

Governing climate futures

The role of municipalities in facilitating circular innovations in the Dutch building sector

MSc Thesis

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Abstract

The transition towards a circular built environment will be crucial to fighting climate change and accomplishing inclusive growth. But while this sector is putting major pressure on natural resources, it is only transitioning slowly. To reach the ambitious targets of the Dutch government, to have an entirely circular built environment by 2050, major steps have to be taken. However, the implementation of national policy on circular economy (CE) is largely decentralized to municipal governments. It seems that municipalities differ in the speed at which they can manage innovation and that organizational factors influence their innovation decisions. This exploratory study, therefore, looked at the role of municipalities in facilitating circular innovations in the Dutch building.

Five contrasting types of circular innovations (eco-parks, individual buildings, or renovation projects that aim for circularity) were selected. For each circular innovation, the concerning initiator and municipality were interviewed. The results of the interviews were used to determine the technological, financial, and institutional drivers and barriers and to identify the governmental mechanisms responsible for them. To validate the result of this study, and to assure the representability for the sector, an expert in the field of circularity in the Dutch built environment was interviewed to discuss the intermediate findings.

A key institutional driver that was observed is the facilitating role that municipalities can have by means of innovative and progressive zoning plans. It was also observed that bureaucratic innovations, flexibility from laws and regulations, and exemptions from certain laws (i.e. the Building Decree) that obstruct innovations are important for circular innovations to emerge. However, municipalities are prone to capacity issues (both in time and knowledge). Moreover, circular construction is currently more expensive due to the novelty of the concept, the labor-intensive character of reusing materials, and the additional costs for certifications. Additionally, it appears there is a shortage of builders and installers for high-demand circular construction, there is a big gap in CE knowledge between architects on one side, and contractors and workers on the other side, and certifying (reused) materials is not a common practice, and requires a lot of effort.

This exploratory study contributed to the existing literature on technological, financial, and institutional drivers and barriers and governmental mechanisms for facilitating circular innovations in the Dutch built environment.

Content

1. Introduction	6
Scientific relevance	7
Problem description	8
2. Conceptual framework	9
2.1 Circular economy	9
2.1.1 Circular economy in the built environment	9
2.1.2 Circular innovations	9
2.2 Drivers and barriers framework	10
2.2.1 Technological drivers and barriers	11
2.2.2 Financial drivers and barriers	12
2.2.3 Institutional drivers and barriers	12
2.3 Small-wins framework	13
3. Methodology	15
3.1 Case selection	15
3.2 Data collection	17
3.2.1 Documents review	17
3.2.2 Interview practitioners	18
3.2.3 Expert review	18
3.3 Data analysis	19
4. Results	21
4.1 Drivers and barriers circular innovations	21
4.2 Conclusion drivers and barriers	34
4.3 Governmental mechanisms for transformative change	37
4.4 Conclusion governmental mechanisms	42
4.5 Expert review	43

5. Conclusion	45
6. Discussion & recommendations.....	48
6.1 Validity.....	48
6.2 Limitations.....	48
6.3 Drivers and barriers	49
6.4 Small-wins	51
6.5 Further research	54
Bibliography.....	56
Appendix 1, overview participants interviews	64
Appendix 2, interview questions initiator.....	64
Appendix 3, interview questions municipality.....	67
Appendix 4, codebook.....	67

1. Introduction

The built environment is one of the largest greenhouse gas (GHG) emitting sectors in the Netherlands, emitting almost ¼ of the nationally emitted GHG emissions (CBS, 2019; Meyer et al., 2014). This sector consumes about 40% of all the materials entering the global economy, while only roughly 30% of those materials are recovered, recycled, or reused at construction and demolition (EMF, 2013; Khasreen et al., 2009). While this sector is putting major pressure on natural resources (Pomponi & Moncaster, 2017), changing its current linear model towards a circular economy (CE) is essential to fight climate change, and accomplish inclusive growth (Circle Economy, 2017). The transition towards a CE has the potential to create sustainable jobs for a growing population, providing them with a livable and healthy environment. In the Netherlands, the transition to a CE even has the potential to create 50,000 new jobs and reduce GHG emissions by 10% (Circle Economy, 2017; PBL, 2017).

By 2050, the entire built environment must be circular (Waterstaat, 2011). This would mean that all 8 million existing Dutch homes and the other approximately million offices, schools, hospitals, government buildings have to be renovated, which is merely impossible (CBS, 2021; TNO, 2019). On top of that, the Netherlands counts a scarcity of 331.000 houses (Groot, 2021) and the Dutch government is planning to build 1 million extra homes in the coming 10 years (Schilder et al., 2021). This means that the Dutch government has a lot of work to do regarding the development of circular buildings but as importantly, making the existing buildings sustainable as well. The Dutch government defines circular construction in the built environment as developing, using, and reusing buildings, areas, and infrastructure, without unnecessarily depleting natural resources, polluting the living environment, or damaging ecosystems (RVO, 2021d).

With the Transition Agenda Circular Construction Economy (CBE, 2018), the Dutch government and the construction sector have set up a 'transition team' where experts, key persons from the construction sector, governments, and academics work together on the transition to a circular built environment (RVO, 2021d). What is deeply rooted in this agenda is the urge for innovative projects from which we can learn and about which knowledge can and should accumulate to accelerate transformative change in the industry (Transitiebureau CBE, 2019). Examples of innovative projects are ones that; incorporate R-strategies (e.g. reduce, reuse, recycle) to minimize waste and use raw materials more efficient, use Cradle to Cradle (C2C) principles to design their products in a way that eradicates waste, and ones that use certification methods (such as BREEAM) to assess the environmental performance of their innovation.

The Dutch construction sector is still quite conservative and its competitiveness is often seen as a barrier to circular innovation (Scheuer, 2020). Laws and regulations are often static and hinder innovation, and the current government-wide innovation policy is mainly aimed at developing innovations instead of the utilization of existing innovations (AWTI, 2018). Moreover, since current incentives are still supporting the linear economy, they are obstructing regulations that can stimulate circularity. For example, innovative start-up construction companies that are active in the field of circular construction are unable to participate in guarantee schemes while big firms can (Ollongren, 2019). Additional bottlenecks that stand in the way towards circularity are that financiers are hesitant about

the risks of innovations and that new policies and changes in legislation are necessary to take out barriers (Transitiebureau CBE, 2019). Also, data on avoided impacts for circular innovations is still lacking and the benefits of sustainable innovations are poorly understood and insufficiently mapped. This leads to poor business cases which makes it more difficult for these kinds of innovations to take place (Kirchherr et al., 2018). This phenomenon is also described as 'the valley of death' (PBL 2015).

It is inspiring to see that there are already some innovative projects (also called circular innovations (Rijk 2020)) working on circularity in the building sector. For example, the innovative ecovillage in Boekel which was built with natural (biobased) and fully reusable (circular) building materials has now grown into a collaboration between the residents, sustainable construction companies, and the province of Noord-Brabant (Ecodorp Boekel, 2016). Another interesting project is the C2C house Recht op wind in Rotte. This was the first C2C house in the Netherlands and can be seen as a real pioneer in the circular economy (Post, 2012). Moreover, the Biosintrum energy-neutral knowledge center in Oosterwolde is a building that consists of more than 80% of biobased materials (Ruiter, 2018). The renovation of the Alliander office in Duiven is also a good example of a circular innovation since it achieved 80% circularity of materials (Leising et al., 2018). Another interesting example of the potential for innovation in CE is 't Eemgoed in Almere, in which 82 gasless and energy-neutral homes are all connected to a collective water purification system for wastewater (Ruyter, 2019). Since these circular innovations seemed, at first sight, success stories, curiosity arose about what made these projects successful. Therefore, the main drivers and barriers were explored for these five circular innovations.

Scientific relevance

Current CE research focuses either on the macro-scale (e.g. smart cities) or micro-scale (e.g. manufactured products). Consequently, it risks ignoring impacts at the meso-scale (e.g. eco-parks or individual buildings) (Fusco Girard & Nocca, 2019; Pomponi & Moncaster, 2017). As Pomponi and Moncaster (2017) also mention, it is important to understand the key roles of for example bottom-up initiatives to understand how the transition towards a CE can be facilitated. To contribute to this transition and facilitate the pathway towards a CE, and to understand what drives CE in the building sector, often researchers make use of a drivers and barriers framework (De Jesus & Mendonça, 2017; Hart et al., 2019; Kirchherr et al., 2018; Mont et al., 2017; Ranta et al., 2018). However, current literature about drivers and barriers in CE in the building sector is often focused on drivers and barriers that can either facilitate or hinder innovations in CE without analyzing which underlying mechanisms are responsible for them (Mont et al., 2017; Termeer & Metze, 2019a). As also acknowledged by the study of Jiao and Boons (2014), who conducted policy analysis for stimulating industrial symbiosis, current strategies result in unclear mechanisms for policy intervention and facilitation. However, these mechanisms are highly important to recognize since they have the potential to reinforce the pathway towards a CE (Klitkou et al., 2015). The small-wins framework from Termeer and Metze (2019) proposes a way to identify these governmental mechanisms and to determine possible interventions that can facilitate the transition towards a CE. This study, therefore, aimed at combining the drivers and barriers framework with the small-wins framework to analyze the responsible governmental mechanisms to determine how municipalities were facilitating circular innovations.

Problem description

With her policy, the government determines to a large extent the rules of the game and the playing field in which the transition towards a circular economy can develop, for example, based on applied taxes, legal standards, and subsidies (PBL, 2021b). Therefore, governmental organizations are seen as a driving force towards realizing a CE in the building sector (Crielaard, 2015). The implementation of national policy on circular economy for the built environment at the meso-scale is largely decentralized to municipal governments. Municipalities prepare national policy and have the legal and financial means to implement regulations. However, it seems that municipalities differ both in the speed at which they can implement innovations and, in the ability, to manage innovation. Also, organizational factors influence the innovation decisions of municipalities (Jans et al., 2013). Currently, observed circular innovations in the built environment seem to be initiated by concerned citizens or ambitious companies (Circulair Buiksloterham, 2015; Ecodorp Boekel, 2016; Leising et al., 2018; Ruiter, 2018; Ruyter, 2019). For example, some websites are fully equipped to help people overcome municipal barriers by providing lists of municipalities that are positive about circular innovations. According to those pioneers, the local political attitude can influence how strictly permits are regulated and whether there is room for innovation (Erfdelen, 2019; Jonker, 2017; Scholter, 2020). Even when municipalities seem to be open for innovation, developers note that to successfully launch a circular innovation you have to work on it professionally, on a full-time basis (Ruyter, 2019). The Netherlands has roughly 30 years to get towards a 100% circular building sector, and municipalities seem to have an important role in realizing this. Therefore, this exploratory study looked at the role of municipalities in facilitating circular innovations in the Dutch building sector with the aim to accelerate transformative change towards a CE.

Main question:

- What is the role of municipalities in facilitating circular innovations in the Dutch building sector?

Sub questions:

- What are the main drivers and barriers that facilitate circular innovations in the Dutch building sector?
- Which governmental mechanisms can be identified that can accelerate transformative change?

2. Conceptual framework

This chapter describes the conceptual framework per topic which was developed for understanding the central concepts of this research. First, the concept of CE in general, in the built environment, and what circular innovations mean for this research are described. Secondly, the drivers and barriers framework is explained to get an idea of which possible drivers and barriers could emerge at the circular innovations. Thirdly, the small-wins framework is explained to elaborate on the governmental mechanisms and to grasp the concept of facilitating or accelerating transformative change in the transition towards a CE.

2.1 Circular economy

CE is in essence the direct opposite of the current 'linear' economy. In this linear approach, we extract materials from the Earth, develop products from those materials, and in the end, we throw those materials away as waste. Conversely, in a CE, we design to minimize waste and make sure that waste is assigned as 'new' raw materials. CE is, according to the [Ellen MacArthur Foundation \(2013\)](#) based on the three design principles:

1. Minimize waste and pollution
2. Circulate products and materials (waste valorization)
3. Regenerate natural systems (e.g. compost as regenerative resources for nature)

In the transition towards a CE in the Netherlands, the intermediate objective of the Dutch government is to achieve the target of 50% less use of primary raw materials (mineral, fossil, and metals) by 2030, with the ambition to realize an entire CE by 2050. With a CE the Dutch government wants to outline a perspective for a future-proof, sustainable economy ([Ministry of IenW, 2016](#)) "that meets the needs of the present without compromising the ability of future generations to meet their own needs" ([Brundtland et al., 1987](#)).

2.1.1 Circular economy in the built environment

Current production methods in the built environment put a significant burden on our planet and the concept of CE is proposing a systematic change. The design of buildings and other infrastructure determines for a large part the waste flows that will be released in the coming decades. By slowing and closing materials loops by reuse of waste materials and resources, CE aims at the development of long-lasting sustainable products. In a circular system, all of the waste materials are designed in such a way that they can be reused as raw materials for similar purposes ([Crielaard, 2015](#); [Leising et al., 2018](#)). So, a CE is restorative and regenerative by design and is a system that aims to maintain the value of materials and keep them in circulation. All to keep living the way we currently do, while having less impact on our natural environment ([Hart et al., 2019](#)).

2.1.2 Circular innovations

This study is looking at various innovative circular 'projects' or 'cases' in the built environment for which there exist many different names or terms which describe the same concept. Therefore it was important to have a suited definition for the projects in this study. Such (circular, or sustainable) projects are named as sustainable innovations ([RU, n.d.](#)), CE projects ([Hart et al., 2019](#)), or circular business models ([Mont et al., 2017](#)), but a definition that seemed more suiting was the definition 'circular innovation' from [Rijk \(2020\)](#). This

author used the definition ‘circular innovations’ for construction or renovation projects for buildings, so similar to what this study would look into.

R-strategies

More efficient use of raw materials in a CE can be achieved with different circularity strategies, which are also known as the R strategies. R-strategies are for example innovations that abandon (refuse and rethink) certain products, manufacture products more efficiently (reduce), reuse and repair certain products (reuse, repair, and remanufacture), reuse materials (recycle) so less waste is created and recovering energy (recover) from materials (PBL, 2021b).

Certification

Current literature for certification on CE in the built environment is mostly aimed at the circular C2C framework (product scale) and the BREEAM sustainability assessment (building scale).

