case. The first part of the research question of 'how CUAD framework can be formulated', points out an exploratory case. The used methodologies are exploratory to formulate and apply such a framework. The second part of the research question 'what can be learned' points out the explanatory part.

Finally, the case-study aims to combine qualitative as well as quantitative research methods (Bryman, 2015). This is visible in the chosen research methodologies and tools. The advantage of a single case-study is to gain more insights in the quantitative and qualitative aspects of the case. And it strengthens the research on the criteria of social research, as further explained in section 4.2.5.

4.2.2. Case-study design

This thesis focuses on implementation of CE in transformation of an existing urban area, taking place in a real-life context. The boundaries between the studied phenomena and the context are not clearly distinct. The Binckhorst is taken up as a particular case to explore multiple socioeconomic dynamics occurring in urban life. The case-study is suitable for this research design, since it provides an in-depth and holistic perspective on a transitioning area. The multiple methodologies can be combined in a single case-study for more in-depth insights.

The Binckhorst will be researched within its physical context (referring to the CUAD framework and MEFA) and socioeconomic context (referring to the CUAD framework and stakeholder analysis). The time scale will be addressed by the backcasting analysis for formulated desired elements for implementing CUAD.
The MEFA is taken up in this research as:

Goal and system definition	The geographical system boundaries is the Binchorst. The metabolic analysis of Superuse Studios will be analyzed and provides an answer to what extend this metabolic analysis can give insights to the existing flows in the Binckhorst. The goal of the metabolic analysis is to provide a data analysis that can be implemented in practice. As described in the literature review, the metabolic analysis can be per formed on different scale of operations. This research has the focus on the micro-level, leaving out for now the meso-, and macro-level.
Process chain analysis	A choice is made to analyze one business operation. The geographical boundaries are set at the Binckhorst. Thus, the inflow consists of import of products by the business unit. The owner of the business unit will be interviewed concerning his business operation.
Accounting and balancing	The metabolism analysis will be operationalized by the computer program Vensim. The program Vensim can be used for simulating material flows and system dynamics. Different equations can be added. Therefore, the simulation program can show if one flow reduces, how this will affect the rest of the system (Bornhöft et al., 2013).
Modeling and evaluation	The model of Vensim will be checked by another supervisor, who's work involves analyzing extraction of raw materials from waste streams.

The stakeholder analysis is taken up in the following steps:

Identify focus	The focus is on implementing CE in the Binckhorst and includes all stakeholders that are involved in this transition. It includes stakeholders on micro-, meso- and macro-level.
Identify system boundaries	The system boundary of this thesis project is to formulate the start of the transition of the system and a normative scenario for the long term.

Identify stakeholders and their stake	Semi-structured interviews – interviews will be per formed with experts, involved in work in the Binckhorst. During this interview, there will be asked who they consider as (1) key stakeholders, (2) what the responsibilities are from these stakeholders and (3) how they operate in the network.
Differentiate between and categorize stakeholders	Interest-influence matrices – this matrix will be filled in by the researches, based on the inventory of the different stakeholders by the previous step.
Investigate relationships between stakeholders	Knowledge mapping – this step involves semi-struc tured interviews for identification interaction and knowledge among stakeholders. It provides a social-network analysis, based on the information conducted from the experts.
Recommendation future activities	Suggestions for future activities will be done, after analyzing results of the stakeholder analysis in combination with the backcasting analysis

If the issue is applicable to these five points, one can consider a backcasting analysis for policy development (Giurco et al., 2007; Dreborg, 1996). Testing these requirement points of the case-study to the development of the Binckhorst gives the following explanation.

Requirements	Explanation	Source
The problem is complex	Increased economic activities in large metropolitan areas create new forms of dynamism	Neuvonen et al., 2017
There is a need for major change	The Binckhorst has great potential for providing large amount of housing for residents, fulfil the ambitions of the vision of the region and provide employment for manufacturing industry	Gemeente Den Haag, 2011
Dominant trends are part of the problem	The following trends are identified by the municipality: increasing wealth, increasing residents of The Hague and increasing demand for resources	Gemeente Den Haag, 2016
Time horizon is long enough to allow deliberate choice	The Binckhorst will be planned for the long term with a time planning of 20 years	Gemeente Den Haag, 2011; Gemeente Den Haag, 2017

Table 10. Indicators for application backcasting analysis
Source: Giurco et al., 2007

The backcasting analysis is taken up in the following steps:

Review of drivers for change	Conducting the drivers for change is done with a literature study. Different sources of datasets will be utilized for the literature review (Bryman, 2015). The sources for this thesis project originate from scientific articles, policy documents, scientific books and government websites. These sources will be tested for the following criteria: authenticity, reliability, representable and significance. The sources will be used for a qualitative analysis, including formulating a set of categories and a scheme (Bryman,2015).
Circular principles and potential	The circularity principles will be retrieved from the interviews. The experts, selected for the interviews, will be asked for their definition and vision on CUAD. The circular principles will be defined from these answers. The circularity principles will form the basis and embedment for the scenario themes of the normative scenario of the Binckhorst.
Development of regional goal and scenario themes	The CUAD framework will form the basis for identifying the scenario themes. The results from the workshop are enriched with the results from the qualitative interviews with the experts. The experts were asked for their ideal Binckhorst in the future. The results are described according to the CUAD framework. Additionally, results from company visits will be taken up in the desired scenario themes. The results of the company visits are taken up in the appendix.
Detailed scenario development	The outlines for scenario development will be given, based on the previous step. No detailed elaboration will be done to this step, due to the time limitations of this thesis project.

4.2.3. Data collection

In order to minimize the disadvantages of a single case-study design, multiple qualitative and quantitative data sources will be collected. Data collection for this thesis research will be done with published reports and papers from the municipality, with a desk study. Additionally, semi-structured interviews with key stakeholders of the Binckhorst will be held, as can be observed in the table below. These interviews will be semi-structured interviews with an interview guide including points and specific questions that need to be answered. This leads to elaboration on specific topics per expert. However, some basic questions need to be answered as well. With semi-structured interviews, knowledge and understanding can be tested (Bryman, 2015). The questionnaire for the expert interviews can be found in the appendix.

List with interviews	Description of function	Motivations for expert interview
Jan Jongert	Founder Superuse Studios and performed the metabolic analysis of the Binckhorst	The metabolic analysis of the Binckhorst will be reviewed in the results and is the first research made of flows in the Binckhorst. Insights of this research can be incorporated in the approach to the UM framework for this thesis project
Gerko Brouwer	Resource broker of the Binckhorst	The commissioning of the resource broker for the Binckhorst is one of the suggestions of the metabolic analysis by Superuse Studios. Insights from practices in the Binckhorst can be of additional value for this thesis project.
Sabrina Lindemann	Initiator of OpTrek, a non-profit organization	OpTrek is a mobile project office for creating networks, projects, interactions, research and reflection to stimulate network formation in the Binckhorst.
Ger Kwakkel	Quartermaster CE of the municipality of The Hague	Ger Kwakkel is active and employed by the municipality of The Hague. The municipality forms policy for development the Binckhorst. Ger researches the potential of CE for The Hague and in specific for the Binckhorst
Eveline Kokx	Secretary Stadswerk	Eveline Kokx is actively involved in the development of the Binckhorst and Environmental and Planning act plan of the Binckhorst
Koos Havelaar	Stichting Haags Industrieel Erfgoed	He developed a walk in the Binckhorst in its historical context that can be followed with an app and aims for protection of industrial heritage of the Binckhorst.
Mirjam Brands	Haagse Milieu Service (HMS)	Mirjam is policy adviser waste and environment for the waste treatment company. She works on the Binckhorst at one of the facilities of Haagse Milieu Service (HMS)
Sjoerd Louwaars	Leiden Universiteit	Sjoerd is project manager of entrepreneurship and founder of changemakerslab at Leiden University. He moderated a workshop about the Binckhorst and an entrepreneurial meeting during the I'm Binck festival
Jos van Boxtel	Stebru	Jos van Boxtel is real estate developer and is currently involved in the development of residential units in Binckhorst

Table 11. List of experts for interview

The interviews were held in the Dutch language to avoid misinterpretation of the information given by the experts. Besides this, all experts were native Dutch and are able to nuance their opinion and clarify their statements. The interviews will take approximately 60 minutes and will be executed on desired location of the expert. All interviews will be recorded and transcribed in the transcription program Express Scribe Transcription Software. The interview reports will be send back to the experts for a final check. Changes will be accepted in the reports, before coding the interviews. The list with coding the variables of the interviews is taken up in the appendix.

The MEFA executed for this thesis project, is on micro-level (firm-level). The data collected for the MEFA will be provided from the company (Kompaan brewery) itself. It contains the overview of the processes, transcripts of orders of materials and energy invoices. The information will be processed by Vensim, a computer program, used for flow analyses. In this program, the specific variables can be given measuring units and formula. Thus, e.g. if processes doubles in amount, all variables will change accordingly, making dynamic modelling possible (Bornhöft et al., 2013).

Data for the stakeholder analysis was collected by the interviews. The power-influence matrix was filled in by the researcher, with additional information from literature. Knowledge mapping was done by the researcher, based on information provided by the expert interviews and literature.

A workshop by the municipality of The Hague was held on the second of October. During this workshop, ideas are generated by a large group of stakeholders for SUAD of the Binckhorst. The organization of the workshop is done without involvement of the researcher. Contact with the municipality is established after holding the workshop. Results of the workshop were shared with the researcher. Results during the workshop were collected according to the following themes:

1. Working
2. Identity
3. Living
4. Nature
5. Mobility
6. Waste
7. Energy

The theme 'identity' is left out of this analysis. This is due to the fact that 'identity' has no direct relation with circularity, as explained in the literature review chapter (2). The themes are specified to the themes as defined for the CUAD framework. The workshop output is photographed and processed in Excel sheets. Since the group of participants was large (approximately 100 participants) and methodologies for 'idea generation' are used, the amount of ideas were counted. The ideas mentioned multiple times, are taken up in the results of this thesis research project. The other ideas are left out, since further elaboration and explanation of these ideas were missing. These results were used to fill in the CUAD framework and backcasting analysis.

Additionally, company visits were executed. Questions were asked to the companies. Since the company visits were executed in the initial phase of the research, the data collection was not structured, providing little information for this research. The results from the company visits as well as the questions for the companies are taken up in the appendix of this document.

Finally, information is collected from the I'm Binck festival on the sixth of October 2017. During this festival, entrepreneurs of the Binckhorst, project developers, political parties and the participants of the festival had an open dialogue concerning the development of the Binckhorst as an authentic, sustainable and all-inclusive area.

4.2.4. Selection of case and reporting

The selection of the case occurred before starting the thesis project. This is explained in the introduction of this thesis project. The Binckhorst is pointed out by the municipality of The Hague for (circular) transformation to a living-working area.

The Binckhorst will be introduced by the CUAD framework and is the physical description of the area itself, done in a narrative way. This is followed by the MEFA analysis and the performed analysis of a single firm as the quantitative part of this thesis. Then a stakeholder analysis of the Binckhorst is performed. The stakeholders are analyzed according to the methodology scheme, as explained above.

The backcasting analysis will be reported according to the first four steps of executing a backcasting analysis. The literature study of drivers of change and circular principles will be integrated with the results from the workshop. Suggestions will be done for outlines for normative scenarios. However, the scenarios will not be elaborated in detail.

Integration of the results of these methodologies will be done in form of presented insights from the CUAD framework and suggestions for implementing CUAD in the Binckhorst with a phased plan. Conclusion and discussion will be linked back to the conceptual framework and literature review of the CUAD framework.

4.2.5. Validation, replication and reliability of the research

Criteria in social research are (1) reliability, (2) replication and (3) validity. Reliability refers to the repeatability of the study. The concepts, as introduced in research should lead to the same measurements. Replication refers to whether the research can be multiple times executed, leading to similar results. Four types of validity are concerned with social research: (1) measurement validity (is the measurement representative for the phenomenon studied?), (2) internal validity (is the causality correct?), (3) external validity (can results of research be generalized?), (4) ecological validity (are scientific findings applicable to natural social settings?) (Bryman, 2015).

The CUAD framework receives an average reliability. This is due to the universal concepts that are used from urban planning that have a high reliability. However, multiple definitions of the CE, including different principles appear in literature. This makes the understanding of what CE entails complicated. Replication of this research will lead to partly similar results. External validity is considered as low, since the literature review pointed out the role of context, specific stakeholders and specific resource and energy flows in this systemic analysis. A more detailed overview of the different methodologies is taken up in table 12 concerning reliability, replicability and the four forms of validity.

	Reliability	**Replication**	**Measurement Validity**	**Internal Validity**	**External Validity**	**Ecological Validity**
MEFA	High	High	High	High	Medium	Medium
Stakeholder Analysis	High	Low	Medium	Medium	High	High
Workshop	Low	Low	Low	Medium		High
Semi-structured interviews	High	Medium	Low	Medium	Low	High
Secondary analysis	Medium	High	Medium	High	Medium	Medium

Table 12. Overview of methods and criteria

The three criteria of the MEFA are considered high, since this method consists of quantitative variables. This is due to the straightforward introduced concepts for this research. The replication of the stakeholder analysis is considered low, since the methodologies are filled in by the researcher. The opinion of the researcher dominates the decision on the power-interest diagram of the stakeholder analysis. The reliability, replicability and measurement validity of the workshop is considered low. This is due to the fact that the workshop was not organized by the researcher. Moreover, the researcher was not present during the workshop. The results of the workshop are analyzed by the researcher, as a secondary analysis. Expert interviews will lead to different answers on the question since opinions of experts can evolve over time. The measurement validity is considered low for the expert interviews. The interviews will be coded, that introduces the possibility of variability (Bryman, 2015). Urban areas are highly complex areas with high dynamics and variations. Analysis of secondary data from policy documents concerning an urban municipality has therefore a low reliability. Besides this, the context of an urban area plays an important role, leading to a low validity (Bryman, 2015).

4.2.6. Limitations of the methods

The limitation of the application of a single case-study, is that the results cannot be generalized. This has to be tested by multiple case-studies (Groat, 2013). The choice is made to combine multiple methodologies to one case-study, instead of applying one methodology to multiple cases. Another disadvantage is the biased view of the researcher for collecting the results and making the conclusions. The multiple sources of data area collected and interpret by the researcher. This can lead to a selective procedure by the researcher, who determines what is relevant and what can be left out.

The MEFA has the limitation of creating a static image of Kompaan. External factors, such as changing destination plans of their current location or internal factors such as financial stress can make Kompaan leave the Binckhorst. Although in the current situation Kompaan can be taken up in a larger MEFA of the area, it can change over time.

The stakeholder analysis can lead to a great variety and large list of stakeholders. A boundary should be made concerning listing all stakeholders that are relevant versus leaving out crucial (future) stakeholders. Additionally, the power-influence diagram is filled in by the researcher, leading to a more subjective opinion where the stakeholder groups are positioned in the diagram. The results of the stakeholder analysis are generalized and brought to a higher level of abstraction, leaving out nuances and the acknowledgement of an informal network (Ackermann & Eden, 2011)

Another limitation is the choice of experts for the interviews. Ten different experts leading to ten different opinions. Adding more experts leading to a greater variety of views. Additionally, the experts are asked in a certain time of the development of the Binckhorst. Over time, opinions and knowledge can evolve and change, leading to different answers to the questions.

Finally, the company visits as well as the I'm Binck festival attendance have leaded to some results. However, these events were planned in the first phase of this research. Documentation of the company visits have shortcomings. The attendance the festival is not documented. The subjectivity of the researcher has a significant role in interpreting the results conducted from these data sources.

5. Development of the Binckhorst

5.1. Context description

As presented in the theoretical framework and the methodology chapter, this chapter is the first step of a detailed context description, based on the analytical framework CUAD, the MEFA and the stakeholder analysis.

5.1.1. Historical context

The Binckhorst received its name through the Binckhorst castle. This was built in 1300 and was set on fire in the decades after. The name 'Binckhorst' remained and the castle is rebuilt in 1727. The Binckhorst became in 1921 an industrial area for The Hague. Due to the financial crisis in the '20s, the Binckhorst was low in development. In 1936 the port of Binckhorst was built. After the first port was finished, businesses established in the area. A few large metal industries established around the port, including the gas factory that was active until 1967, when the gas bel in Slochteren was discovered and production of city gas from coals was no longer desired. Only the buildings from this factory remained in the Binckhorst and got a new destination plan (StichtingHaagsIndustrieelErfgoed, 2017). In the '70s, the industrial area was modernized, more offices were added to the Binckhorst and some large industries disappeared. The municipality of The Hague decided to remain the Binckhorst as an industrial/business area and set up a plan in order to stimulate industries in the Binckhorst and Laak (Stichting Haags Industrieel Erfgoed, 2017).

Figure 5.1. Binckhorst castle
Source: SmitslooGroep, 2015)

Figure 5.2. Gas factory
Source: StichtingHaagsIndustrieelErfgoed, 2017

In 2005, the Binckhorst was taken up as one of the nine development areas in the StructuurvisieWereldstadaan Zee in 2005. With the vision of The Hague for 2020, the Binckhorst was key in providing place for planned residential units to fulfill the increasing housing demand. The location of the Binckhorst relative to the center of The Hague, makes the area attractive for residential development (Gemeente Den Haag, BVR, BGSV, 2005). The goal was to transform these nine areas to a sustainable and high-performance work-living area (Gemeente Den Haag, 2011).

Figure 5.3. OMA Binckhorst plan
Source: bvr, 2007

The municipality of The Hague wrote for the south part of Binckhorst a new destination plan in 2007, together with the architecture firm OMA. This 'master plan' involved an integral approach to urban planning. With a few investors, the large investments would be carried by the Dutch national government and the municipality of The Hague (Gemeente Den Haag, 2011). A new aspect of the Binckhorst was the additional 7000 residential units in this masterplan (StichtingHaagsIndustrieelErfgoed, 2017). The financial crisis in 2008 brought radical change in this masterplan. The investors withdrew from the plan due to financial risk. Besides this, the businesses and small industries expressed their discontent of the masterplan, since it did not include the current businesses and industries in the masterplan. This destination plan was replaced with a regional plan for the Binckhorst. The aim of the plan was that the Binckhorst will be transformed from an industrial area to a mixture of working and living area in through organic development. The speed of development is determined by initiatives of private parties with the municipality in the facilitating role (Gemeente Den Haag, 2011). The only active role the municipality assigned itself is the development of the Rotterdamse Baan, a highway that connects the A4 with the city center (StichtingHaagsIndustrieelErfgoed, 2017).

The *OmgevingsplanBinckhorst* is written in 2017 with a vision on the development of the Binckhorst for the coming twenty years, with a slightly different direction. With an increasing national economic growth and increased pressure on the residential market, the role of the municipality is more controlling and compelling, compared to the destination plan in 2011. In this plan, the Binckhorst is divided in the following segments according to the policy documents of the municipality of The Hague (Gemeente Den Haag, 2017). Each part has a general destination plan of working areas, living areas or a mixture of working and living areas. The plan is written according to the new law, the Omgevingswet, (Environment and Planning Act) that gives more space to organic development (Gemeente Den Haag., 2017).

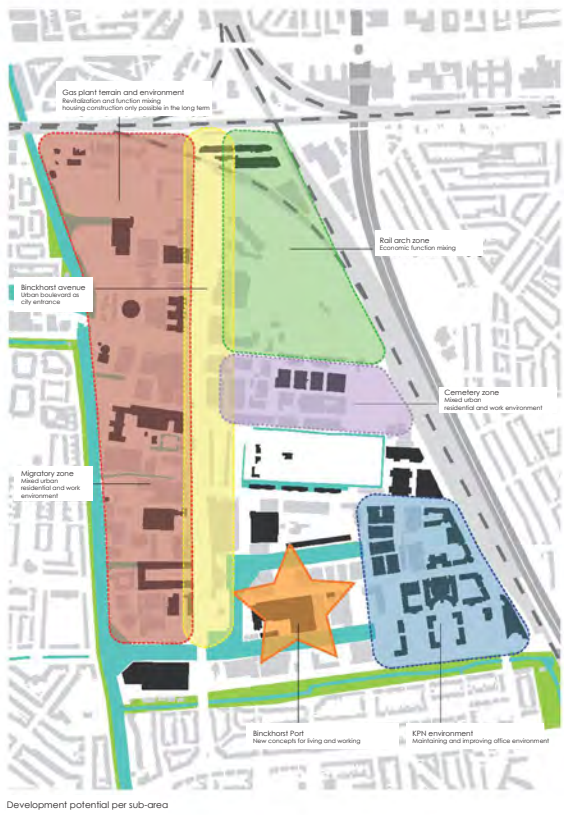


Figure 5.4. Division Binckhorst for development
Source: Den Haag, 2011

To provide a current overview of the Binckhorst, (1) the energy and (2) resource flows will be discussed. This is followed by a description of the four entities (3) economic experience, (4) mobility and infrastructure, (5) public space and (6) households.

5.1.2. Energy

An energy analysis is done by RO-Online. This is the national ICT facility of the government, accessible for inhabitants, companies and public organizations for information concerning regional planning program (VROM, 2008).

