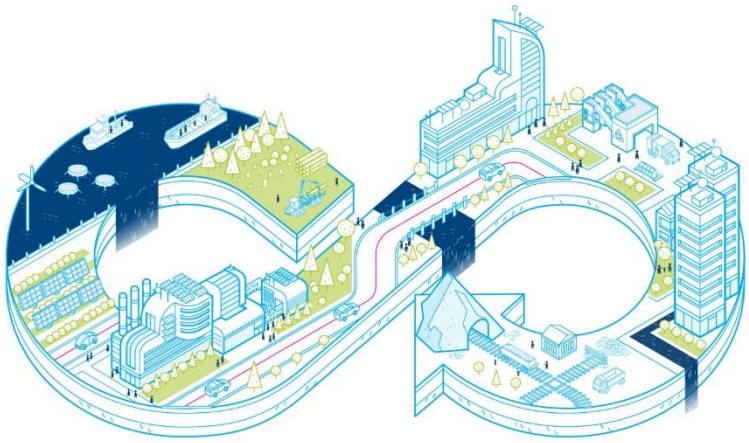
# Implementing Circular Economy in the Built Environment

## Comparative Study between China and the Netherlands



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# PREFACE

This research is a result of two-and-half-year study in Management in the Built Environment track at Delft University of Technology. It took me a while to realize being an architect is not my cup of tea. My interest is located in a bigger picture: connecting with right people, mobilizing the right resources and making the right decisions. What's more, I am curious about how the decision can be successfully implemented in the practice.

The research covers a wide scope: circular economy, built environment, China and the Netherlands. I position myself as a "connector" to connect theory, academia and practice, as well as two different systems. During my research, I figured there are so many opportunities to learn from the best practice between two countries regarding implementing circular economy. I hope this research will explain the theories that practitioners need to understand in a simple way, also help academia get a better understanding of practice.

I want to say thank you to the people who helped me during my research:

First, I would like to thank my graduation mentors, Ruben and Alexander. Thanks for sharing your knowledge and guidance during the research process.

Second, I would like to thank all the interviewees who participated in my study. Thanks for your valuable insights into circular economy and the application in the built environment. Without your inspiring inputs, I could not have been able to conduct the analysis.

Also, I really appreciate unwavering support from my friends in the Netherlands. You already have become my family in the Netherlands. You have the most beautiful heart in the world, and I feel so lucky to be loved and trusted by all of you.

Last year was not the best year in my life. But that also reminds me that life is too short, I need to cherish every moment in my life to love those people who love me with all their heart. "Yesterday is history, tomorrow is a mystery, but today is a gift, that is why it is called ***Present***."

Shuyu

April 2019

# SUMMARY


## *Background*

Circular economy is gaining global momentum as a new economic system to achieve sustainable development. EU and China signed a memorandum of understanding on circular economy in 2018. The cooperation recognized the importance of joint supports and cooperation between two sides in circular economy towards a resource-efficient and sustainable development. The built environment plays an important role during the transition to a circular economy. The Netherlands has been a frontrunner in driving circular economy in Europe. China and the Netherlands share a common basis on enhancing resource efficiency by circular economy, which provides opportunities for mutual learning. Therefore, it is important to conduct a comparative study how circular economy is understood and implemented differently in China and the Netherlands.

## *Problem Statement*

China has great experiences in circular economy policy making and government-led experiments at different scales in the form of eco-city initiatives which mostly focus on heavy industrial sectors. The built environment is still following a linear growth model in general. Meanwhile, the circular economy development in the Netherlands is more resilient and integrated with the development in the cities. The Dutch government tend to provides innovative solutions together with different parties to circular economy from best practices. In contrast, construction is one of the five priorities in circular economy. Why do two countries implement circular economy in different ways and have different priorities? What are the opportunities for circular economy in an urban context besides the eco initiatives in China? Is it possible to apply circular economy principle in other forms of urban development?

Therefore, in this research, we focus on learning lessons from Dutch circular development in the cities to explore possible ways to apply circular economy principles in Chinese urban context besides government-lead eco-city initiatives. To achieve this, it is necessary to understand how circular economy is introduced differently in China and the Netherlands, and how circular economy is implemented differently in the built environment.

## *Research Objectives*

The research contains three objectives: first, to develop a framework to compare the adoption of circular economy in China and the Netherlands; second, to provide practical guideline on circular economy implementation for the built environment based on the comparison; third, make recommendations for sustainable urban area development based on the lessons learned from Dutch practices.

## *Research Questions*

*Main research question:*

How can circular economy be implemented in the built environment in China and the Netherlands and what lessons can be learned from Dutch circular area development in the cities?

*Sub-questions:*

1. What does circular economy mean to the Netherlands and China?

- How is circular economy defined in two countries?
- How is circular economy implemented in two countries?
- How is circular economy measured in two countries?

2. What does circular economy mean to the built environment in the Netherlands and China?

- What are the features of construction sectors in two countries?
- What are the opportunities and challenges for the built environment in two countries?
- What circular approaches can be applied in two countries?

3. What lessons can be learned from Dutch circular area development for a Chinese urban context?

- What are the forms of urban-scale development are relevant to circular economy in China besides government-led eco-city initiatives?
- What are the key problems of those development in China?
- What circular economy approaches are adopted in Dutch circular area development?
- What solutions can be found in the Dutch circular area development?
- How applicable are the lessons/solutions to a Chinese urban context?
- What drivers and barriers can be defined for the development and implementation of circular economy in urban areas in both countries?

## *Proposition*

To implement circular economy in the built environment, Chinese government should combine top-down and bottom-up approaches, creating space for stakeholders and local business to break down the silos in government ministries. The priority in Chinese construction sector is to embed circular economy principle in continuing urbanization. Specifically, there are opportunities to apply circular economy principles in current urban revitalization. Dutch construction sector will focus on retaining the value of material and business opportunities with a more bottom-up approach. However, the interaction with government is still necessary regarding creating target or guidelines as well as support and supervision.

## *Research Design and Methods*

This research is a qualitative research, which specifically aims to understand the different circular economy culture, meanings and the relevant experiences, knowledge as well as action within Chinese and Dutch contexts. Therefore, it can be seen as cross-national research (Hantrais & Mangen, 2007) and comparative study (Hantrais & Mangen, 1996). Desk research and explorative interviews are firstly conducted to explore the research topic, research questions and concpets as well as theories, which results in a theoretical framework. Contextualization is central to the cross-national research methods. The findings are bound to particular Dutch and Chinese social and cultural context. Therefore, in our research, hypothesis are not tested. It emerges from (part of) the research data, which is defined as qualitative hypothesis-generating research by Auerbach and Silverstein (2003).

The proposition of the research is confirmed by empirical study. The empirical study consists of narrative research and case study. Narrative methods can be considered “real world measures” that are appropriate when “real life problems” are investigated (Lieblich et al., 1998). The experts who have sufficient experiences in urban revitalization projects and the experts of circular economy in China are interviewed, and by analyzing their “stories”, the problems are identified. Case study is designed and conducted for the empirical part in the Netherlands to gain applicable experiences for the problems identified from narrative study in China.

Lesson-drawing method is used to analyze the results of narrative research and case study to provide possible solutions and recommendations. We focus on how two countries can inspire and learn from each other to better facilitate the transformation of Circular Economy. From the narrative study and case study in urban context, the focus is how we can apply the experiences from circular urban development to a Chinese context.

## *Results and Conclusion*

The results of the research are conducted by answering the sub-questions.

1. What does circular economy mean to the Netherlands and China?

Take-home note:

- Circular economy in China is implemented from a top-down manner at three levels: macro, meso, micro, focusing on resolving the industrial pollution.
- CE in China still lack systems thinking with government ministry silos and lack of a much unified Circular Economy community: Clean energy have their community; organic food theirs; industrial parks have theirs.
- Dutch circular economy starts from bottom-up, following up by top-down to interact with market.
- Dutch conception of circular economy has a narrow environmental scope, focusing more on waste and materials as well as business opportunities.

2. What does circular economy mean to the built environment in the Netherlands and China?

Take-home note:

- Motivated clients especially big companies with sustainable visions, are the key to the transition of current built environment to a circular one.
- Don't ignore the old way. It is not possible to own a circular economy in one day. We still need the traditional way of producing. Key point
- Make sure that the actors in your supply chain can reach the circular material as close and easy as possible. When people find it difficult to change, they go back to old way.
- Think out of box by involving social interest organization to broaden the scope of circular economy.

3. What lessons can be learned from Dutch circular area development for a Chinese urban context?

Take-home note:

- A supportive government is the key in applying circular economy principle in urban area. Government still dominate the decision-making process, however government has little knowledge of circular economy.
- The experiences of reusing materials can be used for different cases: think in layers. Not just building skin can be circular, services, interior, spaces and settings can all applied with circular interventions.
- Collaboration between practice and knowledge institute is also an important factor to successfully apply circular economy in urban development.
- Respect the existing business. Try to include not exclude them.

Concluding remarks:

To conclude, we can confirm the proposition made in previous chapter is basically correct. To implement circular economy in the built environment, Chinese government should focus on mainly two things: one is implement top-down enforcement in the continuing urbanization to really reduce the material volume and flow on macro level; second is to encourage bottom-up initiatives at local level, implement the idea of 'transition management: to highlight different government departments and smart innovative enterprises, bring them together with local business, provide resources, potential allowance to support them, instead of chasing short-term economic targets. Specifically, there are opportunities to apply circular economy principles in current urban revitalization. Dutch construction sector focus on retaining the value of material and business opportunities with a more bottom-up approach, mainly because of the innovative atmosphere among enterprises. Government plays as a network connector without too much governmental intervention. However, the interaction with government is still necessary regarding creating target or guidelines as well as support and supervision.

| China | Netherlands |
|---|---|
| **Macro CE** | |
| Top-down enforcement on construction production<br>Bottom-up approach on real estate & service | Bottom-up initiative in the market<br>Need more clear top-down vision to speed up |
| **Meso CE** | |
| *Along value chain:*<br>Upgrade traditional value chain in pilot zones<br>➔ Scale up across the country | *Across value chain:*<br>small innovation + social aspect = client's attention<br>➔ Create circular momentum |
| *Between government and business:*<br>➔ Require less governmental control<br>➔ Seek new collaboration among government, private sector and knowledge institute to break the silos | *Between government and business:*<br>➔ Require more governmental interactions regarding guidelines, standards and supervision for private sector |
| *City network:*<br>Collaborate with other circular economy community<br>Manage the existing secondary material market | *City network:*<br>knowledge creation and sharing<br>Localize secondary material information |
| **Micro CE** | |
| Focus on material quantity<br>Facilitate the on-going urbanization | Focus on material quality<br>Retain the value of materials and business |

## *Recommendations for Future Research*

Due to the limitations of this research, we only focus on the potential solutions for Chinese issues presented in circular development in urban areas. There is potential for the Netherlands to learn from China's best practice as well. Therefore, we can make some recommendations for future research:

- Experimentation at different scales
- Development of indicator systems
- Digital solutions related to circular economy

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# PART I: INTRODUCTION

## 1. RESEARCH BACKGROUND

### 1.1 MAJOR TRENDS

*EU-China Partnerships and Initiatives*

"Circular Economy" is a global buzzword. China and Europe, two world's largest economies as well as circular economy leaders could make great impact on the transition to a circular economy at a global scale. China and the EU signed a Memorandum of Understanding on Circular Economy in Beijing to strengthen cooperation on circular economy. Specifically, the Netherlands is ambitious to become a "living circular hub" that spreads knowledge and experiences in practice to other countries. China provides many opportunities to adopt circular innovation and cooperation. Carrying out a comparative study between China and the Netherlands is a way to improve the understanding of circular economy through comparing the policy systems, implementation structures, cultures and patterns of actions in two countries. What's more, the comparative study will provide a variety of experiences and practical knowledge to circular economy for both countries.

*Importance of the Built Environment*

The term *built environment* covers in scale from buildings and parks to neighborhoods, transportation systems, and entire cities. The importance of the built environment sector for achieving Circular Economy cannot be underestimated. It consumes massive resources and materials as well as energy. The construction sector is the largest consumer of raw material in the world and is responsible for 25-40% of global carbon dioxide emissions (Pomponi, 2016).

Circular economy theory has been implemented in practice in industrial and manufacturing sectors for a long time aiming at reducing the waste and pollution and increasing the resource efficiency. While in the built environment, especially in construction sector, the innovation diffuses rather slowly (Leising et al., 2017), because of its long lifespan, inherent complexity and difficulties in charge of use during its service life (Pomponi, 2016). Circular economy is still a relatively new topic for both China and the Netherlands, and only energy efficiency is being widely discussed (Leising, 2017). A

linear economy means that the materials used in the buildings are lost for future use after the functional life time. The materials are disposed of primarily as waste or in low-value applications (Thelen et al., 2018a). To achieve the goals, the actions are to create a level playing field for circular materials, products and services and eventually form a new normal in the sector.

The transition to a circular economy requires a systematic solution because the challenges are interconnected: technology, political, legislation, business. The challenges in practice are different, while the theoretical challenges are the same. Transition to a circular future opens up many opportunities to both China and the Netherlands to develop new economic system to better serve our business, our environment and our people. To unlock those opportunities, we need to compare and share our policies, knowledge and best practices to facilitate the adoption of circular economy in both countries. Therefore, it is important to study how circular principles can be applied in the built environment, what knowledge and tools we need to develop, and review the best practices globally.

## 1.2 Problem Fields

*Industrial parks limit circular economy in China*

China has been a frontrunner on circular economy policies and practices for more than two decades. China contributes the largest share of CE research and case studies in the fields of the development and practice of eco-industrial parks based on industrial ecology to achieve cleaner production and waste and pollution reduction (Lieder & Rashid, 2015; McDowall et al, 2017). China started from taking the top-down actions to transform to circular economy, thereby becoming one of the first countries to implement CE in the constitution (Lehmann et al., 2014). China passed the *Law for the Promotion of the Circular Economy* in 2008 and the ideas of CE are adopted as the basis of economic development to reform the traditional development model. China has a lot of experiences in developing experimental eco-industrial parks in terms of policy-making, implementation and assessment. The systemic economy-wide implementations of CE in China mainly are concentrated on the industrial sectors through industrial symbiosis at three economy-wide levels: macro (urban metabolism and symbiosis), meso (industrial parks), mico (individual enterprises and supply chain) (Ness & Xing, 2017; Adams et al., 2017; Kalmykova et al., 2018). However, China's industrial parks limit circular economy (Miao & Tang, 2016). The interdependence of manufacturers creates a vulnerability on supply chain. From urban planning perspective, parks cannot be built everywhere. Local manufacturing priorities as well as local environmental, social, technological conditions also have great influence on the performance of the industrial parks. Therefore, China's CE approach should "break" the boundaries of eco-industrial parks and develop integrated system-thinking approach. The circular economy development in different sectors and industries is unbalanced. China's national government always takes the lead in circular economy initiatives by building new experimental pilot zones under hierarchy governance (McDowall et al, 2017). However, bottom-up local initiatives without national government support tend to fail due to the implementation gap between political goals and local environment (de Jong et al., 2016; Zhao et al., 2016). This is the general problem of the circular economy policy implementation in China.

*New Urbanization in China*

For the past three decades, the rapid urbanization played an important role in reforming China's economy and sustaining China's development. Building and construction sector has always been a favored effective tool of Chinese authorities to stimulate the economy during this phase. Chinese construction sector has the largest market in the world and has been through an unprecedented growth after reform and opening up policy in 1978. Recent years, together with the downturn in construction, China's economy is facing a structural change towards a new development model, focusing on economic, environmental and social sustainability. The sector excessively consumes

domestic and imported resources and therefore, has large potential in embracing the opportunities presented by a circular economy to provide even greater economic and societal benefits, while addressing its negative impacts on living environment (EMF & ARUP, 2018). The Chinese government has recognized that it is not sustainable anymore to follow this myopic developing mode. Sustainable construction plays an important role in China's future urbanization process and promoting China's New-style Urbanization Plan (2014-2020), aiming at 'incorporating the concept of ecological civilization into the construction of cities to conserve land, water and energy and promote green buildings' (Chang et al., 2016; EU SME center, 2015).

By 2050, China will build 40 billion square meters of floor space. The main types of buildings in the newly built environment are commercial and residential buildings, which consume enormous domestic and imported resources (Fernández, 2007). Industrial heritage has become more and more important in the process of urban renewal in China's new urbanization (Yu, 2012). In the early 2000s, conversing old factories and warehouses into office space for creative and cultural industries started gaining momentum in Chinese cities. Local government realized that preserving heritage buildings helps boost local economy (Hartmann et al., 2016). Following China's conservation and real estate de-stocking policies, China's urbanization will also focus on refurbishing built environment.

**Destocking policy: It refers to the national economic policy targeting at the reduction of property inventory to tackle overcapacity problems to ensure the sustainable development of the property sector.*

### *A Circular Netherlands?*

If we take a look in the Netherlands. Dutch government is aiming at positioning the Netherlands as a frontrunner in the transition towards a circular economy. The goal is to develop a circular economy across the country by 2050 and achieve an interim objective of a 50% reduction of raw materials use (minerals, fossil and metals) by 2030. The Dutch government launched *"The Green Deal"* on the economy-wide scale to support local and regional government, civil society organizations and coalition of companies to stimulate sustainable innovation. Bottom-up steps are initiated by companies to create sufficient mass for change from linear business in "niche" phase, followed up by top-down steps by public authorities to shift the business environment to achieve the "mainstreaming" phase (IMSA Amsterdam, 2015). Similar with China, Dutch circular economy program is planned and implemented on different scales: internationally, nationally, regionally and locally.

The Dutch government-wide program also follows the priorities of European Commission propitious sectors, namely biomass and food; plastics; manufacturing industry; construction sector; consumer goods (SER & Rli, 2016). In Dutch construction sector, circular economy approaches are introduced to the market. Unlike other industrial sectors, resource scarcity is not the main issue for construction sector. Its impact on environment and the risks in volatile commodity market are the key issues (de Angelis, 2018; Jesus et al., 2018). Construction and demolition waste has already been recycled on a large scale for years in the Netherlands. However, it is still difficult for construction sector to close the material loop (Ghisellini, 2016; Schut, 2016).

Both China and the Netherlands share common basis of circular economy in order to consume natural resources in a more sustainable way (McDowall, 2017). Both countries propose systemic economy-wide implementation of CE from national efforts to local and individual efforts (Kalmykova et al., 2018; Lieder & Rashid, 2016). However the focuses, scopes and processes differ. As a master student, I have observed that different circular economy activities are happening in two countries. The challenge is to understand why two countries are following different paths, and how we can learn from best practices? Therefore, the research synthesizes circular economy and the built environment. The research will cover the circular economy concepts and the applications in Dutch and Chinese built environment in theory and practice. The research takes place within the limited boundaries of a master research. Therefore, the main focus of the research is to get insights on circular economy implementation in practice.

# 2. Links to Research

## 2.1 Problem Statement

Although China contributes the most circular economy research regarding policy, implementation as well as evaluation. The implementation, specifically focuses on heavy industrial sectors and eco-initiatives. What are the opportunities outside the industrial parks? For example, in the urban renewal in the New Urbanization in China? Besides this, the link to construction sector is missing. The Chinese construction sector still operates in a very linear way, most Chinese construction corporations are not aware of the importance of apply circular economy in construction sector (Chang et al., 2016). The linear growth model facilitated by the unprecedented urbanization starts to show its strains because of the inefficient use of capital, labor and land (The World Bank, 2014). Applying circular economy principles in China's new urbanization process will help China achieve a new restorative and regenerative development model toward resource-efficient and sustainable urbanization (Fernández, 2007).

Circular economy in a Dutch context differs in terms of understanding of concepts, policy articulation, industrial structures as well as institutional governances. In contrast, construction is one of the key sectors driving circular economy, and there is a lot of research available on the topic of circular economy in construction. Dutch cities are looking for the opportunities for integrated and circular solutions for sustainable urban future in cities. The Dutch government tend to provides innovative solutions together with different parties to circular economy from best practices. More applicable lessons should be learned from the practices to scale up the circular approaches.

Therefore, in this research, we focus on learning lessons from Dutch circular development in the cities to explore possible ways to apply circular economy principles in Chinese urban context besides government-lead eco-city initiatives. To achieve this, it is necessary to understand how circular economy is introduced differently in China and the Netherlands, and how circular economy is implemented differently in the built environment.

## 2.2 Research Objectives

Central to the objectives of the research is to compare and draw lessons from the circular economy implementations in two countries. In order to compare and draw lessons, we need to collect the equivalent information from two countries as per the conceptual model summarized from problem statement. Before collecting and comparing the information, we need to develop a framework to guide the comparison.

The ***objectives*** of the research therefore are:

*First, to develop a framework to compare the adoption of circular economy in China and the Netherlands; second, to provide practical guideline on circular economy implementation for the built environment in two countries; third, learn lessons and make recommendations for implementing circular economy in urban context.*

## 2.3 Main Research Question

By formulating the research question, we can explore the defined problems from both theoretical and empirical perspectives. Based on the problem statement and research objectives, the main research question is formulated:

*How can circular economy be implemented in the built environment in China and the Netherlands and what lessons can be learned from Dutch circular area development in the cities?*

## 2.4 Deliverables

The research aims to compare the implementation of circular economy in China and the Netherlands and provide practical guidelines for the actors in the built environment in two countries in order to contribute to sustainable urban development with the synergistic relationships between government and individual enterprises.

Therefore, first, a comparison is drawn between China and the Netherlands in terms of the implementations of circular economy. Second, based on the comparison, we can provide possible guidelines or directions for Dutch and Chinese circular built environment. Third, lessons and recommendations can be drawn for the circular urban development for Chinese side from Dutch practice.

# PART II: METHODOLOGY

## 3. RESEARCH DESIGN AND METHODS

### 3.1 RESEARCH DESIGN

This research is a qualitative research, which specifically aims to understand the different circular economy culture, meanings and the relevant experiences, knowledge as well as action within Chinese and Dutch contexts. Therefore, it can be seen as cross-national research (Hantrais & Mangen, 2007) and comparative study (Hantrais & Mangen, 1996). Contextualization is central to the cross-national research methods, and the central issue in cross-national comparisons is the equivalence of concepts, operations and interpretations of research objectives in different contexts (Hantrais & Mangen, 2007). And it can be addressed by reflecting – in the planning process of a project – on questions such as, "*Why* do I want to compare?"(Adequacy of comparison); "*What* do I want to compare?"(Conceptual equivalence); "*How* do I plan to compare?"(Operational equivalence); and "How can I make sure *my findings are comparable*?(interpretative equivalence)" (Kosmützky & Wöhlert, 2015).

The findings are bound to particular Dutch and Chinese social and cultural context, and are not generalizable to particular "groups" or "population". Therefore, in our research, hypothesis are not tested. It emerges from (part of) the research data, which is defined as qualitative hypothesis-generating research by Auerbach and Silverstein (2003). It involves collecting interview data from research participants, creating a phenomenon of interest in order to develop propositions for research.

To verify the propositions, narrative inquiry method is used to collect empirical data in China. Narrative study is a specific type of qualitative design in which "narrative is understood as a spoken or written text giving an account of an event/action or series of events/action, chronologically connected" (Creswell & Poth, 2016). The procedures for implementing narrative study consist of focusing on studying one or multiple individuals, gathering data through the collection of their

stories, reporting individual experiences, and chronologically ordering the meaning of those experiences. Narrative methods can be considered “real world measures” that are appropriate when “real life problems” are investigated (Lieblich et al., 1998). The experts who have sufficient experiences in urban revitalization projects and the experts of circular economy in China are interviewed, and by analyzing their “stories”, the problems are identified.