The C2C philosophy is that waste does not exist and that every raw material and every material used for a product must also be able to be reused. In C2C, they distinguish the biosphere and the technosphere as two cycles in which materials can circulate. Materials in the biosphere can eventually biodegrade and materials in the technosphere can be reused endlessly for industrial applications. When a product is designed according to the C2C principle it can also get certified and currently we see more projects in the built environment that use products that are C2C certified (EPEA, 2020).

The Building Research Establishment Environmental Assessment Method (BREEAM) certification method is a tool for assessing the environmental performance of the design, construction, and the use of buildings in the built environment. The BREEAM certificate aims to realize sustainable construction projects or renovations with minimal environmental impact (Aspinal et al., 2012).

2.2 Drivers and barriers framework

Literature regarding progress towards a CE is rather extensive. While developing this conceptual framework for identifying drivers and barriers, inspiration was found in the paper of Burger (2021). This author developed a framework for analyzing under which conditions circular area development could take place. Furthermore, based on the studies of De Jesus and Mendonça (2017); Hart et al. (2019); Kirchherr et al. (2018); Mont et al. (2017); and Ranta et al. (2018), the most used categories (Table 1) were used to determine which categories would be most useful for this research.

Table 1 Categories of drivers and barriers used by other authors

(Hart et al. 2019)	(Kirchherr et al. 2018)	(De Jesus and Mendonça 2017)	(Burger 2021)
cultural	cultural	cultural	cultural
regulatory	regulatory	institutional	institutional
financial	market	economic	financial
sectoral	technological	technical	implementation

By looking at the variety of methods used by the authors, it seemed that everyone was using four categories but used a slightly different approach or use of terminology. The cultural category for example has an overlap with the institutional category as shown by the study

of Ranta et al. (2018) which means that those categories could potentially be combined. Moreover, since this research is mainly aimed at innovations from an institutional perspective it seemed reasonable to let these categories collude. The categories of drivers and barriers that were selected are technological, financial, and institutional. Figure 1 shows the selected drivers and barriers of this conceptualization for each of the categories. In this study, the institutional drivers and barriers get extra emphasis as this study is aimed at the role of municipalities.

	Drivers	Barriers
Technological	<ul style="list-style-type: none"> Living labs³ Availability of ICTs and open source data³ Favorable climate for R&D⁵ 	<ul style="list-style-type: none"> Lack of data (e.g. on impacts)¹ Lack of technical support³ Lack of proven technologies⁴ Sector is wary of innovation⁴
Financial	<ul style="list-style-type: none"> Cost savings and recovery⁵ Improved margins⁵ Meet low-cost competition⁵ 	<ul style="list-style-type: none"> Limited funding¹ High investments costs³ Poor business case⁴ High labor costs⁵
Institutional	<ul style="list-style-type: none"> Regulation supporting CE initiatives² Recyclables as valuable² Fiscal support⁴ Governmental coordination³ 	<ul style="list-style-type: none"> Obstructing law and regulation¹ Lacking consumer awareness¹ Lack of certification CE² Consumer perception trade-off price/performance²

Figure 1 Drivers and barriers framework, after (Kirchherr et al. 2018)¹, (Ranta et al. 2018)², (De Jesus and Mendonça 2017)³, (Hart et al. 2019)⁴, (Mont et al. 2017)⁵

2.2.1 Technological drivers and barriers

Technological drivers that facilitate innovation in the building sector that are commonly observed are living labs, availability of ICTs and open-source data, and a favorable climate for R&D. Living labs can have a big impact on raising awareness on CE and the future of the building sector. Through pilot experiments, the sector gets a better idea of practical innovations, and pilots also contribute to raising awareness about CE in the industry in general. The availability of ICTs can be considered a facilitator in dematerializing the economy since it is very important to reuse raw materials (De Jesus & Mendonça, 2017). A good example is the Raw Materials Information System (GRIS) that the RIVM and the Netherlands Environmental Assessment Agency (PBL) are currently developing to structurally monitor data on raw material flows, their usage, and stocks (Van Der Maas et al., 2019). Additionally, open source data can help speed up development. Also, creating a favorable climate for R&D is a driver for technological innovation since it reduces risks associated with circular business models.

Technological barriers that hinder innovation in the building sector that are commonly observed are lack of data, lack of technical support, lack of proven technologies, sector is wary of innovation. Lack of data can lead to limited funding for circular business models and low pressure to remove obstructing regulations. This will in turn make CE innovations more expensive. Knowledge about the potentially avoided ‘impacts’ or positive externalities

should be mapped out carefully with the available instruments to get a good view of why these business models should become the standard (Kirchherr et al., 2018). Some companies lack an extensive network and appropriate support when experimenting with circular innovations (De Jesus & Mendonça, 2017). There are not many large-scale demonstration projects yet, so a lack of proven technologies currently exists in which projects cannot be initiated convincingly. Moreover, the building sector is wary of innovation, is uncollaborative, and is usually taking a risk-averse approach. These three aspects are possibly restraining innovation further (Hart et al., 2019).

2.2.2 Financial drivers and barriers

Financial drivers that facilitate innovation in the building sector that are commonly observed are fiscal support, cost savings and recovery, improved margins, and the potential to meet low-cost competition. Fiscal support by for example reduction in VAT on circular innovations or funding by the government (Hart et al., 2019). Cost savings in the manufacturing and waste management process can be achieved by recycling and reusing waste. Cost recovery can additionally be achieved by selling valuable second-hand, refurbished, or upcycled products. Improved margins can for example come from a reduction in price for secondary materials that substitute the concerning raw material. The potential to meet low-cost competition could arise when the company differentiates from the market by adding extra products or services products (Mont et al., 2017).

Financial barriers that hinder innovation in the building sector that are commonly observed are limited funding, high investment costs, poor business cases, and high labor costs. Limited funding can result in entrepreneurs going for a different (non-CE) project that is suitable for funding. In many cases, limited funding is related to a lack of data on for example avoided impacts (i.e. externalities), therefore CE innovations are sometimes still more expensive than regular ones (Kirchherr et al., 2018). High initial costs and market uncertainty can lead to high investment costs and these issues need new economical tools such as green financial innovation funds (De Jesus & Mendonça, 2017). Sustainable innovations are still often poorly understood and benefits are insufficiently mapped and communicated towards the general public which leads to a poor business case (Hart et al., 2019). Product disassembly, separation of waste, and technicians for new product design come with high labor costs (Mont et al., 2017). Financial barriers have a direct influence on technological barriers since market forces (e.g. funding) are sometimes needed for a technology to emerge (Kirchherr et al., 2018).

2.2.3 Institutional drivers and barriers

Institutional drivers that facilitate innovation in the building sector that are commonly observed are regulation supporting CE initiatives, recyclables perceived valuable and governmental coordination. When regulation is supporting CE initiatives, it can establish its legitimacy. For accelerating the transition to a CE, governments should extend support for recycling- and reuse schemes. This can already be done by incentivizing reuse efforts. An example of such a regulation is banning landfilling waste that includes a certain percentage of organic material, this will directly support the initiative of producing biogas. When recyclables are in an early stage already perceived valuable by customers and factories, they will more likely be used as secondary materials as can be seen in China, since they have the infrastructure for recycling plastic (Ranta et al., 2018). Another driver of innovation is governmental coordination, in which agencies take a proactive stand and set appropriate conditions and measures to stimulate circular innovations (De Jesus & Mendonça, 2017).

Institutional barriers that hinder innovation in the building sector that are commonly observed are obstructing law and regulation, lacking consumer awareness, lack of certification CE, and consumer perception trade-off price/performance. There is a need for changes in current laws and regulations in the transition towards a CE. Current (traditional) governmental incentives are still supporting the linear economy and therefore obstruct the laws and regulations for CE. Despite the increasing attention in recent years, CE remains a niche discussion among developers. CE is a long-term undertaking that takes time and effort to work out, it is rather complex and sometimes also more expensive. The barrier of lacking consumer awareness has risen since circular innovations cannot be marketed like traditional concepts would. The same goes the other way around, when consumers are lacking awareness, it is not valuable for the company to market those kinds of goods (Kirchherr et al., 2018). Certification schemes to reduce material usage in products are scarce. No one could argue that the existing certifications for recycling and sustainability, when are not looking at the reduction of material usage, can even have a negative effect on actual material usage. Unfortunately, the consumers' perception is still that sustainability is a trade-off between price and performance and is therefore also selected as a barrier. Most literature about CE focuses on the rather technical side of the concept, while the institutional drivers and barriers are just as important for the adoption of the CE approach (Ranta et al., 2018).

2.3 Small-wins framework

Determining only drivers and barriers has proven not to be sufficient on its own (Mont et al., 2017). To get a better understanding of the underlying mechanisms responsible for the drivers and barriers and what the role is of municipalities in facilitating (or hindering) circular innovations in the Dutch building sector, a different approach has to be taken. Current strategies for innovations in CE result in unclear mechanisms for policy intervention and facilitation and therefore, mechanisms that can accelerate transformative change have to be identified. These mechanisms are highly important to recognize since they have the potential to reinforce a certain pathway of development (Klitkou et al., 2015). For example, circular innovations can inspire others to do the same or prove to municipalities that these are valuable business cases. Since this study is focused on how municipalities can contribute, the small-wins framework from Termeer and Metz (2019) was used that look at general propelling mechanisms in organizational change science. The six mechanisms are; 1) energizing, 2) learning by doing, 3) the logic of attraction, 4) the bandwagon effect, 5) coupling, and 6) robustness.

The energizing mechanism 1), states that governments can and should encourage actors to be innovative and that focusing on problems can be counterproductive. Moreover, it notes that the observable result of a small win and the mutual trust between actors can encourage actors to look ahead for the next possible small win, to keep seeing concrete results and therefore, contributing to the accumulation of small wins, to subsequently, reinforce the transitional pathway towards a CE.

The learning by doing mechanism 2), is more focused on the idea of trial-and-error. It states that broadening and deepening come from initiatives that simply start and try something out and learn from it. For example, innovations can lead to uncovering resources that were invisible before which can subsequently lead to new innovative ideas. Therefore, experimentation results in new experiments, and whether these experiments are successful

or not, they always result in new ideas. Governments can accelerate this by, for example, organizing exchange activities.

The logic of attraction mechanism 3), is about the positive influence that projects can have on political and societal resistance. For example, concrete successes can make other actors want to be part of the initiative and support it. Governments can for example play a role in advocating circular innovations with awards or subsidies, to reward the actors who pursue systemic change and increase their credibility.

The bandwagon effect mechanism 4), the phenomenon where people act because they are inspired by others, also called exemplary leadership, is selected as an important governance mechanism since governments have the authority and the network to share inspiring projects with other stakeholders.

The coupling mechanism 5), says something about how innovations can accumulate and be coupled together to enable them to touch upon other topics. Governments can, for example, bring together circular innovations for knowledge sharing or use project results for their political agenda.

The robustness mechanism 6), is saying something about the strength of the institutional change, in which there is a point of no return where going back to the linear models is very difficult. Governments can play a role in framing circular innovations as experiments or they can rearrange existing policies to make innovations possible (Termeer & Metze, 2019b).

3. Methodology

3.1 Case selection

In this exploratory study, five contrasting cases of circular innovations in the built environment have been selected across different municipalities throughout the Netherlands. These circular innovations were examined using a comparative case study approach, a common method in qualitative research used to examine generalizations that extend across multiple cases (Knight, 2001). Since current CE literature is mostly focused on the macro-scale (e.g. infrastructure) or micro-scale (e.g. product manufacturing) this study has chosen to focus on the meso-scale (e.g. individual buildings). This includes circular innovations such as eco-parks, individual housing, commercial buildings, and circular renovations. Contrasting types of circular innovations were selected to get an idea of differences per type of circular innovation and to get a glimpse of the meso-scale as a whole. Moreover, to see possible differences between the Dutch municipalities concerning circular innovations, the circular innovations were selected in different parts of the country.

The journey (of selecting circular innovations) started, at the preliminary research (the Dutch Transition Agenda) and the development of the conceptual framework. It soon became clear that circularity in the building sector was mostly dominated by 'cases' that were at least conducting circularity strategies, also known as the R strategies. Moreover, what also seemed to distinguish 'circular innovations' from 'normal' building projects in the novel world of CE, was that they made use of certification methods such as C2C or BREEAM. Therefore, to identify if a case was related to CE, circular innovations that profiled themselves as conducting one or more R-strategies, or applied principles such as C2C or BREEAM were selected. Through extensive document review (both academic and newspaper articles) regarding circular innovations in the Netherlands, a total of 11 potential circular innovations came forward that matched these criteria (Table 2).

Table 2 Initial potential circular innovations

	Project initiator	Municipality	Construction type	Relation CE
1	Buiksloterham	Amsterdam	sustainable redevelopment	R-strategies
2	Recht op Wind	Lansingerland	C2C construction	C2C
3	Biosintrum	Oosterwolde	circular construction	BREEAM
4	Het Savannehuis	Blijdorp	C2C construction	C2C
5	Hotel Jakarta	Amsterdam	circular construction	BREEAM
6	Swettehûs	Leeuwarden	circular construction	R-strategies
7	Ecodorp Boekel	Boekel	circular construction	C2C
8	Henk Veerman	Ulft	sustainable renovation	R-strategies
9	Alliander office	Duiven	circular renovation	BREEAM
10	't Eemgoed	Almelo	sustainable construction	R-strategies
11	De Gouverneur	Rotterdam	circular construction	R-strategies

From these 11 potential circular innovations, a selection had to be made. For using the comparative case study approach a minimum of two or more cases was necessary (Goodrick, 2014). Since this study wanted to examine different types of circular innovations in different parts of the Netherlands it seemed more than logical to at least have a case for each type (as determined by the literature). So an eco-park (1), individual housing (2), commercial building (3), and circular renovation (4) already meant four cases. For the eco-park, the choice was simple since Ecodorp was the only eco-park from this selection. For the individual housing, Recht op Wind was selected because it was the only housing project and it also seemed like an interesting case since this was the first C2C house in the Netherlands. Subsequently, for the commercial building, Biosintrum was selected because it seemed that there was more literature available for this project compared to the others. For the circular renovation, Alliander was selected because from the two renovation cases this one seemed most promising since it was explicitly framing its renovation as circular (as opposed to the 'sustainable' Henk Veerman). Moreover, while identifying the circular innovations, I stumbled upon another compelling building project called 't Eemgoed. The reason I found it so compelling was that everything pointed out that they were developing circularly, but not a word was spoken about circularity. Also, newspaper articles showed that there were some institutional conflicts during the development, which made it even more interesting for this study. This made a total of five circular innovations to be investigated (Table 3).