Infrastructure for district heating is present in the Binckhorst. In the image, the infrastructure is indicated with blue and red. The green lines are the connection of these buildings with the district heating. The current usage of district heating is generated by fossil fuel sources. There are plans to expand the district heating infrastructure (RO-Online, 2017).

The gas infrastructure is given in figure 5.6.The gas infrastructure is relatively old infrastructure and replacement of the major part of the infrastructure is needed. The current ambition of the municipality is to disconnect the new constructed residential units from the gas infrastructure. An important decision needs to be made whether the gas infrastructure will be replaced or left in the ground (RO-Online, 2017).

Concerning the energy labels of the buildings in the Binckhorst, the major part is currently unknown. The part that is known for their energy label, is relatively low: between label E and G are most of the buildings. These low energy labels come with high carbon dioxide emissions, related to electricity generation and heating up the buildings. The emissions are around 30 000 to 40 000 ton per year (RO-Online, 2017).

Figure 5.5. Heat district infrastructure
Source: RO-Online, 2017

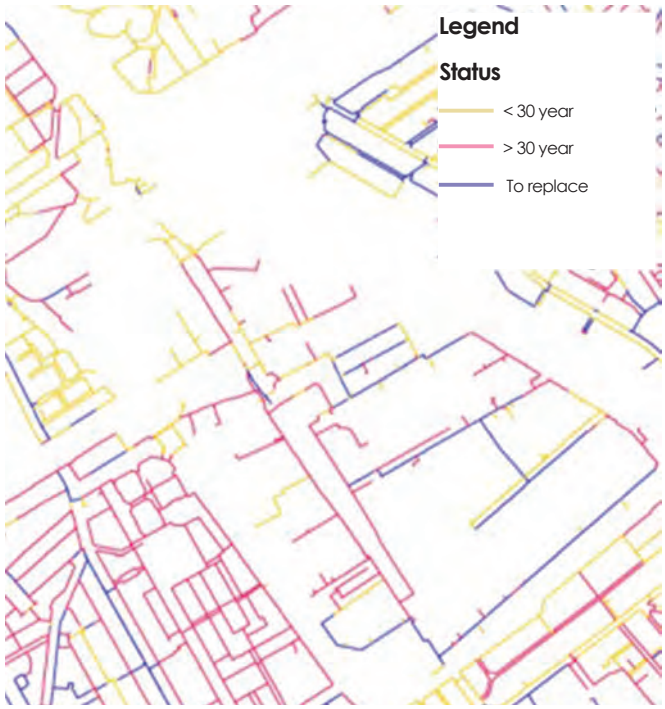


Figure 5.6. Gas infrastructure
Source: RO-Online, 2017

The potential of renewable energy can be considered as high for solar power, according to ZonAtlas. The large part of the roofs on the Binckhorst are suitable for solar panels and solarpower generation, since the radiation of the sun is considered high on these roofs (Zonatlas, 2017). Furthermore, potential of biogas generation from biomass is considered low to average (RO-Online, 2017) and the potential of geothermal heating is considered as average for the Binckhorst (RO-Online, 2017).

Figure 5.7. Energy labels
Source: RO-Online, 2017

Figure 5.8. Potential solar panel roofs Binckhorst
Source: Zonatlas, 2017

5.1.3. Resources in the Binckhorst

Superuse Studios and the municipality of The Hague have started a metabolic analysis of the Binckhorst. This metabolic analysis is based on secondary data collected from regional data sources. The analysis is limited to organic and inorganic resource flows through the area. In order to start the calculations of the metabolic analysis, the activities of the companies are divided in the following sectors:

- Nutrition and natural stimulants
- Car sector
- Wholesale and resale businesses
- Transport, storage and mail
- Waste treatment
- Food service industry
- Services
- Energy
- Construction sector

Altogether, these sectors account for 8967 full-time equivalents employment in the Binckhorst. The total flows in volumes are displayed in figure 5.9. Superuse Studios estimates that the waste treatment counts for 65% of the total volume in- and outflows in the Binckhorst. The food service industry takes most of the organic flows (food and beverages). Finally, the environmental impact and the economic impact are quantified in this metabolism analysis (Gemeente Den Haag, Superuse Studios, 2016).

The metabolic analysis concludes with the following remarks: the data used by CBS (central bureau of statistics) and the data provided by the municipality were not sufficient for achieving a precise image of the employment of the Binckhorst. Furthermore, there is a need for more exact registration of data of employment and material flows on a company level for implementation of closed loop options in practice. Finally, according to the analysis, the rest flows are currently unused, and these flows have a negative impact and it costs money. Using the rest flows will create additional value to the plot. The Binckhorst has a CE potential of €20 million on a yearly basis (Gemeente Den Haag, Superuse Studios, 2016).

The metabolic analysis of the Binckhorst provided insights in the types of flows coming in and going out of an urban area. However, Jongert (int., 2017) stated in the interview that around 20% of the calculated flows in the Binckhorst correspond to reality. This is due to the outdated and inaccurate databases of the public authorities and registration of data. Additionally, it remains unclear where and on what time resources are released. Thus, the total yearly resource flow is an estimation of reality, while data the time scale and geographical location of these resources are lacking.

The proposed step is to create a platform that contains the right level of detail for MEFA (Jongert, in., 2017). Therefore, the choice is made for a second analysis to provide the level of detail for implementation in practice. Since the policy of the municipality is for organic development and no strict policy measurements are veneered for the companies. A starting point for analysis on company level is done to investigate further implementation.

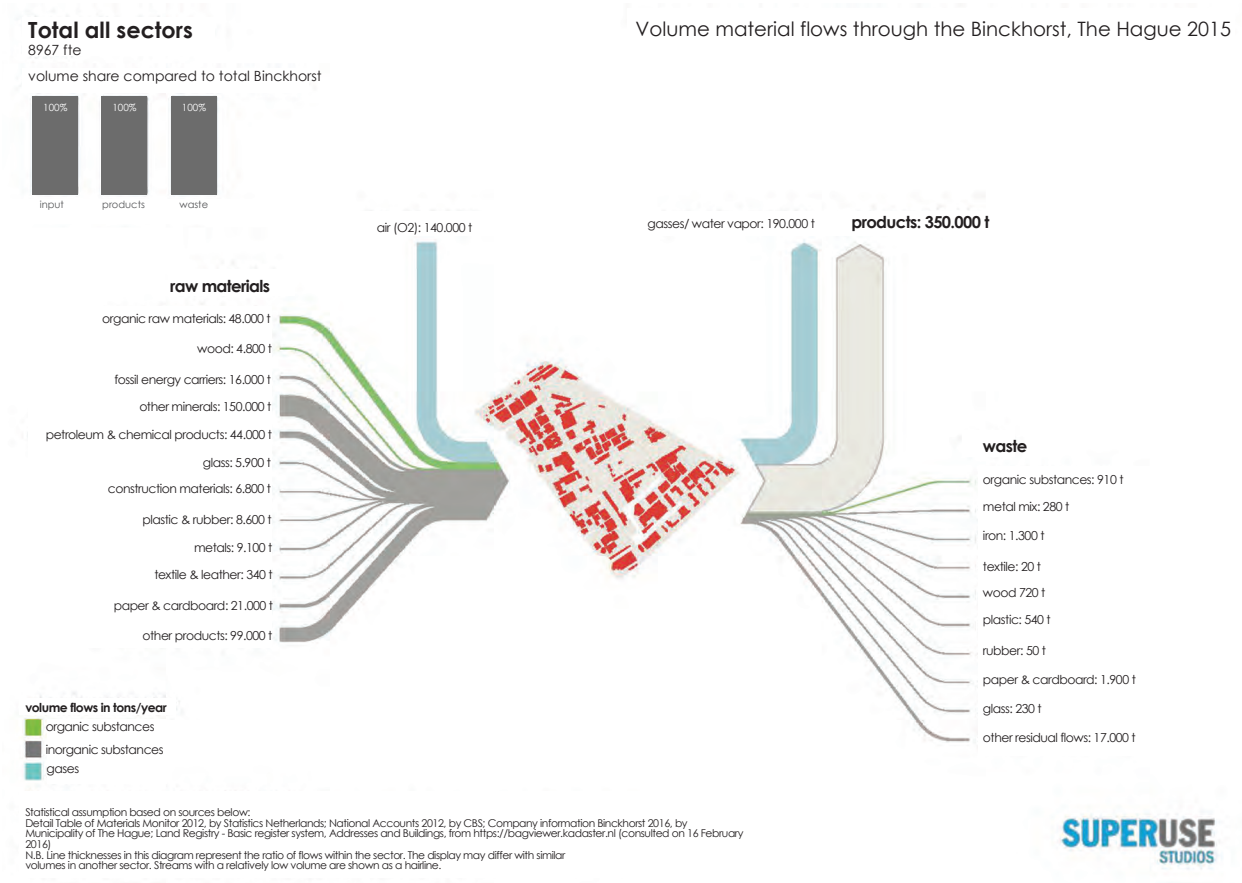


Figure 5.9. Flow analysis Binckhorst. Source: Gemeente Den Haag, Superuse studios, 2016

Referring back to the CUAD framework, the metabolic analysis can be categorized as a MFA on meso-level: it analyses the flows on inter-firm level and researches the possibilities of exchange of resources. However, the level of detail concerning the temporal scale and scale of operations lacks insight in possible closed loop interaction among firms concerning resource flows. Seasonal differentiation in resource flows are not indicated. Furthermore, the category 'products' in the different sectors are not specified, leaving a gap of knowledge of what these products contain and how these products are assembled. The quality of the categorized products, such as 'wood', 'plastic', etc. remains unknown, the same accounts for the form of these products.

Another point is the different flows coming in and going out of the urban area. As indicated in the CUAD framework, analyses of MEFA are needed on all different levels, since interaction of these levels can be possible. E.g. rainfall can be considered a flow coming from the macro-level in the Binckhorst. A MEFA has to consider this flow, that can have possible meaning for stakeholders on micro-level and the other way around. The CC model does not provide significant insights in closing the loops, since the differences of the layers have minimal geographical and technical meaning. E.g. closing loops on regional levels and peri-urban areas do not lead to significant different technologies or geographical locations.

A last point is considered to the companies operating in the Binckhorst. Superuse Studios & gemeente Den Haag (2016) modelled three companies more in depth with a shorter time scale, smaller scale of operations and resources more specified. One of these companies is KPN with a large office building of around 4000 employees. After the research was finished, it became clear that KNP will move the office to another location, outside of the Binckhorst (AD, 2017). These dynamics are difficult to predict, whether specific flows will remain in the Binckhorst or do not fit in the visions of the municipality. The same accounts for future flows that are not present in the current analyses.

5.1.4. Economic experience

The working subparagraph focuses on the business activities of the Binckhorst, including the industrial activities.

The Binckhorst has some remaining large industries, such as a paper recycling factory, concrete plant and asphalt plant. The Binckhorst was well-known for the car-breaker yards (fig. 5.12). However, since the municipality of The Hague initiated The master plan for reorganization of the Binckhorst, the car-breaker yards had to be removed from the Binckhorst. This was done by the municipality that bought large properties in the Binckhorst (Omroep West, 2014). There are three large buildings that contain a collection of small businesses. This is the former Caballerofabriek (fig. 5.10), an old cigarette factory, the former PTT-building Binck 36 and the Besturing, a collection of art studios (Gemeente Den Haag, 2017). The industrial insurance board BLF is an interest group for the companies in the Binckhorst, Laakhaven and Fruitweg. They come up for common interest and individual interest of the companies in the new destination plans of the municipality (I'm Binck, 2017). The economic experience of the Binckhorst is highly diverse. This is due to the multiple transformations of the business area. Some old businesses remained and new were added. This makes the area currently a composition

Figure 5.10. Caballero factory
Source: Cabfab, 2017

Figure 5.11. Graveyard St. Barbara
Source: Reliwiki, 2009

Figure 5.12. Car industry Binckhorst
Source: DeZon, 2017

of a graveyard (fig. 5.11), motorcar paint shop and printing offices (HaagsIndustrieelErfgoed, 2017). Half of the businesses consists of offices in the Binckhorst, the rest is working spots, retail, showrooms and industry (Den Haag, 2017). The different industries and businesses caused heavily polluted ground in the Binckhorst. In specific, the gas factory leaked toxic substances in the ground for decades. Soil decontamination of the Binckhorst to prepare the ground for other purposes (e.g. preparation for construction of residential units) is estimated as highly costly (HaagsIndustrieelErfgoed, 2017).

The Binckhorst contributes to The Hague economy since it is an industrial area. Besides this, the Binckhorst provides around 10000 job positions for the area. Therefore, the Binckhorst has a regional function for industries and the manufacturing industry in the region (Gemeente Den Haag, 2011). The Binckhorst has a few facilities and companies active in the food service industry since there is little to no demand for these facilities from other companies.

The development of the Binckhorst occurs gradually and therefore it is important that the entrepreneurs and companies are aware of the plans of the area. The businesses on the Binckhorst are mainly active in the service industry. This is followed by construction segment, wholesale and retail trade and industries (Gemeente Den Haag, Superuse Studios, 2016). Since the Binckhorst is an industrial/business area, there is little exchange and interaction among the businesses and industries.

Currently the vacancy of office buildings is 30%. This has two causes: large office users in the area KPN and the ministry of defense shrunk their office employment. On the other hand, office users have more flexible office work. Therefore, offices are less rented, and more offices are empty. Most of the vacant offices are around the office of KPN, soon to be transformed in residential units. The risk is that the amount of vacant offices will increase in the future (Gemeente Den Haag, 2016).

5.1.5. Mobility and infrastructure

The mobility and infrastructure as described in this paragraph, is the physical infrastructure for transport of goods and people. Thus, this is mainly roads and waterways, since the Binckhorst includes a large port that is used for transport.

The accessibility to Binckhorst is part of the 'Rotterdamsebaan' project (fig. 5.14). The Binckhorst is part of the central zone of The Hague city and therefore fulfils an urban function. The Rotterdamsebaan is the new connection between the intersection Ypenburg and the center. This road will be connected by a tunnel to the highway the A4 at the Binckhorstlaan. The construction of the Rotterdamsebaan is of great need for improvement of the accessibility of the city center and the region.

The Binckhorst will experience benefits from this new infrastructure and it will form new possibilities for the transformation from only industrial area to a mixed urban environment with living and working areas. The Rotterdamse-baan is of influence on the current infrastructure of the Binckhorst, due to large construction activities (fig. 5.13). A large bicycle path will be realized next to the Trekvliet, that connects the Binckhorst with the rest of the city. Due to the development of the Rotterdamsebaan, buildings at the Binckhorstlaan will be demolished. These areas will be sold to property developers (Gemeente Den Haag, 2011).

Figure 5.13. Rotterdamse Baan
Source: Omroep West, 2016

The Binckhorst has one bus line running through the area as the connection with public transportation.This bus line is not running during the weekends. Transport occurs mainly through cars, trucks and by boat over the water (Gemeente Den Haag, 2011).

Figure 5.14. Future Rotterdamse Baan
Source: Den Haag Direct, 2014

The Binckhorst includes three ports: the Poolsterhaven, the Fokkerhaven and the Binckhorsthaven (fig. 5.15). This gives the Binckhorst a watery and industrial outlook. According to the municipality, the main character of the Binckhorst will be industrial and commercial activities. Some assigned sites will be a mixture of living and working. The other sites will have the destination plan of commercial activities. The Poolsterhaven will be in the short term as a temporary storage space for touring vessels. Next to the storage space, initiatives for nautical activities can occur. Due to the commercial activities around this port, the area around the Poolsterhaven will not develop in a mixed living-working area. The area around the Fokkerhaven will develop as a mixture of living working area in combination with services, recreation supplies and green creation around the port. The area around the Binckhorsthaven will mainly remain for industrial and commercial activities in the short term and aim for a multifunctional urban area in the long term (Gemeente Den Haag.b, 2016).

Figure 5.15.Binckhorsthaven
Source: Studio Leon Thier, 2016

5.1.6. Public space

The public space in the Binckhorst is little present. This is due to the business and commercial activities. However, there is potential present for development of green areas and water rich areas. Currently, the Binckhorst port is only used for commercial activities and not taken up as part of the public space (Gemeente Den Haag, 2011). The castle has little green around the building. However, the castle is behind an office building and therefore not visible from the Binckhorstlaan (Gemeente Den Haag, 2017). There are ideas generated for creating green zones in the Binckhorst. Further elaboration on these plans will be found in the backcasting analysis results.

5.1.7. Households

At the Binckhorstlaan, there is one apartment block for residential purposes. Approximately 300 people live currently in the Binckhorst (Gemeente Den Haag, 2011).

For living, 5000 houses can be realized in the Binckhorst (fig. 5.16). These houses will be planned in the following areas: 1000 houses in the Trekvlietzone. This is the west part of the Binckhorst, at the Binckhorstlaan. Another 1000 houses will be built at the Maanweg. 300 houses will be realized at the SDU area. For the remaining 2700 houses, there are possibilities at the Trekvlietzone with another extra 1700 houses and 1000 houses around the Saturnusstraat. The houses will be mixture of condominiums, private renting and social renting (Gemeente Den Haag, 2011).

Figure 5.16.Planned residential units
Source: Omroep West, 2016

The first residential units are currently constructed in the Junoblok, Binck Island, Maanplein (former KPN offices) and Kavel – 1 (Gemeente Den Haag, 2017). As one can see on the map, the residential units are mainly currently constructed in the south part of the Binckhorst (fig. 5.17). These projects will not conflict yet with the existing industries, operating more to the north of the Binckhorst. However, nuisance and conflicts are expected in the future between the residents and industrial units.

Figure 5.17. Construction of residential units
Source: Google maps, 2017

Since the residential units will provide housing to a substantial number of residents, it is expected that this will influence the demands of the physical environment (public space) and facilities of the Binckhorst. Residents have different demands from the environment compared to operating businesses or industries.

5.2. MEFA

This paragraph accounts for the description of the flows in the Binckhorst. This is for resource flows as well as energy and water flows. As explained in the UM, the level of detail needed for MEFA depends on (1) research goal and (2) targeted resource (Voskamp et al., 2016). The level of detail refers to the (1) time scale and (2) scale of operations. E.g. decisions for policy, based on resource flows need an analysis on regional level with a yearly time scale. Decisions for individual companies need an analysis on local level with a monthly time scale. An analysis of the existing metabolic analysis is given. This MEFA aims to provide insights to use the data of resource and energy flows in practice.

5.2.1. MEFA Kompaan

Kompaan is a brewery, located on the Binckhorst. They started brewing beer in 2012 and won the Dutch beer challenge in 2017. This leaded to an exponential increase of demand in Kompaan beer. The location on the Binckhorst includes the brewery and a restaurant/bar where people can drink a beer or eat dinner (van Ditmarsch, int., 2017). The restaurant of Kompaan is out of scope for this analysis, due to the complex streams of different organic flows and variation in these flows. Besides this, Superuse Studios was in possession of data for the MEFA analysis of the brewery process of Kompaan. This is used in order to create the overview.

Goal and system definition

The geographical boundaries of the Binckhorst are taken as a system boundary. Thus, the products for Kompaan brought to the location are taken as an inflow. Kompaan is used as a starting point. Kompaan is added to the program Vensim to include a complete overview of resource inflows and outflows. In the program Vensim, units per flow and equations per variable and flow can be added. If this is done by the company, calculations can be made if production increases with x amount, the waste flows increases with y amount. The waste, taking up by waste processing companies, leaving the Binckhorst is again the system boundary. The same accounts for import and use of energy.

The goal of the MEFA is to gain insights in possibilities of applying CE strategies for closing, slowing and reducing loops of resources and energy.

Figure 5.18. Energy flow analysis Kompaan

Process chain analysis
The process of beer production uses energy in forms of electricity and heat. The correlating image of energy usage is made in figure 5.18.

The following table includes the quantified input and output for 50 liters of beer. The proportion is filled in the Vensim model for Kompaan.