Case study is designed and conducted for the empirical part in the Netherlands to gain applicable experiences for the problems identified from narrative study in China. According to Yin (2013), case studies are the preferred strategy when “how” and “why “questions are posed. According to Gustafsson (2017), single case studies are better when the researcher wants to create a high-quality theory and have a deeper understanding of the exploring subject. According to Yin (2013), the focus among all types of case study is that “it tries to illuminate a decision or set of decisions: *why they were taken, how they were implemented, and with what result*”. And cases are not only analyzed at the level of the entire pilot project, but also at the level of actors, organizations, institutions and their collaborations. However, the limitations of carrying out single case study is the potential vulnerability that it may later turn out not aligned with the intention at the beginning (Yin, 1994). Therefore, it is important to do broad investigation of the potential cases to minimize the chances of misrepresentation and to maximize the access needed to collect the case study evidence.

Lesson-drawing method is used to analyze the results of narrative research and case study to provide possible solutions and recommendations. Dolowitz & Marsh (2000) distinguish seven alternative ways of lesson-drawing including photocopying, copying, adaptation, hybrid, synthesis, disciplined inspiration, and selective imitation are defined by Rose (2005). Janssen-Jansen et al. (2008) propose three levels of lesson-drawing: *inspiration, learning,* and *transplanting*. Within countries with different system, it is very likely to inspire, and likely to learn, and less likely to transplant (Heurkens, 2012). China and the Netherlands are distinctly different regarding political, economic, social systems. It is difficult to compare and learn from each other at macro and micro level. Therefore, we focus on how two countries can inspire and learn from each other to better facilitate the transformation of Circular Economy. From the narrative study and case study at meso level, specifically, the focus is how we can apply the experiences from circular urban development to a Chinese context.

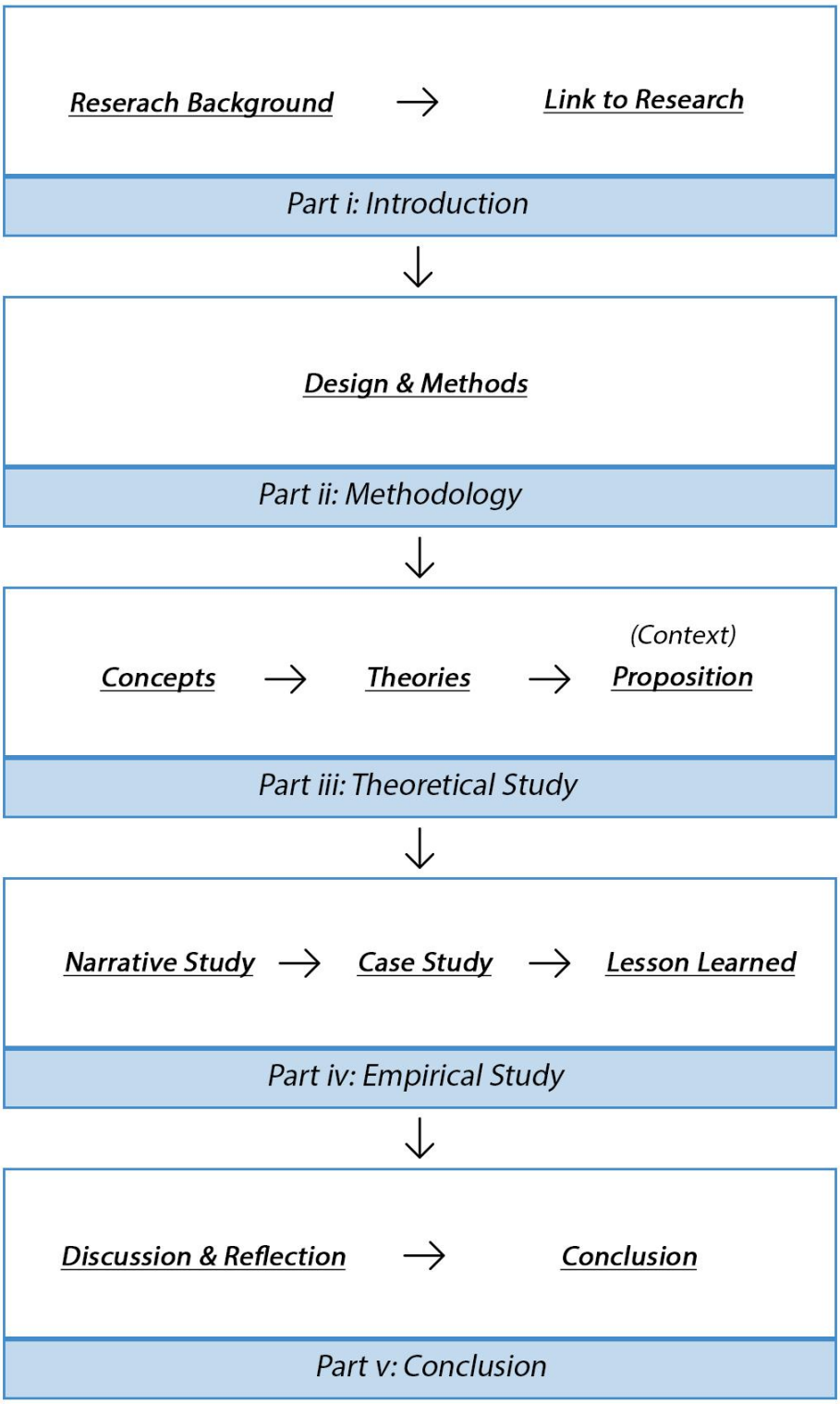


Figure 1. Research Design (Own illustration)

## 3.2 Research Methods

Research methods predefine the set of procedures to answer the main research questions. Following the main research question "*How can circular economy be implemented in the built environment in China and the Netherlands and what lessons can be learned from Dutch circular development in the cities?*" sub-questions are raised below. This section will introduce the methods used in the research process to answer each sub-question:

1. What does circular economy mean to the Netherlands and China?

- How is circular economy defined in two countries?
- How is circular economy implemented in two countries?
- How is circular economy measured in two countries?

To answer this question, a literature and document study as well as explorative interviews are conducted to understand the concepts of circular economy and relevant concepts in two countries. The literature will review the theories to develop the theoretical framework for comparison. The answer of this sub-question will help generate the proposition for the research.

2. What does circular economy mean to the built environment in the Netherlands and China?

- What are the features of construction sectors in two countries?
- What circular approaches can be applied in two countries?
- What are the opportunities and challenges of the circular approaches?

To answer this question, literature review and interview methods are used to investigate the questions to combine the theory and practice, and give the theories and literature a reality check. The literature consists of the problems and challenges in the built environment in general for both countries as well as the specific challenges in each country. The interviews with Dutch and Chinese interviewees provide insights on the specific contexts.

After answering the first two questions, a proposition for the research is proposed. Sub-question 3 will study the feasibility of the proposition.

3. What lessons can be learned from Dutch circular area development for a Chinese urban context?

- What are the forms of urban-scale development are relevant to circular economy in China besides government-led eco-city initiatives?
- What are the key problems of those development in China?
- What circular economy approaches are adopted in Dutch circular area development?
- What solutions can be found in the Dutch circular area development?
- How applicable are the lessons/solutions to a Chinese urban context?
- What drivers and barriers can be defined for the development and implementation of circular economy in urban areas in both countries?

This question focuses on gaining insights from practice. Therefore empirical study is conducted for both countries. An analytical framework is developed from the literature study. Narrative method is used to study the situation in China to analyze the generic problems in order to gain practical insights from Dutch case and a case-based empirical research is carried out to study the Dutch practice. The case will give insights on how circular approaches will help achieve a sustainable urban development, and from the case, possible solutions and recommendations will be provided for future circular urban development in China.

## 3.3 TECHNIQUES

### 3.3.1 Data Collection

It is important to distinguish quantitative and qualitative approaches to data collection. The qualitative methods are inductive, focusing on understanding of phenomena in their social, institutional, political and economic context. The data collection techniques are introduced here.

*Literature review*

The first part of the literature review is studied to understand the problem background and to define the problem, locate my own research within the context of existing literature through all databases of Science Direct (SD), Google Scholar (GS) and Scopus. For this part, a systematic review of literature about Circular Economy and the policy in EU and China; Circular Economy in construction; construction and demolition waste. The second part, theoretical review, helps to scan what theories already exist, then build the relationships between them, and create a framework for the research as the theoretical study. Also, the literature review consists of an overview of existing pertinent evidence which is related to the research question and contexts. And the literature helps to understand the different concepts adopted in the research as a basis for the empirical study. The literature review will be an iterative studying, going throughout the whole research.

*Interview*

It is necessary to differentiate between two types of data: structured data and unstructured data. Structured data is highly organized and analyzed with statistics. Unstructured data is disorganized, often generated by open questions, observation etc.

This research adopts *semi-structured interview* - This type of interview consists of predetermined questions and special topics. These questions are typically asked of each interviewee in a systematic and consistent order, but the interviewers are permitted (in fact, expected) to probe far beyond the answers to their prepared standardized questions (Berg & Lune, 2011).

Also, *key informant* is important at the beginning phase of the research – There may be several people who are key to the research, whom it will be important to interview to gain key information about the project or the concept of Circular Economy. It is used at an exploratory stage of the research, when the issues are being identified.

### 3.3.2 Data Analysis

After collecting the data through interviews, transcript is made. Qualitative study usually relies on inductive reasoning processes to interpret and structure the meanings that can be derived from data. Schutt, (2011) defined three flows of activity of qualitative research analysis is used here:

- Data reduction: organization and categorization and the data into concepts.
- Data displays: connection of the data to show how one concept may influence another.
- Conclusion drawing: decide what the data and the connections mean.

In this research, the data has two objectives. Frist, first part of data is to display the circular economy status quo in two countries. The data reduction process focusses on the policy vision, development process and the development in construction sector. Second, for the circular area development case, the data reduction focus on the governmental, organizational and social aspects. By analyzing and displaying data on the basis of the analytical framework, we can draw lessons from the case and examine the applicability within a specific Chinese context.

# Part III: Theoretical Findings

## 4. Concepts

### 4.1 Circular Economy

But why do we need circular economy?

Our current economy has a basic structure: we exploit things from the ground, turn them into products, use them for a period, from days to years at most, and then bury them back under the ground again as landfill. This is how a linear economy works: take, use, and dispose. It really does work for us to develop our industries and boost our economies. The global population is continuously growing, our ecosystem, where we get raw materials to produce and support our economic system, is declining, then we realize this myopic way is hugely wasteful, terrible for our environment and not a sustainable option for our future. In principle, based on the linear model, we have more and more people, then we need more and more resources. However the reality is that the resources are running out, we in fact have less and less resources. To maintain the economic growth we have now, we need to figure out a way to make the same amount of products with way less raw materials.

In a circular economy, when a product meets its useful life cycle, we don't throw it away, instead we reuse it as same use, or recreate it to new use. Wautelet (2018) studied the concept of circular economy's origins and evolution. The concept of CE introduced in 1970s, building upon different schools of thought: Industrial Ecology (Preston, 2012; Andersen, 2007; Murray et al., 2017), Cradle to Cradle (McDonough and Braungart 2002), Performance Economy (Stahel and Reday-Mulvey, 1981), Blue Economy (Pauli, 2010) and Biomimicry (Benyus, 1997). Sustainable development with its sub-dimensions (environmental quality, economic prosperity and social equity) was integrated as a coding dimension as the main aim of circular economy (Kirchherr et al., 2017). Therefore, the goal of circular economy is to decouple economic growth from the use of natural and social resources by using those resources more effectively to achieve better environmental performance.

Linear economy is non-sustainable. The basic premises of linear model are the requirements of growth. And the growth should be exponential, which cannot happen within this limited system, earth. Therefore, doing more is not practically necessary, doing better is. According to Ellen MacArthur Foundation (EMF)'s definition, Circular Economy (CE) is "... an industrial economy that is *restorative* or *regenerative* by intention and design". Murray et al., (2017) figured *restorative* is an important concept in CE. "Restoration" replaces the concept of "end-of-life".

Circular economy is the current name we give to any economy system which defines regenerative ability as its sustainable ability. It doesn't merely reduce pollution by preventative approaches, it is also aiming at repairing damaged from previous production process by designing better system within the industry, during which more value is obtained from resources while reducing material throughput (Ness & Xing, 2017). Murray et al., (2017) re-evaluated the definitions of CE and suggested a definition of CE as "...an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being...". It is seen as a new business model leading to a more sustainable development, decoupling environmental pressure from economic growth (Murray et al., 2017; Pomponi & Moncaster, 2017a; Ghisellini et al., 2016). According to EMF, the three principles of Circular Economy are:

(1) Design out waste and pollution;

(2) Keep products and materials in use;

(3) Regenerate natural systems.

Figure 3 illustrates the outline of a circular economy, the famous "butterfly diagram". The material flows can be divided into two interacting loops. First, at its core, to *design out waste and pollutions*, components and products are designed and optimized to be easily disassembled and then stay in the system to be reused, set it apart from disposal, and even recycling. That is because, in the process of recycling, large amounts of energy and labor are embedded. Therefore, reuse becomes the best option in circular economy (World Economic Forum, 2014).

Second, in a circular economy, it is important to differentiate consumable and durable components in order to *keep products and materials in use*. Consumables in CE are made of biological ingredients or "nutrients" as much as possible that can be returned to the biosphere safely as a part of it. The consumables are used more frequently, therefore they should be non-toxic and possibly even beneficial to the biosphere. Durables such as engines or computers, however, can be operated for a longer time, and normally are made by technical nutrients such as metals and most plastics, which cannot be digested directly by the biosphere (EMF, 2013). Therefore, they should be designed from the beginning for maximum reuse, and agile and flexible enough for rapid technology upgrades. Third, the energy that we used to run this cycle should be renewable by *nature* instead of depending on other parties to generate the energy. Therefore, we can decrease resource dependence and increase systems resilience, for example, oil shock, and metal prices (ARUP, 2016).

For technical nutrients, the Circular Economy also replaces "customers" by "users", which defines a new relationship between clients and product producers and calls for new business mode based on product performance. In this case, durable products are leased, rented or shared as much as possible. If they are sold, agreements or incentives are needed to ensure the return and the reuse of products as well as materials at the end of its use time (World Economic Forum, 2014). Key work is to slow down the use cycle to delay and slow down waste output. Therefore the resource use is reduced (Murray et al., 2017). For those products that can no longer be repaired and reused for their original purposes, the components or materials should be extracted and reused or remanufactured to avoid landfill and create a closed-loop cycle (ARUP, 2016).

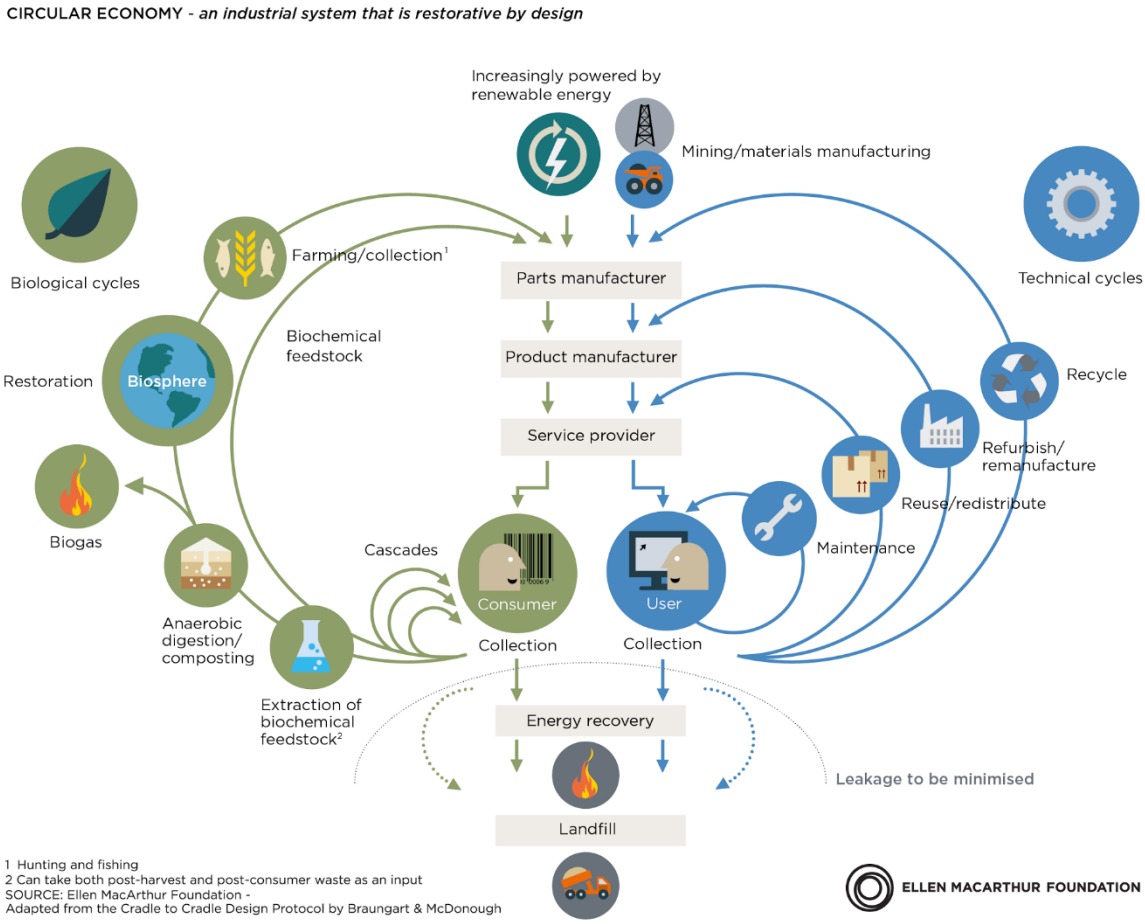


Figure 2. "Butterfly" diagram, Source: Ellen MacArthur Foundation.

## 4.2 Circularity and Sustainability

Circularity and sustainability are two terms that are often interchangeably mentioned together, which is confusing and misplacing areas of actions for two fields. Therefore, it is important to explicitly understand how two terms are differentiated and relating to each other.

The sustainability is seen as an umbrella term. The often quoted definition of sustainable development is "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs..." (WCED, 1987). The practice of sustainability is presented in the left part of the "butterfly diagram" (Figure 3), which is focused on and grounded in biosphere. Circularity does exist here in terms of carbon cycle, nitrogen cycle, water cycle etc.

Meanwhile, the practice of circularity is focused on and grounded in techno sphere, which involves intentional designs by human to intervene raw materials for consumption beyond simple needs of food and water for survival. The design behavior is the key difference between circularity and sustainability.

In current system, basically we pay for sustainability. We are forced to adopt sustainable measures to minimize the negative effect of current system: doing less of something intrinsically bad (e.g. pollution, waste etc.). While we spend so many people and money on it, meanwhile the economy

mechanism doesn't favor any additional investment on the mitigation of negative effect. Circular economy however invests in value retention without adding functional value, which means circularity brings you money by reshaping the economy mechanism while sustainability costs you money. Circularity is fundamentally different from sustainability.

In conclusion, sustainability is a multidimensional concept that consists of environmental, economic and social perspectives. Circular economy is an instrument aiming at reducing the environmental impact by utilizing the material in a more efficient and effective way and optimizing the material flow to ease on resource prices, and it certainly has impacts on all three pillars of sustainability. Especially, comparing to sustainable development, circular economy keeps sustainability in mind, and reinterprets the economic paradigm, which stimulates investments and business innovation with technologies as enablers. CE is the key to sustainable development.

## 4.3 Circular Economy as Externality

Circular Economy is of clear externality. Externality appears when private income and social benefits are inconsistent: When the private income is greater than social benefits, it causes negative externality. When the private income is less than social benefits, it causes positive externality (Li & Li, 2011). Minimizing the negative externalities is a core aim of the circular economy (ARUP, 2016).

Positive externality is a benefit that can be enjoyed by a third-party as a result of economic transaction. For example, under the current technological level and price system, environmental-friendly products will not only bring direct economic benefits to companies but also reduce environmental pollution, therefore the consumers and society can get indirect social benefits (Li & Li, 2011). In the market where we make economic transaction, individual market actors react to market price, and each participant acts according to his own economic interests. Thus, externality fails due to market mechanisms (Li & Li, 2011).

To fix the failed market mechanism, there are two main ways from private sectors and government perspectives: first, from the private sectors can correct the market failures themselves; second, government can adopt corrective measures i.e. economic policies, to promote positive externalities (Li & Li, 2011).

## 4.4 Equivalence of Concepts

The key of comparative research is the equivalence of concepts. There are some semantical confusions about the terminology of circular economy and related concepts in two countries. In both regions, CE is seen as a new model to reconciling economic and environmental imperatives through innovations in technology and social perspective (McDowall et al., 2017). However, the terms and descriptions vary in two countries. Same term can be understood and implemented in different ways in two countries, and different terms may lead to the same actions in practice. Those confusions happen in both literature and practice which make it difficult to collect right information when you don't know what you need to search. Here we compare and explain the equivalent concepts of circular economy. The different concepts of the implementations at different levels and concepts at different stages of value chain are listed in Table 1 below:

- *Circular Economy* | *Ecological Civilization*

*Circular Economy* in a Dutch (European) context follows the definition of Ellen MacArthur Foundation which focuses on economic competitiveness and innovation as much as environmental goals (McDowall et al., 2017). By capturing the value of waste as secondary raw materials via

innovation in technology and new business models, circular economy in Dutch context covers economic, environmental and social objectives.

*Ecological Civilization* refers to the idea of resolving the conflicts between environment and economy through technical and social innovation (e.g., new business models) (McDowall et al., 2017), which contains three elements: clean energy, circular economy and sustainable development. The concept of circular economy in China is one of the underlying principles to build ecological civilization which focuses on improving material and energy efficiency, it has origins in cleaner production and industrial ecology (Geall, 2015). Environmental objectives like dealing with the waste are still the priorities.

- Scale

Dutch and Chinese circular economy at macro level share same general basic on restructuring industrial composition and provide solutions including governance, waste, energy, water, infrastructure, building etc.

At urban district and urban area level, Dutch side focuses on both newly built district and transformation of the old industrial district. In China, the focus is on the development of eco-industrial parks in different regions. For existing urban area, Chinese perspective also pays attention to urban revitalization regarding transforming old industrial district into new business area. However, circular economy concepts are not widely involved.

- The Built Environment

For circular construction, the similar concept in China is *"sustainable construction"* which is defined by Chinese government as a strategy to conserve resource and protect environment with a focus on comprehensive construction cycle (Chang et al., 2016), which basically share the same commons with circular construction in the Dutch context.

Table 1: Equivalent concepts in two countries. Own illustration.

| Area | Netherlands | China |
|---|---|---|
| Concept | Circular Economy<br>• Economic competitiveness; new business model; value capture of wastes | Ecological civilization/harmonious development:<br>• Environmental political rhetoric<br>• Contains clean energy, circular economy, and sustainable development.<br><br>(Circular economy);<br>• Improving material and energy efficiency |
| Scales | | |
| City level: | Circular city<br>• Material flow, infrastructure and the built environment, economic activity, socio- cultural activity, health & wellbeing (Metabolic) | Eco-city<br>• Self-reliant, minimize the demands on resources like energy and water and reduce waste (Register, 1993, 2006)<br><br>Low-carbon city<br>• Decouple economic development from energy and/or CO2 emissions mainly in terms of building, transport and production (Chen and Zhu, 2013) |
| District/area | Circular area development<br>• Newly built business park<br>• Transformation of old industrial parks | Eco-industrial park<br>• Focus on Industrial activities<br>Urban revitalization<br>• Industrial heritage and business |
| Construction | Circular construction<br>• Cutting down on raw materials<br>• Reducing residual and waste matter; Generate quality improvement<br>• Cost reduction throughout an object's life cycle<br><br>10R principles:<br>• Refuse<br>• Rethink<br>• Reduce<br>• Reuse<br>• Repair<br>• Refurbish<br>• Remanufacture<br>• Recycle<br>• Recover | Sustainable construction<br>• Balance future urbanization;<br>• Conserve land, water, energy;<br>• Protect environment;<br>• Green building<br><br>3R principles:<br>• Reduce<br>• Reuse<br>• Recycle |

# 5. THEORIES: WHAT TO COMPARE?

Kalmykova et al (2018) distinguished two directions in circular economy implementation: (1) systemic economy-wide implementation, e.g. macro, meso, micro levels; (2) implementation with a focus on a group of e.g. sectors, products, materials and substances. The pathway to achieve circularity can be shaped by different scales of the economy in terms of the forms and constructs of buildings, infrastructure, districts and cities (Hardman, 2018).