Table 3 Selected circular innovations, project initiator, permit assessor, architect, and type of innovation

Circular innovation	Project initiator	Municipality	Type of innovation
1) Ecodorp	Ad Vlems	Boekel	Eco-park
2) Recht op Wind	Jouke Post	Lansingerland	Individual housing
3) Biosintrum	Municipality	Ooststellingwerf	Commercial building
4) Alliander office	Alliander	Duiven	Renovation
5) 't Eemgoed	Sant Ruyter	Almelo	Eco-park

Case description

1) Ecodorp in Boekel, is an Ecovillage located in the eastern part of Noord-Brabant. The village has room for 36 rental homes and consists of a community center with office spaces, a workshop, and a knowledge and information center. All buildings are built with natural (biobased) and fully reusable (circular) building materials (Ecodorp Boekel, 2016). 2) Recht op wind in Lansingerland concerns a single residential house that is located in the north of Rotterdam near the Rotte peat river. Recht op Wind was built in 2012 and was the first C2C building in the Netherlands. Where possible, C2C certified materials were used, toxic materials are excluded, meaning that all materials can be reused in a biological or technical cycle (Post, 2012). 3) Biosintrum is an energy-neutral knowledge center in Oosterwolde that consists of more than 80% of biobased materials and meet, therefore, the BREEAM Outstanding requirements. This makes it one of the most sustainable and innovative buildings in Europe. The Biosintrum is a source of inspiration for students and professionals involved in the biobased economy (Ruiter, 2018). 4) The Alliander office in Duiven is an office from the Dutch energy grid operator which was completely renovated in 2010. Five of the existing office buildings were transformed into one big sustainable building with the

vision of achieving 80% circularity of materials (Leising et al., 2018). 5) Ecobuurtschap 't Eemgoed in Almere is a plot of approximately 7 hectares with 82 homes and a building with shared facilities. The plot is completely car-free and parking is only possible on the edge of the site. All of the houses are energy neutral and the gray and black water treatment takes place via a collective water purification system using helophyte filters on the estate itself (Ruyter, 2019).

3.2 Data collection

First, publicly available documents for each of the five circular innovations were gathered to gain an understanding of the circular innovations and to lay a robust foundation for gathering primary data (Wagh, 2021). These documents originated from governmental organizations, research/consultancy firms, were self-published (by the circular innovations), or were newspaper articles. The results of this document review enabled me to identify the initiators of the circular innovations and the associated municipalities. The triangulation method (Figure 2) was used to guarantee the reliability of my research results framework (Alassafi et al., 2017; Thiel, 2010).

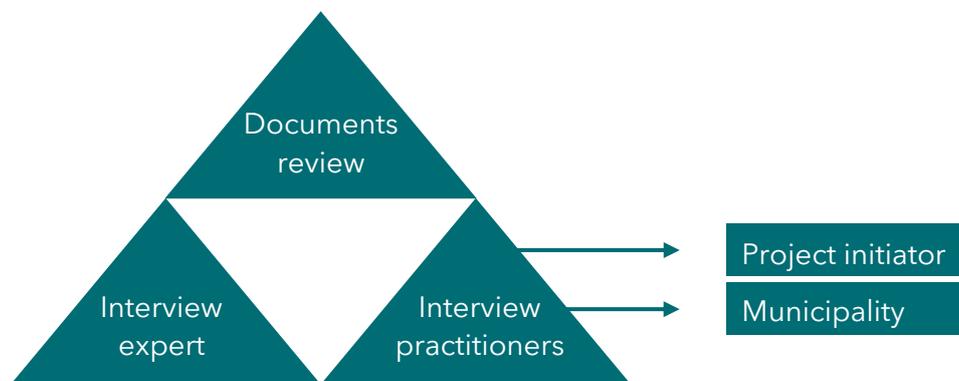


Figure 2 Method for validating the results, after Alassafi et al. (2017)

Secondly, interviews (primary data) were held with the initiators of the circular innovations to validate the results of the secondary data and to determine if new or conflicting factors came to light. All of the five initiators from the circular innovations were interviewed. The results of these two types of data enabled me to answer sub-question 1: "What are the main drivers and barriers that facilitate circular innovations in the Dutch building sector?"

Thirdly, the municipality of each of the circular innovations was interviewed to determine what the role of the municipality was in the succession of the circular innovation and to validate the results from the interviews with the initiators. For this part of the analysis, the small-wins framework was used to find clear mechanisms for policy intervention and facilitation. This enabled me to answer sub-question 2: "Which governmental mechanisms can be identified that can accelerate transformative change?"

Thirdly, an expert in the field of CE in the built environment was interviewed to discuss the intermediate findings. The result of the two sub-questions enabled me to subsequently answer the main question: "What is the role of municipalities in facilitating circular innovations in the Dutch building sector?"

3.2.1 Documents review

The focus for this part of the data collection was to understand how the circular innovations had emerged, what the main drivers and barriers were (sub-question 1). From each type of publication (government, research centers, self-published, and newspapers) at least one

document per circular innovation was used. This means a total of at least four documents per circular innovation. Keywords that were used to collect secondary data are among others: CE, circular economy, circular innovations, built environment, barriers and drivers, the transition towards circularity, CE in Dutch building sector, mechanisms, accelerating (transformative) change.

3.2.2 Interview practitioners

The focus of the interviews with the practitioners (so initiators and municipalities) was to determine if additional drivers and barriers were not observed throughout the document review, to identify relevant governance mechanisms, and to subsequently validate the results of the secondary data. This was done through structured interviews ([Appendix 2 and 3](#)), with both the initiator of the circular innovation and the concerning municipality ([see Appendix 1 for an overview of all participants](#)). This type of interview is considered one of the most commonly used interview methods in qualitative research ([DeJonckheere & Vaughn, 2019](#)). This method has allowed me to collect open-ended data, not limited to a certain response, to get in-depth knowledge about the main barriers and drivers within the circular innovations and the possible mechanisms that can accelerate transformative change. Structuring the interviews for the initiators regarding the drivers and barriers was done by using a deductive reasoning approach (also called top-down), based on the conceptual framework ([Trochim, 2020](#)). Meaning that the existing theory (so the conceptual framework) was leading for developing the questions.

I succeeded to get in touch with all of the intended practitioners except for the municipality of Almere. When a practitioner came into contact, a meeting was planned in Microsoft Teams (which enabled recording). Each online meeting was recorded, so that full attention could be paid to the relevant interviewee (each participant was asked before the meeting there were any objections in recording the meeting for transcribing purposes). Moreover, 2-5 days before each interview took place the concerning participant was sent an e-mail with the questionnaire so that they could prepare the questions that would be put to them. The conversations were transcribed completely and a summary was made in which the irrelevant points were left out. This summary was then sent back to each participant for validation.

Questionnaires

For the questionnaires regarding the initiators, based on the drivers and barriers framework ([Chapter 2.2](#)), an extensive interview was developed that consisted of 27 questions ([Appendix 2](#)) divided over the technological, financial, and institutional categories. This research was mostly aimed at mapping institutional drivers and barriers, but additionally, mapping technological and financial drivers and barriers were done to determine the responsible governmental mechanisms and find possible ways for intervention. For the questionnaires for the municipalities, based on the small-wins framework ([Chapter 2.3](#)), a semi-structured in-depth interview was developed to determine which mechanisms were applicable for the concerning circular innovations. This resulted in a more concise interview that consisted of 8 questions ([Appendix 3](#)).

3.2.3 Expert review

Lastly, as part of the validation method, as described above, an expert in the field of CE in the built environment was interviewed to discuss the intermediate findings. The expert was selected based on the Transition Agenda, the leading agenda for CE in the Netherlands. This agenda was written by a 'Transition Team' that was set up by the Dutch government

and the construction sector, in which experts, key persons from the construction sector, governments, and academics work together on the transition to a circular construction economy (Transitiebureau CBE, 2019). The chairman of the Transition Agenda was selected as the expert, and at the time of this study, this was Prof.dr.ir. V. Gruis. Gruis is a Professor on Housing Management and is the Departmental Chair of Management in the Built Environment at the TU Delft where he is working on the question of how housing managers and developers can adapt their stock and activities to the social challenge.

To review the results of this study in contrast with the Dutch building sector and to test the initial findings of this study, the expert was presented several interesting observations that resulted from the data analysis (described below).

- Innovative and circular zoning plans are important for innovation
- Municipalities are prone to capacity issues (both in time and knowledge)
- Subsidy can be important for innovations to emerge
- It seems that material passports are an important innovation for CE to emerge
- It seems there is a shortage of builders and installers for circular construction
- There is a big gap in CE knowledge between architects, contractors, and workers

For each observation that was presented, the expert got a moment to determine whether the observation was correct and in line with his experience from the sector. When my observations seemed different from the perception of the expert, extra time was spent on this topic, and differences were discussed.

3.3 Data analysis

This study has analyzed five case studies (circular innovations) through an observational method of gathering data, also called qualitative research (Tesch, 2013). The specific data concerning the individual circular innovations enabled me to strengthen the conceptual framework and help to detect patterns and regularities, to subsequently, develop a general conclusion. Since qualitative research is rather subjective and I as an individual perceives the world differently than someone else (Khan, 2014), it is was important to build a proper method for analysis of the received data. Therefore, the primary data were analyzed according to the coding/indexing principle in which the data was fragmented systematically. This process helped to avoid personal bias with the subject and jumping to conclusions too fast (Wijngaarden, 2019). Moreover, this process enabled the results of this study to be traceable, so that with the same research, similar results would be attained and repeatable, so the method could be used to repeat the research with new data. The application that was used to facilitate this strategy is the program ATLAS.ti, a program specially designed for coding and analyzing transcripts.

Transcripts were read and notes were made about the first impressions (step 1). Next, relevant words were labeled such as phrases, sentences, or sections, also called coding/indexing (step 2). Subsequently, based on the conceptual framework and additional findings, in combination with the coding (previous step), it was determined which codes were most important (step 3). In the next step, each category was labeled and there was determined which categories were the most relevant and in what way they were connected (step 4). Based on the conceptual framework and the document review, the codebook (Appendix 4) was developed in which all the relevant codes regarding the analysis of the

drivers and barriers and governmental mechanisms are mentioned. Lastly, the results were analyzed and the first interpretations were made (Brinkmann & Kvale, 2021).

All documents regarding the secondary data (document review) and the primary data (interviews) were imported in ATLAS.ti. For each of the to be analyzed data, a different ATLAS.ti file was made. So, one for the initial document review, one for the drivers and barriers regarding the interviews with the initiators, and finally, one for the governmental mechanisms regarding the interviews with the municipalities. Below are some examples of how the data was coded.

Example 1, the sentence *"During that period the initiator had worked closely with the portfolio holder (the mayor) and it was of the utmost importance to keep politicians informed about the concept"* was assigned the primary code 'Local political attitude' under the category of institutional drivers.

Example 2, the sentence *"They did not want to build the minimum allowed parking spaces near the building. The municipality allowed this since Alliander had an alternative arranged"* was assigned the primary code 'Flexibility with existing laws and regulations' under the category of institutional drivers.

Figure 3 and 4 give additional examples to illustrate how this was conducted within the software.

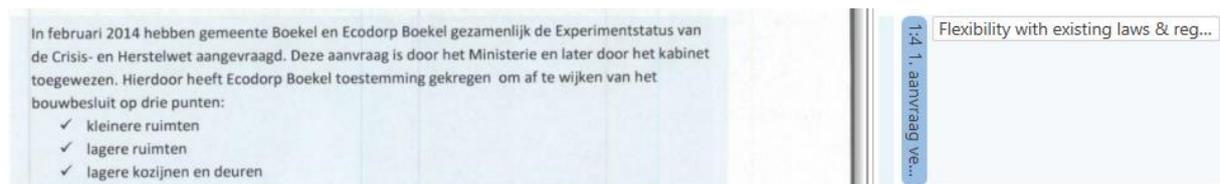


Figure 3 Example 1 for the working method for coding in ATLAS.ti

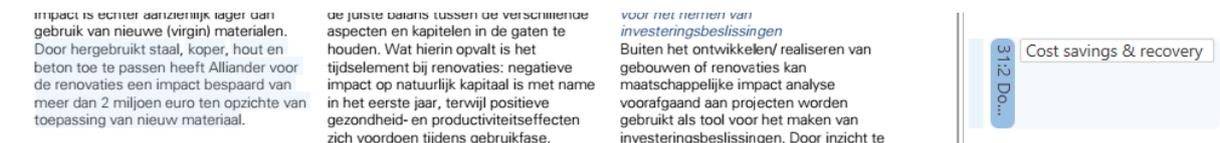


Figure 4 Example 2 for the working method for coding in ATLAS.ti

In example 1 (Figure 3), you can see a marked paragraph on a document from Ecodorp Boekel. The text says something about how the municipality of Boekel, together with the initiators from Ecodorp applied for an experimental status on the crisis and recovery law. Since this grant them exemptions from the building decree this paragraph was coded as: 'Flexibility with existing laws and regulations' within the category of institutional drivers (see Table 4 above). In example 2 (Figure 4), you can see a marked paragraph on a document from Alliander. It says something about that reuse of steel, copper, wood, and concrete has saved them money in the renovation (relative to applying new materials). Therefore, this paragraph was coded as: 'Cost savings and recovery' within the category of financial drivers. This method was repeated for all of the data that was analyzed.

4. Results

In this chapter, the findings of this research are presented by answering the sub-questions followed by the main question. First, the most important drivers and barriers for each circular innovation are discussed based on the three categories from the conceptual framework (Chapter 2); A) technological, B) financial, and C) institutional, to subsequently answer sub-question 1 "What are the main drivers and barriers that facilitate circular innovations in the Dutch building sector?" (Paragraph 4.2). Next, sub-question 2 'Which governmental mechanisms can be identified that can accelerate transformative change?' was answered based on the interviews with the concerning municipalities (Paragraph 4.3).