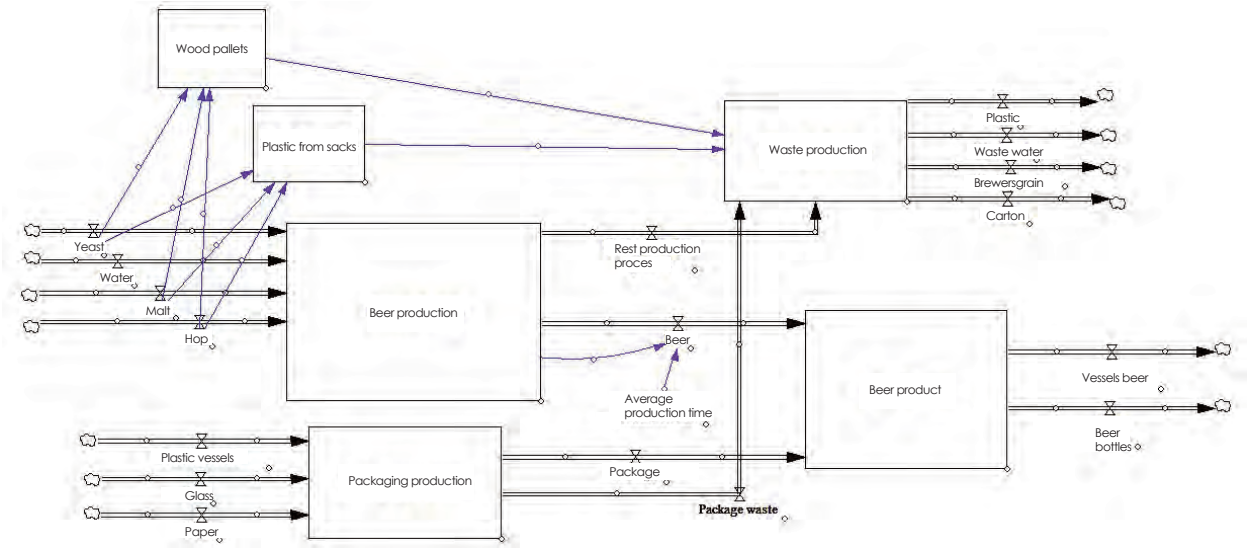


Figure 5.19. MFA Kompaan beer production

Accounting and balancing
After an analyzation of the model, one can conclude there are several potential waste flows (table 13):
- Plastic
- Brewers grain
- Waste water

Brewers grain can be an ingredient for the production of bread (Lindemann, int., 2017). There is a bakery operating on site: Maison Kelder. This model determines the outflow of brewer's grain that can be as a source of income for the bakery. The production of beer determines the outflow and the possibility of how much bread can be baked on this type of outflow (Jongert, int., 2017).

Product in	Amount	Unit	Source
Malt	10	Kg	Jongert, 2017
Yeast	0.02	Kg	Jongert, 2017
Water	125	Liter/kg	Jongert, 2017
Plastic sac	0.015	Kg	Val-I-Pac, 2009
Packaging	3.75	Kg	Val-I-Pac, 2009
Propane gas	9.3	Liter	Jongert, 2017
Electricity	0.828	kWh	Jongert, 2017

Table 13. Overview of products in

Product out	Amount	Unit	Source
Brewers grain	10	Kg	Jongert, 2017
Yeast sludge	0.06	Kg	Jongert, 2017
Water	75	Liter/kg	Jongert, 2017
Plastic sac	0.015	Kg	Val-I-Pac, 2009
Packaging	3.75	Kg	Val-I-Pac, 2009
Waste heat	-	-	Unknown

Table 14. Overview of products out

Excess of water used for the processes is currently drained in the sewage. Another company can use this water, since this water is not contaminated with other substances. Some water is reused for cleaning the tanks after the brewing process. However, not all water can be used for this and is therefore drained in the sewage (van Ditmarch, int., 2017). Infrastructure is needed to transfer the water to another company for utilization.

Plastic is not collected in the municipality of The Hague. Therefore, for each 50 liters of beer, 3.77 kg of plastic package materials (if the beer is packed in a vessel) is incinerated. In the past years, plastic separation increased in The Netherlands. This is since most plastic was incinerated. However, plastic is a resource that can be recycled. In line with the policy goal of implementing CE in The Netherlands, the aim is to recycle and reuse plastic where possible (KIDV, 2016).

This model provides insights in data of flows that can be reused by other companies on a meso-level. Companies that can use these waste flows as input for their business model can be introduced to the Binckhorst or companies on site can be searched and links can be made between these companies. In order to increase circularity in the Binckhorst, a complete analysis is needed on multiple levels. The interaction of flows of businesses with flows of residents or public space can lead to more possibilities. The same accounts for involving the macro-level.

Exchange of resources requires a relationship of trust, long-term planning and investments in infrastructure (Gibbs, 2008). The MEFA accounts for the theoretical possibilities of different flows. The stakeholder analysis will provide insights in the underlying socio-economic system with all parties involved.

5.3. Stakeholder analysis and dynamics

The following steps are executed for collecting the information of stakeholders. First, (1) the stakeholders are identified with data collected from desk research and expert interviews. (2) the stakeholders are categorized according to the power-influence diagram. Lastly, (3) the relationships are pointed out between the stakeholders.

5.3.1. Identifying stakeholders

This chapter elaborates on the identification of the stakeholders. The stakeholder groups are categorized according to the scheme of Bryson. Table 15 presents the stakeholder groups currently involved in the Binckhorst.

Public sector	**Private sector**	**Social Domain**
• Dutch national government • Metropolitan area The Hague - Rotterdam • Municipality of The Hague	• Project developers • Housing corporations • Investors • Small and medium enterprises of the Binckhorst. • Interest group for companies and industries for the Binckhorst • Constructing companies • Architects • Waste processing companies	• (Future) residents
International organizations	**Knowledge institutes and sience**	**Interest groups**
• European Union Horizon 2020	• HaagseHogeschool • TU Delft • Leiden University	• Non-profit organizations that work related to the Binckhorst

Table 15. Stakeholders overview Binckhorst

Dutch national government
In line with the directives of the European Commission, the Dutch government aims for implementation of a CE. The Dutch government launched the programme Nederland circulair in 2050 (The Netherlands circular in 2050) in September 2016. On the 16th of April 2017, the kick-off produced the transition agendas for the five themes: biomass and nutrition, plastics, production industry, construction sector and consumer goods (Circulaire Economie Nederland, 2016). The transition agenda will separately function as a pathway to contribute to the first and second goal of the program. The transition agendas for the themes construction sector and consumer goods are specifically relevant for the notion of CUAD. As explained in the policy overview in the literature review, the Dutch government initiated the Green Deals as packages where municipalities, private parties and other public parties can subscribe themselves for setting shared ambitions and exchange knowledge. A few of these Green deals are applicable to the Binckhorst, such as Cirkelstad.

Additionally, the Dutch government is involved in the development of the Rotterdamse Baan (Rijkswaterstaat). The Dutch government is in general partly responsible for legislation concerning housing and housing standards, employment and infrastructure. The execution of plans is the responsibility of the municipality, however, overarching policy and developed standards is done by the national government.

Metropolitan area Rotterdam – The Hague
This collaboration is mentioned due to the Roadmap Next Economy. This agreement aims for collaboration in the region, in specific for CE (Metropolitan area Rotterdam and The Hague, 2016). This stakeholder can be of significant relevance concerning exchange of knowledge. The port of Rotterdam has executed MEFA to determine possibilities and challenges for exchange flows (Fabrications, 2014). This can provide relevant information or collaborations with areas, such as the Binckhorst.

Municipality of The Hague
The municipality adopted different roles in the Binckhorst and is involved in multiple roles as a stakeholder. As mentioned in multiple expert interviews, the role of the municipality of The Hague is multifaceted and therefore unclear and contradictive (Kwakkel, int., 2017; Brouwer, int., 2017).

The municipality of The Hague as estate owner in the Binckhorst. The municipality bought a significant part of the ground of the Binckhorst for redevelopment (StichtingHaagsIndustrieelErfgoed, 2017). The current strategy is to sell ground to small project developers for construction of residential units (Gemeente Den Haag, 2017).

The municipality as director for increasing mobility in the city of The Hague. This is done in practice in the Binckhorst with the construction of the Rotterdamse Baan in collaboration with the national government (Gemeente Den Haag, 2011). Furthermore, the municipality is responsible for public transportation, other types of infrastructure (e.g. bicycle paths) in the area and the public space.

The municipality as facilitator with local projects in the Binckhorst and stimulator of employment (Gemeente Den Haag, 2011). This describes the facilitating role of the municipality in the development in the new destination plan. The municipality gives preference for private initiatives that contribute to quality increase of the Binckhorst. This can be in forms of improvement of the environment, stimulating employment, intensification of use of space, renewable energy initiatives, etc. (Gemeente Den Haag, 2017). A significant part of the population of The Hague is middle to lower educated (Kwakkel, int., 2017; Lindemann, int., 2017). The municipality has a responsibility to provide employment and housing for this segment of the population.

The municipality as policy maker, including visions for The Hague in the future. Besides contributing to the national goal of 100% CE in The Netherlands in 2050 and the City Deal Next Economy, The Hague set the goal to be climate neutral in 2040 in the policy document 'Klimaatplan Den Haag'. The document 'Circulair Den Haag' is formed by University of Leiden, TNO and Circle Economy. This is a first identification of a MFA of the municipality to gain insights of a starting point for the transition. It displays the largest resource streams in the municipality of The Hague (Circulair Den Haag, 2016). Furthermore, the municipality is executor of national policy, formulated by the government and province.

Project developers
The municipality of The Hague decided to put the development of the residential units to different project developers. Therefore, the integral urban development of the Binckhorst does not exist anymore and is done by different market parties. The velocity of the development is depending on the project developers and the tenders of the municipality (Gemeente Den Haag, 2011).

Some project developers currently involved in the Binckhorst are Stebru (van Boxtel, 2017), BPD (I'm Binck, 2017), AM, De Mannen Van Schuim and Amvest (Binckhaven, 2017). Project developers of the Binckhorst are members of the Vastgoedsociëteit Haaglanden, as a collective for real estate professionals (vshaaglanden, 2018). As indicated before, the first housing projects are planned. It is estimated that the 5000 residential units will be constructed by 2035 (Gemeente Den Haag, 2017).

Architects
Architects received increased attention as stakeholders in the Binckhorst due to the development of the residential units in the area. A symposium was organized in the beginning of 2017 with 250 key stakeholders from the real estate sector. In collaboration with the project developers and housing corporations, the residential units will be designed (Binckhaven, 2017).

Non-profit organizations
The Optrek is a mobile project office that creates together with the inhabitants of the Binckhorst impulses for development of the area. The existing qualities and potential of the area and the involved businesses is the starting point. It became active in 2011, since the plans for redevelopment of the Binckhorst stopped in 2008. The interaction among businesses increased to unite against the large development plans of the municipality. The businesses did not feel represented in the redevelopment plans. The projects of the OpTrek consist of three building blocks: interactions, research and reflections. The interactions happen with the inhabitants of the Binckhorst, the entrepreneurs, the municipality of The Hague and other stakeholders. Research is done in collaboration with the HaagseHogeschool and Technical University of Delft (OpTrek, 2017).

Resource City is a project of the OpTrek and one of the initiatives, mentioned in the 'Roadmap Next Economy' as potential to realize CE (Metropolitan Region Rotterdam and The Hague, 2016). Resource city is a bottom-up initiative to empower the economic, social and cultural aspects of the Binckhorst. It aims for creating new connections between local craftsmanship, knowledge, resources and external expertise.

I'm Binck is since 2011 an independent initiative from entrepreneurs of the Binckhorst that are actively involved in the development of the area. It makes the existing prosperity such as entrepreneurship, craftsmanship, innovation and culture visible with monthly network meetups and a yearly festival (I'mbinck, 2017).

Businesses and industries
The businesses and industries are discussed in section 5.1. A list of current businesses and industries was provided by the municipality. The list was checked, and a significant part was not present on the Binckhorst, due to movements or bankruptcy. In the past decade, the collection buildings were added to the Binckhorst, attracting small and medium enterprises from the creative industry. Businesses have generally a higher throughput, compared to residents, leading to fluctuating types of businesses and correlating flows. The focus of the municipality is to attract businesses from the creative sector, manufacturing sector, service sector and handcraft sector. The municipality provides place for 'mixed concepts' of business activities combined with residents, sports, offices, leisure, etc. (Gemeente Den Haag, 2017).

BLF is the collective association of the Binckhorst, representative for the existing businesses. This organization received increased attention when the master plan was dropped in 2007.

Waste processing companies
This group consists of a few companies active in the area. There are four waste processing facilities on the Binckhorst, such as HMS, AVR and Reparco. It depends on the contract of the company with the waste processing company, who is treating the waste. For example, waste processing company van Ganzewinkel and Omega are mainly active on the Binckhorst, while their facilities are situated somewhere else in The Netherlands. An illustrative example is the Caballerofabriek who has the paper waste contract with van Ganzewinkel, while the office building is located next to Reparco, which is a paper recycling facility (Brands, int., 2017).

Waste collection of businesses falls under different legislation, compared to waste collection from residential units. The waste from residential units are in possession of the municipality (Brands, int., 2017).

Constructing companies
A few major constructing companies are active in the Binckhorst with for example the construction of the Rotterdamse Baan. This is done by BAM (BAM, 2015).

Future residents
Currently, approximately 300 residents live in the Binckhorst. This will be strongly increased in the coming decades. However, no current residents can specifically be pointed out yet. They will receive increasing importance in the future.

Knowledge institutes
The knowledge institutes, TU Delft, Leiden University and HaagseHogeschool, are involved in center for innovation and other research projects. For example, a list of circular initiatives of The Hague is made by a group of students of the Hogeschool The Hague (Brouwer, int., 2017). Other classes (engineering for sustainable development) from the TU Delft do research to engineering assignments in the Binckhorst.

European Union
The European Union wrote directives concerning implementing the CE that are applicable for the Binckhorst. An overview of all CE policy can be found in the literature review of chapter 2.

5.3.2. Differentiating between and categorizing stakeholders
The categories mentioned in the previous paragraph are put in the power-influence diagram. Their location in this diagram is based on a literature study of policy documents of the municipality and interview results from the experts. The diagram is presented in figure 5.20. The motivations of the locations of the stakeholder groups are discussed below.

The municipality of The Hague is identified as key stakeholder by multiple experts (Louwaars, int., 2017; Brouwer, int., 2017; Jongert, int., 2017; van Boxtel, int., 2017). This is confirmed by literature (Gemeente Den Haag, 2017). This is the reason for the placement of the stakeholder in the upper right corner. As Kwakkel (int., 2017) states in his interview, the municipality owns a large part of the ground. This makes the municipality a unique stakeholder. The exact division of ground in the Binckhorst is further given in paragraph 7.4.

Project developers, as well as architects and housing corporations are put high on the diagram. This is due to the 5000 residential units that will be constructed by 2035 (Gemeente Den Haag, 2017), the symposium organized for key stakeholders from the real estate sector (Binckhaven, 2017) and the experts confirming the role of project developers (Kwakkel, int., 2017; Louwaars, int., 2017; van Boxtel, int., 2017). Therefore, the project developers have currently relatively high interest and stake in the Binckhorst.

Currently, the Rotterdamsebaan is constructed. This received increased attention in the land-use plans of the municipality in 2011 and 2017. The highway is highly relevant for connecting the city center of The Hague with the A4 (Gemeente Den Haag, 2017), although the highway is of lower interest for the Binckhorst itself. It includes currently inconvenience in the connectiveness of the Binckhorst and existing businesses at the Binckhorstlaan are affected by it (Den Haag, 2017). The active construction companies have therefore relatively low interest and medium power since they received the acceptance for the work and are the executive party.

The Dutch government has some power concerning policy and ambitions concerning CE and the Green deals (Circulaire Economie Nederland, 2016; Green deals, 2017). However, the interest of the Dutch government specifically in the Binckhorst is considered low since no specific national policy is written concerning the Binckhorst.

The residents have a low interest and power, since it is not clear who will be the future residents of the Binckhorst. The first residential units will be ready by the end of 2018, as indicated in the analysis of the household theme in section 5.1. From this moment onwards, the residents will become more interested and will increase in its power (Binckeiland, 2018).

Multiple universities and academies are interested in the Binckhorst as a point of research and involvement by other stakeholders, such as in the case of the center for innovation district (Gemeente Den Haag, 2017). Or other engineering classes and assignments made by students. Therefore, their interest is considered high, while their power is considered low as it remains unclear what will be done with research results.

Businesses on the Binckhorst cover the large part of the area. The area is historically seen as a more industrial/business area (HaagsIndustrieelErfgoed, 2016). The businesses vary from character with businesses active in the waste processing industry to creative designers in the Caballerofabriek (Gemeente Den haag, Superuse Studios, 2016). The current land-use plan of the municipality indicates to attract companies functioning in the new economy with high innovative and creative ideas, companies in the service sector, painting companies and handicraft companies (Gemeente Den Haag, 2017), while more polluting companies have to leave the Binckhorst. Therefore, the interest of these companies is considered high since most of these companies are present on the Binckhorst for a longer time and it is an attractive location for establishment. However, their power is relatively low since the municipality can decide whether they fit in the new destination plan of the Binckhorst. Finally, the future residents will demand specific economic experience related to facilities such as small shops. This will influence the types of economic experience.

The industries have lower power compared to the companies, since industries tend to conflict with residential units (Gemeente Den Haag, 2017). It is expected that some industries, such as the concrete plant and paper recycling facility will have to leave when the residential units are finished.

The non-profit organizations are organized to increase cohesion among the businesses and industries (Lindemann, int., 2017) and to protect existing industrial character of the Binckhorst (Havelaar, int., 2017). Network meetings are organized to meet other businesses and exchange knowledge (Lindemann, int., 2017). These non-profit organizations have a relatively high interest in the area, also since they represent the current businesses and industries. However, they lack in decisive control in the area.

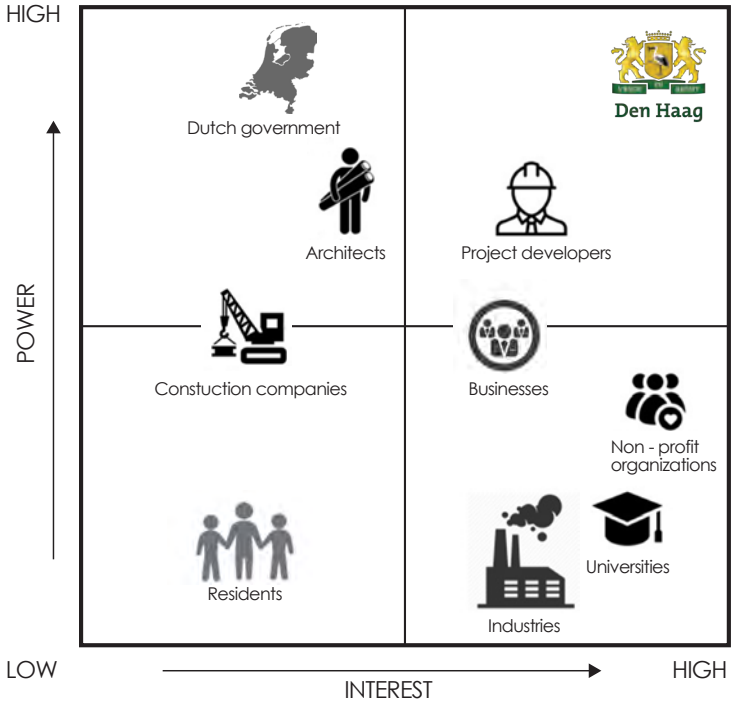


Figure 5.20. Power-interest diagram

5.3.3. Investigate relationships between stakeholders

The dynamics between the stakeholders are visualized with the program cmap. The information and relations among the stakeholders are based on input from experts, as well as policy documents.

The municipality of The Hague is visualized with its four core roles in the Binckhorst. As one can see is that multiple stakeholder groups are around the multiple roles of the municipality. Example given: whereas businesses rent their place from the municipality, they depend as well on the municipality concerning legislation. However, in return the municipality depends on businesses and industries for employment in the area in order to make it an attractive area to work and live. These multiple faces of the municipality make it a highly complex stakeholder that can work in a contractionary way.

The multiple roles of the municipality are expressed in the Environment and Planning Action plan for the Binckhorst (2017). Additionally, the roles of the municipality change over time. Whereas the municipality had a facilitating role in the development of different businesses and residential units in 2011 (Gemeente Den Haag, 2011), the controlling hand of the municipality is more expressed in the latest plan (Gemeente Den Haag, 2017).

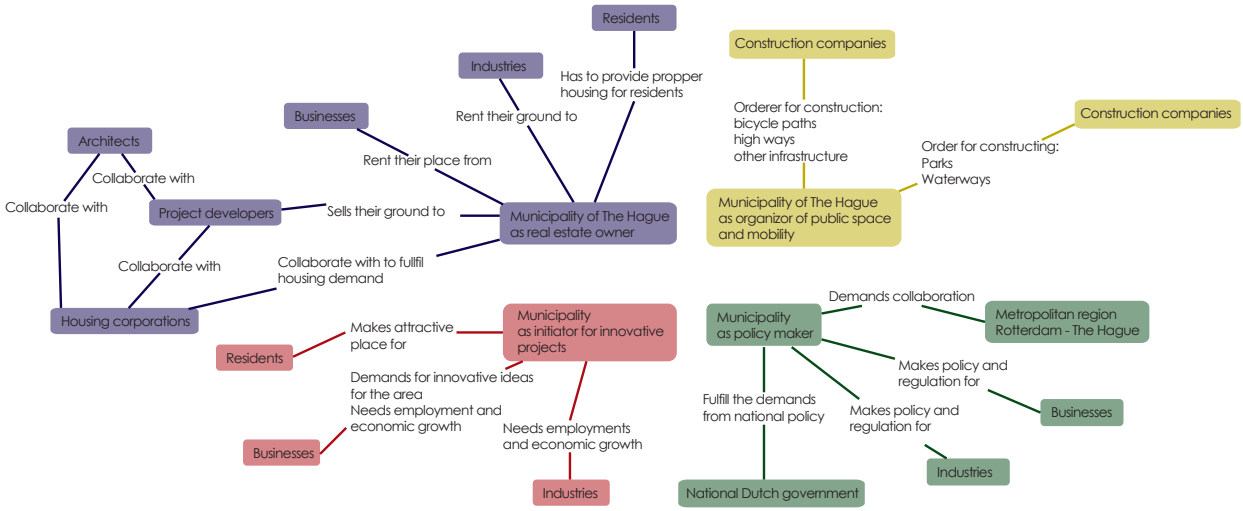


Figure 5.21. Knowledge mapping of the stakeholders

5.4. Conclusion

This chapter aims to create current overview of the Binckhorst and the planned developments. The description of the Binckhorst is done according to the CUAD. All the themes of this framework are part of implementing circularity, since circularity affects mobility and public space as well. The description of the urban planning entities showed some overlap with the MEFA as well as the stakeholder analysis. Information concerning the business and industry stakeholder group, was already mentioned with the economic experience description. In other words, the introduced entities showed significant overlap, leading to a less structured overview.