Circular economy has been framed in an almost identical way as industrial ecology (see Appendix 1) with three levels of initiatives (Murray et al., 2017; Pomponi & Moncaster 2017; Banaitė, 2016; Ghisellini et al., 2016; Lehmann et al., 2014; Koczij, 2014; Jesus et al., 2018; Kirchherr et al., 2017). The concept recognizes the importance of the implementing circular economy effectively at all scales – for large and small businesses, for organizations and individuals, globally and locally. CE research mainly focuses on three levels: micro, meso, macro level (See Figure 6). The theories will be investigated based on those levels in this research.

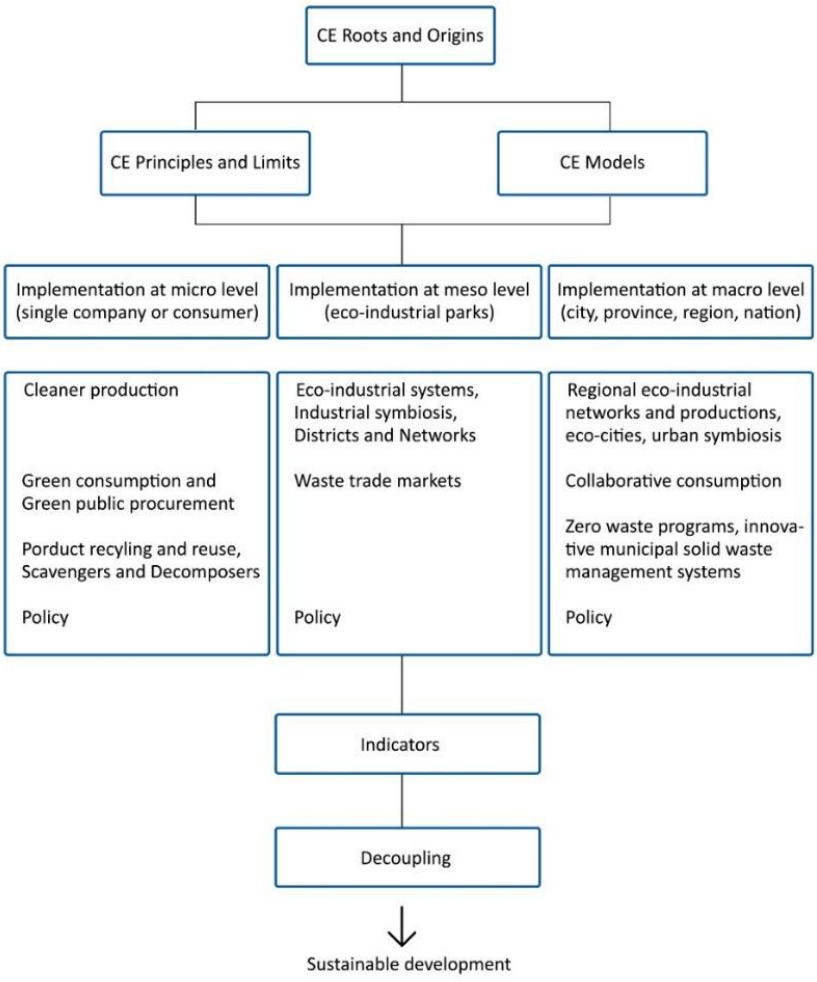


Figure 3. A review of circular economy research. Own illustration based on Ghisellini et al., (2016).

## 5.1 Macro CE: Urban Integration and Transition

### *Macro-system in Circular Economy*

The macro-system in circular economy refers to the adjustment of industrial composition and the structure of entire environment by policy implementation on a wide scale (Jesus et al., 2018; Kirchherr et al., 2017). Key aspects are: 1) systematic and multidisciplinary methods; 2) governance and public policies to promote CE; 3) resource efficiency and waste management at wider national and translational scales. It also involves regional eco-industrial network and renting service and urban symbiosis and industrial metabolism (Koczij, 2014; Lehmann et al., 2014; Ghisellini et al., 2016; Murray et al., 2017). Relative concepts are discussed below, more details see Appendix 1.

**Circular Economy (CE) and Industrial Ecology (IE):** Closed-loop paradigm in industrial ecology is the origin of CE. Particularly CE shares the same quality with IE in utilizing residual waste materials, including energy, water, and by-products (Ness & Xing, 2017).

**Industrial/urban symbiosis (IS/US):** Industrial symbiosis is the subfield of industrial ecology. Separate industries as well as other sectors collaborate for competitive advantages by physical exchange of materials, energy, water, and by-products. Keys are inter-relationship, collaboration and synergies.

**Industrial/urban metabolism (IM/UM):** Metabolism studies analyze biophysical change between humans and nature. It is extension of biological metabolism which is guided by dependence of human activity and economic systems on natural systems.

### *Transition Management*

The transition from current economy to a circular economy requires insights into the stages and processes (Jackson et al., 2014). From a macro level, a transition is a process of structural socio-technical change. Socio-technical systems consist of individual actors (or organizations), their operations within institutions (social and technical norms, regulations and standards of good practice) and the influence of existing knowledge and technologies (Markard et al., 2012). Therefore, moving from a relative stable system, which is our current linear economy, to sustainable development model, which is circular economy, requires the synthesis of markets, networks, institutions, policies, technologies, autonomous trends as well as individual behavior. Complexity, transition and sustainability are three principles of governance processes (Loorbach, 2007).

### *Role of Government in Transitions*

Government plays an important role to enable, facilitate as well as guide the transition to sustainable development by providing context, ensuring coordination and promoting new more efficient industrialization models (Loorbach 2002; Kemp and Loorbach 2003). Visions are an important management instrument to start and gain new insights for achievements (Loorbach, 2010). Political vision and commitment may trigger the initiatives and actions (Yin et al., 2016). However, clear and consistent vision and goals articulated at the top level are often short-term fluctuation (Yin et al., 2016). Long-term empowerment is also required. Properly designed and enforced regulations can trigger innovative responses by firms (Mathews & Tan, 2011).

According to Yin et al. (2016), political intentions to achieve particular initiatives or goals are criticized regarding providing legitimacy, endowing formative power and integrating environmental innovation in policy-making and planning practice. Policy and legal conflicts are often a strong obstacle for companies to build industrial symbioses that's why policies should be designed so as to provide political instrument (e.g. issuing regulations or policies, combining incentive subsidy etc.), coordinative mechanism, educational and infrastructural support and initiating demonstration

projects (Bellantuono et al., 2017). In some environmental innovation cases, governmental also support projects by assigning some actors with political power in policy-making (Goess et al., 2015); rewarding of individual actions; provision of suitable infrastructures. A certain supervision from government is necessary. Government should assist to supervise the legitimacy and financing of the process of innovation (Loorbach, 2010). It is crucial that both process quality and output quality are clearly specified and monitored. Continuous monitoring and evaluation of implementation of circular projects and initiatives from government is important to develop a solid knowledge base and provide feedback to guide and adjust the transition process.

## 5.2 Meso CE: Network and Interactions

*Network Theory*

Network theory approach is the key to articulate the network collaboration between socio-technical system and governance system. Collaborative inter-organizational networks are often characterized by novel ways of organizing that suit the different purpose of the network (Fjeldstad et al., 2012). A number of organizations or units with diverse skills, abilities and attributes are involved in the network. However they are at same level of interdependence (Richard, 2006). Sustainable visions primarily include the shared principles for long-term development, which at the same time leaves room for dissent upon shot and mid-term solutions, goals and strategies (Loorbach, 2010). Based on network theory, the core elements of network theory are identified as (1) goals and network boundary (Gulati et al., Yang & Zou 2014, Mok & Shen 2016); (2) actors (Håkansson, 1987; Fieldstad et al. 2012; Patala et al. 2014); (3) resources owned by actors (Håkansson, 1987); (4) commons and protocols (Fieldstad et al. 2012, Patala et al. 2014); (5) activities to combine, exchange or create resources (Håkansson, 1987); (6) network stratification and process (Gulati et al., Yang & Zou 2014, Mok & Shen 2016) (7) permeability of boundaries (Patiala et al., 2014).

In a network, operational logic of actors describe the focus of their actions and the drivers of the networks. Based on eco-industrial theory, there are two main models of development process. First is self-organizing symbiosis by Chertow (2007). Companies spontaneously initiate programs to achieve efficiency in resource and cost or expand business by exchanging resource with other organizations. The business-specific features relate to the characteristics of the company, local industrial structure decide how circular approach is integrated among the network in the local context. Second, the development can be set up by an exogenous promoter, called initiator (Brand and de Brujin, 1999). The initiator can be a national or regional government agency as well as an association of companies or entrepreneurs etc. Sometimes a core group of initiators need to be identified which include experts on the process and the transition subject (Loorbach, 2007). In some cases, the initiator promotes demonstration programs. The existence of iconic projects with a high level of risk that can make a potentially large innovative contribution to the transition are identified at the operational phase. Often a major company which is heavily committed in research and design activities and having at least a partial absorptive capacity in a given technological area plays a key role in promoting the emergence of self-organizing enterprise networks (Bellantuono et al., 2017). An anchor company (i.e. a large industrial company) will attract other companies and represent a core around which complementary partners can be sought (Eilering & Vermeulen, 2004). Diversity is considered key factor to distinguish an eco-industrial park from other types of business aggregations (Bellantuono et al., 2017). It is also important to know the mechanism that drives the network. Drivers for the networks could be economic and environmental benefits, legislation, personal values, consumer demands, stake holder pressures, existing environmental challenges, acquisition of knowledge on new environmental solutions.

*Circular Economy Network*

Meso level of circular economy focuses on networks and interactions in the implementation of industrial ecology (Jesus et al., 2017). Circular economy network can be developed in or within value chains (i.e. "green" supply chain); industry (i.e. industrial symbiosis and eco-industrial parks); local government initiatives (i.e. eco-cities and urban symbiosis) (Jesus et al., 2017).

First, from a value chain perspective, the life-cycle of a single product can be improved via its supply chain. The closed-loop supply chain is related to industrial ecology (Sassi, 2008). By refusing and adapting technical materials, the life cycle of material is extended and the value is retained (Ness & Xing, 2017). Sometimes, extending the use of products consume more energy. Therefore, circular economy value chain contains not only a closed loop of material flow but also renewable energy system (Kalmykova et al., 2018). However, this has to be feasible within current technological capabilities and within the existing status of the natural environment (Sassi, 2008).

Second, from an "industrial systems integration" perspective, the relation between network and sustainability is that industrial networks will decrease environmental impacts through cooperative action through industrial symbiosis (Patala et al., 2014). The implementation of industrial symbiosis often occurs in eco-industrial parks. Eco-industrial parks retain the positive externalities of industrial park (close located business, inter-firm communication, centralized transportation etc.). Patala et al., (2014) identified four forms of eco-industrial networks:

**Industrial symbiosis network:** According to Schut et al., (2016), Faraud (2016) and Beavis (2015) emphasized the networks for resource sharing and reuse in a Circular Economy. This concept is aligned with *industrial symbiosis network* in which firms have a more entrepreneurial mindset, extracting value from waste and focus on system-level reduction of environmental impacts. The key issues of industrial symbiosis network are the exchange of resources (material and non-material), geographic proximity of actors and collaboration between industries.

**Sustainable supply network:** Leising et al., (2018) defined CE in supply chain collaboration as "...connecting a network of actors in their supply chain by managing data transparency, material flows and exchanges, responsibilities, predictability and sharing benefits..." which goes beyond the concept of supply chain management by thinking in a strategic perspective on the new role of organization and redevelopment of supply chains through collaboration.

**Environmental issue network:** Environmental sustainability is profoundly affected by complex networks of actors including industries, NGOs and governmental agencies. Environmental issue network refers to coalitions collaborating around certain environmental problems or policies. Actors focus on policy development and value creation through institutional changes and collective actions.

**Environmental solution network:** Another identified network form close to Circular Economy is *environmental solution network*. It means different organizations combine their knowledge and technologies as well as other resources to create an eco-efficient solution (Patala, 2014). Usually, a center actor acts an integrator is involved.

Third, from urban symbiosis perspective, the network rationale is extended to urban actors. This is an integrated approach to maximize the benefits of the interrelation between city and its industrial context (Jesus et al., 2017). According to Ahuja et al., (2012), Gulati et al., (2000), Patala et al.,(2014) and de Jong et al., (2016), actors in networks cannot attain their goals by themselves with insufficient legal, financial, organizational and knowledge resources, and networks enable organizations access resources that are difficult to get one their own. Sharing information is a premise for the effective integration among companies in eco-industrial parks (Bellantuono et al., 2017). A culture of knowledge creation and exchange is very essential in inter-organizational and cross-sector cooperation, especially for specific new concept like circular economy. Different sector departments and professions may hold different interests and objectives which makes it difficult to achieve on consensus (Yin et al., 2015). Learning behavior and knowledge sharing is also crucial. Continuous monitoring is an important part of transitions (Loorbach, 2010). Different aspects need

to be monitored: for circular transition process, physical changes in the projects, movements of individual and collective actors at regime level need to be monitored and evaluated. For management process must be monitored with regard to actors' behaviors, network activities, alliance forming, and knowledge transferring, social and institutional learning.

## 5.3 Micro CE: Value, Methods and Models

The micro level focuses on capabilities and involvement of CE of specific agents (deJeus et al., 2017). Key strategies are: CE at micro level requires us to rethink product value and ownership through time. Individual actors need to rethink what value is. The linear economy measures material value with life-cycle, by material value. The circular economy considers the value after use-cycle. The use-cycle emphasize the functionality. Value develops with time. Things need to be measured by function value, not material value.

Circular economy brings about the integration of technical and financial design from a complementarity. The creative thinking of circular design aligns with the value creation in circular economy. For example, one of the circular design principles is, design for disassembly. Modular design ensures the future agility that we can always adapt something at lowest possible cost. Take steel in the building for example. If we demolish quickly and cut and melt the steel, at the end of the use cycle (not life cycle), new life is scrap metal. For 150 kg scrap metal, that is roughly 25 euros of material, taking all kind of energy you need to put in back to melt and reform them to make steel beam into account. However, if you can take the steel beam out, the same 150 kg beam will be 250 euros value, which is tenfold in value you are destroying if you don't have the regenerative strategy in the design. However, this only happens when the financial underpins the design. Therefore, people need exploit the **residual value**: who owns what? Where is it? What stay with it? Who uses it? What is the common value? Traditional linear model only looks at the operation cost that are involved in purchase and ride-off. However, if we consider from purchase, ride-off to the total cost of use and ownership and how it pertains to what pays per time period to start product system. Residual value is the factor that lower the entire cost of use to below what we normally spend on linear design. Now it starts making economic sense: larger cost at the beginning but saving money at the end.

To make it happen, we also need to trust the performance of the product by the end of the contract, which brings the concept of *selling service* (of which products from a part), rather than products themselves, forms a key aspect of performance. Ness & Xing (2017) widen the perspective of 'service economy' (Stahel 1997) and 'performance economy' (Stahel 2010) from the industrial production system to the urban built environment, which aims at delivering physical assets more efficiently with improved quality and productivity. The built environment is categorized by physical layers or life cycle layers. Based on the different frequencies of the changes, different products in the built environment can be applied to different business models (e.g. elevator as transportation service, and lighting service by Philips). "Selling service" refers to providing the offer with a flat fee of the right of use a product. The product provider retains the ownership, instead of buying new product, the user extends the right of using the product. Virtual residual value drops the total cost of the product during the use phase.

Taking the built environment into account, the table below collects the circular methods and models implemented in the built environment categorized by building stage.

Table 2. CE methods across building life cycle stage.

| Building stage | CE methods | Actors | Suitable for | |
|---|---|---|---|---|
| | | | New | Existing |
| Design | Design for adaptability and flexibility | Architect, supplier | √ | |
| | Design for standardization | Architect, supplier, government | √ | |
| | Design out waste | Architect, supplier, constructor | √ | |
| | Modular design | Architect, supplier | | |
| | Demountable design (LEGO) | Architect | √ | |
| | Low material design | Architect, supplier | √ | √ |
| | Design for recycling (C2C) | Architect, supplier | √ | |
| Manufacture and supply | Eco-design principles (easy to repair and disassemble/minimize waste and maximize reuse) | Supplier, government | √ | |
| | *Resource passport | Supplier | | |
| | Use secondary materials | Supplier, government | √ | √ |
| | Responsible sourcing of raw material | | √ | |
| | Alternative business models | Supplier, contractor | √ | |
| Construction | Minimize waste | Contractor | √ | |
| | Procure reused materials | Contractor, government | √ | √ |
| | Procure recycled materials | Contractor, government | √ | √ |
| | Off-site construction | Contractor, supplier | √ | |
| | Delivery and reverse logistic | Logistic, constructor, supplier | √ | |
| In use and refurbishment | Minimize waste | Client, facility manager | | √ |
| | Minimal maintenance | Contractor | | √ |
| | Transformation | Architect, project developer | | √ |
| End of life | *Material bank | Wholesaler, demolisher | √ | √ |
| | Selective demolition | Demolisher | √ | √ |
| | Reuse of products and components | Supplier, contractor | √ | √ |
| | Demolish and recycle | Demolisher, recycler | √ | √ |

*Based on (Deloitte, 2015; Ellen Mac Arthur Foundation, 2015b; Schut et al., 2016; SER, 2016; Adams et al., 2017;* Ghisellini, Ripa, et al., 2018*;* Ghisellini, Ji, Liu, & Ulgiati, 2018*; Jonker & Navarro, 2018).*

*Materials bank: When a building cannot be transformed it can serve as 'resource / building block' for other building structures. Reusing parts has preference over reusing material in order to hold as much value as possible

*Resources (material) passport: A resources passport records at molecular level what resources are used in the building or building materials and how many. In the Building Information Model (BIM), the resources used are recorded and can be passed on from supplier, contractor, owner and finally to the demolisher/dismantler.

## 5.4 Analytical Framework

In this section, a framework to investigate the features of circular urban development is proposed, based on the key elements defined from literature review and empirical inquiry study in last chapter. The framework links the theoretical question to the empirical analysis by summarising what is theoretically known about relevant empirical phenomena (and thus needs to be empirically investigated). The model will be applied to the narrative study and case study as an analyzing device to understand how the theories are applied to practices. Three dimensions are identified in last chapter: **governmental**, **knowledge**, and **organizational**. First, in terms of governmental dimension, two aspects are analyzed: top-level vision and governmental support; Second, at knowledge level, we need to analyze what the circular vision is about and how we develop the knowledge. Third, at organizational level, the operational logic and collaboration among actors need to be analyzed to understand the mechanism in practice.

For each dimension, a number of variables are provided, each related to a peculiar aspect of circular development. Sub-variables under each variable will be shown in the table below:

Table 3. Analytical model aspects

| Dimensions | Variables |
|---|---|
| Governmental | Top-level vison<br>• Political will and commitment<br>• Clear and consistent goals<br>• Long-term empowerment<br><br>Governmental support<br>• Properly designed and enforced regulations<br>• Coordinative mechanism<br>• Externality<br>• Supervision |
| Knowledge | Circular vision<br>• Type of circularity: what circular approaches are used<br>• Shared principles<br><br>Knowledge development<br>• Knowledge creation and exchange<br>• Leaning behavior |
| Organizational | Stakeholder collaboration<br>• Actors<br>• Commons and protocol<br>• Network stratification of process<br>• Permeability of boundaries<br><br>Operational logic<br>• Focus of action (WHAT)<br>• Drivers (WHY) |

# 6 Context and Proposition

Contextualization is the key to cross-national comparative research. Therefore, the contexts related to the theories in two countries are analyzed here, which shape the proposition and form a theoretical answer to the research will question. Therefore, we first analyze and compare the circular economy status quo, features of construction sector, and circular economy in urban context in two countries. Second, a proposition is made based on the theoretical and contextual framework.

## 6.1 National Circular Economy Development

### 6.1.1 China

*Vision and Focus*

As mentioned before, circular economy in equivalent to ecological civilization in the Chinese context. From the literature review we can see there is a greater focus on specific manufacturing and measures to efficiency improvement as well as waste and pollution reduction in order to diminish pollution. This is because manufacturing and exports play a greater role in China's industrial structure and economy, and 50% of the manufacturing activities are centralized in industrial parks (Mathews & Tan ,2016; McDowall et al., 2017). Therefore, the prominent role of CE in China is to eliminate the pollution, while incorporating materials, resources, waste. The goal is to build a "resources saving and environment-friendly society" as well as to achieve ecological civilization. Circular economy provides eco-innovation in domains like clean technologies, renewable energies, water services, green transportation, waste management, green buildings and sustainable agriculture and forests etc. at diverse scales: firm, industrial park, city and regions.

*Development Path*

CE development in China is driven by strong *top-down* governmental actions. (Kalmykova et al. 2018; Ghisellini et al., 2016; Wang et al., 2018). Generally, circular economy policies include command-control, tax, fiscal, financial and pricing measures (Qi et al., 2016). There are over 280 CE policies following the typology of a life-cycle perspective: resource-oriented, production-oriented, consumption-oriented, and environmental-oriented. The legal framework related to CE in China focuses on the production side, while lacking a perspective of consumption side.

According to Heilmann (2008) and Zhao el al. (2006), using regional pilot zones is a frequently used governance tool in China. Designations of this tool are used by both central and provincial governments, leading to special zones with areas often receiving multiple designations (McDowall et al., 2017). The government will choose several regions and sectors to construct institutional innovation pilots for CE. After exploring and forming core and typical circular economy system and institution, the government will make a promotion nationwide. China's approach to CE involves a major program of experimentation at different scales through designation of circular economy zones and projects, which has some resemblance to the prescriptions of *transition management*. It focusses on creating arenas for transition experiments, leading firms and institutions toward upscaling (McDowall, 2017).

*Supervision and Measurement*

To access and track the progress of CE development, and also provide guidelines to further develop policy instrument, the central government publish system of indicators ("*Evaluation Index System of Circular Economy Development*") to assess national level development and guide local government to develop their own CE evaluation indices with the goal of incorporating more local CE practices (Wang et al., 2018). "Target responsibility system" plays a key role in China's governance system, local government is tied to performance against target (McDowall et al., 2017b). In addition to binding CE targets, there are also extensive system of indicators which are specifically set for three-level implementations: micro (firms), meso (eco-industrial parks), macro (city or province). The consistent national indicators help regional and local governments to understand, compare, and measure progress of regional experimental projects.

### 6.1.2 Netherlands

*Vision and Focus*

Circular economy became prominent at the highest levels of European policy agenda. The European Commission launched the initiative on resource efficiency (Mcdowall et al., 2017). Dutch policy follows the EU action plan "*Closing the Loop – An Action Plan for the Circular Economy*" in the form of a policy program "*From Waste to Raw Material*" which intends to promote the transition to a circular economy. The Netherlands adopts Ellen MacArthur Foundation's circular economy concept: it is an economic and industrial system focusing on the reuse of products and raw materials, and the restorative capacity of natural resources and generating new business opportunities.

In a circular economy, value creation is the key. The circular economy attempts to maximize the value creation in each link in the system and minimize the destruction of value in the overall system. Ideally, in a circular economy, waste streams and emissions would be used to create value, therefore to provide secure and affordable supplies of raw materials and reducing the pressure on the environment. However, the use of primary raw materials and the creation of residual streams can probably never be completely avoided. Therefore, (1) for the raw materials in existing supply chain, we need to increase the use efficiency to decrease the demand; (2) if new raw materials are still needed, the fossil-based and critical produced raw materials should be replaced by renewable and generally available raw materials; (3) for supply chain, new production methods should be developed, and the products should be designed and organized differently. Also, we need promote new ways of consuming products (SER & Rli, 2016; Schut et al., 2016).