Figure 5 The five selected circular innovations (Authors own work)

For each of the circular innovations (Figure 5), the most important findings on both secondary (self-published, governmental, news, and policy literature) - and primary (interview) data were combined to explain which drivers and barriers are most common.

4.1 Drivers and barriers circular innovations

4.1.1 Case description Ecodorp

Ecodorp, which is situated in Boekel (east-Noord Brabant) started in 2013 as a small-scale citizens' initiative and has now grown into a collaboration between the residents, sustainable construction companies, and the province of Noord-Brabant. The village has room for 36 rental homes and consists of a community center with office spaces, a workshop, and a knowledge and information center. All buildings are built with natural (biobased) and fully reusable (circular) building materials (Ecodorp Boekel, 2016).

4.1.1A Technological drivers and barriers at Ecodorp

At Ecodorp, the most important technological drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ houses are CO₂ positive
 - ✓ used similar projects for development
 - ✓ extra support from the government
 - ✓ coupled with similar projects

 - ✗ initial house shape was not possible
- ✓ At Ecodorp, the timber frame constructions and natural insulation from hemp fiber enable the buildings to store more CO₂ than is emitted during construction. The area is also provided with a battery containing a thousand cubic meters of basalt, and Ecodorp is in collaboration with a cable company to develop a 'circular' power cable, entirely made from waste. Moreover, the buildings are provided with green roofs for isolation which at the same time is a part of an efficient water management system. The community is designed in a way that it can largely meet its own needs for water, food, and energy. The pipes of the underfloor heating for the houses are C2C certified, which means they are made from waste and are also easy to reuse. During the development of Ecodorp, the developers used open-

source data of similar projects in Germany to accelerate development. Additionally, the developers also had a lot of technical support from water boards, water companies, energy companies, and other innovation experts (A. Vlems, personal communication, November 12, 2021). The municipality did not have a role in this but the department head of the municipality notes that in exceptional cases, for example when a small-scale project does not get off the ground, they offer support from their departments (H. van Zutven, personal communication, November 23, 2021). Moreover, Ecodorp Boekel also participated in a competition (the sustainable suitcase) from the Ministry of Infrastructure and Environment which granted them extra-governmental support that was very helpful in the further development of their project (A. Vlems, personal communication, November 12, 2021). In addition, the municipality has also brought Ecodorp together with similar projects. For example, they brought Ecodorp Boekel into contact with the local food forest because the municipality thought that the food forest could provide good input concerning the food garden in the Ecodorp. In addition, they also brought Ecodorp into contact with the Boekel Energy initiative because the municipality had the idea that Ecodorp could get interesting input from Boekel Energy (H. van Zutven, personal communication, November 23, 2021).

- ✗ The initial plan of the initiators of Ecodorp was to design the houses in the shape of a cloverleaf. However, this would make construction more difficult and therefore more expensive, so in the end, the initiators have chosen a round shape instead (H. van Zutven, personal communication, November 23, 2021).



4.1.1B Financial drivers and barriers at Ecodorp

At Ecodorp, the most important financial drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ financing from bank
- ✓ do not have to pay sewerage tax
- ✓ extra income through ecotourism

- ✗ difficulty getting financing
- ✗ high-risk profile for innovation
- ✗ relatively expensive due to novelty CE

- ✓ Ecodorp Boekel got financing from the GLS Bank in Germany because the bank was already common with similar concepts and knew that this kind of innovation had a low-risk profile. Since Ecodorp Boekel is not connected to the sewage system, they do not have to pay sewage tax, which saves them costs (Ecodorp Boekel, 2016). To generate extra income, Ecodorp is building tree houses that they can rent out to eco-tourists. Also, there will be an "Artist in Residence" which can be hired by different artists every 3 months. Moreover, Ecodorp gives guided tours twice a month to generate extra income and to inspire other actors to make conscious and sustainable choices. Moreover, to reduce construction costs by about 10% the inhabitants of Ecodorp will help with the construction of the houses (Ecodorp Boekel, 2016).

- ✗ However, Ecodorp also shows that, due to its novel character, financing can be limited and interest rates can be high due to high-risk profiles for innovation. Sometimes banks did not grant the project loans due to a lack of knowledge on similar projects. Therefore, having a proven business model seems essential for obtaining financing (Oostveen, 2020). Moreover, Ecodorp is about 5% more expensive compared to regular housing projects.

However, this is mainly due to its novelty and the relatively low production quantity of the materials that are used, and due to the higher labor costs since construction workers are not familiar with these new techniques (A. Vlems, personal communication, November 12, 2021).



4.1.1C Institutional drivers and barriers at Ecodorp

At Ecodorp, the most important institutional drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ innovative bureaucracy
- ✓ exemptions from the Building Decree
- ✓ subsidy from the EU, state, and province
- ✓ the project has a material passport

- ✗ extra complex due to high ambition
- ✗ high-risk profile for innovation
- ✗ the construction sector is not progressive

- ✓ The Municipality of Boekel is very innovative concerning bureaucracy. For example, it was the first municipality in the Netherlands to allow informal care homes (mantelzorg) on the site (Oostveen, 2020). Also, Boekel municipality introduced the flash permit (flitsvergunning¹), and there is no longer a welfare committee (welstandscommissie) which was a very important factor in the succession of the project. Additionally, the department of ground affairs within the municipality was flexible regarding legislation about the fact that Ecodorp was not connected to the sewer network (A. Vlems, personal communication, November 12, 2021). Moreover, Ecodorp Boekel falls under the Crisis and Recovery Act. This means that the area is assigned as an "experiment area" where restrictive regulations are temporarily declared inapplicable until the new environmental law takes effect (Luiten et al., 2018). This is mainly because the 2012 Building Decree offers too many restrictions for this innovative experiment. Therefore, concerning daylighting, surface ceiling heights, and minimum ceiling and door heights, there have been exemptions from the Building Decree. This also enabled them to test sustainable and innovative products on their site. Also, this made it possible to install wind turbines without a permit and use second-hand material in construction (InfoMil, 2020). This makes Ecodorp Boekel a testing ground for many companies that want to develop sustainable products (Ecodorp Boekel, 2016). Ecodorp Boekel got support in the form of incentives from the EU, the ministry, and the province for a low-carbon economy and innovations in sustainable energy. The province of Noord-Brabant had granted them a loan of €1.2 million and subsidized €1.2 million. The European Union is also responsible for subsidizing €2.5-million and the Ministry of Economic Affairs and Climate for half a million. Moreover, all homes are provided with a so called 'material passport' that consists of a list of the materials that were used to build the homes. Therefore, the homes will become a source of raw materials in the future. This enables them to actually be a part of CE since it is a condition to justify what will happen with the used materials when the buildings will be demolished in the future (Ecodorp Boekel, 2016).

¹ A flash permit is an environmental permit that is processed within 1 week or even within 1 day. The concept of a flash permit is a test that is currently only being carried out in a limited number of municipalities (de Lepper, z.d.).

✗ However, the extra incentives from the province and the European Union made Ecodorp their ambitions even more ambitious and the intended achieved goals also became more compelling, which made the project more complex to conduct (A. Vlems, personal communication, November 12, 2021). Moreover, the initiators had some issues with banks that did not want to co-finance since the project had a relatively high-risk profile and there was a lack of data on similar projects in the Netherlands (Oostveen, 2020). The initiator of Ecodorp has the idea that the construction sector is not progressive, he illustrates this statement with the example of the sustainable construction award that they have won in 2021, while they were one of the very few contestants who did not have much experience with construction projects (A. Vlems, personal communication, November 12, 2021). During the 2021 Sustainable Built Congress, the organization 'Duurzaam Gebouwd' rewarded Ecodorp with the Circular Ring for the most sustainable organization in the Netherlands (Duurzaam Gebouwd, 2021). This was not necessarily a barrier for the completion of Ecodorp, but it is a barrier in the transition towards a sustainable construction sector because the Netherlands lacks good examples. And often sustainability is cut short during the first cutbacks in these kinds of projects. 2021 (A. Vlems, personal communication, November 12, 2021).

4.1.2 Case description Recht op Wind

The Recht op wind in Rotte is the first C2C house in the Netherlands that was built in 2012. The house has been tested against the principles of C2C and the materials used are all tested for their composition. Where possible, C2C certified materials were used, toxic materials are excluded, meaning that all materials can be reused in a biological or technical cycle. The house is equipped with PV panels for electricity generation and the solar collectors supply the hot water for the boiler. This is sufficient for the bath, shower, and kitchen. Additionally, a helophyte filter is installed to clean wastewater. With the geothermal heat, the rest of the house is heated. Moreover, the house was designed to use natural ventilation through an air supply pipe under the house, which through the bottom provides cooled air (Post, 2012).



4.1.2A Technological drivers and barriers at Recht op Wind

At Recht op Wind, the most important technological drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ first C2C house in the Netherlands
- ✓ used other data for development
- ✓ technical support from manufacturers
- ✗ C2C materials not available

✓ Recht op Wind has been widely used as an example because it was the first C2C house in the Netherlands, and therefore, the initiator had received many new assignments in the field of circular construction based on this project. The initiator used other data for the development of the project and they had a lot of technical support during the development of the project. Especially in the form of collaborations with manufacturers that were responsible for the production of certain parts and materials needed for building the house (J. Post, personal communication, November 15, 2021).

✗ Many products and materials that are C2C were not available in the Netherlands and there is the difficulty of processing, and uncertainty of guarantees. Therefore, the initiator had

conversations with the producers of all possible construction elements and materials that could be used. It turned out that some companies were very interested, but many companies had not yet heard of C2C but were willing to 'take it up' internally. In the end, all these consultations, investigations, and offers eventually led to initiatives from the companies (J. Post, personal communication, November 15, 2021).



4.1.2B Financial drivers and barriers at Recht op Wind

At Recht op Wind, there were no financial drivers observed, financial barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- no observed financial drivers
- × relatively expensive due to novelty CE
- × uncertainties lead to higher costs

× At the time of the project, there were no financial drivers. This is partly due to the relatively small scale of the project, but also because this was in 2005 and CE was a relatively new concept. The initiator thinks that his project was in essence not more expensive than opposing similar (non-CE) projects but that contractors usually charged more because the concept was unknown. In the end, Recht op Wind had high initial costs because there were a lot of uncertainties in the project, so unknown factors that builders and contractors were not yet used to. Also, the costs of labor were higher because the principles are new and new things take extra time (J. Post, personal communication, November 15, 2021).



4.1.2C Institutional drivers and barriers at Recht op Wind

At Recht op Wind, the most important institutional drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ flexibility due to civil scale
- ✓ the project has a material passport
- × much longer procedure times
- × cultural complexities with contractors
- × certification too expensive

✓ Due to the civil scale of the project, the municipality was flexible with law and regulations, *"the municipality was willing to interpret the rules as broadly as possible"*. The Recht op Wind project also made use of a material passport, which was connected to the C2C certification system (J. Post, 2021).

× The initiator of Recht op Wind has also been a key developer in other (larger) projects and has the idea that with larger projects (more formal) the municipality is less flexible. The initiator also sees that policy is not ready yet for circular innovations (note that the project was developed in 2011) and that larger projects have to stick to all the laws and regulations, which often results in projects being shut down. Civil servants have no space or flexibility, so municipalities must consciously make exceptions to restrictive laws and regulations to make such innovative large-scale projects possible (J. Post, personal communication, November 15, 2021). The municipality of Lansingerland acknowledges that at that time there was no real question of sustainable and circular policy, and consistent policy on those topics only started to develop after 2015. Back then, the municipality played especially a

'testing role' instead of a perhaps more inviting role in which the municipality thinks they can be more successful in the future (R. Crince, personal communication, November 29, 2021). Moreover, in the realization of Recht op Wind, the procedure time was much longer than before suggested by the municipality. There was no clarity about the volume to be built, nor about the certainty of demolition. It gradually became apparent that a new zoning plan had to be drawn up, at the expense of the initiator. This made the initial costs much higher and resulted in a delay of eighteen months (Stedebouw & Architectuur, 2012). The initiator has been in this business for approximately 30 years and notices that there is (slow) progress regarding circularity. Also, he thinks that CE is not necessarily more complex but the lack of knowledge with contractors especially results in cultural complexities. What is meant with this, is that there is a big knowledge gap between the parties (installer, contractor, architect) that have to work together, resulting in conflicting issues on what their own opinions are on developing a building. Moreover, the initiator has made use of the C2C framework but has not actually used the certification company for the development because the certification was not fulfilling for his project. The certification is very expensive, laborious, and there are often conflicts of interest. Therefore, the initiator opted for a more pragmatic approach for ensuring his building would be C2C. He acknowledges that the BREAAAM certification is probably a better functioning and more advanced system for circularity in the building sector (J. Post, personal communication, November 15, 2021).

4.1.3 Case description Biosintrum

Biosintrum is an energy-neutral knowledge center in Oosterwolde that consists of more than 80% of biobased materials and meets. As a knowledge center, the building is a source of inspiration for students and professionals involved in the biobased economy. The Biosintrum has a wooden modular construction that remains visible and gives the building a very natural look. The window frames are from untreated Accoya, the insulating air dome is made of recycled plastic, and the façade cladding is from bio-composite. The floors are covered with a C2C certified carpet. A carpet made entirely from recycled yarn, polyamide 6 (also known from fishing nets), can be recycled for 99% into the same product (Ruiter, 2018).