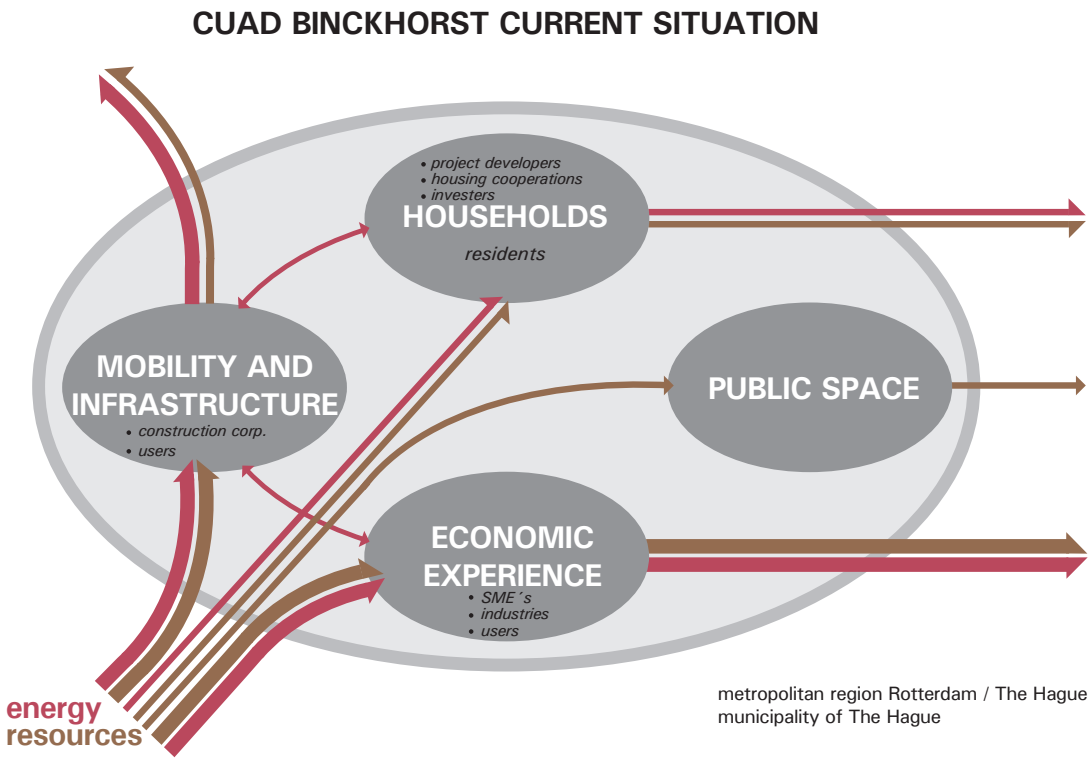


Figure 5.22. CUAD current situation Binckhorst

The MEFA is done for one operating business in the Binckhorst. A choice is made to analyze an operating business on site. This is due to the fact that the current businesses have the largest inflow and outflows concerning materials and energy, since they occupy a major part of the area. Observing the flows (schematic representation of the size of the flows) in the Binckhorst in figure 5.22 shows that economic experience has the largest input and output in the area. The mobility and infrastructure have a high input, due to the construction of the Rotterdamse Baan. The resources remain in the area for infrastructure. The energy is mainly going through the area by the users of this entity in the Binckhorst. The pubic space is a relatively small area, accounting for rainwater flows going in and leaving the system. There is hardly exchange among the different entities and the flows come in and leave the Binckhorst in almost a balance.

The level of detail from the analysis of Kompaan is on micro-level. Some flows, for example recycling of plastics will be collected on the larger scale, following the lines of economies of scale. This level of detail is not modelled in the CUAD framework. A few suggestions can be made, based on the insights from the MEFA.

The framework of CUAD demands for a socioeconomic overview, that is provided by the stakeholder analysis. The stakeholder analysis identified groups of current stakeholders. With data from expert interviews and policy reports, their power and interests in the Binckhorst are mapped and their network dynamics are described. The review of policy documents indicates that roles of stakeholders, in specific the municipality changes over time. However, figure 5.22 is a static image of current stakeholders. As one can observe in the overview is that the household entity currently involves several stakeholder categories since the construction is currently planned. However, this activity is not seen back yet in the flows.

With the developments planned for the (near) future, this stakeholder image will strongly shift (as well for the correlating resources). The stakeholders in the (near) future remains unclear, since the development and transition of the Binckhorst is still for most part in the planning phase. Another insight is that the future development brings uncertainty for the current stakeholders and their dynamics. It is expected that mainly industries and businesses are not certain of their role in the Binckhorst. Concluding, the stakeholder analysis provides some insight in the current socioeconomic situation, however, major changes will occur and change this stakeholder field and dynamics.

Different levels of detail

This analysis is executed on micro-level; however some flows occur on meso-, or macro-level. As stated in the theoretical framework, implementing CE leads to a recycling-oriented society. This accounts for the Binckhorst as well with the ambition of the Ministry of Infrastructure and Environment and association of Dutch municipalities is to decrease household waste from 250 kilograms per inhabitant to 100 kilograms per inhabitant in 2020 (VANG, 2017). These levels need to be taken into account as well.

Another suggestion is that figure 5.22. displays flows of energy and resources to and from an entity. Modelling a specific resource through the area can provide additional insights in closing loop opportunities. E.g. modeling of water flows can be executed for analyzing where the most water is used and how water can be reused on the different levels. Same counts for flows of energy.

Other disciplines for further insights
The CUAD framework provides an overview of flows. However, insights in other factors such as legislation and finance lack. This overview can function as an inventory for focus point. This can be followed with questions regarding legislation and finance. What is needed to make it possible to use waste flows. Parallel to this, a step is needed for financial research. What are the costs and benefits of such a system transition in the short- and long term. Another important question is whether it is more an optimization of processes due to the scale of the model, than approaching the area as a whole from a larger perspective. Is it a truly circular transition. These insights can be provided with additional tools such as the LCA.

6. Backcasting analysis of the Binckhorst

This chapter elaborates on the second step 'determination of the desired types'. It is done through the first three steps of the backcasting analysis. Results were conducted through a workshop and expert interviews.

6.1. Review of drivers of change

The review of drivers for change is done with a literature study to (1) determine what drives CE for implementation and (2) what drives in specific The Hague to implement CE. It provides answer to the third question of the framework; 'which factors drive the system?'. The drivers for change influence the current system and will influence the Binckhorst in the future. A distinction is made between external drivers, which can result in reactive measurements and internal drivers of change, which are more proactive (Lozano, 2013).

These drivers are presented in the appendix. The trends are further explained in the table in the appendix and checked with the PESTEL analysis whether all factors from the domains were taken into account. These drivers will influence the Binckhorst and clarify strategies and dynamics of the stakeholders. The drivers are taken up in the formulation of desired scenario themes (6.3) and suggestions for CUAD in the Binckhorst (chapter 7).

With a review of drivers of change, the complexity becomes clear. Additionally, the relationships between different drivers becomes clear and their specific effects in the short- and long term (Kull &Talluri, 2008). These drivers for change are not quantified and it is not clear how they will exactly affect the future Binckhorst. Additionally, the drivers for change can be interrelated with a causal effect or a positive/negative feedback loop.

6.2. Circularity principles

The definition of CUAD given by the expert varies per expert. According to Lindemann (int., 2017), CUAD means that *an ecosystem can be created in the area that activates diversity and movement and makes connections with multiple value creation on economic, ecological and social level.* This is a broad definition that applies to all aspects present in the Binckhorst.

The definition of Brands (int., 2017) is two-folded: *closing the loops with the existing resources and designing side of putting resources in the loop in such a way that it can be reused. This accounts for products as well as buildings. CUAD should be focused on how to get materials in the area and treat them in buildings and products.* This is in line with the definition of Brouwer (int., 2017) who defines CUAD as *products that are used and produced in an environmental responsibly manner with renewable energy and resources that can be reused, after they lost their initial function. The same accounts for buildings that can function for other purposes after losing its initial purpose.*

According to Kwakkel (int., 2017), the definition is *related to CE in a sector or value chain. CE can be applied to each sector. Circularity is about the fundamental questions that leads to transitioning to another system. CE demands for a redevelopment of the system and therefore it becomes a transition question. CE becomes the power of system change and this takes a step further than sustainability. Rethink is one of the most important steps of the CE. It is not per se about lowering consumption, but also about doing it differently by applying different materials or recyclable materials.*

While Louwaars (int., 2017) has more the focus on *metabolism, value chains and streams in an area. Different parties should be working on collective issues to determine the different and shared values of these parties. Value cases should be created, instead of business cases.* The important difference between the definition of Kwakkel and Louwaars (int., 2017) is that Kwakkel (int., 2017) has the focus on a value chain with correlating processes, while Louwaars (int., 2017) considers the geographical location as the system boundaries for circularity. Louwaars (int., 2017) defines in its statement the ongoing process of finding shared values among the different parties in an urban area.

While for Havelaar (int., 2017) CUAD is related to *production of waste by the companies can be re-used in the area. Therefore, waste acquire a new function in the area of the Binckhorst.* The definition of Kokx (int., 2017) is in the same line with the essence that *products circulate in an urban area and it must strive to a balance.* Van Boxtel's (int., 2017) definition is similar: *use the most resources out of the assigned area and use the resources most efficient.* This approach is narrower, focused on the companies and products in the Binckhorst. Van Boxtel (2017) mentions in his definition as well the *dynamics of the companies. Adopting circularity is the new 'networking' with different collaborations and dependencies.*

6.2.1. CUAD principles

The following CUAD principles can be distilled from the definitions:

- The comparison with an ecological ecosystem. An ecosystem is a closed system that does not need support from the outside. The aim of CUAD is that this can function as a closed urban system, inspired by the functioning of natural ecosystems. Thus: **a comparison can be made with the functioning of a natural ecosystem, including value creation on environmental, social and economic dimension.**
- Another important element that is mentioned is the transition towards another system by asking fundamental questions. Summarizing: implementing circularity demands for **system transition.**
- Circularity has the focus on life cycles: a rethink should be done about the waste flows in an urban area. Simultaneously, rethink should be done about the design phase of products or flows. Concluding: **circularity contains rethink of waste as well as product design.**
- Circularity can be applied to the current businesses, as well as residents and functions of buildings (including construction and demolition). Resources that are used by businesses (or residents) should be completely recyclable in the circular perspective. Buildings should be able to have a new function after a

loss of the initial function. Summarizing: **circularity is applied to businesses, residents and buildings.**

- These stakeholders have all different dynamics and new interactions when adopting circularity. Therefore, circularity demands for new collaborations and different network formations.
- Circularity can be applied to value chains, that exceeds boundaries of a geographical location. It observes the value chain that is related to the production, use and disposal of a product. However, circularity can be applied as well in an urban area, including the diversity of exchange between value chains. Thus: **circularity applies to value chains as well as urban areas.**
- The different parties are mentioned with their different values to find common values. This can be done in an ongoing process. Therefore, **circularity is considered as an ongoing process by finding the optimal solutions.**
- Lastly, diversity as a requirement for circularity comes back in each principle. Multiple solutions are possible within circularity with the diverse group of stakeholders. Concluding: **diversity can be considered as a key element in an urban area.**

As a comparison with literature, an increased amount of literature is brought out concerning CE, as Ghisellini et al. (2016) reviewed over 1.000 publications concerning CE. Since the literature is diverse of different principles and strategies overlapping in meaning and definitions (Geissdoerfer et al., 2017), this is shown as well in answers of what CUAD encloses according to the experts.

More specific, comparing the insights from the experts concerning CUAD with theoretical literature, as presented in chapter 2, remarkable is the general notion of CE of the experts. 'Diversity as key element' is a general notion without a clear indicator of what this diversity implies. The 'system transition' is taken up as a feature of CUAD, correlating with the literature review.

The comparison with the Binckhorst as an ecosystem is more similar to SUAD notion and to the conception of CE in Chinese policy. The three R principles – reduce, reuse and recycle - of the theoretical framework are not explicitly mentioned by the experts. Although 'rethink the system' of the Ellen MacArthur Foundation (2015) principle came back in the answer of Kwakkel (int., 2017).

According to literature, circularity can be implemented on different levels (Yuan et al., 2006; Geng et al., 2012). The distinction between these levels do not come out in the principles mentioned above. Circularity is mentioned here around items, such as products, people and physical environment. Although experts mentioned the Binckhorst *too small and inefficient to close all resource loops* (Brands, int., 2017; Kwakkel, int., 2017; Brouwer, int., 2017; Lindemann, int., 2017), insights in the optimum scale lacks. Some mention the metropole region as a suitable scale (Lindemann, int., 2017; Brands, int., 2017), however this is not accountable for each flow.

6.3. Regional scenario themes

For each of these themes, some smaller groups generated ideas and desired themes for the Binckhorst. These ideas are documented. Since prototyping generates multiple ideas per group, the amount of ideas varied and was large in quantity. When an idea was mentioned by multiple groups, the idea is taken in this chapter. The more the idea is mentioned, the heavier it weights as a desired element for the scenario development.

The desired themes are supplemented with the results of core values for the Binckhorst. This document is composed and signed by companies, users and residents of the Binckhorst. Most of the desired themes are mentioned in the identity category.

6.3.1 General

The general themes mentioned in the workshop were counted. There are four main elements mentioned for the Binckhorst and the development of the Binckhorst in general. The stakeholder 'builders' includes all stakeholders from the construction chain (project developers, contractor, architects, etc.).

GENERAL	**Explanation**	**Assets**	**Stakeholders**
Mixing the functions	Making the Binckhorst visible and connect as an ecosystem. Offer an attractive functional	Not mentioned	Municipality of The Hague, (future) residents, builders, companies
Diversity	Diversity in the area in terms of mix of age, types of work and arrangement of the area	The government should take the lead. Keep plots empty and free for experimentation	Municipality of The Hague and the province
Multifunctional construction	Mixing the utilities with working and living buildings. Zoning the buildings	Dialogue with the government, future residents, companies and construction companies	Municipality of The Hague, (future) residents, builders, companies
Starting the dialogue with stakeholders	Make the connection in the area with the past and the future. And anticipate on possible conflicts of mixture of businesses and residents	Workshops and meetings per district. And apply new construction techniques to remain the historical buildings on plot	Municipality of The Hague, (future) residents, builders, companies

Table 16. General desired elements

Remarkable is that the first three mentioned aspects are interrelated. It elaborates on emphasis on the diversity in three levels: the diversity of the complete area, the diversity per plot and the diversity in a construction unit. The aim is to achieve diversity of residents, businesses and construction of the public space. However, diversity is not further specified. The relation between circularity and last point 'starting the dialogue with stakeholders' is unclear.

Jongert (int., 2017) specifies the diversity to: *highly diverse due to the variety of different businesses and industries that are present on the area. These businesses account for a great diversity of resource flows and waste flows. Brands (int., 2017) elaborates on the flows as inflows and outflows (of physical flows as well as knowledge and skills flows) in the geographical area.*

Concluding, in general, the Binckhorst will be **highly diverse with mixing functions (working and living)**. The diversity relates to the **physical functions** as well as the **people who work and live in the area.** Besides this, with the development of the Binckhorst, there should be involvement of **all stakeholders in any stage of the development process.** This is for **informing as well as providing suggestions.** A reflection leaves us with the questions:

- How is diversity defined?
- How can diversity be measured?
- How will the involvement of stakeholder contribute?
- How does a diversity of people lead to more circularity?

The general conclusion can be made that the mentioned topics are general and a direct relation to CUAD cannot be clearly made. Involvement of stakeholders can be a key feature of SUAD (Runhaar et al., 2009).

6.3.2. *Energy*

The energy themes were counted, and five items were mentioned more than once. These five themes vary from possible practical solutions to energy consumption in the Binckhorst to policy recommendation for the municipality. The stakeholder 'builders' includes all stakeholders from the construction chain (project developers, contractor, architects, etc.).

ENERGY	Explanation	Assets	Stakeholders
Interdependent exchange of energy	Start collective responsibility of residents for a roof and reserve space for energy generation and storage on plot	Start an energy platform, provide place for solar collectors and heat pumps	Collaboration among future residents, builders and companies
Installation waste heat recovery from showers	Reuse energy and recover heat	Implement installation in construction of houses	Future residents, builders
Deadline for gas connection residents	Provide the houses without gas connection	Facilitate the alternative	Future residents, builders, municipality of The Hague
Make renewable energy financial attractive	Cheap energy in the Binckhorst and new implementation of EPC	Governmental subsides and stimulation	The Dutch government, municipality of The Hague
Energy market place in the Binckhorst	Exchange of heat and cooling demand with companies and residents	Digital marketplace	Future residents, companies, municipality of The Hague

Table 17. Energy desired elements

Two types of platforms are mentioned multiple times. This is for providing electricity as well as smart exchange of residual heat or cooling. The mixture of residents and businesses will lead to a more balanced demand of energy throughout the day by the companies and in the evening by the residents.

Two themes are suggestions for the municipality and the Dutch government to make renewable energy financially more attractive by subsidies and regulations. These suggestions will have a positive effect on the renewable energy supply on the Binckhorst. However, it remains unclear which financial instruments should be implemented for favoring renewable energy generation.

The contribution from the expert Brouwer (int., 2017) that in the Binckhorst *electricity should be locally produced. And residential units should be built with a low energy usage*. According to Lindemann (2017), the *companies and residents should collaborate when it comes to energy. Since companies use energy throughout the day and residents in the evenings and early mornings, a balance can be in using energy*.

Concluding, the desired elements of energy for the Binckhorst is to **create a shared platform, where exchange of energy can occur.** This platform should be created for **electricity as well as heating and cooling energy.** An infrastructure for district heating is partly present in the Binckhorst (RO-Online, 2017). This can be expanded for exchange of heat and cooling. This platform can function for **households** as well as **exchange between households and businesses,** since this mixture will balance out the energy demand. The **gas connection** is considered as **'old'** and should not be implemented in the new constructed houses. Furthermore, the **EPC** of the new constructed houses should be **zero**. The potential of renewable energy by solar panels is considered high (Zonatlas, 2017), making it an opportunity to invest in this renewable energy source.

This leaves the questions of the future demand of energy with the increase of users and residents in the area. Besides this, the practical solutions of what exactly the potential of the Binckhorst is regarding energy flows. Additionally, the newly constructed residential units with implementation of EPC 0 is mentioned, while the question remains what to do with existing buildings and how to transform these.

6.3.3. Households

The household themes include four suggestions. The themes have some overlap with the working themes and general themes.

HOUSEHOLDS	Explanation	Assets	Stakeholders
Housing diversity	Mix the functions and add flexible living	Has as an objective to implement 5000 residential units with 30% social renting	Youngsters, social renting, private renting, families, elderlies, the municipality of The Hague
Add subplans per plot	Different subplan for each plot can reduce the risk of inconvenience	Area division in different plots	Municipality of The Hague and the province
Manage the expectations of the inhabitant	The Binckhorst is an old industrial area that will not lose its characteristics. Residents should not banish current activities	Monitoring of the residential needs and company needs	Municipality of The Hague, (future) residents, companies
Introduce new forms of living	Mix the company activities with residents. Create a stage for handicraft	Mix the company activities with residents. Create a stage for handicraft	Municipality of The Hague, builders, companies

Table 18. Households desired elements

Havelaar (int., 2017) suggests *reuse of historical buildings to remain the character of the Binckhorst, as well as from a reuse perspective. An example of this is the Caballerofabriek that currently functions as a business collection building. This can be done to other buildings as well.* An example of this is given by van Boxtel (int., 2017). Stebru rebuilds the *van Klingerenpaviljoen in the Binckhorst. This pavilion should have been demolished on its old spot. However, a new destination is found in the Binckhorst. The steel construction of this pavilion is used for the building: Frank is een Binck. This is a great example of the development. Old emotions of this pavilion remain and is reused in a new location.*

Additionally, according to Brouwer (int., 2017), *the residential units should consist of materials that can be reused when the buildings loses its function.* Lindemann (int., 2017) brings up that *circular tender should be a requirement of the Binckhorst. A coalition should be formed with project developers and the municipality to develop an urban area from a circularity perspective.* Another point that is brought up by Brouwer (int., 2017) is *the addition of a bio gasification system where food rests from restaurants are put in to supply the residential units with gas to heat up the houses.* This idea is supported by Brands (int., 2017), who observes *the additional value of a bio gasification system that is run locally. Residents will feel ownership of this plant that supplies them in their needs.*

A desired example that Kokx(int., 2017) wants to see being implemented is *that residential blocks can be designed that it stimulates sustainable behavior from the residents. This can be implemented in waste separation, car parking spots and bicycle facilities. Building blocks can be designed in such manner that it can be functional for multiple purposes. For example, parking garages can be formed into office blocks or residential blocks.*

To conclude, a suggestion is done concerning integration of energy needs and resource flows. To gain insights in these flows, a MEFA on macro-level would suit in calculating amounts. Social factors come up with this desired element as well, mentioned by Brands (int., 2017) with the feeling of ownership.