*Development Path*

Compared to China, CE development in the Netherlands is much more cooperative and resilient. A prevailing bottom-up approach is facilitating CE implementation in the Netherlands. The transition path to a circular economy firstly starts from bottom-up steps to kick-off the first "niche" phase in a relatively linear atmosphere. Second, a number of top-down steps will follow to make the circular business environment a mainstream. Once the implementations become financially feasible and influenced by changing market dynamics (i.e. higher prices of energy and resources and deregulation of market entry), it would be a change in culture that may eventually lead to political support for more fundamental changes among individual players (IMSA Amsterdam, 2015). Dutch cities utilize the governance strategy including businesses, governmental agencies, citizens and NGOs. The government plays not just a policy maker or commissioning party, but also facilitator and provides advisory support for new green initiatives to arise. For example, building-related ministries with the commercial sector, develop a vision for this renewal together. Any organization can present its own business idea, showing the hurdles and potential solutions to overcome and how to successfully reach the results. If the proposal is in line with the policy aim and is profitable, the government will support the initiative for two or three years to monitoring the results.

The Dutch government realized that many circular economy opportunities were lost because of non-financial barriers, such as the "lack of experience among companies and policymakers to detect and capture" new circular economy business. Therefore, government also takes a role of network partner, bringing organizations together and help to set a process in motion if necessary. Moreover, the government can contribute by assisting the further development of environmental assessment instruments and integral cost instruments.

*Supervision and Measurement*

It is important to measure the progress in the transition to the circular economy for both government and societal partners. The government gives knowledge institutes the assignment to develop monitoring system and baseline assessment with the focuses on (1) the progress of agreed actions; (2) developments in resource flows to, within and from the Netherlands; (3) transition dynamics (transition progress, role of individuals and organizations, partner interventions etc). Dutch government commissioned PBL (project leader), Statistics Netherlands (CBS) and National Institute for Public Health and the Environment (RIVM) to develop a monitoring system and a baseline assessment, local knowledge institutes are asked to contribute on specific area. Most of

the indicators now still focus only on effects, only few related to transition dynamics at a national level.

## 6.2 Features of Construction Sector

### 6.2.1 China

*Urban Land Finance*

As mentioned before, China's CE implementations mainly focus on manufacturing industry, the built environment has been overlooked. The complex and large-scale urbanization of the country directly drives the construction sector. From 1995 to 2016, China's rapid urbanization led to a substantial rise in urban land area devoted to the built environment (EMF & ARUP, 2018). During this rapid development and accelerated growth phase, Chinese government adopted real estate land transaction as the main revenue source, which is known as "urban land finance'. Local governments boost both local GDP growth and revenue by leasing out land to developers to promote urban development projects (de Jong et al., 2016a) and this lead to the rapid conversion of land from low-density agricultural and light manufacturing to new urban zones of high density and material-intensive commercial and residential buildings, as well as urban infrastructure.

*Cornerstone of China's Economy*

Why is the building sector left out from the prevailing circular economy trend in China? The building sector stimulated unprecedented economic growth across China. As a result, the building sector has become accustomed to this unsustainable growth and lifestyles. The short-term economic interests overweigh the long-term environmental and resource value to the cities. Government keeps silent to building and construction sector because it still plays an important the role in China's economy. In 2016, it represented 7% of urban GDP and provided 50 million jobs (EMF & ARUP, 2018). For the building sector, the resource scarcity is definitely not the main reason for driving a circular economy in China. In spite of the large scale of waste flows during construction and demolition activities and the massive impact on environmental and energy consumption, the government's priority is on the heavy pollution industrial and manufacturing sector have caused over 40 years.

*Continuing Urbanization and Regional Differences*

The property boom in Tier 1 cities has shifted to Tier 2 and Tier 3 cities. The continuous urbanization is still a trend in China for next 20 years, and this trend has a huge impact on building and construction sector. By 2040, China's urban population is expected to double, creating substantial demand for new housing and infrastructure. The huge demand in cities requires even more raw materials which makes it difficult to consider the environmental impact of excessive use of natural resources. A small scale of the local demolition waste is already used in infrastructure construction (e.g. land reclamation in coastal cities), however the huge demand for new construction still requires raw material. Because of the scale of Chinese cities, it makes it extremely expensive to transport reused material from another region, especially taking the scale of urban projects and the required amount of materials into account. Therefore, it is really difficult for the building construction sector to move to a circular economy which focus on reusing materials and managing materials at a large scale across the country due to the unbalanced regional development.

### 6.2.2 Netherlands

*Priority in Circular Economy*

Construction sector is one of the five industry priorities to implement circular economy principle, next to biomass and food, plastics, the manufacturing industry and consumer goods. Circular economy in the Netherlands focuses on resources efficiency and the value of waste. For the construction sector in the Netherlands, the majority of construction and demolition waste is recycled into foundation materials. That doesn't mean the construction sector actually has a circular economy. It is also very difficult for building sector to come up with a long-term perspective

fund-based management system solution. However, the opportunities lie in the volume and the scale of the building which can make a huge effect on environment.

Why is construction sector a priority for the Netherlands? One fact is that the Netherlands and Europe are dependent on third countries for raw materials to a high degree. The Netherlands imports 68% of its raw materials from abroad (SER & Rli, 2016). The production of basic construction materials requires energy which usually has with a fossil origin. In addition, some materials like bitumen, are the residual products of oil industry, which become increasingly scarce globally. Although most of the materials of the buildings are used in civil engineering after demolition, in building and construction sector secondary material is hardly used. As mentioned above, most of the materials are recycled in construction sector. Different from electronic devices, buildings are barely built by recycled products because the value weight is relatively low comparing to rare metals. However, it largely destroys the value of buildings and materials as well. In addition, the market for foundation materials in civil engineering is slowly becoming saturated, we need to find new ways to reuse materials.

***Material is the Key***

In the fields of sustainable construction, we only pay attention to fragmented segments, for example, focusing only on energy issues or carbon emissions, especially in use phase (heating and lightning etc). From European level, new buildings are required to be energy neutral from 2020. To make a circular built environment, more attention is given to materials. For new construction, the individual actors in construction should already think how to minimize the use and maximize the reuse of entire buildings and materials at the early phase of construction process. For the existing built environment, the materials we used for construction before are not designed with circular principles. Therefore, the challenge here is how to use the materials with circular principles in the existing building stock.

The definition of circular economy in building and construction sector vary from projects to projects. There is no clear definition in practice, and there is not only one specific definition for circular principle. People should be aware that the scope of circularity is broad. Material is the key: from using bio-based material to reusing material to improve local material flows. However, more aspects should be involved (e.g. labor concern and social network) to make the business case possible to create a bigger picture.

## 6.3 Circular Economy in Urban Context

### 6.3.1 China

The root of circular economy in an urban context is the so-called “eco-city” development which has been implemented by government as a tool for sustainable planning and development of urban areas. Those eco initiatives aim to eliminate the negative environmental impact and operate the city by renewable sources; minimize the required inputs of energy, water, food and the waste output; organize the cities with higher population densities; stimulate economic growth etc (de Jong et al., 2013).

The concept of circular economy is associated with sustainable urban development in China, such as eco-city, low-carbon city and low-carbon eco-city. The scopes focus on efficient land-use, transportation, restoration of damaged urban environment, affordable and decent mixed housing, social justice, urban greening projects, resource recycling and conservation encouraging business to support pollution reduction, reducing excessive consumption and enhancing public awareness of sustainability issue (de Jong et al., 2013; Chang et al., 2016). Eco-city development is a common urban-scale development in Chinese cities (see Table 4). Eco-cities in China focus on industrial areas in cities, for example, developing industrial parks by implementing industrial symbiosis. Eco-cities focus on new urban development within existing cities. There are different implementation practices across eco-city implementation and organization types. Eco-industrial initiatives focus on

co-industrial activities among different industrial sectors, for example, sugar, coal mining, chemistry, machinery, IT manufacturing etc (Mathews & Tan, 2011)

Table 4. Major eco-initiatives in China. Source: (de Jong et al., 2016)

| Program | Lead | Target | Approaches |
|---|---|---|---|
| Eco cities, districts & counties | Ministry of Environmental Protection (MEP) | Energy intensity, ratio of tertiary industry to GDP | Nationwide demonstration projects |
| Low carbon eco cities | Ministry of Housing and Urban-Rural Development (MOHURD) | Green transport, green transport, green buildings and circular economy | New cities or district are eligible for applying |
| Low carbon provinces & cities | National Development and Reform Committee (NDRC) | Reduce the emission of GHGs | Local governments bid for national demonstrator project |

Another urban-scale regeneration development form, urban revitalization, is closely related to the built environment. The activities mainly focus on regenerate industrial districts or historical district renewal. For a long time after reform development, the demolition based urban regeneration has been a solution for urban development, which was also the major contribution to China's urban economy. That is because urban areas like science parks, industrial innovation campuses and innovation districts are the driving forces in economic development in cities, local governments also earn revenues from leasing out land to developers (Zheng et al., 2014). In big cities like Shanghai and Beijing, the preservation of old buildings and transforming them into commercial complex or tourism attraction have become a marketing tool and a trend across the country. Therefore, major cities in China are undertaking and more urban revitalization initiatives with local governments. It aims to preserve old buildings during the country's conservation and destocking policies (see side note). Especially state-owned enterprises (SOEs) in China are not allowed to sell their properties, they therefore need to come up with approaches to utilize their vacant properties. For example, outsourcing their property management. The circular economy is about preserving the added value of existing things, both materials and buildings. Therefore, when possible it is preferred to engage in renovation of buildings to save the added value of its existing elements. Renovation is especially relevant in economies with a vast amount of existing buildings (Thelen et al., 2018a).

In this study, we focus on urban revitalization development only. The industrial-heritage reuse in different cities are highly regional. The regions in China are qualitatively different. However, there are certain development patterns that mega-cities follow. As mentioned before, Tier 1 cities show more successful cases in transforming industrial districts. Chen et al., (2016) collected the examples of industrial-heritage revitalization in three mega-cities: Beijing, Shanghai and Chongqing. The current urban revitalization projects basically follow three patterns (summarized in Table 7): to transform industrial or historical districts to (1) cultural-based landmark; (2) creative business cluster; (3) tourism attraction, focusing on real estate and retail; in rural areas, development modes are basically tourism and folk culture entertainment. Four development modes were identified: (1) bottom-up initiatives by artists occupying industrial areas; (2) top-down initiatives among local government, investor, developer and SOEs; (3) public private partnership (PPP) to coordinate both interests; (4) private development by private developer with government's supervisor. Our focus in this study is on what lesson can be learned to apply circular economy principle in transformation of local-initiated industrial districts in cities.

Table 5: Main development of industrial area transformation in Beijing and Shanghai.

| Pattern | Policy | Development process | Users |
|---|---|---|---|
| • Tourism precinct<br>• Creative industry cluster<br>• Cultural landmark | • National destocking policy<br>• Local heritage conservation policy | • Bottom-up<br>• Top-down<br>• PPP<br>• Private development | • Design company<br>• Independent artists<br>• Public park<br>• Governmental cultural project<br>• Exhibition/studios/artwork<br>• Restaurants/café |

### 6.3.2 Netherlands

In this research, the aim is to get inspirations for Chinese urban revitalization projects to adopt circular economy principles. Therefore, for case study, the case Werkspoorkwatier is chosen because most aspects are aligned with the urban revitalization projects: (1) the goal is more business-oriented; (2) transformation of industrial building is involved. Besides, Werkspoorkwatier contains few aspects that can be specifically learned for the urban revitalization projects in China: (3) bottom-up initiative; (4) circular elements.

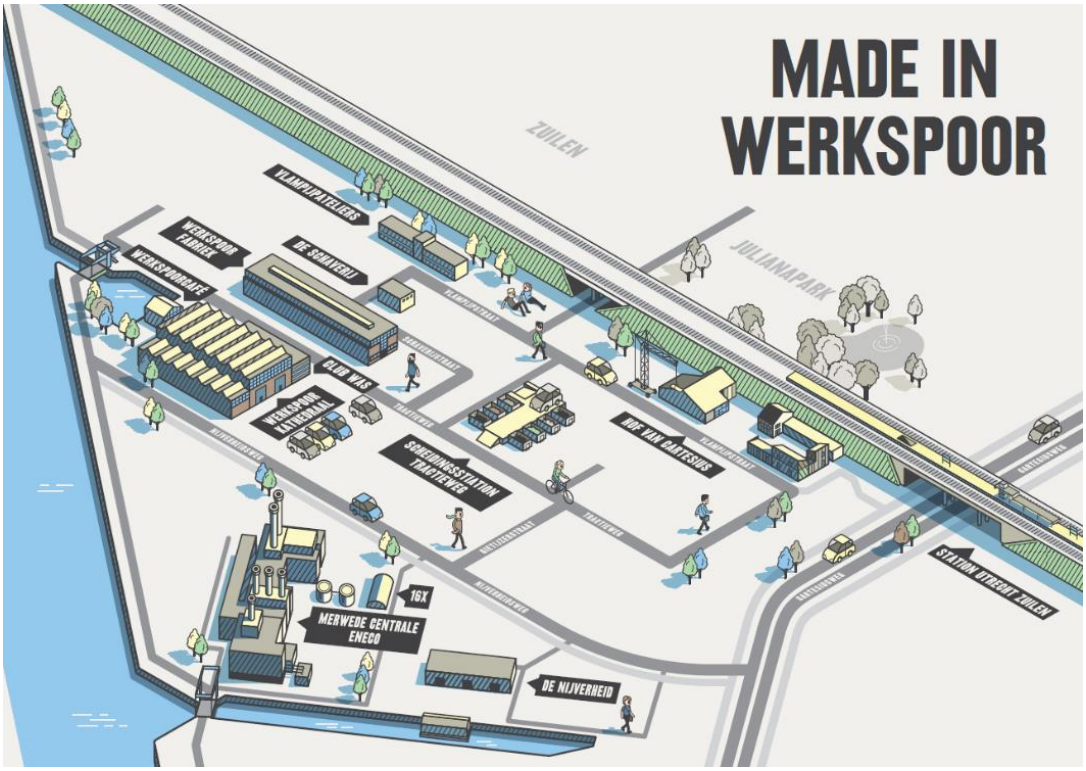


Figure 4. Circular development in Werkspoorkwatier. Source: https://efro-wsk.nl/

## *Case Background*

Werkspoorkwartier (WSK) is a pilot circular area redevelopment currently developing in Utrecht. The old business park will be transformed into a leading area for creative, city-oriented circular manufacturing companies and start-ups. WSK has a rich industrial history. It used to be the heart of Zuilen in the first half of 20th century, large companies moved in this area and thousands of factory workers worked on the production of train, bridges and other steel construction in Werkspoor. The steel company left around 1970, after which some city department moved in, and the city bought the land from the company: energy department, city social housing department, and waste management department. Around 1980 the business park Cartesiusweg was created. At the beginning it was located at the outskirt of the city, now it has been the important part of the city. Although the area is occupied by some companies from time to time, it remained an area with a lot vacant space and land. Therefore, the municipality of Utrecht started the transformation initiative for WSK to regenerate the area by establishing attractive creative and sustainable industries. The area is redeveloping as much as possible with circular principles, and goals are more business-oriented: to generate more than 10,000 sqm of new business and more than 200 new jobs. The core circular focus is on realizing to use material in a circular way: circular building, circular hub which makes connections between demolished and new projects.

The project is financed by European Regional Development Fund (EFRO) which aims at strengthening regional competitiveness and increasing employment. The project is a joint venture between four provinces: North and South Holland, Utrecht and Flevoland, and four major cities: Amsterdam, The Hague, Rotterdam and Utrecht. The University of Utrecht stepped in with some seed money to make a plan to execute it and link it to education. The funding period is till 2021 after which the project should expand further on its own. The project gives an impetus to new employment in the area, and to initiatives with a sustainable business case that can be continued profitably after the end of the project period. This way the partners work together to put the area on the map for a long time as a creative and circular breeding ground. The project partners also make the acquired knowledge available to similar projects inside and outside the city.

## *Project Development*

In 2010, there was no attention to this area. Business moved out and the city changed. Some artists and designers moved in and initiated underground scenes in WSK. There was no attention for the heritage and architectural value of all the vacant buildings. As the city owned the buildings and the land, municipality tended to demolish those industrial buildings. However, the artists wanted to keep the monumental buildings from being demolished. Then a regional investor came in and bought the buildings with very low price from the city, with obligation to redevelop and maintain for the future use.

Municipality of Utrecht made a global vision for WSK in 2012, however the city didn't want to spend financial resources to actively develop the area. A workshop for 50 people was organized to discuss the development plan but not much happened. The image and the dynamic were municipality's intention with business park Cartesiusweg, which was designated as a "creative hub". The goals are to make the area a more dynamic area with circular approach, providing more office square meters and jobs, giving room for small-scale initiatives, connecting the densely living area and WSK to associate the sustainable urbanization in Utrecht. The price of renting working space in Utrecht is really high. WSK used to be in the peripheral area of the city, but now half of the population lives here, and it is close to city center and the highway, which makes it an ideal location for companies. Therefore, one of the goals is to provide more working space and job opportunities.

## 6.4 Research Proposition

Based on the data from explorative interviews, contextual information and theories, a proposition for the main research question is given:

*How can the implementation of circular economy in the built environment contribute to a sustainable urban development in China and the Netherlands?*

The main research questions consists of three parts: circular economy methodology in two countries (Sub-question 1); circular economy application in the built environment (Sub-question 2); synthesis of circular economy and the built environment in urban context (Sub-question 3). Theoretically, the circular economy aims at increasing resource-efficiency, reduce environmental impact as well as achieving economic benefits by implementing at three economy-wide levels in two countries. The different circular economy methodologies and the huge differences in construction industry market sizes as well as culture in two countries lead to different problems in reality.

The literature study and the interview show that CE began nearly two decades ago in China. Following a strict top-down manner, CE becomes strategic development model for China with the long-term vision and strategy support from central government. China's circular economy vision prioritize the environmental benefits in heavy industry because large proportion of them are concentrated in industrial parks therefore it makes industrial symbiosis easier than in Europe or US. However, up to now, there is a lack of Circle City development. At local level, the implementation is inconsistent. There is still a lack of systems thinking with government ministry silos and lack of a much unified circular economy community. For example, clean energy, organic food, industrial parks all have their own communities. As a cornerstone of China's economic growth, the construction sector is not one of the top priorities of circular economy on government's agenda. In an urban context, besides eco-initiatives, another trend in urban (area) development is urban revitalization, which focus on the architectural and historical value of the industrial buildings, and transforming into new use to attract tourism and boom local economy. The starting point is different from circular economy goals, but it has huge potential to realize circular economy.

In the Netherlands, circular economy development in general follows a more bottom-up manner. Construction is one of the priorities, therefore the innovation in Dutch construction sector is ahead of Chinese construction. The construction industry has totally different features from Chinese construction sector, the basic principles regarding circular economy are similar. In an urban context, different types of urban development are gaining momentums in cities which focus on different level of circularity. However, compared to China, Dutch government has no clear measurement yet and supervision is not enough.

➔ Propositions

To implement circular economy in the built environment, Chinese government should combine top-down and bottom-up approaches, creating space for stakeholders and local business to break down the silos in government ministries. The priority in Chinese construction sector is to embed circular economy principle in continuing urbanization. Specifically, there are opportunities to apply circular economy principles in current urban revitalization. Dutch construction sector will focus on retaining the value of material and business opportunities with a more bottom-up approach based on diverse market and network. However, the interaction with government is still necessary regarding creating target or guidelines as well as support and supervision.

# PART IV: EMPIRICAL FINDINGS

## 7. TOWARDS CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

### 7.1 PRIORITIZED CIRCULAR STRATEGIES

#### 7.1.1 China

According to Tan et al., (2011), the sustainability in construction focuses on the application of sustainable development principles to the comprehensive construction cycle, from the extraction of raw materials to the management of the resultant waste (Chang et al., 2016), especially cleaner production (Ghisellini, Ji, et al., 2018). The opportunities of circular economy lie in the management of whole construction cycle. The circular economy should be adopted by the construction sector in a way that suits the large scale and volume of the sector. However, it is not possible to propose a "one-fits-all" circular approach across the country because of the unbalanced regional development, especially the regional economic imbalance in eastern, central and western areas. It leads to implementation problems during the enforcement of policies. This section has carried out a prioritization analysis based on desk research and interviews to identify which circular strategies will work in a Chinese context, and what the potential challenges are.

*Modular construction and prefabrication*

The buildings in China are not designed in a flexible and durable way. The average lifespan of a building in China is 25-30 years. The short-termism is prevalent in construction sector. Construction companies follow the traditional way of construction to deliver buildings as fast as possible, also tend to use low-quality materials to reduce the cost of buildings. One consequence of such way of construction is inefficient use of primary materials associated with high greenhouse gas emissions and energy consumption. The use phase of buildings is also extremely energy intensive. The "quick

and dirty" way of construction generates high volumes of construction and demolition waste, most of which ends up on conventional landfill or dumping at countryside illegally.

Following the New-Style Urbanization Plan, the continuous urbanization in Tier 2 and Tier 3 Chinese cities will still face a huge demand or raw material extraction. The construction will still focus on residential buildings and commercial buildings. CE focus on both supply-side mechanism and sustainable consumption or sufficiency. It is not only important to use resources and goods more efficiently, but also to limit unnecessary demand (Ness & Xing, 2017). However, the consumption side in construction is steered by Chinese government, which requires actors in construction to operate the construction cycle as fast as possible. Innovative usage of eco-materials doesn't fit the rapid pace required in construction. The strategy should be considered from the supply side which focuses on the optimization of the construction process.

Modularizing the construction activities is an approach to solve the problems in the construction cycle: from design to end-of-use phase. Modular construction can reduce the dust and waste during construction phases as well as energy and material consumption. The Chinese national government aims to have prefabricated buildings to save resources and the problems of excessive industrial capacity. Based on the guide from the ministry, 30% of new buildings will be constructed by prefab structures by around 2026, especially for the residential buildings.

The transition to a prefabricated construction requires the collaboration between all stakeholders. Architects and architecture education need to adapt to new roles: gain more knowledge about materials and design for modularity. Contractors and suppliers should work together to industrialize construction processes to enable modular off-site construction and prefabrication. The problem for now is that modular techniques cost more than traditional way of construction, and the market for modular building is still at experimental phase. However, with larger scale in the future, the cost be lower. The Chinese society is extremely dynamic, it is really difficult to standardize the modularity across the whole country. Also, for tenant, just like transition from brick to concrete, it will take more time for people to accept steel-structure prefab buildings for their houses.

- Opportunities
    - Government is promoting prefabricated buildings in residential building market.
    - Prefabrication and modular design can also save construction cost and social resources - Interview with Wang Dan (2018, Tianjin).
    - The use of steel in prefab construction help resolve the excessive industrial capacity – interview with Yu Lei (2018, Skype), Xin Shanchao (2018, Tianjin).
- Challenges
    - There are issues with cost and structural strength for current technology. Cost is still higher than traditional techniques, and the technology at enterprise level is not mature enough - Interview with Yang Wei (2018, Tianjin).
    - "It is difficult to industrialize construction because of the social diversity in China. It is not possible to have only one module across the whole country." – Interview with Sun Delong (2018, Tianjin).
    - "Design for disassembly" is not embedded in architectural education. Architects, students as well as prominent developers are not aware of the value of it. Everyone wants to design "cool stuff" – interview with Wang Dan, Yang Wei (2018, Tianjin).

*Use of secondary materials*

The secondary material market should be discussed in two types: market for historical buildings and market for buildings in urbanization process. Historical buildings refer to the buildings with high architectural value; reflecting the historical and cultural characteristics; reflecting industrial development in China; with historical and cultural significance. When demolishing historical

buildings, the government or the developers will hire demolition companies. They will identify, separate and collect all valuable components, and with their own networks, they develop a market specifically for the reuse of the building materials and components from historical buildings.