4.1.3A Technological drivers and barriers at Biosintrum

At Biosintrum, the most important technological drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ built from 80% biobased materials
 - ✓ developed from innovative policy
 - ✓ used other data for development
 - ✓ technical support from manufacturers

 - ✗ biobased materials regulation bans
- ✓ The Biosintrum knowledge center consists of more than 80% biobased materials. The window frames are from untreated Accoya, the insulating air dome is made of recycled plastic, and the façade cladding is from bio-composite. The floors are covered with a C2C certified carpet, carpet made entirely from recycled yarn, polyamide 6 (also known from fishing nets), and can be recycled for 99% into the same product (Ruiter, 2018). The Biosintrum was a pilot experiment from the province of Friesland which was very cooperative in facilitating the project. Moreover, the Biosintrum was also developed as a

practical example of the policy formulated by the municipality of Ooststellingwerf to use the principles of the biobased economy in the areas of living, working, and recreation. The project contributed to raising awareness about CE in the built environment by having excursions regularly and company visits from (construction) companies that want to develop something similar. On top of that, the Biosintrum won the best performing construction prize in 2018 and won the Dutch Construction Award in 2019. However, the initiators of Biosintrum notice that there is still obstructive regulation and they think that while circular projects like theirs will be more common, the government will have to change certain regulations. For example, types of materials that are formally not allowed, that is proven to be successful at Biosintrum will in the future be more convenient to use and subsequently, laws that are obstructing the use of this kind of materials will be changed. During the development of the Biosintrum, there was a lot of technical support from the organization Circular Friesland, an organization founded by the Frisian business community with many parties (contractors, provinces, municipalities) working together to commit to a CE (A. Zwart, personal communication, November 11, 2021). It is interesting to see that collaboration from an early stage had played a significant role in the development of the Biosintrum. Everyone involved came together at an early stage: from contractor to constructor and from client to the installer (Platformduurzamehuisvesting, 2018). The developers think that the construction sector is not as conventional as people think it is anymore, and that it is changing rapidly to a more innovative sector. Major parties such Dijkstra Draisma, Jorritsma Bouw, and BAM are also working on circularity in the sector.

- ✗ The initiator had some issues with biobased materials that were banned by regulation due to the lack of knowledge about practical examples. The initiator thinks that this will hamper demand and therefore slow down production. This means that we need innovative pioneers who work with new materials to set practical examples (A. Zwart, personal communication, November 11, 2021).

4.1.3B Financial drivers and barriers at Biosintrum

At Biosintrum, the most important financial drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ increase in exploitation revenue
 - ✗ relatively expensive due to novelty CE
 - ✗ extra time makes labor expensive
- ✓ The initiator mentions that higher costs are not necessarily a problem. He has experience with similar projects in which a higher rent is paid since this way of (circular) construction is unique and often matches the core of other circular minded companies who are in turn willing to pay more for exploitation (A. Zwart, personal communication, November 11, 2021).
 - ✗ The Biosintrum is about 8% more expensive compared to regular construction projects. This was mostly due to the higher initial costs for the extra time and money to get everything technically in order with regard to construction and materials (A. Zwart, personal communication, November 11, 2021).

4.1.3C Institutional drivers and barriers at Biosintrum

At Biosintrum, the most important institutional drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ part of a new implementation program
- ✓ fiscal support from the government
- ✓ exemptions from the Building Decree
- ✓ winner of Dutch Construction Prize

- ✗ extra complex due to the novelty of CE
- ✗ municipality too closely involved

✓ The construction of the Biosintrum was part of the actions on the biobased economy implementation program, that was launched by the municipality of Ooststellingwerf. Together with its businesses, residents, neighboring municipalities, the province, educational institutions from the region, and other stakeholders they wanted to set in motion a paradigm shift regarding biobased economy (BREEAM-NL, 2019). The province of Friesland was highly involved in the development of the Biosintrum and the business park (Ecommunitypark). Therefore, the largest component for the succession of the Biosintrum was the policy expressed in a sustainable zoning plan. This made the development of this framework possible, and for example, prescribes that only BREEAM certified buildings may be developed in this area (E. Veenhuizen, personal communication, November 30, 2021). The Biosintrum received a provincial subsidy on the condition that the Biosintrum has a 'BREEAM Outstanding' certification. This is the highest attainable ranking in sustainability in terms of construction and use of a building (Leeuwarder Courant, 2020). The municipality of Ooststellingwerf also provided them with €1 million in subsidy and a loan of €1.6 million. Moreover, the municipality and the province were flexible with existing laws and regulations and the building decree (Bouwbesluit). For example, the insulation that was made from old jeans was formally not allowed. The same applied to some loam walls that were considered load-bearing constructions. The municipality of Ooststellingwerf wanted to use the Biosintrum to facilitate business and education in research and innovation regarding the biobased economy and they wanted to have a leading role. As a means to stimulate the local economy, but also to serve the entire country utilizing a practical example. Therefore, the municipality took a proactive stand and was very involved with coordinating the project. Moreover, the initiator does not have the idea that CE is a niche discussion among developers anymore, but he also declares that it depends on which companies you speak to. Currently, the initiators of the Biosintrum are in a collaboration with the Hanze University of Applied Sciences in Groningen to develop a digital system (similar to a material passport, but more in the philosophy of open-source) that can show the materials used in the construction of the building digitally to inspire other actors and enable them to this rather valuable information (A. Zwart, personal communication, November 11, 2021). The Biosintrum was an example project of an integrated approach to biobased materials and circular construction. Therefore, it was awarded the Dutch Building Prize for buildings in 2019 (Luning, 2019).

✗ However, the project Biosintrum was relatively complex because the whole concept of CE is still new to many developers and architects, everything just takes some more time. Moreover, it seems like circular buildings or buildings that are for example BREEAM certified have better exploitation opportunities. This is also noticed at the Biosintrum already, where they get so many applications for exploitation that they sometimes run short on capacity (A. Zwart, personal communication, November 11, 2021). However, during the development, the Biosintrum still did not meet the BREEAM requirements, and if they had not been able to meet those requirements, the province could reclaim the 1 million euros

subsidy that was already paid, which laid a lot of pressure on the developers (Leeuwarder Courant, 2020). Moreover, more recent data from the municipality shows that the board of directors and the council in Ooststellingwerf were so eager to build the Biosintrum that they had too little critical distance. Therefore, they have set up the foundation much too late and did not meet the expectations of involved parties such as companies and schools (potential operators). Partly because of this, the Biosintrum is currently not yet profitable (Rekenkamercommissie Ooststellingwerf, 2021).

4.1.4 Case description Alliander

The Alliander office in Duiven is an office from the Dutch energy grid operator which was completely renovated in 2010. Five of the existing office buildings were transformed into one big sustainable building with the vision of achieving 80% circularity of materials. Materials that were needed were reused as much as possible and decommissioned materials were discharged with so-called “resource passports”. One of the most important characteristics of this renovation was connecting the five buildings. Therefore, an atrium was developed consisting of steel structures that were made of an old rollercoaster construction. Next to that, materials such as bricks and concrete were collected and reused. Additionally, scrap wood was used for façade material and doors and toilet bowls were reused. The Alliander office was built after C2C principles, which is in line with the ambitions of the company (Leising et al., 2018).



4.1.4A Technological drivers and barriers at Alliander

At Alliander, the most important technological drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ technical support from the consortium
 - ✗ the construction sector is traditional
 - ✗ insurance issues circular materials
- ✓ Alliander engaged a consortium of parties, such as architects, builders, property managers, and installers. Through the consortium they noticed signs of a favorable climate for R&D. The company invested in circular and environmentally friendly techniques and for some of them, government subsidies were available. The consortium provided them with all the technical support needed for a successful deployment of the project. According to the spokesman of Alliander, the construction sector is very traditional in the basics, but their innovation demand within European tenders has had an impact on the sector (E. van Drumpt, personal communication, November 24, 2021).
- ✗ For the development of the inner façade, wood from the demolition was used. This wood, however, had no identity because it was waste. Therefore, the properties were unknown and Alliander had to get in contact with TNO to determine the fire resistance. Alliander thinks that if the entire chain would share more information, waste flows can also be given material passports, which makes reusing faster and easier (PBL, 2021a). A lesson from Duiven is also that circular choices can sometimes lead to problems. For example, materials that are reused have no guarantees or certificates that demonstrate certain properties. This can cause insurance problems. For example, during a major leakage in Arnhem, it turned out that the recycled insulation materials in the wall panels had been written off and had no value for insurance. The example shows that circular (re)construction requires different agreements with insurers to assign a new construction value to recycled materials (PBL, 2021a).



4.1.4B Financial drivers and barriers at Alliander

At Alliander, the most important financial drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ cost savings materials and location
 - ✗ insurance issues circular materials
 - ✗ subsidy schemes were not applicable
 - ✗ relatively expensive due to novelty CE
 - ✗ extra time makes labor expensive
- ✓ Because in the development of the office, Alliander reused a lot of materials, they were able to save costs in manufacturing. However, re-use of material has lower material costs but very high additional human costs. On balance, the effect was, however, minimal (E. van Drumpt, personal communication, November 24, 2021). By using recycled steel, copper, wood, and concrete, Alliander has saved an impact of more than 2 million euros for the renovations compared to using new materials (KPMG, 2017). Previously, the offices of Alliander were scattered. The concentration of workspace to this location, together with the sustainable renovation of the Duiven location will ensure savings in accommodation costs over the next fifteen years (Shuco, 2016).
- ✗ The spokesman of Alliander thinks that if we want to continue this path of (circular) development, the tax model in the Netherlands has to change. Labor is currently disproportionately taxed in relation to (raw) materials. Moreover, the circular renovation of the office was probably more expensive than opposing projects, but Alliander thinks this is mostly because the concept was fairly new. However, funding was not the biggest issue at Alliander since the company has the means to invest in such a project on its own. The whole development is seen as study material for multiple value creation, so the company sees the project more as an investment. The subsidy schemes that were running at the time were often not applicable to circular energy-positive buildings such as the head office. The project had higher costs and market uncertainty due to new applications of techniques. For example, due to the use of scrap wood, the reuse of toilets, and insulation material, the labor costs increased (E. van Drumpt, personal communication, November 24, 2021).



4.1.4C Institutional drivers and barriers at Alliander

At Alliander, the most important institutional drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ gather knowledge through Green Deals
 - ✓ flexibility with parking space design
 - ✓ intensive collaboration with authorities
 - ✓ fiscal support through EIA scheme
 - ✓ the project has a material passport
 - ✗ CE is a niche among implementation
 - ✗ extra complex due to the novelty of CE
 - ✗ certification not always provocative
- ✓ The Alliander office was part of the Green Deal Circular Buildings (with knowledge input on energy-positive buildings) and the Green Deal Circular Procurement (GDCl). With the Green

Deals, they were able to collect and share a lot of knowledge regarding CE, and currently, the project is being displayed as an example on governmental websites such as PBL and RVO. Also, the company gives regular tours to all major organizations for CE, real estate clubs, and governments (E. van Drumpt, personal communication, November 24, 2021). For the municipality, it was important to keep a company like Alliander, with a big portfolio of FTEs (about 1500) in their municipality. So they helped facilitate this project, but in a way, it would not give them a pioneering role, because it is the task of the municipality to create an even level playing field for all their entrepreneurs. To facilitate the renovation, however, the municipality looked at restrictive laws and regulations and whether they could work with exemptions where extreme measures had to be taken to promote circular construction (J. Venema, personal communication, January 4, 2022). Moreover, there has been intensive collaboration with nearby businesses and local authorities to improve sustainability, energy, and accessibility. This partnership has contributed to the construction of a fast cycle path between Westervoort station and the Duiven location, a bus stop near the Alliander office, the use of shared bicycles in the industrial area, and the sharing of knowledge in the field of waste separation and energy measures (PBL, 2021a). The fast cycle path and the bus stop were arranged by the municipality because those forms of infrastructure are being tendered by the municipality (J. Venema, personal communication, January 4, 2022). Alliander did also not want to build the minimum allowed parking spaces near the building merely because they did not want to stimulate people coming to work by car. The municipality allowed this since Alliander had an alternative arranged so, in case of high quantities of cars, employees could still park nearby on already existing parking lots. Moreover, the Alliander office in Duiven has a paper raw materials/building passport, and with the development of the office, Alliander also helped to develop the Madaster Platform. An online registry program for registering buildings and the materials and products used in their construction. This initiative is being undertaken in collaboration with Rijkswaterstaat and ProRail as well (E. van Drumpt, personal communication, November 24, 2021). The innovative approach of Alliander their renovation was in line with the wish of the municipality of Duiven to provide space for companies that stimulate the transition to sustainable energy management (J. Venema, personal communication, January 4, 2022). The consortium, Alliander, and the municipality of Duiven have therefore set up the 'Green Alliances Foundation' to make the Nieuwgraaf business park more sustainable (Shuco, 2016). With several government schemes, the company was able to invest in environmentally friendly techniques at a tax advantage. For example, Alliander made use of the Energy Investment Allowance (EIA²) to invest in the solar panels, but also to invest in (sustainable) lighting, ventilation, insulation, glazing, and a heat pump (RVO, 2016). Moreover, there was funding available for the renovation in the form of green bonds. Those are loans whose proceeds are used exclusively for the financing of projects that contribute to the environment. All concerned provinces have 100% of the shares.

- x Regarding the idea, if CE is still a niche discussion among the sector, the spokesman of Alliander thinks that the building sector is indeed a traditional sector. However, among developers, it seems to not be a niche discussion anymore but it is mostly niche among implementation (contractors and workers) (E. van Drumpt, personal communication, November 24, 2021). In the view of the Advisor Environmental Affairs at the Municipality of Duiven (who is a former architect) the construction sector is still a conservative sector that is

² A scheme for CO₂ reduction, energy-efficient techniques and sustainable energy where investment costs can be deducted from the profit (RVO, 2021a).

not open to innovation unless there is a lot of money to be made from it. Companies know that they have to move towards circular construction and that they have to use more sustainable materials, but they seem to prefer to wait until the government has to. Then they immediately have a reason to sell this to their customers instead of having to do this voluntarily (J. Venema, personal communication, January 4, 2022). Moreover, at that time (2014-2015) it was more complex to renovate a circular building because the development of a project like this was fairly new and ambition levels were usually very high for this kind of project. For the certification schemes, the spokesman of Alliander thinks that BREEAM and C2C are fulfilling. However, sometimes these certification schemes can be expensive so in terms of investment, it is not always the best option to certify. Also, they had some issues with their insurance company because they used old materials for the insulation of the facade. After six months they had water damage and the insurance company refused to compensate the company for their damages. Moreover, there were no certificates available for reusing old materials such as demolition wood and indoor cabling. Additionally, at the time of the development, the rules were still very much focused on 'sustainability'. For example, disposing of the toilets was more 'sustainable' than cleaning and reusing the old ones. Moreover, Alliander does not think that people have the idea that sustainability is a trade-off between price and performance, and often they experience the direct opposite. However, most of the times people find it very appealing and unique and the value of their real estate with sustainable certificates is mostly rising (E. van Drumpt, personal communication, November 24, 2021).