The question is whether housing diversity and managing expectations of the residents contribute directly to circularity. Havelaar (int., 2017) mentions an important principle of the CE principles of reusing buildings (Zjihun& Nailing, 2007; Yuan et al., 2008). Circular tender is mentioned for the residential units. The question remains how to create such a circular tender and which elements should be taken into account.

Kokx (int., 2017) mentions how design can contribute to sustainable behavior. However, this is considered not similar to circular behavior (Geissdoerfer et al., 2017). Although there is overlap in shared ambitions, these two concepts cannot be directly replaced by each other.

6.3.4. *Mobility and infrastructure*

The mobility category includes five themes that were mentioned multiple times. The mobility themes are more focused on practical solutions for traffic in the future.

MOBILITY	Explanation	Assets	Stakeholders
Collective garages	Since the area will be a mixture of working-living, parking spaces can be double used: during the day for the companies and in the evening for the residents	Not mentioned	(future) residents, companies
Collective usage of cars	Cars can be shared among multiple residents	Introduce and facilitate carsharing	Future residents, the municipality of The Hague
Public transport connection	A public transport connection should be realized with the two stations: central station and Hollands spoor.	Apps can be introduced for monitoring the public transport needs	Future residents, municipality of The Hague
Safe and attractive bicycle route	The route should be lighted to increase safety perception	Introduce share bicycles	The Dutch government, municipality of The Hague
Introduce a water taxi	Make usage of the water and port in the Binckhorst to The Hague and other surrounding cities	Launch water taxis	The Dutch government, municipality of The Hague

Table 19. Mobility and infrastructure desired elements

The mobility themes have a high focus on sharing concepts. These sharing concepts are translated in shared parking spots, bicycles and public transportation. The Rotterdamse Baan will be opened in 2020. However, this will only partly influence the connectivity of the Binckhorst.

Concluding, the sharing economy is brought back as an important element that was mentioned as one of the strategies of the CE by Castellani et al. (2015). The ideas of collective usage of cars, public transportation and collective garages fits in the idea of such economy. Bicycle routs refer more to sustainable transportation, rather than circular transportation.

6.3.5. *Public space*

The public space category includes five themes, mentioned multiple times by different groups.

PUBLIC SPACE	Explanation	Assets	Stakeholders
Part of the Binck-horst green	The Binckhorstlaan and around the bicycle path green should be added	Financing can be arranged by private parties	The municipality of The Hague, compa-nies
Improvement quality in green and water areas	Public area quality improvement. Create a robust recreation area	Municipality sets preconditions	Province, municipality of The Hague
Allotments	Common gardens in the Binckhorst. The management is done by the residents	Spaces for these gardens should be a part of the tender	Future residents, municipality of The Hague
Utilization of green in and around the buildings	Green can be added on facades and roofs	Tender should demand for these types of green	Municipality of The Hague, builders
Connect green places in the Binckhorst	Reserve plots for green and add grade separated intersection	Municipality sets preconditions	Province, municipality of The Hague

Table 20. Public space desired elements

This category demands for green places in the public space as well as on private ground. The municipality can set preconditions for the residential units to add green to facades and roofs. These measurements can be beneficial for future climate adapta-tion and resilience of the plot for extreme weather events and water control.

The suggestions for nature will have multiple purposes. It provides a space for recreation and sports. Additionally, it contributes to the physical outlook of the area. It provides measurements for climate adaptation, as mentioned in the previous paragraph. Lastly, it contributes to reduction of air pollution.

Concluding, the question is whether the ‘public space’ theme generated elements re-garding CUAD. Climate adaptation and the direct relation to circularity is unclear. The same accounts for multiple functions of public space. These elements fit to the SUAD definition and ambition, rather than closing the loops of circularity. Although improve-ment of green areas and water areas improves the environmental part of CUAD and certain flows can be regulated e.g. rainfall, however the direct economic benefit of green areas remains unclear.

6.3.6. *Resources*

The resources category includes five themes for suggestions of development of the Binckhorst.

RESOURCES	Explanation	Assets	Stakeholders
Circular knowledge center in the Binckhorst	Information utility and research center for circularity	Create space for a center	Residents (with lower incomes), students
Material bank	A place that demonstrates how waste can be utilized	Website with supply/demand of resources	Municipality of The Hague, companies, residents
Location for waste categories	Underground waste separation facility with specific procedures	Waste separation facility should be part of the tender	Future residents, municipality of The Hague
Package deposit money	Introduction of package deposit money for waste	This should be organized by the Dutch government or more local governments	Dutch government, (future) resident, companies
Upcycle center	The waste should be treated more locally	Make space for experimentation, including manager and storage facility	Companies, (future) residents

Table 21. Resources desired elements

In this category, circular solutions are proposed. The material bank, circular knowledge center and upcycle center can be united in one center or one location. The government should initiate this, and the residents and companies have to participate in the project. Brouwer (int., 2017) supports this and specify to *create an experiment center, especially for waste to create new products. This center should be accessible to local startups and businesses to collaborate. Experimentation should not be hold back by legislation. The same accounts for construction and demolishing activities. When a location is demolished, automatically space is available to store secondary materials that can be used in another project or later stage.* Brands (int., 2017) elaborates on this experiment center more specific with the proposal to *engage startups with the experiment center and HMS. Startups function as daughter companies of HMS that can experiment with the waste. This relationship is two-folded in the sense that: (1) the knowledge that these startup gain, can be exchanged with HMS and start learning processes. And (2) HMS has in return the licensees and abilities to transport and treat waste that can be used by these startups. Lindemann (int., 2017) finally adds to this point that a resource bank should be digital as well in order to realize matchmaking for resources.*

Brands (int., 2017) argues for more initiatives that can contribute to more circularity in the Binckhorst. *HMS is currently looking into the option of a resource round-about. This resource round-about separates the different waste flows. A distinction is made between the different materials to separate and observe the possibilities for reuse. Next to the resource round-about a repair café will be planned. In this café, there is the possibility to repair residential equipment and partly education to learn how to repair equipment.*

The idea of package deposit money, by the workshop, is assessed as not feasible to implement and the items lacks further elaboration on how this should be executed, how it contributes to circularity and it can be measured. The upcycle center and knowledge center is taken as one item in the material bank.

Concluding, the desired element of a resource experiment center, including innovative startups and a repair café can be directly linked to CUAD. It elaborates on the principles of CE, the three R's. It can be considered as a platform, functioning on the meso-level in the CUAD framework. The previous chapter elaborates on the diversity of the economic experience part of the Binckhorst. Due to the development, it will drastically change over time. With these changes, future resources in the Binckhorst remain unknown. This leads to no concrete solutions or desired elements for this topic.

6.3.7. *Economic experience*

The economic experience category includes five themes that were mentioned multiple times by the group. The themes are mentioned by other categories as well.

ECONOMIC EXPERIENCE	Explanation	Assets	Stakeholders
Attract freelances to the Binckhorst	Create studios for providing workspace to freelancers	Reserve space on plot	Companies, the municipality of The Hague
Utilities on plot, in the Binckhorst	Utilities should include shops, sport facilities, playground facilities	Reserve space for utilities on plot	Municipality of The Hague, companies, residents
Protection of companies in the urban plan	The current vital companies and handicrafts should be protected and made more visible	Handicrafts should be placed in the public space to make it more visible. Create jobs for MBO-level 3000 jobs, 2000 HBO jobs and 2500 WO jobs (7500 in total)	Municipality of The Hague
Search for companies and residents that can exist in one neighborhood	Search for new collaboration among companies and take into account the (future) residents	Start a platform for collaboration	Municipality of The Hague, companies
Cross-over education and innovation	Develop innovative concepts and collaboration with students	Facilitate this with finance	Companies, universities, academies, the municipality of The Hague

Table 22. Economic experience desired elements

As one can observe, is that two themes conflict: the theme of protection of current companies and the search for companies that can exist next to residents. The decision of protection is not further elaborated. Therefore, the likelihood of practical implementation is low.

Adding the facilities to the Binckhorst is mentioned most by all groups. This is a highly favored element, especially when residents will live in the Binckhorst. Facilities include supermarkets, small shops, sport facilities and playground. The aim is a highly diverse supply of utilities. An implication of adding facilities to the area, is mentioned by Brands (int., 2017): *the supermarket that has its products in the Binckhorst can demand for 100% circular products. However, the circularity of the products in the supermarket depends on the producer and supplier of these products. In order to become circular, the complete value chain should become circular.*

A key element of CUAD is (Lindemann, int., 2017) *new employment that emerges due to new connections among businesses. These connections are not only related to resources, but as well to humans.* Kwakkel (int., 2017) observes the *need for new employment in The Hague. By implementing circularity, new jobs will be created in the manufacturing industry for middle and low educated segment of the population of The Hague.* According to Kwakkel (int., 2017) *the different roles of the stakeholder should be more fluid: the resident is producer of materials, that is bought and used by a company. And the consumer buys again from the company. The classic roles and responsibilities of company and resident disappear. Residents can be local producers with innovations such as 3D printing at home. Another example is the startup Urban Mining. A consumer can turn in deficit electronics and becomes shareholder in the company. When Urban Mining sells resources, gained from the electronics, the consumer shares in the profit. Consumers become owners of problems.*

Brouwer (int., 2017) sees already some collaborations that can be exemplary CUAD, such as *coffee grounds from the office building of KPN that is reused to grow mushrooms by HaagseZwam. Another example is that the cemetery will contact the Beeldhouwwinkel when they will remove gravestones. Since some stones can be possible reused after the name of the person is scratched off.* Another exemplary showcase is mentioned by Brands (int., 2017) that the *waste facility in The Hague is carbon dioxide neutral with solar panels to generate electricity and moss on the roof to absorb rainwater. The façade is made from left-over iron plates where our trucks are cut out.* Kwakkel (int., 2017) mentions a few examples as circularity examples: *CE is for me Spotify. They asked the question: 'why do you want to possess CD's and use resources to create these CD's? Another example is Picnic, which is an online supermarket. They operate demand-driven. The supply is only online and when products are ordered by the client, Picnic orders the products for them. This is a fundamental different way of operating compared to the conventional supermarket. They did the 'rethink' step of the CE and this is the most important step of circularity. Another example in The Hague are the thrift shops. The infrastructure for these thrift shops in The Hague is advanced. With these examples, visibility of circularity can be created that can function as a source of inspirations for other stakeholders. Lindemann (int., 2017) observes the Binckhorstas experimental garden with manufacturing industry combined with innovations such as 3D printer and robot-arms.*

Livability is according to Lindemann (int., 2017) a crucial element. *Social connections are made between companies through collaboration. Usage of stuff is connected to livability and safety. In this way, value is created on different levels. Exchange of expertise is circularity as well.* This is shared and extended by Brouwer (int., 2017), an important desired element of working should be *including labors with distance to the employment market. Since circularity includes livability and social factors.* According to Havelaar (int., 2017), the *middle-large enterprises should remain in the Binckhorst to provide labor for remaining the manufacturing industry of The Hague.*

An example of CUAD in a project is found in the work of Lindemann (int., 2017). She started in 2011 the non-profit organization OpTrek. A project that is developed from her work is the BinckseBelofte. *It was a testcase for observing whether companies were open for coproduction. Another project is Resource City. This is an initiative that aims to create cases for collaboration around resources.* What is important for these initiatives is that *context specific these parties, streams and chances should be interacting,* according to Louwaars (int., 2017). These parties need the *capacity-to-impact. Therefore, a diversity of people and skills are needed in order to succeed certain projects that need specific skills.*

On the sixth of October, I'm Binck festival was organized by Lindemann (int., 2017). This festival included a dialogue with different stakeholder and their vision on the urban development of the Binckhorst. Jongert (int., 2017) brought up that from his metabolic analysis, the CE was worth 20 million euros on a yearly basis of lost resources. A proposed initiative is that a physical place on the Binckhorst should be created and 1% of these 20 million euros yearly, should be invested in this place to start projects that restore value from these lost resources. This idea came back in the expert interview of Louwaars (int., 2017), who moderated this dialogue. He argued that this idea *is democratic: everyone that develops something, can join this initiative. It can create projects in the early phase and articulate ambitions and intentions.* Lindemann (int., 2017) pointed out this example as well and that this initiative should *be embedded in policy to make this possible.*

Brouwer (int., 2017) envisions that the *companies in the future will produce without emissions and establish in buildings that can be used for other functions. And the materials used for production, can be completely reused when they reach their end-of-life stage. An image should be created to overview the surpluses and demands of materials. This includes adding a material passport to buildings and products to gain insights in the value.*

Jongert (int., 2017) envisions an *open-source platform in combination with a resource broker. The open-source platform should be carried by the municipality and local companies. Each company should make its data of importing resources and waste numbers on the platform. This creates insight for other businesses to use or deliver certain resources or waste flows. The resource broker should coordinate the platform and is responsible for maintaining the network.* This was taken up as one of the main recommendations and conclusions of the metabolic analysis. *The metabolic analysis functions as one of the first instruments to stimulate companies to make the data available for other stakeholders that are connected to the Binckhorst.* Kwakkel (int., 2017) aims for *the Binckhorst should function as a Blue City concept. The Binckhorst as ecosystem including companies that are connected through transverse stiffness to feed each other with resources, people and knowledge. The ecosystem develops organically with HMS as resource cluster.* This is supported by Lindemann (int., 2017) who sees the *Binckhorst as an ecosystem with different people, houses and companies. The same accounts for public space: it should serve the companies and residents. For example, if a restaurant needs apples for apple juice, the public space should contain apple trees. Public space becomes part of the ecosystem.*

Concluding, the addition of facilities to the area is self-evident. How these facilities can contribute to circularity is unknown. The question remains how this will contribute to closed loops in the area. The ideas mentioned from the workshop cannot be directly linked to CUAD. It is unclear how attracting freelancers to the Binckhorst contributes to CUAD. Further specification is missing for concrete solutions explicit for the Binckhorst. Circular ideas are generated, however whether these ideas fit the Binckhorst, remains unclear.

Examples are mentioned of exchange of resources by companies. suggestions for desired synergies came up in this theme as well. The social aspect of creating employment by implementing CE and other benefits concerning collaboration received attention, especially by Lindemann (int., 2017). Remarkable initiatives, such as the 1% investment in CE are mentioned as desirable element, that can possibly lead to innovative ideas and the integration on meso-level in the CUAD framework. Initiatives are mentioned on the meso-level with integration of public space for economic experience and the recognition of social factors as part of the CE implementation.

6.4. Conclusion

The backcasting analysis is performed, based on multiple data sources. Due to a workshop held by the municipality, the planned backcasting workshop for this thesis project was cancelled. However, since the municipality performed a backcasting analysis, the results are used for this analysis. The goal of this thesis project with the backcasting analysis is to formulate desired elements for CUAD. Remarkable is that the mentioned elements from the workshops and from the expert interviews are more related to SUAD, compared to CUAD as defined for this thesis project. Additionally, the ideas were diverse and did not show coherence. Moreover, some ideas were contradicting. Since the ideas were generated per theme, the integration or exchange among the themes lacked.

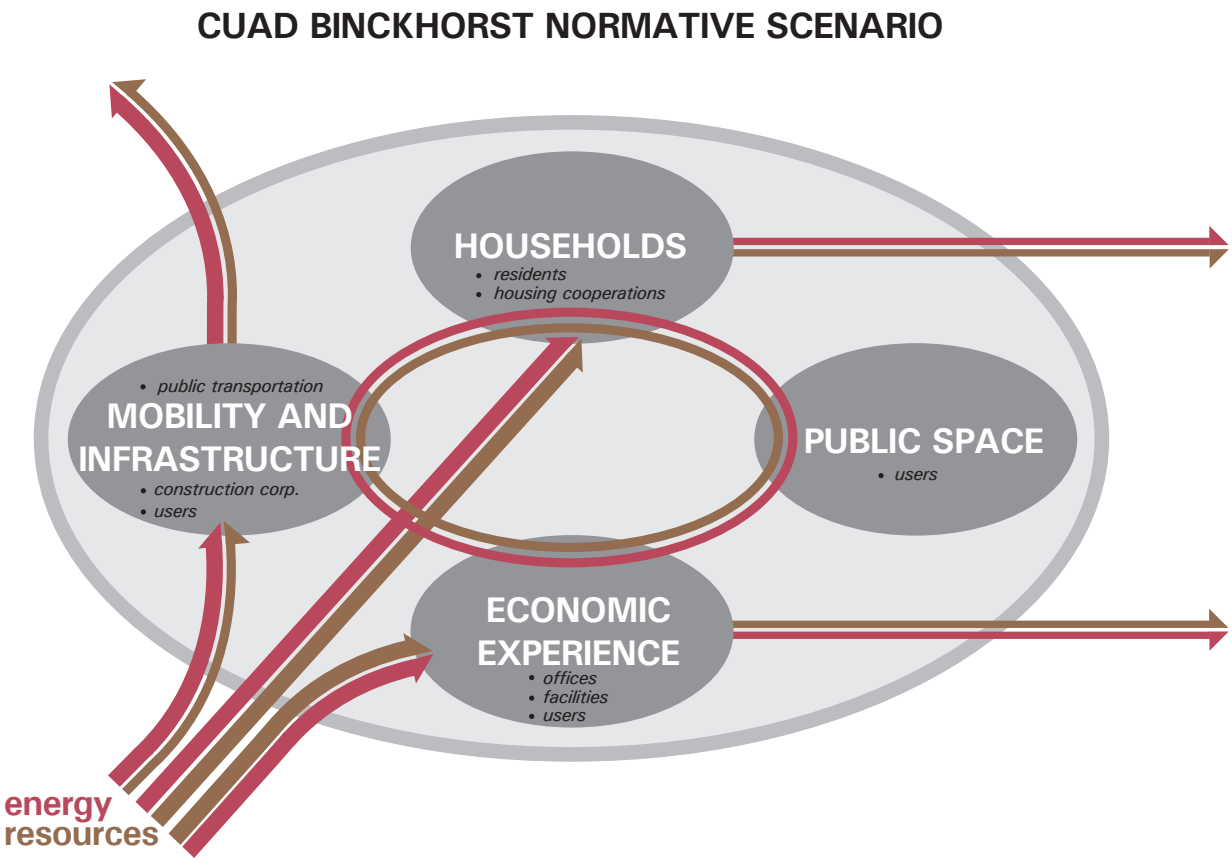


Figure 6.1. Normative scenario Binckhorst

A sketch is made of the CUAD framework for the normative scenarios of the Binckhorst. One can conclude, based on the policy documents that the Binckhorst will significant increase in terms of (1) residents and (2) users of the area. Increasing these two groups will lead to increase in resource and energy demand to fulfill their needs. In the long-term future, the construction and transformation activities will be slowed down, and it is expected that the household and economic experience entities have a balanced demand in terms of resources and energy. The meso-level is introduced with multiple initiatives, such as the resource bank and public space that can serve the households and economic experience. Energy of the mobility remains high due to the connectivity of the area and the traffic on the Rotterdamse Baan. The Binckhorst is an urban area that is expected not to completely lead to closing loop systems. Thus, flows of resources and energy will leave the Binckhorst in the desired future. In almost every mentioned idea per category, the municipality is mentioned as key stakeholder. This makes the involvement of the municipality in desired elements for the future diverse and for the large partresponsible for the realization.

Based on the circular principles that imply to have multiple solutions to circularity, a suggestion is done to the outline for two normative scenarios for the Binckhorst. One scenario is based on implementing circularity on the small scale. Some experts mentioned that CUAD cannot be realized in the Binckhorst itself. However, other experts mentioned that small plans should be made on plot level with urban living labs and expand from this point.

The scenario on the large scale is argued by Havelaar's (int., 2017) desires that the Binckhorst is *taken up in the region. Some areas will have more resources of X and other areas of Y. The region will become a mixture and exchange of resources.* In addition, Lindemann (int., 2017) states that *a balance should be made of what is missing in the region and which resources are needed to close loops.* Van Boxtel (int., 2017) states that *diversity is key when it comes to implementing circularity. Therefore, the Binckhorst is not diverse enough to be self-sufficient. The Binckhorst should aim to become a neighborhood in the city, based on an old industry area.* The large-scale scenario can be compared with the Stockholm Royal Seaport. Sustainable districts are commonly approached as independent island, neglecting the connection to their surroundings. However, cities and urban districts are heavily depending on their surroundings, concerning resources and energy (Holmstedt et al., 2017). The same statement can be made with CUAD. With the increased complexity trend in urban areas (Pincetl et al., 2012), local context should be taken into account, while considering ambitions on a higher level to avoid lock-ins and sub optimization (Holmstedt et al., 2017).