> "In Northeast part of China, there are many old buildings constructed during Japanese-Russian war time. The demolition companies select all the useful and valuable stuff, for example roof, tiles, even doors and windows. They have their own way and channels to sell those components. For example, all the bricks used in Japanese buildings in Dalian, have high quality. The demolition companies cut the brinks into slides and sell them as interior decoration materials. The wood was designed as furniture. All the doors and windows were sold as well because there is a huge market for the interior design with historical value." – Interview with Wang Dan (2018, Tianjin).

Buildings in urbanization process refer to, for example, residential, commercial, industrial buildings, which were built in massive urbanization phase, constructed and demolished in a traditional way. Construction and demolition waste (CDW) in those buildings mainly consists of concrete, brick and block, ceramics and other materials. The discarded materials are processed in different ways In China, the demolition phase is required to be as short as possible. The collection and classification system are not well developed, and the recycling technology is immature. China built enormous amount of urban residential buildings in 1970s-1980s, which will soon face the end of their lifespan in coming years. It is necessary to scale up the reuse and recycling of CDW and implement circular economy principles in urban planning. The barrier is there are not even any published statistics on the amount of CDW at national or municipal level, which makes it difficult for the research of reusing and recycling of material.

However, the valuable building materials and components are mostly recycled via informal collection and recycling sector by human resource because the cost of labor is relatively cheap in the sector. There is actually a developed market for those valuable building materials initiated by spontaneous self-organizing informal sector. For example, the steel in reinforced concrete will be separated from concrete and sold to recycling center or other sectors. For new construction, the government focuses on strengthening the institutional supply by promoting the utilization of recycled products and raw materials to force the utilization of certain proportion of recycled construction products. However, the existing CE policies are aimed at streamlining the waste and secondary materials flow through the *official channels* only, including bans on informal recycling (Gu et al., 2016; Williams et al., 2013). However, those informal recycling channels actually contribute to recycling CDW:

> "If we only talk about the use of the demolition waste, most of them are recycled, but maybe down-cycled. Because of the low cost of the labor, valuable steel, windows, doors are almost recycled. Big bulks of concrete will be grinded and used for subgrades in civil work or aggregate. Those not well-shaped materials are used for land reclamation. " – Interview with Yang Wei (2018, Tianjin).

- Opportunities
    - There is already a self-organizing secondary market for building materials with high historical value.
    - Most of the valuable materials (e.g. steel) was recycled manually due to the cheap labor cost.
    - Government requires to utilize certain proportion of recycled construction products.
- Challenges
    - China is still at the peak time of its urbanization process. The demand for new development is much more than demolition. Economy overweighs environment in Tier 2 and Tier 3 cities.

- No published statistics on the amount of CDW, which makes it difficult for the research of secondary materials.
- Landfills in rural areas because of the unbalanced development between cities and rural areas

### 7.1.2 Netherlands

There are opportunities to apply circular economy principles at every stage of the building lifecycle: design, manufacture and supply, construction, in use and refurbishment, end of life. The concept stage and the selection of strategy are important to deliver a successful product. It is not possible to cover all the aspects of circular economy. To define the circular intervention opportunities, in practice, building-layer model and by Brand (1994) and Bergman (2011) as well as 10Rs strategies by Word Economic Forum are used. Normally new constructions start thinking from the outer layers, and inner layers are the focuses for existing buildings. See Figure below (more details see Appendix 3).


Figure 5. Link between building layers and priority to apply circular strategies.

Source: (Thelen et al., 2018)

The buildings can be seen as a material bank where stores different building components (product). The components are differentiated by 'consumable' and those that are 'durable'. For durable components in buildings, (e.g. services and facilities), the principle is to extend their use life. The consumable components (carpets etc.) can be recycled into new products. As mentioned before, each element of building has different lifetime. By thinking in layers, the durability, resilience and lifespan of products and materials in the building can be optimized.

Different stakeholders are involved in different layers, products and materials at different layers should be defined. Once the opportunities available for circular intervention are identified, they can be addressed through 10Rs strategies. To retain more value of the building products, the products should be produced and used in a smarter way by refusing, rethinking and reducing; the lifespan of the products and its parts should be extended by reusing, repairing, refurbishing,

remanufacturing and repurposing; materials of the products should be applied in a useful way by recycling and recovering. See the Table below:

Table 6. 10Rs strategies (World Economic Forum, 2018)

| | Strategies | Description |
|---|---|---|
| Smarter product use and manufacture | R0 Refuse | Make product rebundant by abandoning its function or by offering the same function with a radically different product |
| | R1 Rethink | Make product use more intensive (by sharing product) |
| | R2 Reduce | Increase efficiency in product manufacture or use by consuming fewer natural resources and materials |
| Extend lifespan of product and its parts | R3 Reuse | Reuse by another consumer of discarded product, which is still in good condition and fulfills its original function |
| | R4 Repair | Repair and maintenance of defective product so it can be used with its original function |
| | R5 Refurbish | Restore an old product and bring it up to date |
| | R6 Remanufacture | Use parts of discarded product in a new product with the same function |
| | R7 Repurpose | Use discarded product or its part in a new product with a different function |
| Useful application of materials | R8 Recycle | Process materials to obtain the same (high grade) or lower (low grade) quality |
| | R9 Recover | Incineration of material with energy recovery |

*Alternative business models*

The freedom to operate within the limitation of social contact is really important. At the beginning phase of transition, the market is not able to throw off the inertia. It is difficult to get circular materials involved because the market is not ready yet. Reusing some materials is more expensive than new materials, and that makes people tend to go back old ways. However, we can **involve more social parties outside the supply chain** to lower the cost of reusing materials.

> "We developed a new thrift shop for the municipality, and we wanted to use local materials. We needed to drain the wood out and cut it right size, and that made it more expensive than using new wood. We made connections with local social services organization, and we asked them if they wanted to work on this project to process the reused wood, and they can do it with low fares. In this way, we help more people get new jobs. What's more, we also reused material. It took longer, but more satisfying. We made better building, better environment, better social concern, and generate a bigger picture." – Interview with Freek Wullink (2018, Utrecht).

The components and materials out of use in the project probably are the demand for other projects. All the materials and components in the buildings have potential to be operated in a new way. **Finding right parties to match the circular demand and supply** is important. It takes longer time to search the right partners and negotiate the issues involved in the process (e.g. logistics). However, it will save money and provide better environmental performance in the end if operated properly. From clients to contractors, most of the people still are not willing to participate in the circular economy, or don't know how to apply circular economy in their culture. By small initiatives, it will inspire more ideas of dealing the materials and keeping them from being dumped.

> "We renovated our own office recently, and the project manager was focusing on finishing it as soon as possible, I convinced him to do it in a circular way. The construction company calculated that it cost 40,000 euros to remove the inner walls. We tried to find a party that wanted reuse the walls instead of demolishing them and dump them. I found an organization that wanted to take the walls for nothing and place them in another project. It

> is a big saving. After that, it really changed the way of thinking and doing. If it worked with that, maybe we can also do for carpet, furniture, etc. It's interesting for clients to work this way." – Interview with Freek Wullink (2018, Utrecht).

However, it is also important to keep "old-schools" in mind. From the whole market, circular-motivated actors only account for small proportion. We need the participation of whole supply chain to make new circular chains. But the old chains don't go away, instead they are threatened. During the transition to a circular economy we will always need the old chains. When we want to make the transition, we need to make the change as easy as possible.

- Opportunities:
  - Small initiatives will inspire more ideas or dealing the materials
  - Big clients are circular motivated.
  - Connections with local social services organizations can not only save the cost of reusing materials but also generate a bigger picture in circular economy.
- Challenges
  - Circular motivated actors only account for small proportion.
  - Government externality not incorporated in prices

### *Document your building*

The social contacts become more important at this phase because the information of buildings and materials are not systematically documented. If you see buildings as product, and you want to decide which products can be reused for future, the generic way is mapping the vision at component level with specific way to digitalize your file. The concept of "material passport" ensures the ability to gain access to the information of building products and materials stored in different buildings in order to reuse a building product or material in the future. The information contains the initial characteristics of the component as delivered from supplier or manufacturer, as well as the actual characteristics and conditions of the component after use (historical exposure to weather, transport, disassembly and contact with chemicals etc.) (Jensen & Sommer, 2016).

There are some existing informal channels (e.g. dealers for secondary materials and independent information at local level) which are not central data-based and organized in a structural way. It takes a lot of time to track all the information in different location, and also it cannot be applied to a bigger scale. For a circular future, scaling up the use of material passport for the whole built environment is necessary.

The development of the materials passport is still in its infancy, and there are different platforms developed by different companies. In the future, we need to build a standard to unite different platforms and also integrate existing (Building Information Model) BIM and BIM-like tools to represent a platform for mapping, storing and connecting the information in the material passport. The current challenge for the application of material passport is that the material is not really local, it's not clear where the materials are from. It is not applicable for bigger scale.

### *Circular procurement*

Circular procurement is an effective circular solution to encourage both public and private clients to integrate circular principles into their projects. For public buildings, the public sector can come up with scalable demonstrate units by requiring certain percentage reused material with a fixed budget as a criterion in public circular procurement, and other projects can copy the format and adopt individual solutions. Fixed budget is the key for scalable solutions. For private sector, the clients tender not for the cheapest but most circular plan. The client's ambitions target, objective benchmarking as well as integrated circular approaches will be translated into circular criteria for tendering. By offering a certain budget, the clients will get the product with highest circular quality. A highly circular-motivated client is the key factor in mapping the circular vision in the project. Bigger clients are also responsible for the goals on both environment and social aspects. When you

use more secondary materials in your project, you get attention from new clients. Therefore, momentum is born for CE. The client has to be circular motivated. The client needs to sit with their "service provider" as well as advisor and consultant to make a feasible circular vision together. The right circular aspects and the right solution should be integrated to business case. Traditional architects become client advisors. They also give advice to contractors on documenting the materials and help contractors to execute in the right way. Culture and trust are the key at this transition phase. The complete chain of the building industry is not ready for fully circular. Most of the suppliers still don't know how to integrate circular economy with their culture. People need room for failure for each other.

Government also plays a role here. The clients are dispersed. Private clients are different from public clients. If government can help to set up a guideline for all clients, and sharp the target for the circular economy with clear definition for CE, it will speed up the whole process. From industry side, externality is not incorporated in prices. We talk about materials here. Standard materials are normally less expensive than sustainable materials. In traditional product, we don't pay for externalities or pollution. If we move into taxes, it would encourage the industry to reconsider sustainable materials. Next to taxes, government need to reward people who are being circular. Government, clients and building firms need to share best practice with each other.

### 7.1.3 Summary

This section analyzes the prioritized circular strategies for two countries.

Circular approaches in Chinese construction sector are to solve the issues and problems brought up by large-scale urbanization, for example, enormous amount of construction and demolition waste. For new construction, modular construction and prefabrication will be an effective solution for the enormous flow of waste. For the use the secondary material, governmental enforcement is the most effective way in a Chinese context. Meanwhile, government should be aware of the informal channels for waste collection and recycling. Dutch construction sector already has a well-developed waste management system. Therefore, the circular actions in Dutch sector focus on material itself to retain the value as much as possible. The table below compares the circular strategies driven by the effects of macro-meso level in two countries.

Table 7. Comparison of circular economy strategies

| | Context of Construction | Prioritized Strategies | Actors | New construction | Existing built environment |
|---|---|---|---|---|---|
| China | Ineffective urban land finance;<br><br>Rapid urbanization causing large volume of construction;<br><br>Unsustainable growth in construction; | Modular construction; Prefabrication; Industrialize construction process | Architect, contractor; material suppliers; government | Largely reduce CDW;<br><br>Save resources | |
| | Large scale of waste; massive impact on environment; energy;<br><br>Continuous urbanization till 2040 requiring raw materials;<br><br>Reusing material is not really feasible<br><br>Buildings from 1970s-1980s soon facing the end of their lifespan | Use of secondary materials | Demolishers, Recycler, Informal recycling sector; Government, Developer | utilization certain proportion of recycled construction products | Reuse or repurpose materials with high historical value<br><br>Scaling up the CDW management |
| Netherlands | EU & NL industry priority;<br><br>Resource dependency;<br><br>High value reused based on advanced waste management;<br><br>Minimize use & maximize reuse building and materials | Alternative business model (within and outside supply chain) | Contractors, Social organization, | | Maximum reuse |
| | | Document your building | Architect, Contractor, Supplier, Manufacture, | Material passport in new building | |
| | | Circular procurement | Client (public/private), Government, | Fix budget with highest circular performance | |

## 7.2 Circular Economy Opportunities in Urban Context

From a transition management perspective, meso level is the central level, which provides societal system stability from macro level and also guideline on individual behaviors from micro level (Loorbach, 2007). Cities are structured by systems within systems, with multiple overlapping networks that interacts at different scales. Cities have density and scale, and they are resource-intensive. Urban areas that make up a city or region differ from each other. Urban areas are the platforms where micro circular individual behaviors meet macro level policies and regulations. Ostrom (2009) believed local incentives for cooperation stimulate collective actions and polycentric approach to tackle environmental issue. Those actions and approaches are implemented by small-scale regional institutions and governance mechanism (Patala et al., 2014). Managing and creating these kinds of buildings, locations and districts is a complex challenge and asks for an interdisciplinary approach. In China, cities play a role as both industrial and population centers in the urban growth, it is necessary to design an integrated approach to tackle environmental problems and mitigate pollution (Jesus et al., 2017). In coming years, circular area development will be a growing priority for Dutch municipalities as well. This section

### 7.2.1 Opportunities for Urban Revitalization

*Narrative research finding*

The findings from narrative study are presented here. The findings will be analysed based on the analytical model defined before, resulting in discussion of the dependencies and interactions of aspects in different dimension to determine the general drivers and barriers for the investigated urban revitalization development.

*Governmental dimension*

- Top-level vision

The success of eco-city development heavily relies on subsidies and public investment following a top-down standard. The more national central government is involved, more successful the projects tend to be especially those paired with structured foreign involvement (de Jong et al., 2016). Those demonstration projects are normally supported by top-level commitment and close governmental supervision and monitoring. Operating with stable funding sources is also the key to a successful project. Strong political leverage can ensure stable funding sources from different actors (e.g. state-owned enterprises, private investment companies and developers). Because of the strong political will and commitment, it is easier to mobilize the knowledge and expertise in circular economy to the projects.

At local governance level, manly governments have also developed sustainable urban development initiatives, however a large number of projects failed since they lack support from higher government levels and the monitoring. Local government is not able to provide sufficient financial feasibility. High level ambition from government doesn't align with eco visons. In the end, those eco local initiatives barely distinct from regular urban construction projects. The knowledge at local level is not available to stimulate eco-innovation activities, and the implementations are not suitable for local economic and social environment (de Jong et al., 2016).

- Governmental support

As the destocking economic policy has been implemented in China, to achieve a sustainable development goal in building and construction sector, government doesn't depend on the income of one-time land transaction anymore. It requires the real estate developers and investors to develop and operate business. From a long-term perspective, taxes on the business provide a more

sustainable revenue source for the government. In China's Tier 1 cities such as Beijing and Shanghai, it is not possible for developers to purchase and develop projects for new use. The developers only get the development and construction permit from the government if the land is used for urban renewal. Compared with the complex procedures for new development, the procedures for urban revitalization development permit is much simpler.

> "There is no effective governmental dialogue mechanism. It is related to the decision-making process and system in the government. First Development and Reform Department, next Land Department, next Construction Department. People from those three department never talk. This process is fixed, you can't turn the process upside down." – Interview with Wang Dan (2018, Tianjin).

We can spot the similar issues in urban revitalization developments. The core issue of existing urban revitalization projects is the dislocated the relationship between local governments and enterprises. Mostly, the ownership of the properties belongs to local government. The developers or investors need to request permission from the government. The permit period is uncertain, and the local government is not able to provide stable financial support, which makes it risky for private investors and developers. The developed regions or cities (e.g. Shanghai, Beijing) have well-developed policies and mostly those projects are developed by big developers because they own years of practices and experiences in big cities. Once the pattern works for one city, other Tier 2 and 3 cities will copy and paste the same pattern without taking the local conditions and local markets into account.

> "Every city has its own standards and regulations. I would say the regulations in South China, for example in Shanghai, are more advanced than northern part of China. From national level, there is still no clear policy to guide urban revitalization. " – Interview with Wang Dan (2018, Tianjin).

However, the bureaucratic decision-making process in the government is another factor to block the urban revitalization projects. Different local departments within government don't have coordinative communication mechanism, which causes delay and changes in almost every phase and negative deviations in the plans.

*Knowledge dimension*

- Circular vision

The circular visions of urban revitalization projects are overlooked even if the projects are developed by big developers: only small parts of the buildings are kept or adapted into new use (normally for marketing), and developers construct more buildings in the area which are normally constructed in a traditional way which is faster and more economical. The value of material is not taken into account. Most of the urban revitalization projects

> "You can only save one side: economy or environment. The problem in China is the great development gap among Tier 1 cities and Tier 2, Tier 3 cities. For example, the environmental problem caused by industry is so unbearable that everyone is aware of it. However, in Tier 2 and Tier 3 cities, people can still 'endure' the pollution. Therefore, the government is not eager to deal with the environmental problems in Tier 2 and Tier 3 cities. Especially in the built environment, the demolition waste only occupy land and space, but most of them are non-toxic waste. So it is not the priority." – Interview with Yang Wei (2018, Tianjin).

- Knowledge development

Hardly any knowledge creation or exchange activities and leaning behaviors were mentioned in the interview. Most of the urban revitalization projects are linked to art, culture and tourism, therefore most of the knowledge sharing activities are around exhibition, art workshops, culture workshops targeting at certain group, and the scope of knowledge is limited.

*Organizational dimension*

- Stakeholder collaboration

Four groups of stakeholders are identified: investor, developer, producers (architect, engineer, contractor etc.), users and government, and former SOE owners. Government includes policy makers and regulation makers.

Information is segmented among actors: the researchers, project managers don't understand business and politics; government doesn't understand business and development and only pursue GDP targets as political goals; investors are only profit-driven. Different parties do not communicate with each other which leads to bitter policy and legal conflicts. The participation of public in decision-making process in urban area development is still missing. However, society recently actually has strong awareness of conserve the old industry areas. Knowledge institutes are normally not involved, in some cases only art academy partly participate in the project.

> "The stakeholders involved are too complicated, especially within government. For one project, so many parties are involved: department of cultural heritage, department of industry and information technology, department of tourism administration etc." – Interview with Wang Dan (2018, Tianjin).

We don't see smart collaboration and interdisciplinary work method among actors. Stakeholder act highly independently. Revenue is the common interest shared by local government and developer. The network is not well developed. Local government still has a great leverage on the project and the selection of tenants. Tenant and public are normally not involved in the decision-making process. Local city authorities need to propose sustainable approach which less depends on heavy public investment and instead depend more on local market and communities.

Table 8: Actor network analysis

| | |
|---|---|
| Actors | Actors are not really connected with each other. Public and private actors |
| Commons and protocols | Shared circular idea, construction experiences, mistakes, success;<br>Co-development of the assessment tool and used within the area;<br>Informal mobilization of actors, negotiations, agreement. |
| Network stratification of process | Government has large influence on the project and decision-making.<br>Big developer has its own network, following one formula. |
| Permeability of boundaries | Only focus on policy-driven industries.<br>Not connected with existing industries. |

- Operational logic

Environmental actions were not mentioned in the interviews. The focus of actions is attracting business and boost local economy and tourism, not promoting knowledge-based industry or creative industry. Government tends to focus on short-term economic target in their tenure.

> "The basis of 'creative industry' is creative people. But there are not so many creative people to support the creativity industry when government and developer only focus on market." – Interview with Wang Dan (2018, Tianjin).

## *Discussion*

To better understand how the separate aspects in each dimension influence each other. Therefore, we analyze the positive and negative feedbacks within different aspects to further define the drivers and barriers in achieving sustainable urban development in China based on narrative study.

In China, the eco-cities or eco-industrial parks are the main approaches to implement circular economy principles in new urban area development. Eco initiatives with strong political support and supervision from central government turn out to be more successful, while the local-led eco innovations tend to fail because of the mismatch between government economic visions and eco vision; lack of circular economy knowledge at local level among government and companies; disability to mobilize local resources. Urban revitalization developments focus on the transformation of the existing urban area. Tier 1 cities provide more successful urban revitalization examples because it has become a tourism attraction to transform industrial buildings into innovation parks or for commercial use. Normally those projects are developed by big developers with the support from local government. While in Tier 2 and Tier 3 cities, urban revitalizations are led by local government with less power and resources, and the experiences and patterns of Tier 1 cities are not applicable. Governmental interventional behaviors (i.e. greatly rely on land finance, lack of knowledge of planning, institutional bureaucracy etc.) are identified as the main barriers. In the end, the projects tend to deteriorate or have no distinctions between urban revitalization and regular urban development.

In summary, eco-city development focuses on city-wide sustainability and circular economy approaches by incorporating CE ideas into pilot industrial zones. Urban revitalization focuses on the large-scale redevelopment in the existing urban environment by market-based revitalization initiatives including real estate, retail and entertainment from economic, social and community as well as cultural and historic conservation perspectives. However, the government-controlled circular economy projects always face a crucial common problem: the inconsistent implementation at local level. This is because, firstly, the projects are mostly not publicly accountable to ensure the transparency; secondly, the visions of central government are not matched by the knowledge of local business and competence of local government officials (Bi, 2004). There are no guidelines for planning from government, however, when local companies and social network attempt to implement innovative market-based solutions, government will intervene against the approach because it doesn't fit government short-term targets. Third, within governments, goals pursued by different sectors are not always aligned, and different governmental sectors appear to lack communication to come up with a common vision. When it comes to real project implementers, they have to amend their planning to meet different requirements, which eventually lead to a less successful implementation.

Frist, from **governmental perspective**:

- Most of China's sustainable development at urban level, follow the top-down implementation approach, or strongly influenced by governmental interventions.
- Those government-influenced projects always involve large amount of public investment holding high expectations of central and local government, e.g., GDP target.
- However **local bottom-up initiatives** without governmental support and supervision tend to fail.

Second, at **knowledge level**:

- There is a lack of awareness of implementing circular economy in the built environment. Each eco-industry or sector has its own circular economy community.
- It is not clear to both local companies and government about how to integrate circular economy principle and knowledge in practice.
- The knowledge and the experiences of local entrepreneurs and the high expectations of government are not well matched.

Third, at **organizational level**,

- Big companies have standardized development process and network to develop successful projects in Tier 1 cities. In Tier 2 or Tier 3 cities, the development patterns are inappropriately applied.
- There are not sufficient experiences among local companies themselves, they are not able to develop a dynamic business network with local resources.
- We don't see obvious organizational innovation in urban revitalization projects. Actors follow the regular real estate development process.

The top-level vision impeded the circular vision development in urban revitalization, especially at Tier 2 and Tier 3 local level. Unlike central government, local government doesn't have the knowledge and resource to develop a circular vision. Local government still greatly rely on urban land finance to achieve their GDP target which affect urban innovation in a negative way as developer tend to finish urban project in a regular way in a short construction cycle. The decision-making process within government involved too many stakeholders, while there is no effective coordination dialogue among actors. It directly influences the progress of project and the collaboration among stakeholders. The focus of actions and the mechanism of how stakeholders make those actions (operational logic) influence the knowledge development negatively. The urban revitalization development heavily depends on real estate business. Big developers have certain development patterns and market network, which hinder the engagement of local typologies. Therefore it gives limited space to develop and share knowledge at local base. However, top-level vision will positively influence the knowledge development in the project. When local government is devoted to promote creative industry or cultural activities, it will attract more interest organizations and contribute to the knowledge development.

Figure 5 illustrates the dynamic interactions among different aspects identified in the analytical framework.. Figure 6 shows the barriers and drivers and the links to


Figure 6: Feedback loop among different dimensions.


Figure 7. Barriers and drivers of implementing circular economy in urban areas (Narrative study).