4.1.5 Case description 't Eemgoed

Ecobuurtschap 't Eemgoed in Almere is a plot of approximately 7 hectares with 82 homes and a building with shared facilities. The plot is completely car-free and parking is only possible on the edge of the site. The houses are well insulated due to the thick roof package and the earth wall on the north side and solar panels have been installed for the generation of electricity and hot tap water utilizing a heat pump. All of the houses are energy neutral and the gray and black water treatment takes place via a collective water purification system through helophyte filters on the estate itself (Ruyter, 2019).



4.1.5A Technological drivers and barriers at 't Eemgoed

At 't Eemgoed, the most important financial drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ extra support from consultants
- ✗ not everyone wants to be innovative
- ✓ The initiators of 't Eemgoed have hired numerous consultancy parties (10-15 parties and suppliers) for technical support who took into account for example drawings on heat, moisture, collective treatment of waste water, etc. Also, the municipal archaeologists were involved on behalf of the municipality. Other than this, the municipality did not have an active role in this matter (S. Ruyter, personal communication, November 24, 2021).
- ✗ The initiator of 't Eemgoed thinks that it depends on who you speak to if the sector is as conservative as many claims. Not everybody wants or has the ability to be innovative. Their strategy for making sure that they get the right collaborations is to put out their best effort to hire contractors who think alike and are open to new ways of thinking (S. Ruyter, personal communication, November 24, 2021).



4.1.5B Financial drivers and barriers at 't Eemgoed

At 't Eemgoed, there were no financial drivers observed, financial barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- no observed financial drivers
- × the project is relatively expensive
- × labor is expensive due to shortages

×

At the time of the project, there were no financial drivers regarding support from the government. This was mostly because of previous bad experiences with arranging incentive schemes and the fact that they are time-consuming. Additionally, the innovative and sustainable character is more emerging from the personal view of the initiator and a more spiritual view of how a society should look like. Therefore, it seemed 'normal' for the initiator to develop the project this way, instead of pursuing actual political goals regarding circularity. The initiator says that the way 't Eemgoed is built is an expensive form of building. All on one floor, semi-detached bungalow construction, a landscape roof, and only 82 homes on 7 hectares, so a relatively low density of 12 homes per hectare. However, people are willing to spend more money on such a house due to the additional communal house, office spaces, and large meeting space. Moreover, high costs of labor are mostly because the costs have increased due to the shortage of people in the sector building sector, not because the work was that deviant (S. Ruyter, personal communication, November 24, 2021).



4.1.5C Institutional drivers and barriers at 't Eemgoed

At 't Eemgoed, the most important institutional drivers and barriers that appeared from both secondary (literature)- and primary (interviews) data were:

- ✓ zoning plan encourages innovation
- × bad experience incentive schemes
- × utility services can be obstructing

✓

The municipality of Almere has drawn up a zoning plan with a broadened scope (bestemmingsplan met verbrede reikwijdte) for the development of Oosterwold. Such a plan is the predecessor of the Environmental Plan from the Environment Act. With this zoning plan, initiators are given a lot of freedom in regards to development and this plan is more aimed at invitation planning instead of admission planning. This zoning plan was developed so that governments can prepare for the integrated approach that will be required with the environmental plan (BZK, z.d.; Omgevingsweb, 2018). When the Environment and Planning Act - scheduled for January 1, 2022, will enter into force, all existing zoning plans will be regarded as an environmental plan (Koppers, 2021). This was a very important factor for the feasibility of 't Eemgoed. Over the years, the initiators have attempted to realize similar projects. They first conducted a feasibility study in Brummen, in the period 2010 - 2013. It concerned a plan of 20 hectares of estate with 24 landscaped houses. This created a lot of chaos among the farmers in the area. The fear was that farms would be 'locked' (prohibition on expansion) due to the arrival of an estate. Subsequently, they made a plan for Apeldoorn. However, the municipality of Apeldoorn had only just come out of a serious financial crisis. Therefore, there was a great need for predictability and little room for innovative initiatives. Next, they received an invitation from the

municipality of Almelo, but this municipality got into political trouble, and the municipality was placed under financial supervision. That turned out to be more than enough to end a promising development. In Oosterwold, the planning was ready, building was possible, landscape architecture is possible, and self-sufficiency is possible. 't Eemgoed is currently seen as an example project by the province of Flevoland. The deputy of the province has paid 't Eemgoed a visit and thinks that the project is very inspirational for what housing construction means for in the province in the near future (S. Ruyter, personal communication, November 24, 2021).

X

The municipality was not flexible with existing laws and regulations, all the regulations that applied at the project location stayed in place. Moreover, although 't Eemgoed has sustainable qualifications, the initiators deliberately did not invest time to arrange incentive schemes because the initiator did not have good experience with them. According to him, the chance of success is very low and it could take a lot of extra time. Additionally, the government was not necessarily proactive but the municipality has acted as a facilitator since the whole zoning plan was designed in a way that suits the project very well. So in essence the government did coordinate by means of policy and working out 'this' special way of development. This is done by the municipalities of Almere and Zeewolde, the Central Government Real Estate Agency, the province of Flevoland, and the Zuiderzeeland Water Board. Concerning the utility services (the infrastructural facilities) such as water, gas, sewage, and emergency services were sometimes obstructing in the development since some of these services have such strict regulation that it is very complex to work around them. This means as a developer that this is costing a lot more time and money (S. Ruyter, personal communication, November 24, 2021).

4.2 Conclusion drivers and barriers

This paragraph answers the sub-question: "What are the main drivers and barriers that facilitate circular innovations in the Dutch building sector?". To answer this sub-question, this paragraph is divided into the three parts, technological, financial, and institutional drivers and barriers, with a focus on the institutional aspects. At the end of this paragraph (Figure 6), those general conclusions are visualized.

Technical drivers and barriers

Technical support appears to be an important technological driver for most circular innovations. And this seems to involve the whole sector, so from collaborations with manufacturers, contractors, and installers, to support from consultancy parties, consortiums, and water boards. This is actually the opposite of what was determined by the conceptual framework, which suggests there is a lack of technical support. A noteworthy technological barrier that was observed is that those certified materials (that are circular) seem difficult to find and that certifying reused materials is not common and required a lot of effort.

Financial drivers and barriers

The most relevant observation regarding the financial drivers is that circular construction projects appear to currently be more expensive than regular projects but it also seems that these extra costs can, partly, be covered by increased exploitation opportunities and certifications (such as BREEAM) that add to the value of the real estate. This was not observed by the literature on which the conceptual framework was developed and can, therefore, be considered an important addition to the literature regarding this topic. However, additional research would have to determine if this observation is actually in line with the generality of the sector. Moreover, the reason that circular projects are currently

more expensive is due to the novelty of the concept and the therefore extra time needed for developing these 'new' types of projects. Also, the labor-intensive character of reusing materials and the additional costs for certifications make circular projects more expensive compared to their regular projects. This can be considered a financial barrier and these observations are well in line with expectations from the conceptual framework.

Institutional drivers and barriers

Bureaucratic innovations, flexibility from laws and regulations, and exemptions from certain laws (i.e. the Building Decree) that obstruct innovations appear to be important drivers for circular innovations to succeed. Additionally, it was observed that when spatial planning and policy is aimed at innovation and circularity, it becomes much more convenient for particular circular innovations to develop. Also, making use of material passports seems to be an important aspect for circular innovations to emerge since they are important criteria for certifications methods such as C2C and BREEAM. Moreover, regarding the institutional barriers, there is an increasing demand for circular construction, which demands a lot from the quality of contractors, installers, and workers. But there seems to be a shortage of builders and installers for circular construction. Besides, it appears that there is a big gap in CE knowledge between architects, contractors, and workers which often results in cultural complexities (e.g. conflicting situations in which architects demand installers for rather impractical applications).

Overview of most relevant drivers and barriers per category

Figure 6 (below) highlights the most relevant drivers and barriers per category. This overview was created to be able to quickly see which drivers and barriers were observed for each category and every individual circular innovation. On the y-axis, the circular innovations are displayed, from top to bottom: Ecodorp, Recht op Wind, Biosintrum, Alliander, and 't Eemgoed. On the x-axis, the categories technological, financial, and institutional are separated to quickly see the results per category. The check marks indicate that the mentioned factor is a driver and the cross indicates that the mentioned factor is a barrier.

	 Technological	 Financial	 Institutional
	<ul style="list-style-type: none"> ✓ houses are CO₂ positive ✓ used similar projects for development ✓ extra support from the government ✓ coupled with similar projects 	<ul style="list-style-type: none"> ✓ financing from bank ✓ exemption from sewerage tax ✓ extra income through ecotourism 	<ul style="list-style-type: none"> ✓ innovative bureaucracy ✓ exemptions from the Building Decree ✓ subsidy from the EU, state, and province ✓ the project has a material passport
	<ul style="list-style-type: none"> ✗ initial house shape was not possible 	<ul style="list-style-type: none"> ✗ difficulty getting financing ✗ high-risk profile for innovation ✗ relatively expensive due to novelty CE 	<ul style="list-style-type: none"> ✗ extra complex due to high ambition ✗ the high-risk profile for innovation ✗ the construction sector is not progressive
	<ul style="list-style-type: none"> ✓ first C2C house in the Netherlands ✓ used other data for development ✓ technical support from manufacturers 	<ul style="list-style-type: none"> — no observed financial drivers 	<ul style="list-style-type: none"> ✓ flexibility due to civil scale ✓ the project has a material passport
	<ul style="list-style-type: none"> ✗ C2C materials not available 	<ul style="list-style-type: none"> ✗ relatively expensive due to novelty CE ✗ uncertainties lead to higher costs 	<ul style="list-style-type: none"> ✗ much longer procedure times ✗ cultural complexities with contractors ✗ certification too expensive
	<ul style="list-style-type: none"> ✓ built from 80% biobased materials ✓ developed from innovative policy ✓ used other data for development ✓ technical support from manufacturers 	<ul style="list-style-type: none"> ✓ increase in exploitation revenue 	<ul style="list-style-type: none"> ✓ part of a new implementation program ✓ fiscal support from the government ✓ exemptions from the Building Decree ✓ winner of Dutch Construction Prize
	<ul style="list-style-type: none"> ✗ biobased materials regulation bans 	<ul style="list-style-type: none"> ✗ relatively expensive due to novelty CE ✗ extra time makes labor expensive 	<ul style="list-style-type: none"> ✗ extra complex due to the novelty of CE ✗ municipality too closely involved
	<ul style="list-style-type: none"> ✓ technical support from the consortium 	<ul style="list-style-type: none"> ✓ cost savings materials and location 	<ul style="list-style-type: none"> ✓ knowledge and support Green Deals ✓ flexibility with parking space design ✓ intensive collaboration authorities ✓ fiscal support through EIA scheme ✓ the project has a material passport
	<ul style="list-style-type: none"> ✗ the construction sector is traditional ✗ insurance issues circular materials 	<ul style="list-style-type: none"> ✗ insurance issues circular materials ✗ subsidy schemes were not applicable ✗ relatively expensive due to novelty CE ✗ extra time makes labor expensive 	<ul style="list-style-type: none"> ✗ CE is a niche among implementation ✗ extra complex due to the novelty of CE ✗ certification not always provocative
	<ul style="list-style-type: none"> ✓ extra support from consultants 	<ul style="list-style-type: none"> — no observed financial drivers 	<ul style="list-style-type: none"> ✓ zoning plan encourages innovation
	<ul style="list-style-type: none"> ✗ not everyone wants to be innovative 	<ul style="list-style-type: none"> ✗ the project is relatively expensive ✗ labor is expensive due to shortages 	<ul style="list-style-type: none"> ✗ bad experience incentive schemes ✗ utility services obstructing

Figure 6 Summary of the institutional, technological, and financial drivers (✓) and barriers (✗)

4.3 Governmental mechanisms for transformative change

Sub-question 2 'Which governmental mechanisms can be identified that can accelerate transformative change?' was answered through the results of the drivers and barriers chapter and the analysis of the municipal interview data. The interview questions (Appendix 3) were based on the small-wins framework (Termeer and Metze, 2019) to find clear mechanisms for policy intervention and facilitation (which are elaborated in the discussion and recommendations). For the interviews, the most involved persons from the concerning municipalities of the five selected circular innovations were interviewed. For each of the municipalities, the most important findings of the primary (interview) data regarding the small-wins framework are explained below. The six mechanisms used are (following the conceptual framework); energizing, learning by doing, the logic of attraction, the bandwagon effect, coupling, and robustness. Secondary (literature) was used in case the municipality was unaware if they were conducting a certain mechanism, or when other (governmental) actors were already doing this (e.g. province, ministry, or other actors). Below is a description of each individual mechanism and whether it is currently being conducted by the municipalities and in what way they are being deployed.

4.3.1 Energizing

The energizing mechanism 1), states that governments can and should encourage actors to be innovative and that focusing on problems can be counterproductive. Moreover, it notes that the observable result of a small win and the mutual trust between actors can encourage actors to look ahead for the next possible small win, to keep seeing concrete results and therefore, contributing to the accumulation of small wins, to subsequently, reinforce the transitional pathway towards a CE.

It was observed that municipalities showed trust and encouraged innovation by granting exemptions from regulation, providing subsidies on circular conditions, and by innovative zoning plans. The municipality of Boekel had trust in Ecodorp (H. van Zutven, 2021) and encouraged them to be innovative by granting them exemptions from the Building Decree because there were too many restrictions for the project to be innovative (InfoMil, 2020). Therefore, Ecodorp was able to test non-certified circular (building) materials which makes them a testing ground for many companies that want to develop sustainable products (Ecodorp Boekel, 2016). The municipality of Duiven showed their trustworthiness by granting Alliander exemption of the minimum allowed parking spaces and cooperation regarding the bus stop and bicycle lanes. At Biosintrum, the province played its part with the provincial subsidy on the condition that the Biosintrum had a 'BREAAAM Outstanding' certification. This is the highest attainable ranking in sustainability in terms of construction and use of a building pushing their sustainability goals to a higher level (Leeuwarder Courant, 2020). This certification criterion additionally made the results of Biosintrum observable (i.e. one more BREEAM certified building on the business park), and therefore this can be considered a small win. Moreover, in Almere, the municipality encouraged innovation at 't Eemgoed with their 'circular vision', which provided them with space to make innovation possible and in which there was a pre-agreed percentage of public green space, water, and (urban) agriculture (BZK, z.d.; Gemeente Almere, 2013). This is considered a small win because it enabled the initiators of 't Eemgoed to successfully develop their project (after being rejected by other municipalities) and possibly encourages the initiators to look ahead for similar projects.