The scenario on the small scale is argued by Louwaars (int., 2017) that *living labs should be created as special places where one can experiment. These living labs on the Binckhorst should be connected to each other and not isolated from each other. A space can be created as design-for-interaction, where parties can meet each other and start together projects or experiments. In a later phase, the project or experiment can be possible scaled-up. The Binckhorst should be divided in subsectors. And for each subsector, a different ambition should be made. Thus, this leads to a subsector in the*

Binckhorst that has the ambition of commercial, residential purposes, industry, etc. And each subsector should function as an urban area, independent from the other areas. Parties should be attracted that are ambitious to work on this topic. And these parties should be guided by other parties, such as the municipality to bring further. This scenario fits the 'living lab' ambition of the Buiksloterham. The 'living lab' status is beneficial in relation to less legislation and regulation, leading to more space for experimentation.

A critical point to the results of the backcasting analysis is that desired elements were mentioned in general terms. Specific elaboration on indicators or reasoning why this element would contribute to CE or CUAD remained unclear. Although the backcasting analysis can create insights and incremental learning concerning transitions, it remains unclear whether the results from this backcasting analysis achieved these points. The expert interviews were taken separately from each other. This lead to no unified future image of the Binckhorst. Additionally, there is no uniform knowledge concerning CUAD. This was visible in the theoretical framework of the great amount of literature concerning CE and the variety of principles, strategies and policies. This is visible in the interviews and workshop results from the experts and participants. Sustainability and circularity are two concepts that are exchanged in explanations of opinions.

7. Discussion implementing CUAD in the Binckhorst

This chapter elaborates on the CUAD framework implemented for the Binckhorst. Recommendations will be done according to the outcomes of the first two steps from the methodological framework framework; 'analysis of current situation' and 'determination of desired elements'. First, (1) the outcomes on the framework will be discussed. This will be followed by suggestions for (2) creating a shared vision, (3) baseline measurement and circular measurement rod, (4) monitoring and evaluation and (5) identification of the challenges for the Binckhorst.

7.1. Operationalization of conceptual framework for the Binckhorst

The CUAD framework is filled in with different tools and methodologies, resulting in chapter 5 and 6. This step is the discussion for operationalization and implementation of the CUAD framework.

Figure 7.1. Methodological steps of the thesis research project

Referring back to the questions of chapter 2, the variables and operationalization of the variables are given in chapter 3 and 4 and the drivers of the system are identified in the backcasting analysis with the first step. The following question considering the variables of the framework are split up in the variables of the flows and the variables of the entities. The introduced urban planning entities consist of multiple variables of the MEFA and stakeholder analysis. A reflection on the question 'what are the variables of these elements?' based on the results of chapter 5 and 6 will be given in the following paragraphs.

7.1.1. Economic experience

As observed from the results, the economic experience has the emphasis concerning resource flows. The analysis is made on meso-level to provide information that can be implemented in practice. The metabolic analysis by Superuse Studios provides an overview of all flows of the economic experience. However, the analysis lacks integration of other flows on the meso-level. It can occur that flows on macro-level, such as water flows due to rainfall, can be integrated in economic experience. The metabolic analysis of the Binckhorst needs further expansion to collect insights in all flows on the different levels. Additionally, the temporal scale needs to be taken into consideration with modelling the flows, as it turned out that the metabolic analysis did not provide the data useful for answering engineering questions.

A stakeholder analysis is done of the economic experience. This consists of a list of approximately 500+ businesses. More interestingly is to gain insights in stakeholder dynamics, over the identification of the specific businesses operating in the Binckhorst. As pointed out by the CUAD framework of the current situation, as well as the future situation, the stakeholders of the economic experience will change drastically. It is expected that the large part of the industries and businesses will leave the Binckhorst during the transition, while new businesses in forms of facilities and especially smaller businesses will be introduced to meet the needs of the households. The municipality has expressed their preferences for businesses from the creative sector, hand craft sector and service sector (Gemeente Den Haag, 2017). The economic experience will have influences from the trend 'increased economic activity' (PBL, 2015).

Concluding, the economic experience consists of the stakeholders in the form of businesses and industries in the area. These stakeholders are responsible for the majority of the flows in the Binckhorst. The stakeholders of the economic experience will change due to shifting policy and introduction of other stakeholders with different preferences. This leads to a shift in flows of resources and energy. Before modelling the flows of stakeholders from the economic experience, it is important to ask the question whether the stakeholder (business or industry) remains on the Binckhorst.

7.1.2. Households

The household entity can be divided into two parts: construction and demolition of the residential units and operating the residential units by the inhabitants. In the case of the Binckhorst, the construction of the residential units is particularly relevant, leaving out the demolition phase of the units.

The flows of construction of the residential units will lead to a large inflow of material and energy. The outflow will occur over a lifetime of a building (average 60 – 90 years). Construction of buildings can be seen in the perspective of micro-level as building components and materials and in the macro-level as eco-cities (Pomponi&Moncaster, 2016). Suggestion for implementing CE in buildings on a micro-level is circular tenders for the construction of the residential units. Suggestions for construction of buildings on the macro-level is the connection among the buildings for exchange of resources as well as energy. The residential units during operational phase will receive increased attention as came apparent in the analysis. The current flows cannot be modelled, since the residential units are not constructed yet. However, an estimation can be made of the flows with data from comparable neighborhoods. Residential waste tends to be a more homogeneous flow of input and waste, since residents have similar needs in terms of nutrition, water and energy.

Observing the stakeholder analysis, the current household entity consists of the stakeholders involved in the construction of the residential units. Since the planning of these units is in the near future (Gemeente Den Haag, 2017), these groups of stakeholders receive increased attention and importance. The power and interest of these groups of stakeholders decrease when the residential units are constructed. The dynamics of the stakeholder 'future residents' will receive increasingly importance. However, current data lacks how this group will influence. Estimations of their dynamics can be made to anticipate to possible future conflicts. The conflicts are observed by expert with the integration of industries with residents (Louwaars, int., 2017; Kwakkel, int., 2017).

As one can see in the current situation, multiple stakeholder categories are involved, that will eventually lead to a strong increase in flows. However, since most of the residential units are currently in the planning phase, the flows are not increased yet. The groups of stakeholders with high interest and power, will loose the interest and power in the future. These groups of stakeholders will be replaced with households. The same accounts for the flows of the household entity. These will change drastically over time.

7.1.3. Public space

The public space can serve an important role in the macro-level of resource flows. These 'natural resource flows', such as rainwater should not be neglected by MEFA, since these flows consist of a significant mass of all flows coming in and leaving an urban area.

Observing the stakeholders involved in public space, there are a few stakeholders. It includes future users of the public space and the municipality that manages the public space. This makes the public space a passive entity, since it can provide resource flows to other entities. However, it is not demanding in resource flows.

The public space will increase in users and flows in the future, since the public space will be expanded to make the Binckhorst an attractive location for the outdoor space and recreation (Gemeente Den Haag, 2017). The public space remains passive and managed by the macro-level.

7.1.4. Mobility and infrastructure

Mobility and infrastructure can be separated into two parts, as with the household entity. It is the construction activities of the highway and bicycle path that has currently the main focus concerning the flows of resources and energy and the involved stakeholders for construction activities. The resource flows coming in this entity is relatively low and have a long lifetime. It will stay in the built environment for the long-term.

The use of the infrastructure is mainly inflows and outflows of energy. it is expected the mobility increases with the addition of the residents. Transport is seen as an energy intensive entity. Moreover, with increase of circular activity, it is expected that mobility increases with transportation of resources.

7.1.5. Micro-level

Desired elements, such as circular tenders are proposed for the construction of residential units on a micro-level. Additionally, old industrial buildings can be transformed to remain the industrial character of the Binckhorst and keep the embodied energy of the buildings.

The desire is that the new constructed units are not connected to the gas infrastructure. New sources of energy for buildings should be found somewhere else. Importance of this element is due to the driver 'non-renewable resources are depleted' (Partidario&Vergragt, 2002) as well as 'political targets of cutting emissions' (ECN, 2016)

The firms on the Binckhorst should integrate CE strategies in forms of CP and eco-design. Renewable energy sources should be used for production processes.

7.1.6. Meso-level

Desired elements, such as exchange of energy is mentioned on the meso-level. The current heat district infrastructure shows potential for expansion to facilitate the exchange of heat and cooling demand. Additionally, renewable energy generated from solar panels shows potential in the Binckhorst. Since the companies operate during the day and residents consume energy through the night, the demand of energy can be levelled out.

The sharing economy is mentioned as a desired element. This can be applied to sharing cars, as well as sharing parking spots and public gardens. Other strategies, such as product-as-a-service are mentioned as well as examples. These new forms of economic experience can lead to new networks among the firms and households.

A resource center is mentioned. The households as well as the economic experience can bring their 'waste' to this place and potentially new products can be made there. The idea of the 1% investment of the lost value of waste treatments fits the resource center.

7.1.7. Macro-level

At macro-level, governmental organizations operate. The municipality of The Hague as well as the Dutch government will have high interest and power in the current situation as well as in the future. This is due to their role for a society as well as for the urban environment. The interest of the different roles of the municipality will change over time; the municipality as real estate owner decreases its position due to selling ground to project developers, while the municipality as manager of public space increases in interest due to the addition of public space to the Binckhorst.

The literature pointed out the recycled-oriented society operating at the macro-level. Thus, users of the area can be considered operating at the macro-level as well. Waste management programs are a part of the macro-level.

7.1.8. Conclusion

The first two steps of the CUAD framework are executed, as presented in the previous chapters. The follow-up steps include (1) selection and prioritize and (2) formulation of environmental ambition (Runhaar et al., 2009). These steps would have been executed during the workshop. However, as described in chapter 4, the workshop was held by the municipality, who did not perform these steps. Based on the results described in the previous chapters, suggestions are done for improvements of the executed methodologies. Additionally, following steps of (3) development of action plans and (4) monitoring, evaluation and feedback will be suggested. Thus, the following sections provide suggestions to the questions 'How to monitor and evaluate?' and 'what are the indicators?'.

7.2. Shared vision development

The question can be asked: do stakeholders follow the flows in an urban area or do flows follow the stakeholders? The backcasting analysis can be used for (1) formulating desired elements, (2) prioritize desired elements and (3) setting goals and ambitions for the area. A suggestion is to make a participatory backcasting analysis with involvement of stakeholder and create such a shared vision during the workshop. By applying this method, it aims for a more integrated vision and create a starting point of common ground concerning the knowledge of CUAD.

As mentioned in chapter 2, key stakeholders are private companies and governments (Geissdoerfer et al., 2017). Private companies can be observed as a sub-category of a system that closes loops for achieving circularity (Mentink, 2014). Identified from the stakeholder analysis, the workshop, the CUAD framework as well as confirmed by the experts, the municipality of The Hague is the main stakeholder in the area and should initiate the participatory backcasting analysis (Brouwer, int., 2017; Louwaars, int., 2017). The municipality should formulate its demand for a backcasting analysis (whether it is normative, process or knowledge) (Quist et al., 2011; Neuvonen& Ache, 2017). A process demand is suggested to include stakeholder participation and level of influence.

A stakeholder analysis performed by the municipality during the transition of the Binckhorst can be a supportive tool (Dreborg, 1996). Key stakeholder groups can be selected for the participatory process. Additionally, key information held by stakeholders can be mentioned during a workshop with stakeholders (Ackermann & Eden, 2011; Bryson, 2004; Bryson et al., 2011). It should be a process approach *where different parties will be brought together for specific objectives, focused on the ambitions where parties can find each other. The process should be guided in such way that not only economic, but social and ecological value is created as well* (Louwaars, int., 2017). This statement is supported by Brouwer (int., 2017), Kwakkel (int., 2017) and Brands (int., 2017).

An outline towards a system transition should be described by the municipality (Quist &Vergragt, 2006). The drivers for change and circular principles can be taken from the literature review. However, the following steps, such as the development of regional goal and scenario themes, scenario development and scenario validation need to be redone. In this way, common understanding and shared ground will be created (Vergragt& Quist, 2011). During the workshop, additional steps should be performed, including prioritize and setting goals and ambitions.

Since CUAD is a relatively new concept and demands for sustainable solutions that are not applied before, the participatory backcasting analysis can lead to innovative solutions that have not been applied before. Additional, it provides incremental learning of what CUAD is and how it can be achieved. The created normative scenario can form the basis for formulating policy (Anderson, 2001). Action plans can be made on three levels: corporate, industrial and municipal levels (Geng et al., 2009). This is suggested for the Binckhorst to incorporate.

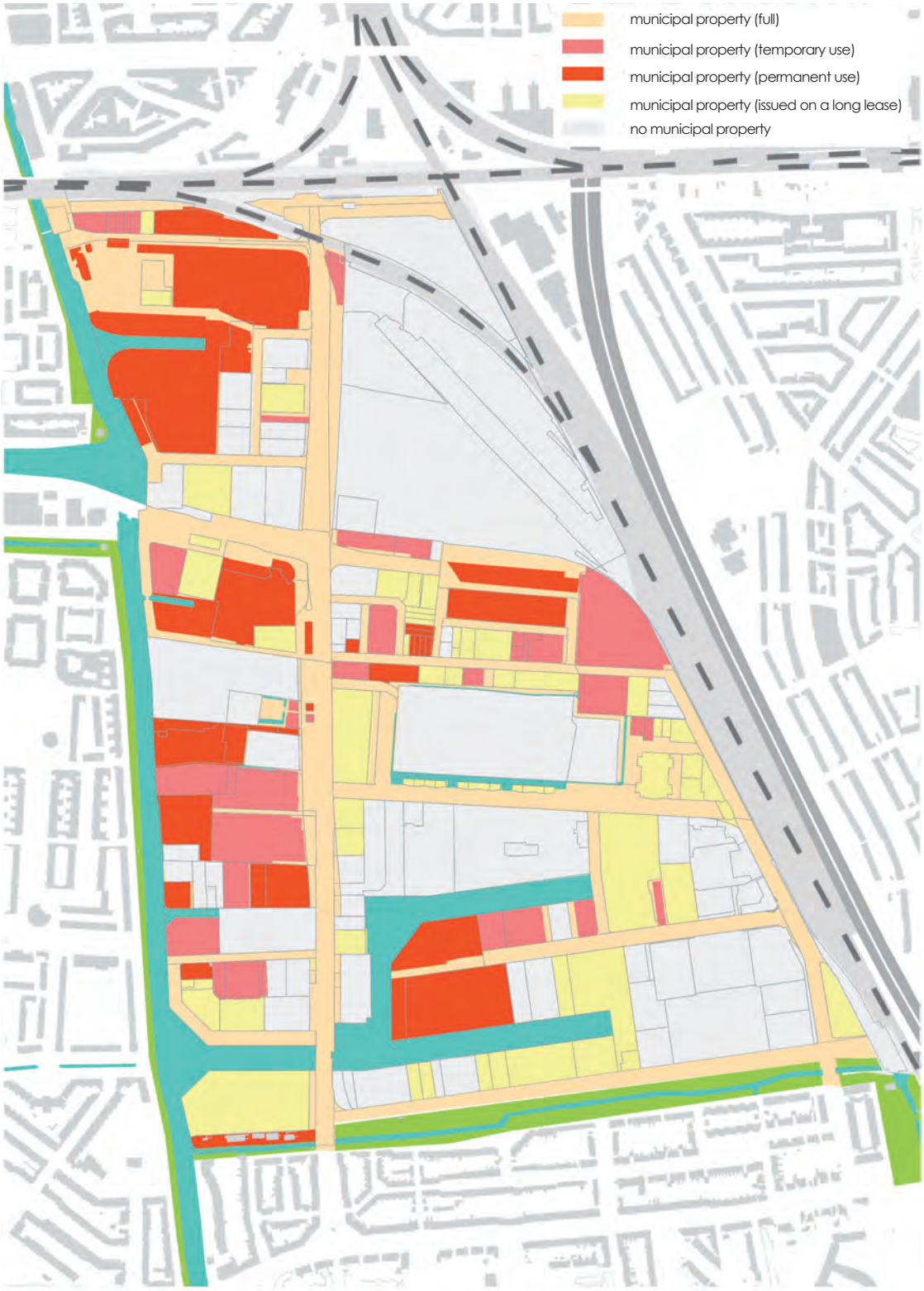
A disadvantage of the backcasting analysis is the role of each stakeholder in the desired scenario (Dortmans, 2005). However, some heavy industries are aware that they possibly will not have a place in the Binckhorst (Reparco, 2017).

7.3. Baseline measurement and circular measurement rod

The involved stakeholders will strongly change over time (due to the transition phase of the Binckhorst), leading to changing flows. As implementing CE comes with building trust, long term planning and investments in infrastructure (Gibbs, 2008), first stakeholders should be integrated, followed by an analysis of flows. Thus the second step is to create a baseline measurement and circular measurement rod.

A baseline measurement of the Binckhorst is mentioned multiple times by experts (Louwaars, int., 2017; Kokx, int., 2017; van Boxtel, int., 2017). No specific suggestions are made how this baseline measurement should be executed during the interviews. Based on the results, it is suggested that UM analyses are made on the three levels. This is followed by implementation of the CE principles and strategies in the mentioned hierarchy. The higher the solution is in the hierarchy, the higher it is valued.

A specific note is made on the ownership of the Binckhorst. As indicated in the stakeholder overview, the municipality of The Hague has a role as real estate owner in the Binckhorst. This is confirmed by expert Kwakkel (int., 2017). This gives the role of the municipality to demand circular requirements to its ownership. As shown on the previous page, the ownership of the municipality and the specific land areas that are rented out to businesses, right to the estate and full ownership. Altogether, the municipality owns 30 properties and 200 rentable units. Concerning the baseline measurement and circular measuring rod, the municipality can initiate and demand innovative experiments. The municipality as the most important stakeholder has itself in a beneficial position for implementing CUAD.



municipal property

Figure 7.2. Division land municipality
Source: Gemeente Den Haag, 2011

7.4. Monitoring and evaluation

Indicators should be developed for monitoring and evaluation. As explained in the literature review of CUAD, a variety of indicators is given for different levels of flows (Geng et al., 2009; Geng et al., 2012; Golinska et al., 2015; Zhijun & Nailing, 2007). The correlating monitoring and evaluation system should be corresponding with the specific urban area.

The review of circular indicators in chapter 2 can be applied to the Binckhorst. The indicators from Delahaye&Baldé (2016) and considered as not applicable, since the monitoring has been done on national level and cannot be applied on local urban area. E.g. percentage of food waste cannot be given, as well as phosphor from natural closed loop. Additionally, Murray et al. (2015) stated for a more integration of the social domain. Therefore, social indicators are included, that lack in the analysis of Delahaye&Baldé (2016).

Indicator	**Explanation**	**Source**
Air pollution	This indicator is included since the Binckhorst contains resource intensive and heavy industry	Zhijun & Nailing, 2007
Green space area per capita	This indicator is included since green space contributes to the attractiveness of an area and captures water flows and decreases air pollution	Zhijun & Nailing, 2007
Unemployment rate/employment rate	This is especially relevant for the Binckhorst, since CE is introduced by experts (Kwakkel, 2017; Lindemann, 2017) as a contribution to The Hague in general	Zjihun&Nailing, 2007; Smol et al., 2017
Revenue in CE	This indicator is relevant for measuring improvements in the Binckhorst concerning economic experience and the CE.	Smol et al., 2017
Ratio of investment	Since investments need to be done, including investments in building relationships and infrastructure, this indicator is relevant for the Binckhorst	Zjihun& Nailing, 2007
Per capita energy consumption	Due to the increase of residential units, the energy consumption should be measured per capita	Geng et al., 2009
Energy consumption per industrial value added	Since it is expected that businesses and industries will remain a significant factor in the Binckhorst, energy consumption should be measured per industrial value	Geng et al., 2009 Geng et al., 2012
Water consumption per capita	Due to the increase of residential units, the water consumption should be measured per capita	Geng et al., 2009

Water consumption per industrial value added	Since it is expected that businesses and industries will remain a significant factor in the Binckhorst, energy consumption should be measured per industrial value	Geng et al., 2009 Geng et al., 2012
Resource output	Resources should be measured per capita and per business	Zhijun&Nailing, 2007 Geng et al., 2012
Per capita municipal waste generation	Waste generation should be measured and numbers should be given in (1) incineration, (2) recycling and (3) landfill	Geng et al., 2009

Table 23. Indicators for the Binckhorst

The monitoring and evaluation indicators can be measured on a different (1) temporal scale and (2) scale of operations, compared to the suggested MEFA on micro-, meso- and macro-level. This is due to the goal of monitoring: make an estimation of the progress made, instead of providing insights how specific flows can be used.

Additionally, building capacity of key stakeholders is relevant for implementing CUAD. By effective usage of stakeholder analysis, insights can be conducted in stakeholder's interests, views, influences, involvements, needs and roles in an urban area (Bryson et al., 2011). Therefore, stakeholder analyses are an essential part of monitoring and evaluation, since it can clarify successes or failures, and can provide insights in room for improvements.

To conclude, a first draft is made to operationalize the CUAD framework with (1) prioritized desired elements and an ambition through creation of participatory normative scenario, (2) baseline measurement and circular measuring rod and (3) monitoring and evaluation including indicators. It became clear that the framework provides an overall overview and with the municipality as a key stakeholder.