- *Barriers*

One of the biggest barriers for applying circular economy in urban revitalization in China is the ***lack of systematic circular economy knowledge***. The relevant circular economy knowledge is in silos, each industry or sector has its own circular economy community. For local government and enterprises, they are not able to create and mobilize knowledge and resource of circular economy and apply to local urban area development from eco-cities and eco-industrial parks.

The intrinsically bureaucratic system in government is the second barrier. There is a lack of effective dialogue mechanism between government and development actors as well as within government Different departments strictly assess the development based on one-sided standard.

The reliance on land finance at local governance level is identified as another barrier. Local governments only focus on short-term GDP target within its political tenure, and real estate business contribute the most GDP for Tier 2 and Tier 3 cities. This requirement from construction sector makes it difficult to innovate in the built environment if government and construction sector only value the economic growth in a short-term.

To lower the risk, and get return on investment as soon as possible, when developing urban areas, big developers tend to use certain development patterns. Hardly innovation in supply chain is involved.

- *Drivers*

In some successful cases, top-level policy on circular economy and governmental vision on culture development and creative knowledge-based industry attract diverse interest organizations to contribute to the creation of knowledge.

### 7.2.2 A Case Study: Werkspoorkwatier

*Governmental dimension*

- Top-level vision

The national policy and EU commission are done in accordance with the municipality vision for the area development. The policy goal is to stimulate CE within the project and influence anther parts of the city – scaling up after experimental pilot project. The state hasn't developed a vision yet. From national level, the goal is to achieve circular economy by 2050, and reduce 50% the use of new materials. At local level, the Utrecht long-term city strategy is focusing on sustainable urbanization. The city of Utrecht creates an atmosphere for circular economy, especially for small circular initiatives in the city. In 2012's vision, in particular, the large existing companies had to make way for small-scale, locally-oriented, creative industries. The municipality's will to strengthen the city's creative infrastructure was linked to the candidacy for the European Cultural Capital, in which Utrecht presents itself as a city of knowledge and culture. The area was given a new cultural destination. **There is no strong political will and commitment** on the project. The project was initiated by small-scale actions with strong individual circular interest and intrinsic motivation, which makes room for actors to operate in practice. In contrast, the **government has little influence** and no leverage to impose measures (i.e. economic goals) against the circular economy because the land and buildings are **owned by private investor**. Also, the government cannot steer the knowledge institute. However, the implementers expect government can have clearer goals and visions to support the development.

- Governmental support

The project team discussed the plan with government and the government provides the funding through the city. To help the development move forward, the municipality wrote an Open Call in 2014 for a temporary function of the green strip along the railway – one of the few lands in its possession. The winner with the best idea can realize the project. The project soon attracted the attention from multiple tenants and the pre-financing went smoothly. However, the realization of the project turned out to be more complex than expected, especially with regards to the contract with the municipality. For example, the lease period of the land. At the beginning, the land can be rented for only five years from the time of construction, which is too short for such unusual construction process. The solution eventually was the regional investor (Bob Scherrenberg) who owned the Werkspoorkathedraal and EWU bought the land and the five-year lease was extended into a twenty-year lease.

There is always a balance and conflicts of interest between innovative party and city maintenance. For example, the reused material used in the circular design is not one of the standardized materials in catalogue, and the regulations don't' allow to use it. Flexibility in adaptive regulations and room for negotiation therefore is important. Next to it, both actors and project manager find bureaucracy in reporting and applying for international funding is against flexibility in project. Actors are expecting the government can simplified the applying and reporting procedures.

*Knowledge dimension*

- Circular vision

Coming up with a circular vision in common is identified as one of the difficulties in the project. The tools used to explore the circular points in this project are R10 models and circular development steps by Metabolics. Building material is the main circular focus in the project. The university as a large sustainable institute works with engineering company to help define the circularity in the project. Both university and companies believe it is also government's responsibility to help define

circularity. At urban level, the circular vision requires a wider scope. For redevelopment project, energy system is always important: make energy system as efficient as possible by using solar panel system and green power generation. Circularity is widely defined in Het Hof. Bio-based raw materials such as hemp, wool and denim trousers were used for the insulation of the walls. Demountable constructions have been used by second-hand construction material. There is a wadi for the drainage of rainwater, energy is taken from solar panels and an installed heat pump. In the end, about ten percent of the building material is new demountable steel profiles, which is was not the idea for Het Hof at the start. Also building Hof van Cartesius with used materials is much more expensive than with new materials because of dismantling process, transportation and storage cost. The table below show how Het Hof follows the 10Rs principle. For the entire area, circular vision of materials and business are equally important. Not only the buildings should be circular, but also the industry as well as the way of working needs to be circular. Hof van Cartesius is also getting more attentions from innovative business partners because it was built in a circular way. The abandoned industrial Werkspoorhaven is being transformed into a public meeting place with sustainable catering as well entertainment facilities to integrate social circular dimension.

- Knowledge development

Knowledge sharing is the key. To develop the circular knowledge of building material, BOOT as an engineering company contributes the practical knowledge, and University of Utrecht and Hogeschool Utrecht give the theoretical input. BOOT develops the system to record and label the material data that other project partners can use to achieve their goals. All materials are checked by Brand's building layer Hof van Cartesius is maximum possibly built by reused materials, and the system is used in the project. The data is given to the university and they measure the data scientifically. The knowledge is developed and distributed in a rather informal way by sharing plans are results with involved actors regularly. The partners share what they have learned, what they have done right and wrong. The informal engagement also provides educational resources by inviting students to do assignments and research in WSK. It is a problem to measure circular economy due to the ambiguous definition of circular economy. Government doesn't have a clear definition or indicators at this moment, therefore the monitoring and assessment tools are being developed by knowledge institute and companies. The knowledge institute focuses on setting up an objective matrix to measure how circular the buildings are. BOOT has experiences in making inventory of buildings that are going to be demolished. And that experiences are reused in the model to assess the potential circularity. BOOT is also together with two more companies trying to develop a practical instrument as yearly benchmark to measure the circularity of materials and progress for entire area. The instrument is not really scientifically developed but from a practical perspective through interviewing and analysing qualitative results (i.e. What have you done? What are your visions? Have you achieved your goals?) The aim is to implement the model on buildings within and outside WSK in the future.

| 10R | Application to Hof van Cartesius |
|---|---|
| 1.Refuse | Try to avoid the use of new materials (as much as possible) and makes use of what is already there |
| 2.Reduce | Reduce the consumption of harmful substances: for example, use sheep wool as insulation material |
| 3.Redesign | Use constructions that can be reused: such as the demountable steel construction and the foam concrete foundation |
| 4.Re-use | Reuse materials saved from demolition as much as possible: doors, frames, trusses, floor beams, sliding doors, sandwich panels etc |
| 5.Repair | Do not throw anything away but want to repair as much as possible and give a new chance |
| 6.Refurbish | All the furniture in Het Hof consists of refurbished furniture that still has a better round |
| 7. Remanufacture | New products are made from second-hand products |
| 8. Repurpose | Old products get a completely different purpose in Het Hof: door becomes window, rail tracks become column, construction waste and ceiling grilles become façade cladding or insulation |
| 9.Recycle | Regain material from raw materials for another or the same purpose: many of the cladding consists of former waste material |
| 10.Recover | Recover its own energy through the solar panels on the roof and the heating by its own heat pump |

Table 9. *10 Rs* principles used in Het Hof van Cartesius.

Figure 8. Het Hof van Cartesius Source: own photography

*Organizational dimension*

WSK initiatives:

| Initiatives | Descriptions |
|---|---|
| Werkspoorkathedraal | The Werkspoorskathedraal offers appealing activities for residents and visitors from the city and region. |
| Werkspoorfabriek | Werkspoorfabriek is undergoing a circular renovation. Young companies in the manufacturing sector can establish themselves in the warehouse. In the former factory, trains were made for the Dutch railways. Its location in particular (Tractieweg 50-51) is an ideal place for companies, not far from the centre and close to the A2 motorway. |
| Het Hof van Cartesius | On a neglected green strip along the track an experimental garden is realized, with space for starting, creative entrepreneurs. The buildings here are made of used building materials and demolition waste. |
| Werkspoorhaven | The abandoned industrial Werkspoorhaven is being transformed into a public meeting place with sustainable catering. |
| Circular Hub | There will be a 'circular hub' for innovative and high-quality reuse of used materials where local supply of discarded materials is linked to demand for raw materials and products. Here, for example, discarded wood is processed into building material for local interior designers. |

Table 10. Main initiatives in WSK.

Het Hof van Cartesius is a breakthrough project in WSK initiated by two ambitious designers, aiming at developing the area organically in stages. The key objective of HvC is to provide new green workplace for creative, sustainable entrepreneurs with the experiment with circular techniques. In order to be able to act decisively, a corporation was established for Het Hof. The tenants of the business premises are also members of the corporation. The board in short time acted as the client and put the construction team and contractors on tender.

Engineering company BOOT actively works with the core team actors by carrying out a baseline measurement and following the other circular developments in the area, including: guiding the research of maximum sustainable and circular parking facilities in WSK; benchmarking and evaluating the circular development in WSK (Hof van Cartesius and Werkspoorfabriek etc) by qualifying and quantifying the materials on circularity; benchmarking circular result of the redesign of Werkspoorhaven; sourcing of materials from circular projects as input for Circular Hub; assessing other circular opportunities in WSK. It also works with the knowledge institute to provide technical knowledge and support to facilitate the circular (re)development of serval buildings in WSK. BOOT has experiences in making inventory of the buildings that are going to be demolished, and it has been working with 12 demolition companies to launch online marketplace to offer the visibility and scale of materials. The working process in WSK is similar with what BOOT is used to do. Their passion is to contribute their knowledge, share their experiences, experiment their tooling. In return they learn from the practice as well as from other partners.

**INSWERT: is a collective of demolition and green companies and civil contractors with no profit motive. The goal of INSERT is to connect and support parties in the construction chain to further stimulate the reuse of building materials. The vision is to normalize the process for materials from demolition, renovation or transformation projects to be given a new purpose.*

- Stakeholder collaboration

| Company/ Organization | Role | Goal | Description |
|---|---|---|---|
| Erfgoed Werkspoor Utrecht (EWU) | Initiator | Improve the quality of WSK | Redeveloping Werkspoorkathedraal, Werkspoorfabriek and other buildings in the area. |
| Eneco | Energy producer | Sustainable energy supplier | The circular redevelopment of Werkspoorkwartier is connected to the Eneco Energy Campus nearby and supports both the mission and the goal of the ERDF project. |
| Het Hof van Cartesius | Initiator | Test ground from experimenting with circular building techniques | Het Hof van Cartesius is a dynamic meeting place that is built with circular materials on a vacant lot. |
| Buurman groep | Reuse / material market | Develop Circular Hub | Using their experience with reusing materials for the development of the Circular Hub in Werkspoorkwartier. |
| BOOT | Circular demolition / re-purposing of material | Make the circularity of the area development practically transparent. | BOOT facilitates the circular (re)development of several buildings. |
| Universiteit Utrecht/Copernicus Instituut | Knowledge institution | Provide knowledge of sustainable development | Research and develop processes and possibilities for sustainable developments within in the areas of sustainability and life cycles. |
| Hogeschool Utrecht/Centre of Expertise Smart | Knowledge institution | Provide knowledge of the development of urban areas | They are involved with several research projects in Werkspoorkwartier, for example in circular building, product development, and logistics and monitoring. |
| Hogeschool voor de Kunsten Utrecht | Knowledge institution | Provide creative contribution to circular topics | Hogeschool voor de Kunsten contributes to the development of the Circular Hub and start-ups. |
| Utrecht Sustainability Institute | Project manager/ Knowledge institution | The focus is on the strategic supplies of materials, energy and water in the city. | Utrecht Sustainability Institute is a regional knowledge and innovation broker in the area of sustainable urban development. |

Table 11. Actors in WSK

*Core team here is made up by Het Hof van Cartesius, EWU, BOOT as well as knowledge and research institutes. Other stakeholders are: Mitros, Gispen, Van Scherpenzeel, Rever, Wij3.0, Cirkelstad, The Wood Collection, Stichting Bouwloods Utrecht, Oskam and the city of Utrecht.

| | Financing | Developer | Energy | Demolish & recycling | Government | Knowledge institute | Housing organization | Social organization | Design & Others |
|---|---|---|---|---|---|---|---|---|---|
| International | EFRO | | | | EU | | | | |
| National/Regional | | | | | Cirkelstad | | Mitros | Wij3.0/ Buurman groep | |
| Local | Universiteit Utrecht | Erfgoed Werkspoor | Eneco | BOOT Oskam Van Scherpenzeel | City of Utrecht | Universiteit Utrecht/Copernicus Instituut<br><br>Hogeschool Utrecht/Center of Expertise Smart<br><br>Hogeschool voor de Kunsten Utrecht<br><br>Utrecht Sustainability Institute | | Stichting Bouwloods Utrecht | Gispen Rever; The wood collection |

Table 12. Stakeholders influencing WSK.

The actors are collectively connected with the sourcing of the building materials and practical and theoretical data generation of secondary materials. Each project has its own circular vision and implementation plan. Different actors are working together to work on giving input to assess the circularity as a whole. There is no hierarchical management in WSK. Although not really visible, the investor in WSK is the key to success because the investor owns the project properties in WSK. Project manager is assigned by the university. He collected all the grassroots ideas and plans and made them coherent. Core team meet every month. All the companies in WSK meet every quarter. The aim is to implement the model on buildings within and outside WSK and make other stakeholders get more knowledge of potential benefit the can get.

| | |
|---|---|
| Actors | Connected actors with complementary resources: practical data and theoretical methodology of circular materials<br>Independent from |
| Commons and protocols | Shared circular idea, construction experiences, mistakes, success;<br>Co-development of the assessment tool and used within the area;<br>Informal mobilization of actors, negotiations, agreement. |
| Network stratification of process | No typical hierarchical management by hub firms;<br>Self-organizing decision-making process.<br>Funding is used to develop tools and circular knowledge for common use |
| Permeability of boundaries | Geographical constraint and constrained by core technology<br>Not connected with existing industries yet |

Table 13. Actor network analysis

- Operational logic

Different from industrial symbiosis networks which focus is improving eco-efficiency of production through by-product in different industries, the focus of environmental actions in WSK is close to

environmental solution networks which refers to develop eco-innovative solutions that integrate the resources and circular capabilities of multiple network actors by **collaborative approach**. The dynamics in the project might be similar with regular urban redevelopment. What makes WSK stand out from other urban scale business parks is the urgency of dealing with material scarcity. The focus point of circularity in WSK is the use of building materials.

From top-down guiding perspective, the city of Utrecht really gives space to small-scale circular entrepreneurs. From bottom-up constructing perspective, each actor has their own way to realize their circular experiments. BOOT can be identified as a pioneer in WSK. It has the most connections with most of the actors in WSK. There is no an obvious anchor company in WSK which attract other companies to join. Het Hof van Cartesius and Werkspoorkathedraal are both iconic projects in WSK which gain the attention from the public and attract all local-oriented projects. As a pilot project, WSK is successful in a way that bottom-up initiatives are happening. Involved actors are intrinsically circular innovative. It is not just an experimental project for the city, but also experiments for companies who have strong sustainable visions themselves. Therefore, they need a platform to realize their circular plans.

On one hand, WSK is making effort on how to be more flexible to help innovative actors realize the plans. On the other hand, there are a lot of existing companies who are not willing to be engaged. The respect of existing business is the key. WSK is developed with the **respect of the local industrial structure**: trying to engage local manufacturing, energy company, demolition companies etc. In addition, WSK has a **strong bond with local knowledge institute**. There are four knowledge or research institutes involved in WSK. Dozens of students are active in the area. They carry out research and assignments around design issues concerning circular design of buildings, interiors and public space, reuse of materials as well as flexible temporary urban design.

## *Discussion*

In the Dutch case, in contrast, there is no strong political will and commitment to intervene the area development. According to Loorbach (2010), in the Netherlands, the interference of central government and top-down manner has decreased. At current phase, the public awareness of the seriousness of circular economy is limited, therefore societal actors are actively interacting with policy making process. The government facilitates to create an open atmosphere. Circular economy principles are integrated in redevelopment activities including new construction and renovation of existing building as well as the way of working. Close collaboration between companies with knowledge and research institutes can be seen in the project. Local–oriented, small-scale creative business are actively involved.

Werkspoorkwartier is an example of bottom-up circular economy initiative with the involvement of diverse societal actors. It is still being further developed. There will be more projects coming up in the future. As a demonstration project, the current goals are to transform the old business park into a lively and creative area with circular approaches to create certain level of circularity in the area, which mainly focuses on the circularity of materials. The key findings of the case study are summarized below from three dimensions:

First, from governmental perspective:

- There is no top-level vision and targets for the pilot project from government. Also, there is no direct funding and subsidy from government. However, the actors are expecting to get clearer guides and supervision from government and support to ease the bureaucracy in funding applications and reporting.
- The long-term vision from government creates atmosphere and gives enough space for small-scale, locally-oriented, creative industries.
- Government has little influence on the project mainly because the investor owns the properties and bought the land from municipality to extend the development period.

- Government is open to negotiate when there are conflicts between regulations and innovative actions.

Second, from knowledge perspective:

- The focus is on developing circular knowledge in terms of the use of circular materials in buildings, developing assessment tools and practical implementation experiences.
- Practical knowledge is the use of 10Rs principle in project to develop circularity.
- It is difficult to align everyone's circular economy vision when there is no clear vision from the government.
- Regional and local knowledge and research institutes play key roles in developing theoretical knowledge supported by practical data from engineering companies.

Organizational

- Iconic projects gain social attention from public.
- Actors are intrinsically circular activated. They mostly contribute collectively on knowledge, but they have their own idea to get money back.
- Connecting with companies and knowledge institutes to explore new idea in an informal way is important, however the connection between students and companies are difficult in practice.

Same here, we discuss the dependencies and interactions among different identified aspects in Werkspoorkwatier.

More positive feedback loops can be observed in the case study. We don't see clear top-level vision imposed on the project, however this has the most connections with other aspects. Global sustainable vision from city of Utrecht creates a circular atmosphere to develop a circular vision. The long-term vision gives space for the self-organizing collaboration among actors. Clear circular vision decides how actors should operate and also promote the circular knowledge learning and sharing. On the other side, lacking of supervision and guideline from the government slow down the process of knowledge developing. One common feature among actors is that they are all intrinsically circular motivated and focus on sustainable business. Therefore the operational logic among actors is the key to develop circular economy knowledge in the area. There are diverse local social companies and interest organizations involved in the project which enable the knowledge development in the project. The project is supported by the EU funding, however the international funding system in EU brings some bureaucracy to the actors, and there is no direct governmental subsidy, which impedes the knowledge development process and circular actions. Figure x shows the feedback analysis in WSK.


Figure 9. Feedback loop among different dimensions.


Figure 10. Barriers and drivers

- *Barriers*

Two main barriers mentioned by interviewees multiple times are the bureaucracy regarding the reporting for international funding. The circular development in WSK is attracting new applications and new business in a highly flexible way, therefore actors find the bureaucratic procedure main barrier in the project. Also, government still cannot provide a clear vision or guideline or instrument to support the development.

- *Drivers*

In this case we can observe more drivers than barriers. A distinct feature in the case is the intrinsic circular network from bottom-level. From top-level, the government also creates a local-oriented atmosphere for sustainable business which drive the creation of circular knowledge and the knowledge contributes not only within the project, will also contribute to the area. With strong circular motivation, all stakeholders present new ideas and share success and failure to learn from each other to accelerate the progress.

Strong collaboration with knowledge institutes is the key in the project. There are four local knowledge institutes involved in the case in both formal and informal ways. With the theoretical knowledge from universities and practical data from involved companies, the knowledge and experiences are shared with all the stakeholders in the project, and applied and tested in the pilot as well.

Diverse societal organizations are involved as well. Especially, the iconic projects, Hof van Cartesius and Werkspoorkathedraal attract more social actors who are dedicated to develop their business in circular economy or sustainable innovation. As a result, not only the buildings and materials are constructed and used in a circular way, more social dimension is involved by applying the circular way of working.

### 7.2.3 Lesson Learned

This section articulates and explains the main issues raised up in literature and perceived in practice regarding circular economy development in urban areas in China. The issues are indicated in section 7.2.1. Based on the findings from Dutch case study in section 7.2.3 possible solutions for Chinese issues will be proposed and discussed below:

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*Circular economy is mainly applied in industrial sectors in eco-industrial parks, local government and enterprises are lacking of knowledge and experiences of how to implement circular economy principle in urban area development, for example, urban revitalization.*

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#### China

The issue involves the insufficiency of know-how about circular economy at local government and local actors in building sector which lead to inconsistent implementations at local level. Although the central government is constantly introducing new legislation to promote circular economy and improve the effectiveness of circular economy initiatives, the knowledge of circular economy is centralized in top universities and industrial sectors from practice. There is still a lack of systems thinking in government ministry silos and lack of unified circular economy community. For example, clean energy, organic food, industrial parks have their own community. At local implementation level, the transformation of industrial district focuses on architectural value but in the end the developers tend to keep some iconic elements in the area and construct new buildings in the areas which has no differences with regular urban development. This is because the sustainable construction costs more and takes longer, but government and investors require to finish the project as fast as possible.

#### Netherlands

The case of Werkspoorkwatier covers both newly built and renovated projects. The newly built buildings followed the circular approach. What makes WSK special is that WSK gathers all circular motivated actors which makes sure not only the buildings are circular but also the way of working among tenants are aligned with circular or sustainable principles. The iconic projects, for example, Het Hof van Cartesius and Werkspoorkathedraal have gained attention from public and attract and give space to innovative actors. The engineering company from practice together with knowledge and research institutes focus on developing collective knowledge by sharing data, experiences and co-developing assessment tool that can be used within the area and outside the area in the future.

#### Possible solutions

- Direct lessons are to use 10Rs principles and building material layers in the designing phase in urban revitalization projects.
- Gather the right people instead of choosing tenant to achieve short-term economic target.
- Use iconic projects and good marketing to engage the public's attention and try to involve more social dimensions aligned with circular principles.

*"Eco initiatives with high-level governmental support and supervision in Tier 1 cities are more successful. However, local-level innovative initiatives tend to fail because of the mismatch between government economic target and eco-vision."*

### China

Central government has 'absolute' power to mobilize financial, knowledge and organizational resources to support the eco initiatives if those initiatives bring themselves to government's attention. Local government in Tier 2 and Tier 3 cities still rely on land finance model to achieve short-term local GDP targets. Therefore, the visions for eco-initiatives are not actually "eco" but GDP-driven. The ownership of some industrial properties is quite complex, normally multiple parties are involved (e.g. government, military-related organization or state-owned companies etc). Most of the local eco-initiatives are government-led. Governments own the land or the properties and develop visions for the areas and then involve the investors in designing and developing phases. However, the investment and management modes normally are not aligned with government's vision or is not able to best match the vision. The investors either have to start over again to develop a plan strictly aligning with government's vision or have to amend the optimal plan to achieve government's goal. In some cases, when governments sell the land to the developer at very low price and ask the developer to plan and develop on its own. However, all the activities are government involved, not social-related. Next to it, regulations are set up by different governmental departments at different administrative levels. Different departments don't communicate at all.

### Netherlands

Werkspoorkwartier case shows a totally different scenario. It is a self-organizing local-oriented project without high-level political will. Local government has a long-term development vision for the whole area and creates an open atmosphere in the city but not a specific plan for WSK. The ownership of the properties for redevelopment is a crucial distinction here. The regional investor bought the land and properties from the municipality and the development right transferred to the regional investor. The government doesn't intervene the project because it cannot steer both investor and knowledge institutes. The conflicts between innovative actions and regulations also exist in the case of WSK. However, the municipality is open to negotiate and eventually gave the innovation a "GO".