4.3.2 Learning by doing

The learning by doing mechanism 2), is more focused on the idea of trial-and-error. It states that broadening and deepening come from initiatives that simply start and try something out and learn from it. For example, innovations can lead to uncovering resources that were invisible before which can subsequently lead to new innovative ideas. Therefore, experimentation results in new experiments, and whether these experiments are successful or not, they always result in new ideas. Governments can accelerate this by, for example, organizing exchange activities.

It was observed that, by granting exemptions from regulation, experiments could take place. Also, by experimenting with circular renovation, new insights were obtained on possible barriers to circular construction. Moreover, at one municipality, exchange activities were organized to stimulate the learning by doing mechanism. Because Ecodorp was granted exemptions from the Building Decree, they were able to test non-certified circular (building) materials which made them a testing ground for many companies that wanted to develop sustainable products (Ecodorp Boekel, 2016). For example, this enabled Ecodorp to test a circular power cable, which they are currently developing with an international cable company, to see if they can make this industry more 'circular'. Moreover, for the development of the inner façade of the Alliander office, wood from the demolition was used. This wood, however, had no identity because it was waste. Therefore, the properties were unknown and Alliander had to get in contact with TNO to determine the fire resistance. Also, it made the project its costs higher since the labor costs increased because developing a façade from recycled wood was very labor-intensive. However, this gave Alliander important insights into how they should renovate in the future, and how the 'circular transition' should be designed. Moreover, only at the municipality of Ooststellingwerf, it was observed that the municipality organized exchange activities. Those activities take place at the 'Biosintrum foundation' which is commissioned by the municipality, where exchange activities and tours are organized regularly (E. Veenhuizen, 2021).

4.3.3 Logic of attraction

The logic of attraction mechanism 3), is about the positive influence that projects can have on political and societal resistance. For example, concrete successes can make other actors want to be part of the initiative and support it. Governments can for example play a role in advocating circular innovations with awards or subsidies, to reward the actors who pursue systemic change and increase their credibility.

It was observed that governments made use of subsidies to reward the circular innovations and other (non-governmental) organizations awarded them with prizes. Ecodorp was subsidized by the province of Noord-Brabant, the European Union, and the Ministry of Economic Affairs and Climate (Ecodorp Boekel, 2016), and the Biosintrum was subsidized by the province of Friesland (Leeuwarder Courant, 2020). Moreover, it seems that the municipality of Almere had a stimulus fund for circular activity available from which 't Eemgoed possibly could have made use of (Gemeente Almere, z.d.; Overheid, 2020). However, the initiator of 't Eemgoed did not attempt to make use of this because *"the chance of success for receiving grants is very low and it just takes a lot of extra time"* (S. Ruyter, 2021).

Governmental actors, however, seem to have not awarded any of the circular innovations in question but this was mainly done by non-governmental organizations. For example, the organization 'Duurzaam Gebouwd' rewarded Ecodorp with the Circular Ring for the most

sustainable organization in the Netherlands. Moreover, the Biosintrum was awarded the Dutch Building Prize for buildings in 2019. Also, Recht op Wind had been awarded the Rotterdam Architecture Prize. However, the Rotterdam Architecture Prize is in collaboration with the municipality of Rotterdam but is only focused on architecture and not innovation or sustainability (Architectuurprijs, 2015). It seems that most of the companies that arrange those prizes are commercial companies. However, some of the companies that arrange those prizes are indirectly connected to a governmental organization.

4.3.4 Bandwagon effect

The bandwagon effect mechanism 4), the phenomenon where people act because they are inspired by others, also called 'exemplary leadership', is selected as an important governance mechanism since governments have the authority and the network to share inspiring projects with other stakeholders.

It was observed that on both an informal- and formal scale the municipalities shared the results of the circular innovations with other actors and that the success of Alliander inspired other actors to develop circular. It seems, however, that municipalities are hesitant with sharing circular innovations with other actors because they are responsible for creating an even level playing field for all developers or due to conflicting municipal politics. On an informal scale, the municipality of Boekel shared the results of Ecodorp with other actors. They did not formally share the results of Ecodorp because they do not have a (political) agenda for this and because it is a sensitive matter in municipal politics (H. van Zutven, 2021). Also, the province of Noord-Brabant shared the results of Ecodorp on multiple websites (Klimaatadaptatie Brabant, 2018; Provincie Noord-Brabant, 2020) and in various other research and policy and the Ministry of BZK³ and RVO⁴ have shared the result of Ecodorp to inspire other actors (Koninkrijksrelaties, 2019; RVO, 2021c). Moreover, the spokesman from the province, who was responsible for the funding, indicated that Ecodorp Boekel was a pioneer in its field (since they were the first ones to developed large scale circular housing that perfectly matched the provincial ambitions) and therefore they granted Ecodorp as a pilot experiment for a later showcase of 'best practices'. This enabled, the initiators of Ecodorp to raise awareness internationally (e.g. EU GEN⁵ symposium in 2018), by giving presentations at various (international) events. An example is the Communities for Future⁶ project in which they create awareness among the ministry and national government (A. Vlems, personal communication, November 12, 2021). It was observed that the municipality of Lansingerland sometimes used Recht op Wind to inspire other actors because Recht op Wind was one of the first 'zero on the meter' house in the Netherlands. However, this was often mainly informal or internal. It does seem to have had an impact on inspiring other actors since the initiator of Recht op Wind got assigned many new projects in the field of circular construction (J. Post, personal communication, November 15, 2021).

3 Ministry of the Interior and Kingdom Relations of Netherlands

4 Dutch Enterprise Agency

5 Global Ecovillage Network

6 Communities for the future is the European network for community-led initiatives on climate change and sustainability, which is funded by the EU (Communities for Future, z.d.).

The municipality of Lansingerland sometimes used *Recht op Wind* to inspire other actors because *Recht op Wind* was one of the first 'zero on the meter' house in the Netherlands. However, this was often mainly informal or internal (R. Crince, 2021). Moreover, the municipality of Ooststellingwerf, shared the results of Biosintrum with other actors by means of the 'Foundation Biosintrum'. This foundation is currently run by external parties on behalf of the municipality (E. Veenhuizen, 2021). The municipality of Duiven also informally shared the results of Alliander with prospective buyers and companies that wanted to build sustainable or circular and it seemed to have resulted in a 'spin-off' for other companies that wanted to start circular projects (J. Venema, personal communication, January 4, 2022). Additionally, because the renovation of the Alliander office was part of two Green Deals, Alliander was able to collect and share knowledge regarding CE. Also, with the Green Deal Circular Buildings, they contributed to a Circular Passport & Manual that was published by the ministry to assess the circularity of buildings. It seems, therefore, that the Green Deals are also an important governance mechanism that can inspire and help developers reach their (circular) targets. The Alliander renovation is also being displayed as an example on governmental websites such as PBL and RVO (PBL, 2021c). Moreover, Alliander gives frequent tours at their renovated office. For example, in 2016, a total of 230 different groups were given a tour of the Alliander office with more than 5,000 (external) people who were interested in the circular way in which the building was renovated and how the tender took place. As a result, Alliander inspires other parties to act in a sustainable and integrated manner to renovate real estate. Various parties now have concrete plans to follow Alliander its example, such as the Central Government Real Estate Agency (renovation of the Royal Library) and OVG Real Estate (KPMG, 2017). However, this seems to be mostly initiated by Alliander themselves.

4.3.5 Coupling

The coupling mechanism 5), says something about how innovations can accumulate and be coupled together to enable them to touch upon other topics. Governments can, for example, bring together circular innovations for knowledge sharing or use project results for their political agenda.

It was observed that, some municipalities or other governmental actors brought this project together with similar projects or that they used the project for their political agenda. The province of Noord-Brabant assigned Ecodorp as a pilot experiment. Therefore, the initiators were able to raise awareness at various (international) events. So it seems that those ministerial organizations were already aiming to bring together complementary knowledge. The municipality of Boekel also brought Ecodorp together with like-minded projects. For a similar reason, the municipality noticed that those actors were working on similar topics and they thought that they could strengthen each other. For example, they brought Ecodorp Boekel into contact with the local food forest because the municipality thought that the food forest could provide good input concerning the food garden in the Ecodorp. In addition, they also brought Ecodorp into contact with the Boekel Energy initiative because the municipality had the idea that Boekel would have interesting input from Boekel Energy (H. van Zutven, 2021).

At the municipality of Ooststellingwerf, this is innovative companies are brought together through the Foundation Biosintrum, where various network activities are organized and circular companies are connected (E. Veenhuizen, 2021). The municipality specifically set up this foundation because they knew that it would help them reach their political targets

and that it would help the community since there was no such thing in the area yet. Although the municipality of Duiven did not bring Alliander together with other projects, they see that the construction of the Alliander office has resulted in a 'spin-off' for other companies that want to build circular (J. Venema, personal communication, January 4, 2022). Moreover, the municipality of Ooststellingwerf declares that when they, as a municipality would be more facilitating in this, the results of the concerning projects would be all the more interesting, because it then would concern a collaboration between the municipality and the company. If they would do this in such a way, it would probably become more convenient for the municipality to share this experience again to inspire others and this would also make it easier to use project results for their political agenda. Moreover, the municipality of Ooststellingwerf notices that there is probably still great gain to be made by, for example, approaching established entrepreneurs, and therefore focusing more on existing companies (E. Veenhuizen, personal communication, November 30, 2021).

4.3.6 Robustness

The robustness mechanism 6), is saying something about the strength of the institutional change, in which there is a point of no return were going back to the linear models is very difficult. Governments can play a role in framing circular innovations as experiments or they can rearrange existing policies to make innovations possible.

It was observed that municipalities made innovation possible by innovative and progressive zoning plans or by assigning circular innovations as experiments. It seems that there is a transition happening towards a more 'circular' model based on the observations made at both the municipalities at Ooststellingwerf and Almere. For example, the requirement for buildings to attain a BREEAM certification at Ooststellingwerf (E. Veenhuizen, personal communication, November 30, 2021), and the zoning plan with a broadened scope in Almere. Both these requirements have made the circular innovation possible (S. Ruyter, personal communication, November 24, 2021). Ecodorp was assigned as a pilot experiment by the province, which made innovation possible. And while at Ecodorp there was no formal objective of the municipality of Boekel, they asked the developers to be involved in the development of the sustainability plan and the sustainability agenda of the municipality. This could mean that the new policy at Boekel could be promising regarding circularity (A. Vlems, personal communication, November 12, 2021).

4.4 Conclusion governmental mechanisms

This paragraph answers the sub-question: “Which governmental mechanisms can be identified that can accelerate transformative change?”. From the analysis, I conclude that the governmental mechanisms (as described in the conceptual framework) energizing, learning by doing, logic of attraction, bandwagon effect, coupling, and robustness were all observed (Table 4) but varied increasingly in the strength of the mechanism.

Table 4 Overview of the observed mechanisms coupled to the institutional drivers- and barriers

Mechanism	Institutional drivers
Energizing	<ul style="list-style-type: none"> ✓ exemptions from regulation to stimulate innovation ✓ subsidy on condition of circularity ✓ innovative zoning plan
Learning by doing	<ul style="list-style-type: none"> ✓ granting exemptions from regulation ✓ outsourcing network activities
Logic of attraction	<ul style="list-style-type: none"> ✓ governmental subsidy ✓ awards (non-governmental)
Bandwagon effect	<ul style="list-style-type: none"> ✓ (in)formally sharing circular innovations with other actors ✓ inspiring other actors ✓ part of Green Deal
Coupling	<ul style="list-style-type: none"> ✓ raise awareness globally ✓ bringing together actors ✓ project results for municipal agenda
Robustness	<ul style="list-style-type: none"> ✓ innovative zoning plans ✓ circular certification requirements ✓ assigning project pilot experiment

Municipalities can facilitate innovation by granting exemptions from regulation because sometimes regulation is too restricting. This governmental intervention has also led to new insights in the field of circular construction. It seems that there is a shortage of certified materials, that certification can be complex (and too expensive), and that circular construction or renovation is very labor-intensive. Also, exemptions that were granted which contributed to innovation will (after evaluation) be formally legalized, therefore, contributing to the enforcement of circular construction. Moreover, when governmental actors provide subsidies on circular conditions, as a result of strict certification criteria it can assure or even increase circularity targets. Also, this very concrete ‘certification’ makes the small win very observable and contributes to the accumulation of other small wins. However, the complexity of the circularity requirements can also increase the complexity of the circular innovation or put extra pressure on the developers. Moreover, municipalities can enable circular innovations to take place by developing innovative zoning plans, because most innovations simply require this ‘new’ type of area development for their project to be successful. Also, when municipalities share the results of ‘successful’ projects with other actors it can stimulate these actors to become more circular. Moreover, it was observed that municipalities brought together similar projects and therefore contributed to knowledge sharing on CE.

4.5 Expert review

To review the results of this study in contrast with the Dutch building sector and to test the initial findings of this study an expert on this topic was interviewed. The expert was presented several interesting observations that resulted from the data analysis.

Innovative and circular zoning plans are important for innovation

Observation 1, When a municipality or province encourages innovation by means of innovative policy or progressive zoning plans, it becomes a lot more accessible for project initiators to develop their circular innovation. For some developers, this was even a precondition to settle in the concerning municipality. Therefore, an important finding is that innovative and circular zoning plans are important for circular innovations to settle.