Implementing the previous proposed steps, does not imply a successful implementation of CUAD. Barriers can hamper the system transition. The following section answers the question 'Which factors and trends put up barriers for the system?'.

7.5. Challenges for the Binckhorst

Awareness of what the system drives and the barriers for the transition are crucial (Gibbs & Deutz, 2007; Boons & Baas, 2004). The challenges of implementing CE are collected from expert interviews as well as literature. The challenges can be categorized on different topics: (1) system dynamics, (2) stakeholder dynamics, (3) policy, (4) technology, (5) knowledge and necessity and (6) finance and investments. Besides this, the driving forces, characteristics and strengths of an urban area differ from case to case (Vernay, 2013).

7.5.1. System dynamics

The challenges according to the experts regarding system dynamics is that the *current system is not organized in regarding CUAD. There are contradictory stimulants present in the system. These should be removed* (Kokx, int., 2017).

The residential units that will be added to the Binckhorst, increases the homogeneous flows of residential waste flows. Besides this, Jongert (int., 2017) argues that *quite some businesses will not exist in the future on the Binckhorst, which will at the expense of resource flows leaving the area, that could have been taken up in closed loop systems. This point is confirmed* by Kwakkel (int., 2017) who expects some heavy industries to leave.

Lindemann (int., 2017) observes in her work that *the companies that exchange flows, will be depended on each other. If one company decides not to collaborate, the system fails. Thus, the process is sensitive to motivations of all involved stakeholders.* This point is confirmed by literature that identifies barrier to value co-creation (Romero & Molina, 2009; Ghisellini et al., 2016). Additionally, transparency and dependency among businesses is not favorable, due to competition (Basteins et al., 2014).

Another point mentioned by Kwakkel (int., 2017) is the *scalability of projects. Most of the initiatives of circularity are on the small scale. There are very little scale-ups. And this is needed for the CE in order to become a success. The risk of small-scale is the thousand flowers that blossom, without a complete system transformation. Each business-case has its limiting factor: some cases it can be the resource, others it is the physical space and others is the ambition of the entrepreneur. In the case of circularity, it is the scale.* This is confirmed by van Boxtel (int., 2017) that sees *upscaling of reuse of resources not clear in a vision yet.* The underlying cause is the finance and investments barrier (Gemeente Amsterdam, 2016; Ghisellini et al., 2016), further elaborated in 7.5.6.

As described in literature, for implementing CE, science and technology are key components. Information of these technologies are required to form adequate planning and management (Geng&Dobberstein, 2008). As indicated in the CUAD conceptual framework, all entities are connected to different levels. This requires systemic knowledge for planning and managing. This knowledge is lacking for policy makers to create a sufficient overview for adequate decision making.

7.5.2. Stakeholder dynamics
Kokx(int., 2017) observes that *stakeholders the transition and development of circularity do not involve themselves. At the utmost upon their organization. A group feeling should be stimulated with a shared vision about the circular development of the Binckhorst.* This barrier is seen as well by Louwaars (int., 2017), who argues that *all stakeholders will take a new role in the transition of the Binckhorst. While not all stakeholders are used to this new role* or do not want to take this role since it is contradicting to their traditional role. Literature refers to this barrier as hinder of powerful stakeholders from the current regime (Leising, 2016).

Most stakeholders, such as the project developers in the Binckhorst have a short-term interest. While CUAD is a long-term process where trust should be built among the residents and businesses. This is recognized by multiple experts (Louwaars, int., 2017; Brouwer, int., 2017). And confirmed by literature (Gibbs, 2008).

7.5.3. Policy
Louwaars (int., 2017) observes that certain strict regulation of the municipality can put up barriers for innovative experimentation. *Some initiatives are supported by the municipality to be developed. However, other regulations of the municipality stop these initiatives.* Brands (int., 2017) observes a similar barrier that *waste regulations do not allow experimentation with waste flows. And it is hard to get out the resources of the production chain, before it is labelled with 'waste'*.This barrier is confirmed by literature, stating the lack of integration of circularity in innovation policy (Kok et al, 2013). Authorization procedures can be slow, compared to innovation of products or processes (Basteins et al., 2014).

Additionally, Lindemann (int., 2017) mentions the *speed of operation of the municipality. The municipality assigned themselves in a facilitating role for CUAD. However, since currently the economy grows, the municipality is late in development and initiating projects.*

A national as well as an international barrier is the resource taxes, leading to industries that buy virgin materials rather than recycled materials. This tax system does not create an economic incentive for purchasing recycled materials (Geng&Dobberstein, 2008). Additionally, consumption taxes are limited to a few products, leading to limited direct and indirect reduction in pollution (Geng&Dobberstein, 2008). Overall, there is an unwillingness of governments to provide adequate economic and financial instruments (Su et al., 2013). Although these political barriers are identified for Chinese policy measurements, similar barriers show in Dutch policy.

7.5.4 Technology
Brands (int., 2017) observes that separated waste streams that are currently collected, the re-use technologies are not advanced. *For example: a system is set up to separate plastic from residential waste. However, technology is not advanced yet that plastic can be completely recycled.* This is confirmed by Kwakkel (int., 2017), who observes the problem of plastics in the mix: *the collection of plastics leads to a large mix of different types of plastics. And therefore, it is almost impossible to recycle plastics to a high-quality product.*

For implementation of the principles of CE, advanced technology needs to be adapted and updating equipment (Su et al., 2013). Literature states that high levels of uncertainties are intertwined with technological risk, leading to market risk and financial risk, creating a barrier for adopting innovative CE strategies (Achterberg& van Tilburg, 2016).

7.5.5 Knowledge and necessity
A challenge of implementing CUAD is according to Lindemann (int., 2017) *the complexity of circularity in urban areas. Since it contains a variety of factors, people don't know what it all contains*. Brands (int., 2017) formulates it more specific that *knowledge of the CE is low in businesses as well as the municipality. The municipality cannot give strong policy directions since it lacks knowledge of what CE means for urban planning. And this does not create an incentive for companies to gain knowledge in the CE since it is not demanded from them.* Kwakkel (int., 2017) confirms this with stating that *the real knowledge to implement CE currently lacks. Each stakeholder has a different view on CE and it can be implemented on different levels. This leads to confusion since circularity means multiple options.* This is confirmed by literature, stating that companies have a lack of knowledge of resources and opportunities in benefits of CE (Basteins et al., 2014). Similar limitations are found in the Stockholm Royal Seaport development. Knowledge of sustainability and how it affects urban planning is unknown. Collaboration and exchange of knowledge among all involved stakeholders is needed for facilitating the transition (Holmstedt et al., 2017).

Additionally, Brouwer (int., 2017) states that *the necessity for implementing circularity is not high. Therefore, there are not examples yet of implementing CUAD*. This is confirmed by Kwakkel (int., 2017), who argues that the current *companies are not aware of the sense of urgency. Especially among existing businesses. Startups can be intrinsic motivated to work on circularity*. Lindemann (int., 2017) mentions this point that *companies live by the day and it costs energy investment to observe a longer term. If the companies do not see this sense of urgency, then no one starts with the CE.* Van Boxtel (int., 2017) observes that most companies function according to *business-as-usual. And therefore, the intrinsic motivation for CUAD lacks.*

In literature, this argument is found as well. Implementing CE is complex with a variety of potential contributions on different levels. It requires support from all different stakeholders (e.g. industrial managers, governments, institutions, community and financial institutions). Broad public involvement leads to large contributions to implement CE (Geng&Dobberstein, 2008; Ahern et al., 2014). Each stakeholder involved in the system is part of a larger system. Thus, not only information within the stakeholder is needed; exchange of knowledge with other stakeholders is required (Su et al., 2013).

7.5.6. Finance and investments

Jongert (2017) observes that *the focus of metabolic analyses and resource flows is mainly on the physical flows and not on monetary flows. Research should be executed in order to determine the exact value of these resource flows in the Binckhorst.*

Finance and investments are brought up as barriers in other documents for starting initiatives in the CE. Value recovery from secondary resources generally requires labor. Brouwer (int., 2017) and Kwakkel (int., 2017) observes this barrier as well. *The 'free resources' circular companies receive, leads to an assumption that the product they make is cheap. However, these companies cannot make use of cheap labor in low salaries countries such as India. This leads that the circular products will not become mainstream since it is more expensive compared to conventional production.* This argument is as well mentioned by van Boxtel (int., 2017), who observes a *circular brick that is double the price of a 'new' brick. This way, a reused resource cannot compete with 'new' products.* This is confirmed by literature, stating that initial investments are high, externalities are not included in the price of resources and a barrier between costs for virgin materials and labor (Kok et al., 2013).

8. Discussion on the CUAD framework

To answer the research questions, the CUAD conceptual framework is introduced in this thesis project with the aim to integrate domains of urban planning and CE. With the addition of methods and tools, the CUAD framework is operationalized and implemented. This chapter elaborates on a reflection on the framework and applied methodologies and tools.

Figure 8.1. Methodological steps of the thesis research project

The discussion is split up in different topics of reflection. First, an elaboration will be done on the theoretical reflections, followed by the choice of methodologies. Suggestions are done for improvement of the conceptual framework. Finally, the outcome of this study is questioned.

8.1 Theoretical reflections on the framework

The review of the CE learned that CE is taken up as a shift in paradigm (Murray et al., 2015), an economic strategy for introducing new businesses (Yuan et al., 2006; Bocken et al., 2016) and policy measurements for governments (Geng et al., 2009). A comparison of scientific literature review of CE in China and Europe indicates that China has taken up CE as a top-down and socioeconomic transformation of society on horizontal level (industrial system, infrastructure, cultural environment and social consumption) (Naustdalslid, 2014; Ghisellini et al., 2016) and vertical level (micro-, meso-, and macro-level) (Su et al., 2013). The literature concerning European directives are more focused on bottom-up approach and waste legislation. European policy shows increasingly interest in implementing CE in urban areas, such as eco-cities, however this is not clearly embedded in EU directives yet. Additionally, eco-cities are not the same as CC: it shows some overlap; however, sustainability ambitions and circular ambitions differ (Geissdoerfer et al., 2017). The same conclusion can be drawn, observing Dutch policy concerning implementing CE.

Sustainability is an emerging concept in urban planning. As these two concepts showed conflicts before, more policy room for integration of these two concepts is made by the Dutch government (Runhaar et al., 2009). As goals, benefits and stakeholders involved differ between sustainability and CE (Geissdoerfer et al., 2017; Muray et al., 2015), integration of phased plan for integrating these two domains can be shared due to the shared perspective and system dynamics of sustainability and CE.

Circular Urban Area Development (CUAD) is introduced as integrating CE in urban planning. 'Development' indicates the process of integration. However, at the core, the framework as displayed in chapter two is more a static image. Phased steps are added for process methodologies, leading to a more hybrid framework. The development of CUAD framework was inspired on the review of the Chinese approach to CC as well as the phased planning of SUAD. CE is a relatively new concept for urban planning, leading to unclarities of how to approach the CE from an urban planning perspective and how to integrate the principles and strategies of CE. To integrate urban planning themes, the CUAD framework was formulated, based on principles of SUAD framework, examples of SUAD/CUAD in practice and the workshop, held by the municipality. However, some limitations appeared in the results. The summary indicates the used frameworks and approaches of different domains, integrated in the CUAD framework, leading to a composition of multiple elements. This increases the complexity of the framework.

The following paragraphs elaborate more in specific to (1) the missing elements of the CUAD framework, (2) the urban planning entities and methodologies, (3) time scale and scale of operations of CE and (4) principles and strategies of the CE.

8.1.1. Missing elements in the CUAD framework

In the CUAD framework, the flows come in the macro-level and leave the macro-level. Suggestion for improvement is to include closing loops on the macro-level, leading to a new delineation of the macro-level. The macro-level is not bound to a specific geographical area. It should enhance all levels that flows can be closed, as visualized in the CC model (figure 2.6). Additionally, the micro-level is specified to a single firm and a singe household. The meso-level includes interaction among firms as well as households. However, the framework is visualized as if the economic experience is solely micro-level. Interaction within this entity is considered as meso-level, according to the literature review. A suggestion is improvement of visualization of the three layers. Another point of critique is the macro-level and its stakeholders. The macro-level is defined according to literature as 'recycling oriented society', leading to individuals as part of the macro-level. And at the same time part of the micro-level. The interaction among these three layers is crucial for insights in flows and stakeholders. However, a lack of clarity around the definition and delineation of the three layers occur in the framework.

Regarding the flows, energy and resources are taken up. However, flow of information and monetary flows are missing. Flows of information between firms and households are considered crucial concerning environmental and financial benefits (Geng & Doberstein, 2008; Mathews & Tan, 2011;Zhijun & Nailing, 2007). A lack of monetary flows is a point of critique on the CE in general (Ghisellini et al., 2016). As finance and investments are used as motivations for and against implementing CE, insights in monetary flows is relevant to identify specific bottlenecks.

8.1.2. Urban planning entities and methodologies

The CUAD framework adopted the methodologies stakeholder analysis and MEFA analysis for insights in the flows and correlating stakeholders in the urban planning entities. The question asked in chapter 7 'does the stakeholder follows the flow in an urban area or does the flow follows the stakeholder?' implies a causal relationship and perspective. By integrating the stakeholders and flows with the urban planning themes a static image appears, leaving out the causal relationship among stakeholders and flows. Additionally, information on the stakeholders and metabolic flows were provided per urban planning entity, categorizing processes artificially in traditional urban planning topics.

More specific, the entities 'mobility and infrastructure' and 'households' can be split up in two parts: (1) the construction and demolition of the built environment of that entity and (2) during operationalization phase. These two parts involve different flows and stakeholders. The CUAD framework and the entities do not make a distinction of these two parts. However, this separation is crucial for implementing strategies of the CE. The same separation of the two parts can be made for the entity 'public space' and 'economic experience'.

CUAD produces a static image of an urban area. In literature, implementing CE was observed as a process, rather than a state of affairs (Boons et al., 2011). In order to choose tools and methodologies for implementing CUAD, different phased plans are reviewed, such as SUAD and the CC model. The CC model from Chinese literature includes the implementation of the four systems: industrial system, infrastructure, cultural environment and social consumption (Naustalslid, 2014; Zhijun & Nailing, 2007). The definition and implementation of these four systems are not extensively discussed in literature. Additionally, the implementation is described as top-down and useful for constructing urban areas instead of transforming urban areas. The case study of this research is a transformation of an urban area, increasing complexity due to the existing structures of the political, social and economic domain.

The six steps for implementing SUAD (Runhaar et al., 2009) seem appropriate as a phased plan for process tools and methodologies. This is due to the overarching perspective of sustainability and CE. Additionally, this phased plan was found in Dutch policy, whereas the EU has a different implementation compared to the Chinese government. The first two steps were performed for this research, leading to not a fully performed proposed framework. Suggestion is to perform all steps as described in chapter 4.

8.1.3. Time scale and scale of operations of CE

As Healey (2002) recognize in its essay the multiple time-space horizons of a city, leading to dynamic structures and influences. These dynamic structures and influences are shaped by stakeholders, technologies and power relations. Stakeholder involved in an urban area and their power and interest changes over time. The same can be considered for flows of resources and energy. The timescale of a stakeholder or resource depends on (1) the type of stakeholder or resource and (2) the activity (Voskamp et al., 2016).

Closing the loops of resources and energy occur on different temporal scales. This is due to the lifetime of certain resources. E.g. construction materials in residential units have a long lifetime (on average 60-90 years) (Pomponi & Moncaster, 2017), compared to furniture (20-50 years) and nutrition products (1 day – 5 years) (Gladek et al., 2015). The CUAD framework is a static image, lacking the temporal scale and lacking a distinction between the different temporal scales of resources or energy. This leads to missing image of coherent resource flows with temporal scales. The backcasting analysis addresses the timescale in the long-term future. However, it fails to make a distinction between the stakeholders and flows with different lifetimes.

To deal with this issue, Boons et al., (2011) introduces a conceptual framework for analyzing dynamics of implementing US with three components: antecedents, mechanisms and outcomes. The antecedents identify the drivers of the system including location specific and business specific features. The mechanisms are processes affecting US. Finally, outcomes are divided in ecological impact and social networks.

Since implementation of CE and CUAD framework requires system integration, the issue of defining system boundaries raises. The system boundaries of this research are set to geographical boundaries of an urban area. However, the question raises concerning other theories and approaches whether implementation of CE is related to geographical area. The geographical area might be of secondary importance when it comes to analyzing flows in a city with the underlying socioeconomic system. The factors of stakeholder dynamics in a value chain or supply and demand of specific resources are of greater value for integrating CE in urban planning.

8.1.4. Principles and strategies of the CE

The CUAD framework, as applied in this research, provides an overview of all resources and flows in an urban area. A suggestion is done in chapter five to model the framework with a specific flow of resource or energy. The CUAD framework provides answer to the 'what' question. The 'how' question of implementing CE can be answered with introducing CE strategies. The three principles of the CE – reduce, reuse and recycle – are not visualized in the CUAD framework, including the phased steps. It is suggested that the CE principles and strategies should be more integrated with the phased plan (step 5) of the CUAD framework. The proposed next step is to determine which principle fits the related resource and stakeholder. The (1) regenerate, (2) share and optimize and (3) loop and exchange (Smol et al., 2017) can be partly modelled in the framework, lacking the complete overview of how these strategies are implemented.

As critique on the CE pointed out is that the social dimension is underexposed, e.g. human health and human rights (Murray et al., 2015). These elements are not reflected in the framework as well. The social factors are integrated in the formulation of the indicators for the specific urban area. However, it is suggested that the social factors need further elaboration.

8.2. Choice of methodologies

This section elaborates on the choice of methodologies. In paragraph 4.2.6. limitations of the methodologies are given. This section reflects on the limitations after executing the methods. The choice is made for an UM framework to gain insights in the flows in an urban area, the stakeholder analysis for analyzing the socio-economic system and the backcasting analysis for the long-term perspective.

8.2.1. Amount of methodologies

A point is the amount of chosen methodologies and complexity of the case. The three methodologies: stakeholder analysis, MEFA and backcasting analysis can be complementary to each other. However, the integration of three methods leads to less in-depth research per method. The stakeholder analysis lacked depth, since stakeholder groups were mentioned, and their dynamics were shortly mentioned in an overview, without reflection of actual involved stakeholders on the proposed stakeholder categories. The MEFA analysis is done for a single firm, lacking prove for implementation in practice by coupling the MEFA to another MEFA from a single firm. The backcasting analysis is performed on only the first three steps, missing a complete analysis of the long-term perspective. Scenario validation is not executed for the normative scenarios. These scenarios are formulated, based on input of experts and the workshop.

However, in order to create a holistic image of all (future) stakeholders and flows, it is suggested to execute more steps of each methodology. The same can be suggested for the backcasting analysis. E.g. the fifth step of the backcasting analysis is validation of the scenario and this step can be essential to gain more public support for the scenarios. The feedback, provided by the experts and participants of the workshop, would make the scenarios more robust and more likely to be taken to the next step. This validation can be done in a workshop form. Although multiple methodologies are performed for the framework, this is at the expense of more in-depth knowledge of each methodology.

8.2.2. Expert interviews

The experts are chosen for their stake and expertise of their work in the Binckhorst. The results conducted for this research are limited to their knowledge of the topic. The experts are chosen on the following criteria: diverse group of stakeholders and work involved in the Binckhorst. Nine experts are interviewed, which leads to nine different visions on the development. If different stakeholders were picked, results will come out differently, even if the stakeholder is from the same organization. The vision on the development of the Binckhorst is subjective of the opinion of the asked expert. Additionally, their views are translated by the researcher in this document, leading to loss of information and biased outcomes.

Besides this, the experts were interviewed according to a semi-structured interview. Therefore, answers to the questions can be changed during answering the questions. The questions are formulated specific to the CUAD of the Binckhorst, while the opinion of the expert can have a different view on how urban planning and management should be done without integrating CE in urban planning. This makes the choice for experts subjective and the knowledge gained from the expert limited.

The answers of the experts were coded in the interview. These answers were categorized according to the CUAD framework in chapter 5 and 6 and translated to English. During these steps, relevant information can be lost due to the subjectivity of the researcher. Additionally, answers of experts can be left out of context during coding of the interview.

8.2.3. Workshop

The workshop of the second of October was held by the municipality and there was no involvement of the researcher. Therefore, the results were collected according to the methodology and vision of the municipality. The results can turn out to be biased. It is suggested to re-do the backcasting analysis, due to the results that are more categorized to SUAD instead of CUAD. Additionally, common ground among the experts and participants of the workshop were lacking, since these methodologies were separately executed. A loss of relevant information from the workshop can occur due to the interpretation by the researcher.

8.2.4. Discussion on the casestudy

A choice is made for a single casestudy of the Binckhorst to create and test the CUAD framework. The weaknesses of a single case-study appear in the research of the phenomenon's in the context, leading to an analysis that cannot be generalized to other cases and is therefore apart from other case-studies (Groat, 2013). The case study of the Binckhorst came out as complex, due to the irregular development path. CUAD was formulated as a desired long-term perspective for the Binkchorst. However, the Environment and Planning act plan for the Binckhorst was published during the research, leading to a different governance direction of the municipality. Suggestions for research to similar cases demands for more collaboration and transparency of governance organizations.