### Possible solutions

- Local governments in Tier 2 and Tier 3 cities should realize the unsustainability and short termism of land finance model and correct the dislocated relationship with companies by setting up a long-term vision.
- Local governmental authorities should provide effective dialogue with practical actors
- Learn from the governance in other industries (e.g. local government adjust the code and technical standards for the development of "Bed and Breakfast" in Mt. Mogan; local government in Chengdu invented a 1-meter wide fire engine to serve in Kuan Zhai Alley).
- Local government should connect and involve more parties and facilitate to create an atmosphere instead of making decision all by themselves.

*"Big developers follow one-formula (tourism attraction, creative industry clusters and cultural flagship) to revitalize urban areas but they are not able to develop a dynamic business network with local resources"*

China

The issue involves the bond between big companies and governments which leaves little space for medium to small sized companies. Big companies have standardized business model to successfully transform industrial buildings to commercial use mainly focusing on economic revenue in Tier 1 cities. In Tier 2 and Tier 3 cities, most industrial parks are transformed to innovation districts or creative business parks. The knowledge and the experiences of local entrepreneurs and the high expectations of government are not well matched. The foundation for cultural innovation districts is "creative". However, there is not so much innovative demand in the market, and it ends up with tenants who are doing regular businesses.

Netherlands

The government helps write an Open Call to create a circular vibe in the area by choosing the most circular proposal. In this way, het Hof van Cartesius achieved the requirements of getting creative tenants even before it started. Project manager only collects great ideas from localities and makes the plans coherent with a respect of existing companies who don't want to be circular. The knowledge and research institutes not just involve in the research but also play a role as consultancy. All the companies in the area have a meeting every quarter to keep each other updated.

Possible solutions:

- From the urban revitalization perspective, governments should explore new collaboration model with knowledge and research institute together with medium to small sized companies in preparation and planning phase.
- Students are the biggest creative sources. Government should encourage students to participate in the projects in an informal way (e.g. internship, graduation project, assignment etc.)
- Knowledge institutes can provide technological knowledge and professional consultant support for government.

# 8. Compare Theory to Practice

This paragraph will compare the findings with the theories to see how much the findings are aligned with theories. The theories are discussed from three levels: macro, micro and meso level in circular economy.

Macro-system in circular economy refers to the adjustment of industrial composition and the structure of entire environment by policy implementation on a wide scale (Jesus et al., 2018; Kirchherr et al., 2017). Key aspects are: 1) systematic and multidisciplinary methods; 2) governance and public policies to promote CE; 3) resource efficiency and waste management at wider national and translational scales. Both countries implement circular economy with systematic and multidisciplinary methods across the country. China focuses more on the environmental impact while the Netherlands has narrow environmental scope. China's circular economy governance follows multilevel system of experimentation under top-down hierarchy, while the Netherlands apply smart governance planning: transition management. The roles of government also differ: Chinese government tends to have more control over implementation, often play as the initiator (government-led eco-initiatives) with specific target and indicator for circular economy. However Dutch government has less control which more play as a network following the transition management principle to bring different parties together.

Meso level of circular economy focuses on networks and interactions in the implementation of industrial ecology (Jesus et al., 2017). Circular economy network can be developed in or within value chains (i.e. "green" supply chain); industry (i.e. industrial symbiosis and eco-industrial parks); local government initiatives (i.e. eco-cities and urban symbiosis) (Jesus et al., 2017). Besides the eco-initiative network, at meso level, there is not obvious innovation among Chinese actors. In the Dutch context, circular network more focuses on knowledge sharing and exchange at this phase which focuses on certain circular intervention, e.g. building material and building up digital platform.

Meso level of circular economy focuses on capabilities and involvement of CE of specific agents (deJeus et al., 2017). From the findings we can see circular strategies prioritized by Dutch construction actors are considered from material value with circular motivated attitude. However, in China circular strategies are triggered by central government, and still focus on the reducing the volume of material flow instead of the value of material itself. The table below summarizes the key points of theories and practice:

Table 14: Compare theory to practice.

| Scale | Theories | China | NL |
|---|---|---|---|
| Macro:<br>Circular strategies/ policies on a wide scale (regions and cities) | Systematic and multidisciplinary methods | Greater concern with industrial production, water, pollution, environmental challenges | Narrow environmental scope, focusing on waste and resources and competitiveness for business |
| | Governance and policy | Multilevel system of experimentation under top-down hierarchy | (Transition Management) Cooperative and resilient bottom-up steps to kick-off first phase, facilitated by top-down support |
| | Role of government | • Strong political will and commitment<br>• Long-term vision<br>• Circular Economy promotion law<br>• Initiator<br>• Set comprehensive CE targets and specific indicators | • Strong political will and commitment<br>• Long-term vision<br>• EU 2015 Action Plan<br>• Networker<br>• Assign knowledge institute to develop monitoring system |
| Meso:<br>Networks and interactions on urban scale | | Narrative analysis | Case analysis |
| | Governmental | • Strong political goals;<br>• Rely on governmental finance and supervision;<br>• Inflexible | • No strong political will or clear governmental goals;<br>• International funding;<br>• Flexible |
| | Knowledge | • Knowledge silos;<br>• Insufficient in construction;<br>• Insufficient at local level | • Develop practical and theoretical circular knowledge with engineering companies and university;<br>• Focus on building materials |
| | Organizational | Top-down interventions<br>Regular real estate development network<br>Dislocated relationship between government and companies; | Bottom-up initiatives<br>Sharing knowledge with all actors;<br>Synthesis of different circular approaches; |
| Micro:<br>Circular model/actions implemented by individual actors | Focus | On-going urbanization;<br>Opportunities lie in Urban revitalization; | Scarcity and resource efficiency;<br>High-value reuse;<br>Economic revenue model |
| | Prioritized Circular actions | • Modular and prefabrication<br>• Use of secondary materials | • Alternative business model<br>• Document your building<br>• Circular procurement |

# PART V: CONCLUSION

## 9. DISCUSSION AND REFLECTION

### 9.1 VALIDITY, RELIABILITY AND GENERALIZABILITY

The objective of this research is to provide an understanding about how China and the Netherlands adopt circular economy in different contexts and how it is applied in construction sector, in order to draw lessons for from Dutch practice.

Unlike quantitative research, qualitative research is designed with methodological strategies to ensure the trustworthiness of the results. Qualitative researchers' personal experiences and opinions may lead to methodological bias. This affects the interpretations of the interviews conducted in the study. To ensure the truth value and consistency of the research, it is imperative that we should be consistent in research design and implementation. An interview protocol is designed for all semi-interviews to guide the data collection. By recording the interviews, we can revisit the data and explore the richness of data. Rich and thick verbatim is extracted from the interviews to objectively describe the data.

Contextualization is the essence of a comparative research. The research includes specific contexts therefore the results cannot be totally generalized. However, the comparison framework and process can be transferred to other contexts. The dependability of the findings also depends on the legitimacy of the research methods. In this research, narrative study and case study are conducted respectively in two countries. The story-telling in narrative study involves a lot of subjective remarks and hidden cultural information. The goal is to gain specific experiences from a similar case, therefore it is difficult to make the findings applicable in other research settings.

The empirical part of the research focuses on the prioritization analysis and drawing lessons from Dutch circular area development. The draft result (including the prioritized circular strategies in two countries as well as case analysis and lessons learned were shared with the same group of experts in China via skype explained by research in Chinese mandarin. Below are the key validation remarks during the validation session:

- *The concept of material passport is not feasible in China*

"The concept of material passport in The Netherlands doesn't really suit the built environment in China because of the short development and demolition period. Normally the demolition

companies are required to finish the demolition work in one month. The rapid pace of real estate development at current phase doesn't allow us to take time document the information of materials. Some cities are building up the information platform which shares some similarities with material passport. However, in practice, all the valuable demolished materials have their own channel to be processed before being recorded."

- *"Design for disassembly" indeed is the future trend for China.*

"Actually the concept of modular design has existed in ancient time already, for example, siheyuan. The composition has the basic pattern, however can be used for different spatial functions: residences, palaces, temples etc. The architecture education also plays an important role here. Students all want to be Rem Koolhaas, that doesn't help with promotion of modular design."

- *"New collaboration modes among government, developer and knowledge institution in urban area regeneration."*

"For example, in Dalian, city government wants to invest in urban revitalization, but government at district level has no idea where to start. The development mode in the case study provides a good example for us. Government can establish a joint research institute, and the funding from government can be used in the joint research institute. After a preliminary planning, private developer can intervene, however, bureaucracy also exists in Chinese universities."

## 9.2 Reflection

### 9.2.1 Research motives and process

The idea of 'Circular Economy' has become prominent globally. The current 'take, make and dispose' way of consuming resources and materials is putting enormous pressure on the natural environment. Circular economy therefore is drawn as a concept to use natural material in a more sustainable way by technical and social innovation and fundamental business and value chain redesign. Next to it, circular economy is seen as a tool to realize sustainable economic growth and a driver for innovation and sustainable, livable social development.

Both China and the Netherlands become the pioneers in implementing the transition to a circular economy, following different policies and strategies. Therefore, the interest of the research is to examine the similarities and differences of the circular economy perspectives in two countries regarding policies, strategies and practices. Also, I am also curious about what the possible reasons are for the divergent circular economy activities in two countries and what the possibilities are for sharing and exchanging policy tools, transition strategies as well as the experiences from practices in two countries.

The starting point of this research is to examine the circular economy solutions from the Dutch construction sector for construction and demolition waste (CDW) issues in China. When I zoom into the facts, I realize the CDW issue is only the top of the iceberg. The fundamental issues underneath the iceberg top are the actions and consequences of rapid urbanization over 30 years, which reflects on extreme consumption of construction material and surplus of real estate inventories. The question is how those problems are influenced with each other and what the possibilities are to address the problems? Therefore, the research interest is switched to investigate and analyze the internal links among the segregated problems and propose strategies from a systematic perspective which take sustainability, business and on-going trends into account. However, first, building up theoretical framework for a comparative research is difficult for me since it is not easy to switch from a design-thinking to a research-thinking. It took me a lot of time to even understand how to formulate a research. Second, circular economy in construction is a new topic in both countries, during my research new research or report keep coming up. Therefore, the literature review becomes an iterative process. Third, as a student it is so difficult to reach the right people or

organizations. Hence, mobilizing personal contact is also important factor for a research. The last barrier of the research is the language limitations. Some reports are only in Dutch, it is really a pity that I cannot include those insights in my report.

### 9.2.2 Research methods

As a comparative research, the concept of 'equivalence' is the key. International comparative research designs are more complex and those principles applied in any good research are more difficult to achieve. The theoretical resources for this research are sufficient to compare in two countries. However, the empirical resources are insufficient for cross-case analysis. Therefore, instead, a narrative study is conducted for Chinese context, and a case study method is used for Dutch context, and this is the weakness of the research design. Because I didn't manage to narrow the research topic down, at the same time I wanted to research too many things, which made it difficult to design the research. The research methods are not clear enough: theoretical data is mixed with empirical data. Besides this, the validation part of the research is not strong enough

### 9.2.3 Research relevance

The concept of Circular Economy has gained a momentum in both China and the Netherlands, CE is still a rather poorly understood concept there may also be tensions and limitations inherent in its appropriation and application (Murray et al., 2017). Construction sector is important for both China and the Netherlands: for China, it still plays a significant role in the country's future urbanization and economic development. Circular economy can be a solution to ease the material and energy consumption as well as the pollution issues in the country; for the Netherlands, it will arise opportunities for utilizing raw materials with greater efficiency and reducing residual and waste matter. Also, it can greatly improve quality and reduce cost throughout an object's life cycle. Social relevance and the scientific relevance will be shortly discussed here:

*Societal relevance*

The research reveals the real barriers of adopting circular economy in building and construction sector as well as its applications to urban areas from practical examples or experiences in China and the Netherlands. By analyzing the real-life problems, and understanding how the problems were formed, possible solutions and applicable lessons will be suggested. The implementations of CE in China and the Netherlands follow different paths; therefore, the research will provide a better understanding of CE development in China and the Netherlands. And the lessons and experiences summarized in the research will be an inspiring reference to look into for both public and private sectors.

*Scientific relevance*

Circular economy study has a dynamic scope. Research in other industries are sufficiently studied, however the studies of its applications to the building and construction sector are still limited in China. China has more experiences in implementing CE at urban level in other industries, and there are sufficient studies regarding the theories and practices. It is important to see how to draw applicable lessons from other fields to the CE in building and construction sector as well as urban revitalization. There are confusions of semantical concepts between two countries, which makes it difficult to understand the CE from each other. The research will contribute to ease the confusions.

Next to it, the study connects circular economy theories to existing urban area development study in China. The research is scattered in silos: eco-industrial park, green energy, urban revitalization. However, circular economy can be an integrated approach to break the government ministry and knowledge silos with a system thinking.

# 10. Conclusion

In the previous chapters we discussed the most important characteristics of Dutch and Chinese circular economy context and circular approaches in construction sector as well as the circular economy development. This chapter builds upon these findings and aims at drawing conclusions from the study, and provide recommendations for future research.

## 10.1 Implementing Circular Economy in the Built Environment in China and the Netherlands

Before we jump into conclusion, let's review the main research goal is to compare implementation of circular economy in the built environment in China and the Netherlands. Since the built environment is a quite new field for circular economy, the research will shed light on how to apply the circular economy principles in specific context.

The objectives of the study therefore are formulated: **first, to develop a framework to compare the adoption of circular economy in China and the Netherlands; second, to provide practical guideline on circular economy implementation for the built environment based on the comparison; third, make recommendations for sustainable urban area development based on the lessons learned from Dutch practices.** The research objectives are achieved by studying and understanding relevant theories and investigating empirical experiences. The main research question is: **How can the circular economy implemented in the built environment in China and the Netherlands and what lessons can be learned from Dutch circular development in the cities? By answering the sub-questions, the main research question will be answered.**

1. What does circular economy mean to the Netherlands and China?

First, circular economy at macro level means the circular strategies and applications of urban agglomeration theories on a wide scale. Chinese and Dutch perspectives on circular economy share a common conceptual basic, which focuses on increasing the resource efficiency. However, two countries follows different development path with different focuses. The equivalent concept of Circular economy in China is "ecological civilization" or "harmonious development", while circular economy is one approach to achieve ecological civilization with the origins in cleaner production and industrial ecology. China's circular economy development follows a top-down manner and provide eco-innovation at diverse scales. China's Circular Economy Promotion Law requires the establishment of target to support the CE. Next to it, China also has an extensive system of indicators to measure the progress of circular economy implementations at different levels.

The Netherlands aims at developing a circular economy across the country by 2050 and reduce 50% of the use of primary raw materials by 2030. This Government-wide program for a Circular Economy coordinates and create interconnectivity with current policy paths. Similar to China's multilevel development, the Dutch program also indicate that circular economy must happen at different scale levels – internationally, nationally as well as regionally and locally. Dutch circular economy development follows a more resilient and systematic way, which starts from bottom-up kick-offs, following up by top-down manners to shift the business environment. Instead of pushing the governments to formulate sustainability ambitions, it really connects to the frame of private industries, since it has this economic competitive dimension of acting responsibly and sustainable. Steering the direction and monitoring are also important for the Netherlands to transition to a circular economy. Associated with the monitoring method and indicators that are being developed by EU, the Netherlands also set up a steering committee to gradually monitor and access the government-wide program, particularly the five priority industries.

Take-home note:

- Circular economy in China is implemented from a top-down manner at three levels: macro, meso, micro, focusing on resolving the industrial pollution.
- CE in China still lack systems thinking with government ministry silos and lack of a much unified Circular Economy community: Clean energy have their community; organic food theirs; industrial parks have theirs.
- Dutch circular economy starts from bottom-up, following up by top-down to interact with market.
- Dutch conception of circular economy has a narrow environmental scope, focusing more on waste and materials as well as business opportunities.

## 2. What does circular economy mean to the built environment in the Netherlands and China?

Second, we look at what circular strategies can be applied in construction sector in two countries. The top-down approach considered first national effort through society, legislation and policies, while the bottom-up approach focused more on individual company effort through industries, competitiveness and profitability. As a result, the initiative for change lies with companies with a long-term strategic vision. There are big differences between Chinese and Dutch construction sectors in terms of market, volume and construction activities. Therefore, circular approaches to construction sectors in two countries follow very different paths. Chinese construction sector should focus on the issues that continuous urbanization will bring up in the future. Chinese construction sectors can take adaptive circular actions from perspective: (1) make construction modular and prefabricated by industrializing construction process to reduce the amount of construction and demolition waste; (2) strengthen institutional support by forcing to use certain proportion of recycled construction products; (3) manage both official and informal collection and recycling channels to facilitate construction and demolition waste management. Circular economy in Dutch construction sector focuses on the high-quality use of materials and the environmental impact, wider social concerns as well as and the opportunities for business. The main circular actions taken by frontrunners in Dutch construction sectors are: (1) explore alternative new business models within and outside your supply chain; (2) document your buildings via material passport; (3) promote circular economy through circular procurement. In both countries, transition to a circular economy in the built environment requires the effort from all actors in the sector. A scan of circular methods for different construction phases are summarized in the table below.

Take-home note:

- Motivated clients especially big companies with sustainable visions, are the key to the transition of current built environment to a circular one.
- Don't ignore the old way. It is not possible to own a circular economy in one day. We still need the traditional way of producing. Key point
- Make sure that the actors in your supply chain can reach the circular material as close and easy as possible. When people find it difficult to change, they go back to old way.
- Think out of box by involving social interest organization to broaden the scope of circular economy.

## 3. What lessons can be learned from Dutch circular area development for a Chinese urban context?

Last, we look at how macro environment and micro innovation and technology interact and influence in urban areas as a lens for systems-level change. Besides government-led eco-initiatives, circular economy opportunities also lie in other forms of urban development in China, for example, urban revitalization projects. We conclude that, to apply circular economy principles to urban revitalization development, both top-down and bottom-up strategies are needed. Circular economy principle should be applied at the early phase of planning in both newly built environment and existing built environment via urban revitalization. China is experienced in designate experimentations under hierarchy to promote circular economy at eco-industrial parks.

However, from urban revitalization perspective, it tends to follow regular real estate development only. However, the market for high-level reuse of materials with historical value has already exist, and urban areas are the perfect platforms to scale it up. Practice shows that a synthesis of top-down and bottom-up actions and a new way of interaction and collaboration between government and enterprise are required to develop circular economy at local level. The Dutch case provide insightful lessons in terms of (1) applications of circular principles in construction activities in practice, especially transforming industrial districts; (2) possible approach to stimulate small-scale business at local level; (3) collaborations with knowledge and research institutes to develop circular knowledge; (4) supportive and effective dialogue. First three points are applicable in a Chinese context. The fourth point however depends on the local institutional atmosphere due to the regional unbalanced development in China.

Take-home note:

- A supportive government is the key in applying circular economy principle in urban area. Government still dominate the decision-making process, however government has little knowledge of circular economy.
- The experiences of reusing materials can be used for different cases: think in layers. Not just building skin can be circular, services, interior, spaces and settings can all applied with circular interventions.
- Collaboration between practice and knowledge institute is also an important factor to successfully apply circular economy in urban development.
- Respect the existing business. Try to include not exclude them.

## Concluding Remarks

The research studied how China and the Netherlands understand and implement circular economy in the built environment in different ways. The study is investigated at three levels: macro CE (circular strategies and implementation on a wide scale); micro CE (circular models and methods implemented by individual actors) as well as meso CE (circular implementation by inter-actor cooperation and networks). The study contributes to clear up the confusions of different understandings of circular economy in the built environment in China and the Netherlands, and make connections to access and exchange circular economy knowledge in two countries. The study also explains the core concepts in circular economy in plain language for actors in practice, and bring useful experiences in the practice to academia.

Circular economy has been greatly implemented in industrial process to ensure the waste from one stage become a valuable input into others. We can extend the circular economy principle beyond industrial sectors to the built environment to develop sustainable urban areas to protect the resources, reduce environmental impact, and bring economic benefits to the society and business opportunities to people. To implement circular economy in the built environment successfully, we need both top-down and bottom-up efforts to generate collective nexus toward sustainable urban development and understand the interrelationship among three levels when implementing at one level. There is no one-fit-all formula to transition to a circular economy, the general circular strategies and methods should be adapted for specific context.

For new construction, in both countries we should focus on the outer layers of the buildings (skin, structure) following circular design perspective. In the Netherlands, circular design principles focus on reusing materials with a higher quality and setting up the material passports to document the information of building materials and components. In China, the circular design principles focus less on the high-quality reuse, but focus more on applying the circular design (modular construction etc.) to facilitate the on-going urbanization.

For existing built environment, we focus more on inner building layers (services, furniture etc.). In the Netherlands, the circular economy opportunities also lie in transforming existing buildings and revitalizing urban areas by incorporating more aspects of circular economy. In China, the transforming of old industrial areas is the key for urban revitalization. Implementing circular

economy principle can be beneficial to business stakeholders as well as societal stakeholders and lead to sustainable urban development. What's more, the role of government is the key to circular economy in both countries. It is important for government to create an open atmosphere and introduce economic policies and instrument at current phase to facilitate the transition to a circular economy. Meanwhile, for both countries, utilizing informal social network and resources is also important to extend the capacity of circularity to achieve a sustainable urban development.

To conclude, we can confirm the proposition made in previous chapter is basically correct. To implement circular economy in the built environment, Chinese government should focus on mainly two things: one is implement top-down enforcement in the continuing urbanization to really reduce the material volume and flow on macro level; second is to encourage bottom-up initiatives at local level, implement the idea of 'transition management: to highlight different government departments and smart innovative enterprises, bring them together with local business, provide resources, potential allowance to support them , instead of chasing short-term economic targets. Specifically, there are opportunities to apply circular economy principles in current urban revitalization. Dutch construction sector focus on retaining the value of material and business opportunities with a more bottom-up approach, mainly because of the innovative atmosphere among enterprises. Government plays as a network connector without too much governmental intervention. However, the interaction with government is still necessary regarding creating target or guidelines as well as support and supervision. Table below shows the key comparison points between China and the Netherlands in the research.

| China | Netherlands |
|---|---|
| **Macro CE** | |
| Top-down enforcement on construction production<br>Bottom-up approach on real estate & service | Bottom-up initiative in the market<br>Need more clear top-down vision to speed up |
| **Meso CE** | |
| *Along value chain:*<br>Upgrade traditional value chain in pilot zones<br>➔ Scale up across the country | *Across value chain:*<br>small innovation + social aspect = client's attention<br>➔ Create circular momentum |
| *Between government and business:*<br>➔ Require less governmental control<br>➔ Seek new collaboration among government, private sector and knowledge institute to break the silos | *Between government and business:*<br>➔ Require more governmental interactions regarding guidelines, standards and supervision for private sector |
| *City network:*<br>Collaborate with other circular economy community<br>Manage the existing secondary material market | *City network:*<br>knowledge creation and sharing<br>Localize secondary material information |
| **Micro CE** | |
| Focus on material quantity<br>Facilitate the on-going urbanization | Focus on material quality<br>Retain the value of materials and business |

## 10.2 Recommendations for Future Research

Due to the limitations of this research, we only focus on the potential solutions for Chinese issues presented in circular development in urban areas. There is potential for the Netherlands to learn from China's best practice as well. Therefore, we can make some recommendations for future research:

- Experimentation at different scales

China has plenty of practical experiences in mobilizing numbers of people, resources, materials and coming up with according policies. Experimentations at different scales are the main approaches to circular economy in China in the past 20 years through designation of large-scale pilot zones and upscale them across the whole country. In terms of policy-making, government will choose several regions and sectors to construct institutional innovation pilots. After exploring and forming core and typical circular economy system and institution, the government will make the promotion nationwide. Researchers together with practitioners have studied on those demonstration projects in China with regards to governance theories, development model etc. Those studies provide important lessons for structuring large-scale demonstration experiments in a Dutch context. This development pattern is aligned with transition path in the Netherlands: from bottom-up niches toward upscaling and mainstreaming facilitated with top-down manners. Therefore, for the future research it will be useful for the Netherlands to get insights from Chinese practical experiences.

- Development of indicator systems

Currently, there is no well-developed indicator system to assess the development of circular economy. China also has experiences with developing national indicators, specifically to different spatial scales (micro, meso and macro) as part of the strategy of regional experimentations. Having a consistent set of national indicator to understand, compare and measure progress of various pilot projects is important to access the effectiveness of the implementation. The Chinese experiences in developing those indicators and applying to different scales could provide lessons for Dutch government.

- Digital solutions related to circular economy

China's circular economy momentum has been largely enabled by China's recent digitalization boom. Leveraging digital platforms is the key to circular economy opportunities in China. From my observation, the digital O2O (Online to Offline) platform builds up a powerful database of customers, second-hand vendors and recycling companies. Currently, the main recycling categories focus on electronics and appliances, however it also covers the office facilities and furniture.

Material passport focuses on document the material itself, including a set of data describing the characteristics. The online platform in China also provide alternative ways for reverse logistics: customers only need to fill in a form, hit enter to see an estimated price, then their products can be collected via courier or same-day visit from an engineer who inspects, collects then provides instant compensation for the device. The platform concept can bring insights for the development of material passport.

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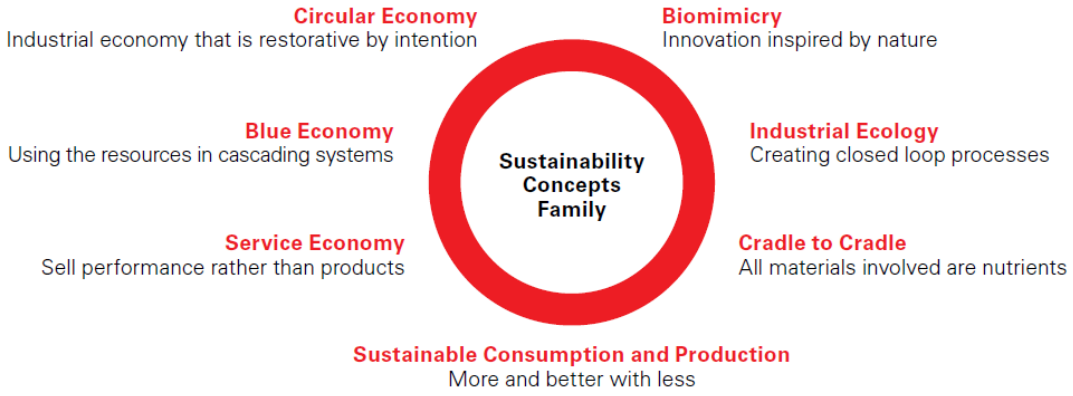
# APPENDICES

## 1. CIRCULAR ECONOMY SCHOOL OF THOUGHTS




(Lehmann et al., 2014):

*Cradle-to-cradle (C2C)*

McDonough and Braungart firstly developed the concept of C2C in their book. They called for a new way of designing our material goods and for going beyond the concept of *eco-efficiency* which only focuses on reducing the negative impacts of human activity on the environment (Wautelet, 2018). The C2C framework focuses on **design** for *effectiveness* in terms of products with positive impact and reducing the negative impacts of commerce through *efficiency* (EMF, 2017), and the design principles provide a basis for the transition from eco-efficiency to eco-effectiveness C2C is in opposition to the current linear economic system. Product components can be designed for continuous recovery and reutilization as biological and technical nutrients. The products are not designed to be recycled will end up with "downcycling" which lower the material value (Wautelet, 2018).

*Industrial ecology (IE)*

IE is a well-established research area considering a systematic perspective, complex patterns of material and energy flows within and outside of the industrial system and technological dynamics (Lieder & Rashid, 2016). This approach aims at understanding how the industrial system works, how flows of material and energy (industrial metabolism) are regulated and how it interacts with the biosphere by creating **closed-loop** processes in which waste serves as an input, thus eliminating the notion of an undesirable by-product (Wautelet, 2018; EMF, 2017).

*Performance economy (PE)*

A Swiss architect and industrial analyst, Walter Stachel, firstly sketched the concept of *PE* in a research report. The study focused on car manufacturing and building construction and analysed the potential for substituting manpower for energy. At macro-economic level, most energy is consumed for mining activities and basic material production while others are used in manufacturing goods from basic material and manpower is used in a reversed way. In that regard, extending the product-life is the best strategy to substitute manpower for energy (Wautelet, 2018). PE calls for a shift in economic thinking from "doing thigs right" to "doing right things" which refers to shifting approach focus from "solving problems" to "favouring resources sufficiency as well as promoting systems solutions over product and business model" (Wautelet, 2018). Therefore, next to product-life extension, long-life goods, PE also focuses on reconditioning activities, and waste prevention. It also insists on the importance of selling services rather than products (EMF, n.d.).

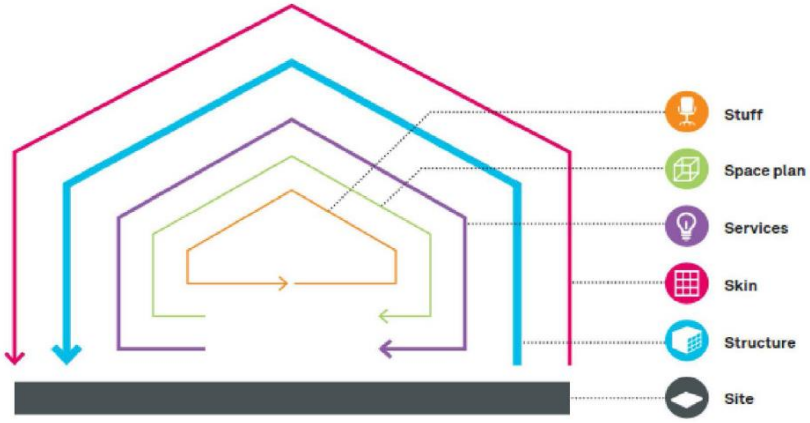
*Blue Economy (BE)*

The Blue Economy was initiated by former Ecover CEO Gunter Pauli (EMF, 2017; Wautelet, 2018). It is an open-source movement which brings concrete case studies together to encourage entrepreneurs to carry out innovative business models, responding to local available demands (Wautelet, 2018). It was expected to generate more revenue and jobs and still compete on the global Wautelet also mentioned the two key characteristics of BE are: **innovative business model** and **competitiveness**. These innovations took "inspiration from the ability of ecosystems to always evolve to higher levels of efficiency, to cascade nutrients and energy, to leave nothing to waste, to utilize the abilities of all contributors, and to respond to the basic needs of all" (Pauli (2010, xxviii)). According to Wautelet (2018), the Blue Economy differentiate itself from prevailing Red Economy and emerging Green Economy. The Red Economy refers to core business and niche product which relies on low production cost and economies of scale to achieve a minimum margin (e.g. China). The consequence of Red Economy is the overuse of natural resources and negative environmental and social impacts. While the Green Economy refers to the emerging business models which promotes green technologies, renewable energies and biomaterials. However, it is criticized by Pauli for its lack of systematic approach and high costs, as well as overlook of global picture.

*Biomimicry*

Biomimicry is defined by The Biomimicry Institute as a new discipline which studies nature's best ideas and then imitates the most relevant inventions of nature for adapting them to provide innovative and sustainable solutions for the society to solve human problems (Wautelet, 2018). Biomimicry relies on three key principles: *Nature as model:* Mimic nature at all scales (forms, process, systems, and strategies) to solve design problems. *Nature as measure:* Use ecological standards to evaluate the sustainability of innovations and designs. *Nature as mentor:* View and value nature not based on what we can extract but what we can learn.

## 2. Building Material Layers




| Building layer | Life-span | Description | Strategy |
|---|---|---|---|
| Site | - | Geographical setting, the urban location, and the legally defined lot, whose boundaries and context outlast generations of ephemeral buildings. | - |
| Structure | 30-70 | Foundation and load-bearing elements. | - |
| Skin | 50-75 | Exterior surface. Change every twenty years or keep up with fashion or technology, or for wholesale repair. Recent focus on energy costs has led to re-engineered skins that are air-tight and better-insulated. | Generous floor to ceiling heights allow flexibility; Spacious cores and risers enable flexibility to adapt to changing expectations; Use bolted rather than welded connections |
| Services | 15-20 | Communications wiring, electrical wiring, plumbing, fire sprinkler systems, HVAC (heating, ventilating, and air conditioning), and moving parts like elevators and escalators. | Ensure services are accessible and demountable for ease of repair or replacement; Look at modular systems that will allow simple upgrade to services without the whole system becoming obsolete; Consider leasing arrangements rather that outright purchase, as this passes responsibility onto the manufacturer for upgrades and changes |
| Space plan | 5-10 | The Interior layout—where walls, ceilings, floors, and doors go. | Look for modular designs that enable partitions to be dismantled and relocated into different configurations, allowing a space to be easily modified to create new spaces |
| Stuff | - | Chairs, desks, phones, pictures; kitchen appliances, lamps, hairbrushes | Think how consumables will be replaced e.g. carpet tiles can be replaced. Individually, when damaged, instead of replacing a wall-to-wall carpet; Select products that can easily be recycled or broken down at the end of life |

Based on (Brand, 1994; UK-GBC, 2018)

# 3. Empirical Study Protocol – Case Study

## Background

Case study protocol contains the instruments, procedures and general rules guiding the conduction of case study (Yin, 1994). Here the protocol is to clarify the background of the case study questions, study propositions and theoretical framework, identification of the units of analysis (object of study), the logical linking of the data to the propositions or theory; the criteria for interpreting the findings (Berg & Lune, 2011).

It is a global trend to transition out current linear economy to a Circular Economy. Circular Economy concept seeks to extract more value from resources by using them for as long as possible, thereby increasing economic prosperity and employment while reducing waste, greenhouse emissions, and pollution. So far, the application of CE principles has largely concentrated on the industrial sector, such as through industrial symbiosis and its extension to urban symbiosis or urban metabolism. In the Netherlands, the implementation of CE in the built environment is already on agenda, and government is also supporting the circular redevelopment in multiple cities. However, the research on CE in the built environment is still relatively undeveloped. Therefore, the case study is conducted to gain insights to articulate CE theory in the built environment and to bridge the gap between theories and practices.

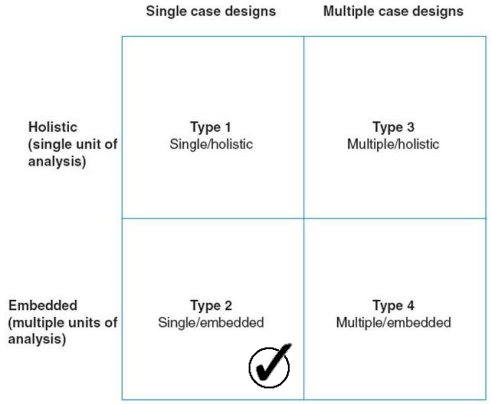
The circular redevelopment of Werkspoorkwartier, Utrecht is chosen as a case study here. Multiple developments take place at various locations throughout the area. It focuses on improving the business climate for the Werkspoorkwartier industrial estate, and it will become an area with a leading location in Utrecht to provide business locations for creative circular manufacturing companies. The project also specifically focuses on circular construction, with an integral cooperation between companies, public organizations and citizens. The projects is carried out by a consortium of building owners from the area, building developers and small and medium-sized organizations from the construction and manufacturing sector. In addition, academic institution and municipality of Utrecht, construction and demolition companies and organizations are connected to support the projects, which makes a large network and broad knowledge and expertise available for the project.

The case study is conducted to mainly answer the question *"How to incorporate Circular Economy concept into construction sector? How are the planning and implementation of circular redevelopment organized?"* The question focuses on the existing built environment and is broken down into three aspects: (1) how to incorporate CE concept in adaptation and redevelopment projects? (2) what is the process of the redevelopment? (3) who are involved in the process and how do they participate? (4) what are the expected results? (5) how to evaluate the process and results of the project?

## Design

Five components of research designs are defined by Yin (1994): a study's questions; its propositions; unit(s) of analysis; logic linking the data to the propositions; the criteria for interpreting the findings. First of all, a primary distinction in designing case studies is between single- and multiple-case designs. Single cases are a common design for doing case studies. Single-case study may be conducted as a prelude and exploratory devices to further study. Yin (1994) suggested the researchers not commit themselves to the single case until major concerns of availability and accessibility of the case is covered. Also, A crucial distinction must be made between holistic and embedded case studies (Yin, 1994). Embedded case studies involve more than one unit, or object, of analysis and usually are not limited to qualitative analysis alone. The multiplicity of evidence is investigated at least partly in subunits, which focus on different salient aspects of the case (Scholz & Tietje, 2002). The proposition of this case study is to research how Circular Economy concept is incorporated in urban redevelopment and transformation projects at different levels: macro level (urban network), meso level (building and supply chain), and micro level (material). The object of study is the development process of the project, and the main unit of analysis is the organization of the project as a whole, with sub-focuses on individual actors involved in the project. The logical

links between the object of study and the question is: to study the whole development process by analyzing the planning process, implementation methods and outcomes (short-term and long-term) etc. The table below summarize the case study design.

| Case study design | |
|---|---|
| Case study type |  <br>(Yin, 1994) |
| Case study questions | • How is Circular Economy concept applied to the project?<br>• How are the circular redevelopment organized?<br>• How do different actors adopt Circular Economy concept? |
| Study propositions | The Circular Economy concept is incorporate with urban redevelopment projects from three perspectives: macro, meso, micro. |
| Unit of analysis | The development process organization of the project as a whole |
| Sub unit of analysis | Individual actors involved in the project. |
| Logic of link | Study the whole process including planning, implementation, outcome, evaluation to analyse how the circular redevelopment projects are organized and draw lessons from the practical case. |
| Interpretation Criteria | The data is collected and analysed at three levels from planning process to expected outcome. |

## Data Collection

Six important sources of evidence are defined by Yin (1994), which are: documentation, archival records, interviews, direct observations, participant observation, physical artefacts. It is suggested that various sources are highly complementary, and a good case study will use as many sources as possible. In this case study, documentation is used as secondary sources to collect the basic information of the case. The document includes the collection and examination of documents describing project case studies through internet research (official website of Cirkelstad) and thus publicly accessible. In the case of the documents obtained from the public domain (internet), documents written in the English language were collected and analysed. Dutch part of the document will be translated into English as accurate as possible.

Second, the primary empirical data will be collected by *semi-structured interviews* on the basis of components and variables provided by analytical framework. To prepare for data collection, the key organizations is accessed as well as the specific companies involved in the case which are the actual implementers. The purpose of the interviews is to learn more about the empirical research. Structured interviews are best used when the literature in a topical area is highly developed or following the use of observational and all given questions are exactly the same to all interviewees. Semi-structured interviewing, according to Bernard (1988), is best used when you won't get more than one chance to interview someone and when you will be sending several interviewers out into the field to collect data. The selected cases are experimental cases, knowledge and information is

not well developed yet. And semi-structured interviews are more flexible and open compared to structured interviews. Therefore, semi-structured interviews are chosen.

### Analysis

According to Yin (1994), there are two general case study analysis strategies and developing a case description. The first and more preferred one is relying on theoretical propositions. The original objectives and design of the case study presumably were based on such propositions, which in turn reflected a set of research questions, reviews of the literatures, and new insights. Before conducting the case study, predicted values have been found and the data collected from the empirical case study will be compared with the hypotheses made before.

| Technological | Organizational |
|---|---|
| Optimise material & energy efficiency | Co-creation |
| Create value from waste | Repurpose for society/environment |
| Substitution with renewables | Develop scale-up solutions |

(Leising, 2016)

### *Interview questions*

*Introduction*

Background:
Master thesis under design construction management graduation lab, the track of management in the built environment, TU Delft.

Subject:
Circular Economy in the built environment: a review in construction sector and opportunities in circular redevelopment in the Netherlands and China.

Interview goals:
To gain insights of how to transition to a circular economy in the built environment from a Dutch perspective and how to incorporate circularity in redevelopment project in the urban area focusing on project development process and collaborations in network.

Topic:
1. Context of circular economy and circular economy in the built environment

- General understanding of circular economy;
- Important factors of the circular economy;
- Drivers and barriers to the circular economy;
- How do different actors incorporate circular economy in their roles;
- Experiences in the circular economy implementation practices;

2. Potential for circular redevelopment:

- Project development
    - The vision of the project;
    - The development process of the project;
    - Business model and value creation;
    - The expected outcome of the project;
    - The actual outcome of the project;
    - Evaluation of the project;

- Collaborations in network;
    - Boundaries;
    - Actors;
    - Resources owned by actors;
    - Commons and protocols;
    - Actives to combine exchange or create resources;
    - Network stratification and process of decision-making

Results evaluation:
This interview will be used as input for comparing the circular economy development in the Netherlands and China. A draft of result will be available in the end November. Would you like to receive and evaluate the end results?

Recording of the interview
Can I record this interview? The recording is used for making transcript of this research and the content of the interview will be cited strictly or anonymously (according to your preference).

Introduction of interviewee
Before we start, can you introduce your background?

*Questions*

Part I: Context of CE and CE in the built environment

1. Can you tell me how you understand the concept of circular economy and its application in the built environment? Why do you think it is important to transition to a circular economy?

2. How do you (your company) work on circular economy in the built environment? Can you give me some examples of projects that you are working on?

3. *Can you evaluate and elaborate the identified circular economy methods? Are you applying any methods in your field?

4. *What are the factors that facilitate and constrain the transition towards CE (based on the identified dimensions and your practical experiences)?

5. What are the most important experiences from the circular economy practices?

Part II: Case Study Werkspoorkwartier

| Concept | Vision establishment | Circular points identification | Implementation path | Lesson learned and evaluation |
|---|---|---|---|---|
| Variable | Long/short term<br><br>Material/non-material | Circular scales (macro/meso/micro)<br><br>Methods in life-cycle<br><br>Building layers | Top-down/ bottom up<br><br>Sustainable network form* | Dimensions of CE<br><br>Qualitative/ quantitative |
| Theory | Transition management | Circularity in the building sector | Transition management/ Network | Transition management |

*Project development*

1. Could you briefly introduce the project?
    - What are the goals of the project? How the goals are developed?
    - How is the project organized? (self-organized? top-down/bottom-up?) What is the role of government in this project?

2. Why are you (your company) involved in this project?

3. What is your role? How are you (your company) involved in this project?

4. What is your (your company) goal of this project? How do the goals shape your strategies?

5. Can you describe the business model applied in this project? What value is created (economic/ecological/social)? How does the incorporation of CE contribute to the value creation?

6. What is the biggest enabler/barrier in this project?

*Circular intervention*

1.What are the circular interventions in this project?
    - What circular economy aspects are involved? (Micro/Meso/Macro levels in the building life cycle, specifically in dealing construction and demolition waste/building material/energy etc.)
    - What are the circular redevelopment activities? (methods/tools)
    - Expected result?
    - Current progress and outcome?

*Actor networking*

1. What parties are involved in the project? What are their roles? Can we draw an organization structure scheme together?

2. How do you collaborate with other actors in the project?
    - How do you align different goals?
    - Do you share any technology/resources/service/programs with other parties?
    - How can you contribute to other parties in the project?
    - How can other parties help you to achieve your goal?
    - Which actor has the most influence on you?
    - Do you share the same standard with other parties? How do you evaluate your performance?

3. What value is created by you and together with other parties (micro/meso/micro or social/ecological/economic)? How do you distribute the value with other parties?

*Monitoring and lessons*

1.How is the project monitored/evaluated?
2.What lessons can be learned?
3. What is the most special part of the project? How to scale-up the project? What are the lessons for other projects?

Part III: Closing

a. Short summary / reflection on conversation
b. Have you (your company) achieved the expected goal? If no, please elaborate the future strategy.
b. What lessons can be learned from this project to apply to other projects?
c. Do you have any further comments?

# 4. Empirical Study Protocol – Narrative Inquiry

## Background

Narrative inquiry is a relatively new qualitative methodology, which collects real-life experiences throughout inquiry. The aim of narrative inquiry is not to find one generalisable truth but to 'sing up many truths/narratives' (Hunter, 2010). As an important part of the comparative study, the narrative inquiry is used to guide the empirical study conducted in China.

## Design

The research is firstly aimed at the inducting application of Circular Economy in China regarding vision, policy, background and relative sustainable concepts and compare with the concepts applied in the Netherlands in order to differentiate the focuses of CE policy in two countries which lead to different development and transformation paths. Secondly, how are Circular Economy and relative sustainable concepts and environmental strategies incorporated into building sector? What are the barriers in the practices? Thirdly, the research is to identify the practical issues and barriers of planning, implementing and management regarding incorporating sustainability and business into the redevelopment projects.

## Data collection

The data is collected via desk research as well semi-structured interviews with four experts in the built environment (architect, project manager of industrial redevelopment area, professors in research of clean production and prefabrication in building). The interviewees are selected and reached out by the researcher based on private network. The desk research consists of the government and public document and literature about Circular Economy research regarding concepts and policy; Circular Economy in the built environment, and related sustainability concepts applied in China (cleaner production, eco-industry etc.). Due to the time limit, a meeting was held with four experts together in China. The meeting will be conducted in mandarin Chinese, but the transcript should be translated into English. Another interview was carried out separately with an expert of CE. This interview will be in English.

Table : Comparison between narrative and case study

| | *Narrative Study* | *Case Study* |
|---|---|---|
| Functional considerations | | |
| Research focus of approach | Exploring the life of an individual | Developing an in-depth description and analysis of a case |
| Unit of analysis | Studying one or more individuals | Studying an event, a program, and activity or more than one individual |
| Type of research problem best suited for approach | Needing to tell stories of individual experiences | Providing an in-depth understanding of a case |
| Nature of disciplinary origins | Drawing from the humanities including anthropology, literature, history, psychology, and sociology | Drawing from psychology, law, political science and medicine. |
| Data procedures | | |

| | | |
|---|---|---|
| Forms of data collection | Using primarily interviews and documents | Using multiple sources, such as interviews, observations, documents and artefacts. |
| Strategies of data analysis | Analyzing data for stories "restorying" stories and developing themes, often using a chronology | Analyzing data through description of the case and themes of the case. |
| Research reporting | | |
| Introduction of written report | Focusing on participants and nature of the story | Using entry vignette and then focusing on central features of the case |
| Description of research procedures | Stating the rationale, significance of individual to experiences, and data procedures | Stating the rationale, type and data procedures |
| Organization of research outcomes | Telling stories using a variety of ways involving "restorying", theorising, and narrative segments | Providing first extensive description of the case followed by key issues (themes, or issues) in the case |
| Concluding format | Interpreting patterns of meaning | Making case study assertions and advancing a closing vignette |

Based on (Creswell & Poth, 2016).

## 5. Interviewee List

| Name | Aim | Organization | Role | Methods | Location |
|---|---|---|---|---|---|
| Bob Geldermans | Explorative interview | AMS/TU Delft | | Face-to-face | Amsterdam |
| Paul van Ruiten | Explorative interview | DCMR | | Face-to-face | Schiedam |
| Maria van Driel/Kees Boot | Collect data for case study | BOOT | Project manager/owner | Face-to-face | Veenendaal |
| Kasper Jensen | Collect data in practice | 3XN/GXN | Architect/Director | Face-to-face | Delft |
| John Ashlin | Collect data in practice | Circle Economy | Researcher | Face-to-face | Beijing |
| Lei Yu | Collect data in practice | HIAD | Structural engineer | Skype | - |
| Cherryl Djoegan | Collect data from practice | Logge | CE Practitioner | Face-to-face | Rotterdam |
| Tony Schoen | Collect data for case study | | Project manager | Face-to-face | Utrecht |
| Freek Wullink | Collect data in practice | Arcadis | Consultant | Face-to-face | Utrecht |
| Evert-Jan Velzing | Collect data in practice/case study | Hogeschool Utrecht | Research input | Face-to-face | Utrecht |
| Dan Wang<br>Shanchao Xin<br>Wei Yang<br>Delong Sun | Collect data for narrative study | Dalian/ Tianjin University | Project manager<br>Researcher<br>Architect<br>Constructor | Face-to-face | Tianjin |
| | Validation of the result | | | Skype | - |

## 6. NOTE OF TRANSCRIPT