Additionally, the scope of the single case-study tends to widen with different data sources, leading to a lack of coherence in the study. Confirmation of the embedded theory is needed in multiple case-studies (Groat, 2013). In this thesis, confirmation of the embeddedness of the CUAD framework is needed with other casestudies, as a recommendation for further research.

8.3. Suggestions for improvement

This section elaborates on suggestions for improvements of the CUAD framework, phased path and correlating methodologies. It does not imply that the suggestions will lead to a better CUAD framework. However, these paths can be further explored. As integration of CE with urban planning is relatively under exposed topic, exploration of different disciplines can provide more insights in the topic.

8.3.1 Suggestions for substitutions of the CUAD framework

Suggestions for improvements and additional insights can be found in the addition of different theories such as the ANT theory and transition theory. Implementation of circularity in urban planning can be observed as a form of innovation process. These innovation processes are commonly a form of technical as well as social elements (Vernay, 2013). As resulted from the stakeholder analysis, the dynamics and dependencies among these stakeholders provide more insights in the dynamics and possibilities of the area, rather than listing all stakeholders by name.

As if incorporating circularity is seen as implementing innovation, methods of studying and steering technological innovations is: (1) the multi-level perspective and (2) strategic nice management (Geels, 2004). The multi-level perspective is a study the dynamics of sociotechnical transitions. The underlying assumption is that a sociotechnical transition does not only embody technical changes, as well as elements of user practices, regulations and industrial networks. The process occurs on three levels: micro- (niche-level), meso- (regime-level), and macro-level (landscape) (Geels, 2004). The strategic niche management is a part of the transition theory that has the focus on the early stage of innovation. The success or failure of an innovation is based on three internal processes: (1) shaping expectations, (2) social networks and (3) learning process. The focus is on internal processes, missing the context of external factors. Therefore, the combination of the multi-level perspective and strategic niche management can provide insights in early stage innovations and external influences (Schot & Geels, 2008; Vernay, 2013). The question is whether urban areas fit the scale for the multi-level perspective. Challenges can be identified that hamper innovations, however it is harder to study the local dynamics and interactions among stakeholders. Additionally, the question is whether small circularity initiatives can achieve the niche status in the strategic niche management or they failed before becoming a niche due to a lack of system integration (Vernay, 2013). The approach with the perspective on the different levels and the assumption of interconnectedness nature of technological innovation and social change fits the dynamic circular urban planning framework. The transition theory as well as the multi-level perspective method can lead to more relevant contributions to this research, compared to the urban planning perspective. Additionally, the strategic niche management can provide insights in the successes and failures of circularity innovations.

The ANT is another theory studying innovation, in specific micro-processes of innovation. The ANT has the underlying assumption that all innovations are bound to a network of heterogeneous stakeholders with similar interests (Walsham & Sahay, 1999). The success or failure of an innovation depends on the capacity of stakeholders to involve others in the network. This process consists of four stages: (1) problematization, (2) interposition, (3) enrolment and (4) mobilization. The outcomes of these stages are not set, and the process is not linear. It is an iterative process and involves negotiation. The ANT advocates no distinction between human stakeholders and non-human stakeholders (artefacts, animals etc.) (Vernay, 2013). The ANT can provide a method for analyzing whether a stable network can be formed around innovation. ANT recognizes the role of power in networks. The role of power is not described as dominating or constraining other stakeholders. Moreover, it elaborates on the fact that configurations of networks lead to power structures in networks. The ANT follows the notion of system integration; however, it does not conceptualize innovation as system integration. The ANT fits the circularity approach in the recognition of the notions: scale and space. Another theoretical approach can be found in the urban ecosystem services. Thus, this models around ecosystem services, such as water quality, air quality, food security etc. Instead of taking the traditional urban planning categories, the flows of resources and energy are modelled around an identified service (Ahern et al., 2014).

8.3.2 Suggestions for substitutions of the methodologies

Adopting other industrial ecology tools such as LCA's and input-output analyses can provide additional insights in improving circularity of an urban area. LCA's take into consideration the impact of resource flows outside of the urban area. It addresses the impacts of mining and processing such resources or energy. If materials are substituted, the LCA tool can provide the information whether the substitution will contribute to more sustainability (Pincetl et al., 2012; Smol et al., 2017). The dynamic stock-flow analysis can provide insights in the resource flows with the different life-times, as explained in the different time scales and scales of operations of resource and energy flows.

8.4. Outcomes of the study

The final question can be asked regarding the definition of CUAD and implementation of CUAD. Is it desirable to implement CUAD? Should urban planning have a more stronger focus on CUAD for the success of implementing CE or is it preferably SUAD for transitioning urban areas. Literature pointed out the advantages sustainability can bring in urban planning, while pointing out the lack of common understanding of the concept sustainability and a uniform notion of how sustainability should be implemented (Runhaar & Driessen, 2007; Holmstedt et al., 2017). The review of CE pointed out that this is a relatively new concept, compared to sustainability (Geissdoerfer et al., 2017). Leading to the question whether CE should be integrated in complex dynamics as an urban area. As indicated from literature, the macro-level of implementing CE is referred to as 'recycled-oriented society' and not further defined. The concept of eco-cities would be related to CE in urban areas. However, not all eco-cities can be defined as CE implemented on macro-level. Additionally, the integration of the four elements of the CC model remains unclear.

An important point is that the destination plans for the Binckhorst are highly dynamic. The plan of 2011 for the Binckhorst includes organic development, with the municipality as a facilitator of private initiatives (Gemeente Den Haag, 2011). While the current land-use plan of 2017, the municipality is a stronger initiator of development. The attention of CE implementation decreased. In the current plan, the CE is referred to as one of the parts of sustainability that 'receives special attention in the redevelopment of the Binckhorst' (Gemeente Den Haag, 2017). While during the last news item of the Binckhorst in the Dutch NOS, implementation of CE or sustainability is not mentioned. In this item, the focus is on redevelopment of the Binckhorst while remaining the industrial character (NOS, 2018).

9. Conclusion

9.1. Conclusion

With the raising sustainability issues for cities and urbanization trend, CE is introduced as a concept to deal with resource and energy challenges. With the CE – system perspective on closed loops - as a promising concept for comprehensive state policy, the urge is visible by policy makers. However, incorporation of CE in system transitions lack behind. This thesis researched how CE can be integrated in urban planning as a perspective to deal with increasing usage of energy and resource consumptions of urban areas. The leading research question for this thesis project is:

What is circular urban area development? How can this be applied to the Binckhorst? And what can be learned to develop the CUAD framework further?

This research is driven by (1) what CE means for urban planning and (2) integration of different disciplines and methodologies to understand transitions of sociotechnical processes. It is an attempt to create a structured elements as well as process elements how CE affects an urban area and how the urban area can be shaped to accelerate CE. CUAD is introduced as a conceptual framework with the aim to integrate CE with urban planning domain. The conceptual framework is based on different frameworks from the SUAD, urban planning and CE domain. A phased plan is introduced with the CUAD framework to determine the process of integrating CUAD.

In order to operationalize the framework, the conceptual framework is applied to a single case-study. The last part of this research question will be answered in this chapter: *'what can be learned to develop the CUAD framework further?'*

To answer this question, first an elaboration will be given on the conceptualization of the CUAD framework. This is followed by the three methodologies (UM, stakeholder analysis and backcasting analysis) that are applied on the single case-study for operationalization of the framework. Finally, elaboration on the integration of the different methods is given.

9.1.1. CUAD

A first attempt is made for developing a CUAD framework, based on the theory of CE in practice and SUAD. Development implies a process framework. However, the proposed CUAD framework is a static and structured overview of an urban area. A phased plan is added to include the process and development element of CE.

In literature, CE can be seen as a new paradigm and development model for the current linear functioning of the economic system, with in its core closed loop systems of resource and energy flows to reduce environmental impact. The three most mentioned principles are – reduce, reuse and recycle -. These principles can be implemented as strategies on three levels: micro- (firmlevel), meso- (interfirm level), and macro-level (recycling-oriented society). These levels are reflected in policy measurements by governments as well.

The CUAD framework has the resource and energy flows in its core with principles and strategies on the three levels. These two flows are integrated with four urban planning categories. Integrating CE in urban planning is challenging due to the large variety of definitions of CE, the different views of principles and strategies of the CE and lastly the great variety of possible configurations of CE. The different strategies and configuration paths of implementation of CE creates a challenging task for integration with the urban planning themes.

The phased path indicates the process element of implementing CUAD. The phased path of the CUAD framework provided handles to choose correlating tools and methodologies. A UM, in specific a MEFA was chosen to gain insights in the resource and energy flows of an urban area. The stakeholder analysis was chosen as a methodology to provide insights in the socioeconomic system in an urban area. The flows as well as the stakeholders provide insights in all the three levels of implementation of CE. Lastly, the addition of the backcasting analysis lead to a time path of what is most desired (normative scenario) and how to get there.

To conclude, research pointed out that rather the stakeholder groups and correlating flows are central for implementing CE. The question remains whether urban planning themes are dominating in implementing CE in urban areas. A coherence and integral approach was missing in the results, leading to single (non) circular ideas. The boundaries of the urban planning entities are subordinate in the analysis of implementing CE. Additionally, the separate elements leading to separate ideas per element, while the aim is to integrate residential units with businesses, based on their flows. Or the other way around: integrate flows, based on their stakeholders.

The CUAD framework provides a static image. However, causal relations of stakeholders as well as flows are particularly relevant for implementation of CE. The phased plan integrates process methodologies for initiating CUAD. However, it leaves out causal relations among stakeholder groups and flows.

To conclude, the advantage of the CUAD framework is the integral approach of CE for an urban area and the addition of the three layers (micro-, meso- and macro-level) for formulating CE strategies. CUAD in combination with the phased plan gives a hybrid approach to implementing CE by giving a structured overview and process steps for implementation. A practical advantage of the introduction of CUAD for policy formation is the holistic approach of CE taken up in the framework. CE is included as a waste strategy in European Union legislation. However, CE can be a more effective and strategic approach towards urban planning, taking resources as a central point with the underlying socioeconomic dimensions, instead of focusing solely waste strategies.

The phased plan of the CUAD framework formulates the first step as the 'analysis of the current situation'. This is done with the UM framework and stakeholder analysis. The second step 'determination of the desired area types' is done with the backcasting methodology.

9.1.2. UM

The UM with the tool the MEFA can be executed on three levels. For this research, the metabolic analysis on meso-level for the Binckhorst was analyzed. Concluding is that this analysis lacked the level of detail for the scale of operations as well as the temporal scale. Additionally, the analysis was based on secondary data sources, calculated for the case-study.

The UM is elaborated for a single-firm, on micro-level. As explained in literature, analyses in multiple levels (micro-, meso-, and macro-level) for insights in all resource and energy flows of an urban area. By implementing CUAD, the MEFA needs to be executed on these three levels, taking the scale of operations and temporary scale into account per resource and energy flow. This implies difficulties concerning different time scales of flows, due to variety of activities. E.g. households process continuous flows of waste and energy, same accounts for operating businesses. Modelling an MEFA of these two entities can be aligned with the same temporal scale and scale of operations. Other activities, such as the construction of residential units or roads lead to a different intensity of resource use and energy use. Additionally, the timelines of the materials used for these examples are a significant stock in the built environment for the long-term (60 – 90 years). Modelling of these MEFA cannot be aligned with the same temporal scale and scale of operations for households or businesses.

A crucial point taking in mind for an UM analysis is since the area will be in transition, it is expected that flows will change drastically on each level, as a similar pattern as the stakeholders. Moreover, a limitation of the UM is the creation of a static image of flows. However, the dynamics between flows over time need further elaboration. The question is what to do with the current development and changes, and the long-term perspective of implementing CE (closed loop systems and building trust for collaboration).

A limitation of the UM analysis is the integration of flows between the three levels. It is desired to model flows on the micro-level. However, flows on meso-, or macro-level can be taken in the micro-level. The question is how to integrate the interaction between the levels in an analysis, without losing the overview. Another limitation is the different lifetimes of resources. These are not modelled in the static overview of the UM. Additionally, it does not model substitution of resources, when implementing CE.

9.1.3. Stakeholder analysis

The perspective of a sociotechnical analysis of an urban area in transition, demands for knowledge of the stakeholders involved in the area. The framework points out the distinction of three levels operating in an urban area.

The stakeholder analysis executed for this research is based on stakeholder categories and the three levels. The overview pointed out the municipality as main stakeholder. This conclusion is found in literature as well, by pointing out governmental organizations and businesses as key stakeholders in a CE (Geissdoerfer et al., 2017).

The dynamics among the stakeholder analysis provides more insights in the demands and power structures of stakeholders. Another insight is that currently, the stakeholders involved in the construction of the residential units are specifically relevant due to their role and power in the Binckhorst. In a later stage of development of the Binckhorst, the attention will go to development of mobility (public transportation) and future residents. It is therefore suggested to extend this part, based on the development phase of the Binckhorst. Additionally, anticipating on stakeholder groups that will be relevant in the near future can be desirable as well. In other words, it demands for a more dynamic image of the involved stakeholders. The temporal scale of a stakeholder analysis and specific the power structures of stakeholders is relevant. However, the temporal scale of the framework lacks in the overview. The backcasting analysis brings in the temporal scale. Although a limitation of the backcasting analysis is that it addresses traditional institutes and organizations. But it fails to integrate new stakeholders (Neuvonen & Ache, 2017).

The stakeholder analysis is performed on data from the expert interviews. However, simple participatory approach can bring significant gains to the stakeholder analysis. This is due to the fact that participatory processes can lead to build trust and relationships and uncover possible biases (Reed et al., 2009). This is particular relevant for building relationships and collaboration for implementing CE among businesses, residents and policy makers.

9.1.4. Backcasting analysis

The backcasting analysis brings in the temporal scale, by creating a desired scenario for the long-term future. Additionally, it is a methodology that makes complex urban areas manageable (Neuvonen & Ache, 2017).

For this thesis project, the start of a backcasting analysis is used for gaining insights in desired elements for the Binckhorst. The outline for desired scenarios was done based on implementing CE on the small scale and implementing CE on the large scale. CE on the small scale is similar to implementation of CE in the Buiksloterham with the addition of living labs for experimentation. Implementation of CE on the large scale follows the example of the Stockholm Royal Seaport. The Binckhorst is seen as part of a larger region, since the area depends on its surrounding concerning resources and energy.

The desired elements were formulated according to the urban planning entities. This leaded to separate ideas per entity, leaving out the integration among these entities. A suggestion would be to adopt a participatory backcasting analysis for integrating all stakeholders in the shared vision. This has benefits on multiple domains: (1) it contributes to incremental learning among stakeholders and (2) creates insights in interests of other stakeholders. Additionally, it is suggested to perform the backcasting analysis around the three levels, aiming for more integration.

Learning's from the case-study, is that the common ground of understanding CUAD was missing, leading to confusions in sustainable suggestions and circular suggestions. This leads to the suggestion to redo the backcasting in the form of a participatory backcasting analysis, providing the benefits of creating common knowledge and incremental learning among the participants.

9.1.5. Integration of the methods

Sustainability is an emerging concept in urban planning. However, this research takes circularity as central point for urban planning. Implementing CE in urban planning demands for a holistic approach and integration of all entities. The traditional urban planning entities were conceptualized with the core flows of CE. To create a complete image, all steps of the phased plan should be executed. This research elaborated extensively on the first two steps. The third and fourth step are not executed during the research. some elaboration is done on the fifth and sixth step. However, it is suggested to start performing the phased plan, while integrating the learning's from this research.

An important issue concerning the structure raises with the addition of three different methodologies and tools to the framework. The methodologies were complementary to each other, however, on other points integration were lacking. Ownership of specific flows were not clearly distinct by the framework. The question is whether the collected methodologies have significant overlap to combine. Other methodologies, based on similar concepts can be found more suitable. Another question is whether the urban planning categories have significant overlap with the methodologies or if these categories increase unnecessary complexity.

Since implementation of CE demands for a sociotechnical perspective and different configurations are related to circularity, an urban area can adapt different technologies that require different regulations and specific stakeholders in networks. This leads to a variety transition processes and different CUAD for cities. A disadvantage of the variety of transition processes is the multiple options, without a clear guidance how CE should be implemented in an urban area.

Specific for the case-study, suggestions are done for starting to develop policy measurements for the municipality of The Hague. The municipality is considered as the main important initiator and facilitator for implementing CE in an urban area. This is due to that (1) municipality has different roles in the area, (2) is involved in the long term in different roles and (3) sets policy and legislation for facilitating CE. It is suggested that the municipality formulates clearly its overarching ambition for the area. When the ambition is clearly formulated, the suggestion is to start (1) a participatory backcasting analysis to create a shared vision, (2) stakeholder involvement in the specific stages of development of the Binckhorst (e.g. future residents cannot be involved during construction of units, since these residents are still unknown.), (3) baseline measurement and circular measuring rod and (4) monitoring and evaluation with correlating suggested indicators, specific for the Binckhorst.

Although the backcasting analysis was partly performed for this research, the suggestion is to redo a participatory backcasting analysis. This is due to the fact that the execution of the backcasting analysis was done differently as is suggested in literature. The aim of the workshop was not made clear and a combination of methodologies (including the backcasting analysis) was executed to generate ideas for the Binckhorst. Although some ideas during the workshop covered multiple domains of involvement of stakeholders as well as closing the loop ideas, the overall knowledge of implementing CE was low. The generated ideas did not have complete coherence and can be contradictory in implementation.

A barrier of CUAD is the capacity of change (Gibbs & Deutz, 2007). The capacity of change is seen in (1) financial investments, (2) stakeholder involvement (3) technological developments and (4) adequate legislation. Creating carrying capacity among stakeholders seems like a greater challenge compared to technology options. Technology exist for implementing CE. It seems that stakeholders hold back the transition of CE, due to the variety of interest of stakeholders and priorities. Additionally, success of implementation of CE depends on all stakeholders, the urge should be carried by all stakeholders. If the problem and urge is not missioned by all stakeholders, implementation of circular measurements is likely to fail. It is a system change and to build a new system, all elements are needed in a new role and new collaboration. The transition of such system depends on the speed of the slowest evolver. Failure in one of these elements leads to hamper the transition.

A last core message of this thesis project is: learning by doing. Adaptive urban planning and design with the addition of circularity is a promising development. However, barriers will come up with adapting sustainability strategies (Ahern et al., 2014; Louwaars int., 2017). This makes the monitoring and evaluation stage a crucial point for evaluating the effectiveness of different forms of urban planning and design. Another point is that although single small steps do not seem to lead to a system change, altogether these steps can lead to a profound and deep transition of urban areas.

9.2. Recommendations for further research

9.2.1. *Theoretical recommendations*

CUAD is introduced as a framework for applying CE in urban planning. However, results pointed out this framework requires improvements, since the integration of stakeholder analysis and MEFA were found too little overlap in integration on certain points. Suggestion is to elaborate further on how to develop such framework. Suggested is that the focus should be more on process research, rather than structure research. Implementing CUAD is considered more a transition, than a state of affairs.

As pointed out in the discussion of the conceptual framework (chapter 8), other theories such as the ANT and strategic niche management can have more integral meaning. The focus of these theories is around the networks and technology. This is more in line with the core principles and strategies of the CE. Tools such as LCA, input-output analysis and dynamic stock modelling can be further explored to provide more insights in flows of an urban area. The point of structure tools as well as process tools are particularly relevant for such a framework.

9.2.2. *Recommendations for policy makers*

A point for further research is recommended to awareness of producers and consumers. Since their role is evidentially important in the adoption of CE; after all the society makes or breaks a transition. This is a point for the Binckhorst, concluding that awareness among experts around CUAD was low. This is confirmed in CE literature by Ghisellini et al. (2016), stating the lack of research about awareness.

As concluded, the stakeholder networks are particularly relevant around technological configurations. This is due to the different interest, power structures and priorities of these stakeholders. As a suggestion from Louwaars (int., 2017), a group should be formed of people that do not represent a specific stakeholder group. This group should operate independently of other stakeholder groups and experiment with circular strategies in an area. Such a group should be equipped with adequate financial and legislative instruments to experiment. As a first step, the group should formulate a goal and ambition for the urban area. A statement is that local governments have a central role in taking the initiative. This is due to the fact that (1) local governments have a central role in coordination and implementation of CUAD requires a large amount of coordination, (2) system transitions demands for stimulation, forcing and convince stakeholders to participate that local governments have the obligation to facilitate and (3) CE is about protecting common resources, that is pre-eminently the role of governments (Vernay, 2013). This last point cannot be carried by mainly private organizations or NGO's since they lack authority.

Additionally, research to legislation, policy measurements and awareness in cities should be executed. This can be adopted in policy measurements as evaluation to what is effective and what is not. Implementing CUAD requires a specific solution per urban area. Thus, for each project, one should research which solution will be most appropriate to that area.

Finally, suggestions are made concerning monetary flows. This is identified as a major barrier for implementing CE by the experts, as well as in literature. It is suggested to identify specifically the benefits and the costs of implementing CE.

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