This was acknowledged by the expert. If a municipality has a policy plan that is geared for circularity and sustainability, it becomes a major driver in facilitating these kinds of initiatives. On the other hand, if a municipality does not have this kind of policy in place, this can be a major barrier, in which an initiator has to be very proactive to succeed, and not everyone is able to do so (V. Gruis, personal communication, January 12, 2022).

Municipalities are prone to capacity issues (both in time and knowledge)

Observation 2, Municipalities mostly do not have the time (and money), or the knowledge to facilitate circular innovations. It was also observed that circularity was just not prioritized because it yields less in terms of social and economic value. Therefore, it seems that municipalities are prone to capacity issues (both in time and knowledge).

This was acknowledged by the expert. Municipalities frequently have to deal with capacity problems (time and knowledge), which often makes it difficult to develop this type of innovative policy. Civil servants do develop policy and implement it, but they already have their hands full with regular planning processes and permit applications, which are often most focused on energy savings, leaving less room for circular construction. In the future, the environmental law potentially offers more opportunities to introduce circular aspects at the forefront of the development of new or existing areas. But the municipalities (except for some larger municipalities) will still have a lack of knowledge on (the preconditions for) circularity and what is practically feasible to stimulate developers (V. Gruis, personal communication, January 12, 2022).

Subsidy can be important for innovations to emerge

Observation 3, For some circular innovations, being part of a subsidy program was important for successful development while for others it had no role at all. It was also observed that subsidy schemes were sometimes not accessible or too difficult to apply for. However, all of the developers succeeded in the completion of their circular innovation. Therefore, it seems that subsidy only plays a moderate role for innovations to emerge.

This was acknowledged by the expert. In practice, it seems that there are only a few developers who qualify or have the knowledge to initiate such a trajectory. Also, only a minority of municipalities will be able to get granted those subsidies because this can be a complex and time-consuming trajectory and in reality, only a handful of municipalities will manage. However, there may be an opportunity for municipalities to help get projects off the ground with their partners through European subsidy applications and regional investment funds, and this can often provide the extra resource for municipalities to hire additional staff. The issue however with these types of subsidies is that they are 'project

based', so not structural. And in his opinion structural funding is necessary to make the transition towards a CE possible (V. Gruis, personal communication, January 12, 2022).

It seems that material passports are an important innovation for CE to emerge

Observation 4, Currently, digital systems such as material passports are being developed on different fronts by different actors. Sometimes a material passport was applied as part of certification criteria and sometimes it was done based on own motivation. The philosophy is that when a building would be using a material passport, it would become a source of raw materials in the future. And therefore, it could protect national economies from a possible future economic crisis caused by running out of raw materials. So, when the entire construction chain should share more information, the waste flows can also be given material passports, which makes reusing faster and easier. Therefore, it seems that material passports are an important innovation for CE to emerge.

The expert is rather skeptical about the importance of a material passport. It is still unclear how important it will be to introduce a materials passport. The conclusion is that we should perhaps be cautious about making materials passports mandatory for new buildings because especially for existing buildings it is extremely expensive to do this inventory. Applying for a materials passport as part of a precondition for a demolition permit, on the other hand, may be more interesting. Also for new construction, it is possible to collect all the data at the front, but when a building will last for 50 years, we can wonder what the costs (or maybe energy consumption) of keeping this data will be (V. Gruis, personal communication, January 12, 2022).

It seems there is a shortage of builders and installers for high-demand circular construction

Observation 5, There is increasing demand for circular construction, which demands a lot from the quality of contractors, installers, and workers. Therefore, people indicate that circular construction is expensive because on the one hand, it takes more time, due to the novelty of circular construction but also because reusing materials is labor-intensive, and it is hard to get qualified employees.

This was acknowledged by the expert. Especially the reuse of material is often labor-intensive. This makes it extremely important to industrialize new construction projects as much as possible (so, as labor-extensive as possible) so that we will keep hands free for renovation, which is often very labor-intensive work (V. Gruis, personal communication, January 12, 2022).

There is a big gap in CE knowledge between architects, contractors, and workers

Observation 6, It seems that CE is not a niche discussion anymore among developers but that it is mostly unknown among implementation (contractors and workers). This often results in cultural complexities between architects, contractors, and workers. Therefore, there is a big gap in CE knowledge between architects, contractors, and workers.

This was acknowledged by the expert. However, the reason for this could be that the architect is too distant from practice. Architects are very good at devising concepts (e.g. biobased, biomimicry) but they are not the ones who have to practically realize it. Contractors are open to these new concepts, but contractors are also only the connecting factor of the production industry and the workers behind it. This requires a transformation of the building sector as a whole (V. Gruis, personal communication, January 12, 2022).

5. Conclusion

This chapter answers the main research question on the role of municipalities in facilitating circular innovations. What the current role of municipalities is in facilitating circular innovations seems to depend much on the scale of the project, the (local) political attitude, but also on the perseverance, experience, and ambition of the initiator. It was observed that when initiators and municipalities are taking steps towards circular construction, based on their own desire and energy, and when the visions of local authorities match those of the initiators, circular innovations are successfully developed. By identifying the mechanisms responsible for both the drivers- and barriers it was possible to determine which interventions should be targeted to activate the propelling character of the small-wins mechanisms, to reinforce the circular pathway of development. This chapter firstly discusses the technological and financial category followed by the more elaborate institutional category.

Technological

Contrastingly with what the conceptual framework tells us, technical support appears to be an important technological driver for most circular innovations. And this seems to involve the whole sector, so from collaborations with manufacturers, contractors, and installers, to support from consultancy parties, consortiums, and water boards. Two governmental mechanisms were observed by which this driver was facilitated. Ministerial organizations shared the results with other (relevant) actors (bandwagon effect) and municipalities brought together similar projects (coupling). However, municipalities seem to only share results informally with other actors and do not regularly bring similar projects together, because there are simply no formal procedures for this. Noteworthy technological barriers that were observed are that certified materials seem difficult to find and that certifying reused materials requires a lot of effort. An observed governmental mechanism to overcome these barriers was enabling participation in the Green Deal Circular Buildings and the Green Deal Circular Procurement (bandwagon effect).

Recommendation: It is recommended that municipalities start to actively develop procedures for governmental intervention to structurally couple relevant (circular-minded) actors. This can enable innovations to accumulate and strengthen the transitional pathway towards a CE and it can perhaps solve the issue of certification by enabling actors to share information or touch upon other relevant topics.

Financial

It seems that circular construction can save costs in manufacturing by re-using old materials and recycling materials such as steel, copper, wood, and concrete. Additionally, it enables to save costs when not using 'traditional' resources (e.g. the sewage system), it can generate extra costs by increased exploitation opportunities or eco-tourism, and certifications can add to the value of the real estate. However, circular projects are currently more expensive is due to the novelty of the concept and the therefore extra time needed for developing these 'new' types of projects. Also, the additional costs for certifications and the labor-intensive character of reusing materials make circular projects more expensive compared to their regular projects. Especially, considering that labor is currently disproportionately taxed in relation to (raw) materials.

Recommendation: While circular construction is still a novel concept, municipalities should continue to encourage actors to be innovative (energizing), be supportive by, for example, granting exemptions from regulation (learning by doing), or provide them with financial means to overcome those financial barriers (logic of attraction). The ministry should revise its policy regarding the heavy taxation of materials in comparison to labor.

Institutional

Firstly, an important institutional driver for project initiators to successfully develop their circular innovations is when municipalities play a facilitating role by means of innovative and progressive zoning plans. This governmental mechanism (robustness) can be considered as one of the most important interventions that municipalities currently have to enable innovation. Especially, considering that municipalities seem to have capacity issues (both in time and knowledge).

Secondly, flexibility from laws and regulations, and exemptions from certain laws (i.e. the Building Decree) that obstruct innovations appear to have been important institutional drivers for circular innovations to succeed. Two mechanisms for governmental intervention were observed by which this driver was facilitated. Encouraging actors with granting exemptions from the Building Decree, and relieving obstructing regulations, enables developers to successfully develop their circular innovations and test innovative non-certified circular (building) materials (energizing). Also, exemptions that were granted, which contributed to innovation, will (after evaluation) be formally legalized and, therefore, contribute to the reinforcement of policy regarding circular construction (robustness).

Thirdly, there is an increasing demand for circular construction, which demands a lot from the quality of contractors, installers, and workers. However, there seems to be a shortage of builders and installers for circular construction, which is increasing the costs of labor, and thus, increasing the costs of circular construction.

Recommendation 1: Municipalities should address the capacity issue by initiating collaborations with circular pioneers (in their region) to continue developing suiting zoning plans. Such a zoning plan should be developed as an inviting plan that is not framed as a blueprint (or regulative framework) but as a plan for (circular) opportunities. Such a plan should have strict regulations in the field of circular construction, assign waste as valuable secondary material, and for example, prefer recycled concrete over new concrete. Moreover, it should designate the circular economy as one of the central aims for the coming decades and possibly link it as a sub-goal to tasks such as a vital economy and sustainability.

Recommendation 2: Municipalities do not have the authority to change regulation but they can use laws such as the Crisis and Recovery Act (Chw) to temporarily deviate from the Building Decree and enable innovation. In which way the municipalities in this study have contributed to the coming into existence of these laws for deviation is not known but it is recommended that municipalities continue to stimulate innovative pioneers by critically reviewing laws that hinder innovation.

Recommendation 3: Because circular construction is more time-consuming, it might become important for ministries to develop a policy that aims to industrialize new construction projects as much as possible (so, as labor-extensive as possible). In this way, the Dutch building sector keeps its hands free for renovation, which is often very labor-

intensive work, to ensure the Netherlands will reach its targets of becoming completely circular by 2050. Moreover, municipalities could advise local schools to offer more detailed studies regarding circular construction or open-up knowledge-sharing facilities to accumulate and spread (new) knowledge (learning by doing). Additionally, when there are no practical examples, municipalities could stimulate others to experiment (energizing) or develop a 'testing ground' for innovation to make sure that practical examples will be more common and obstructive regulation can be lifted.

6. Discussion and recommendations

This research explored the main drivers and barriers that facilitate or hinder circular innovations in the Dutch building sector and looked at the governance mechanisms that could accelerate the transition towards a CE. This chapter starts with the validity of the research. Afterward, it elaborates on the conclusions by interpreting the results, linking them to the expectations, and giving recommendations. Subsequently, this chapter will discuss the limitations and possible implications of this research followed by suggestions for further research.

6.1 Validity

To enhance the external validity of the research, this study has attempted to generate generalizable outcomes. It asks the question of how well the outcome of this research can be expected in similar settings. Therefore, to guarantee the results of this exploratory study, contrasting types of circular innovations were selected (Chapter 3) to create an overlap in knowledge about different types of circular innovations. An additional criterion was that circular innovations were located in different parts of the Netherlands, to ensure that different 'types' of municipalities were selected and potential differences between them could be observed. The most important findings of this study could be relevant for every emerging circular innovation. This is similar for the governmental mechanisms, which can provide insightful suggestions to municipalities who are facing similar issues. Therefore, this study has contributed to the acceleration of the transition towards a CE.

6.2 Limitations

This is an exploratory study and provides an indication of Dutch municipalities. This study selected municipalities that were involved with circular innovations. It could, therefore, be possible that other municipalities (which were not examined) deal with circular innovations differently. This was, however, not explored in this study. Therefore, it could be that the governmental mechanisms that were observed will not occur in every 'similar' situation. Also, using five circular innovations to determine the role of municipalities in the whole Dutch construction sector might not be sufficient. Moreover, in some regions, there are already more circular innovations than in others. Since this project has spoken with pioneers on the topic of circular construction, it is only logical that these were successful. This, however, does not mean that this is the case for the rest of the industry. Therefore, the results of the specific circular innovations might not give a good view of the construction sector as a whole. For example, the idea that CE is still a niche discussion (according to the conceptual framework) was refuted as initiators had mostly positive experiences with contractors and architects. However, all respondents (so initiators and municipalities) were already intrinsically motivated by circular construction, and the network of the initiators was mostly filled with like-minded people and often those partners again were specifically selected for their circular vision. On the one hand, this could have enhanced the internal validity because I wanted to see the role of municipalities at those particular circular innovations, and these initiations and municipalities were exactly what I asked. However, to make a transition towards a CE possible, developers and municipalities that are not yet familiar with circular construction should additionally be involved. Following studies should, therefore, also look at contrasting cases that do not have anything to do with CE.

6.3 Drivers and barriers

Innovation in zoning plans and capacity issues at municipalities

This study shows that innovative and circular zoning plans seem important institutional drivers for circular innovations to emerge. However, municipalities are prone to capacity issues (both in time and knowledge) to plan and design such zoning plans. A possible explanation for this is that when provinces or ministries stimulate circularity by providing municipal funds, they seem to underestimate the amount of work it requires civil servants. Also, municipalities are mostly involved in a regulating way and currently do not have any formal procedures to actually gain knowledge on this subject. Since municipalities are not involving innovative initiatives, this can be considered a counterproductive governmental intervention with regards to the energizing mechanism. Moreover, the political playing field seems to play an important role as well. A possible explanation for this is that the political ambitions mainly last for four years and municipalities are therefore more inclined to invest in projects such as road construction, and regular housing. It was also observed that municipalities that are already equipped with progressive plans are often already personally inclined towards sustainable development. However, despite the lack of time municipalities seem to have been supporting many of the projects. These circular innovations would not have been possible if the municipalities would not have been actively involved in the development of the circular innovation. A possible explanation for this can be that the concerning initiators were very proactive. This could mean that for less proactive developers it might be much more difficult to develop similar projects.

Recommendations: Municipalities should make sure that circular development is encouraged and made possible through environmental visions and zoning plans that are well suited for this new way of development. Municipalities should address the issue of capacity by inviting circular developers in their region and start to collaborate about the new environmental visions (as was observed at Boekel). After all, this is not a job for the municipality only and if municipalities and companies work together, the chances are likely that they even suit the needs of developers better. Moreover, municipalities should be proactive and open to suggestions and/or changing obstructive legislation to make sure that developers can continue circular innovations. Also, use the new Environment and Planning Act (Omgevingswet) as momentum to develop such policy. Especially considering that the new Environment and Planning Act (Omgevingswet) will be put into operation this year. Some of the basic principles of the new Environment and Planning Act are that procedures will become more convenient, that policy is open to new initiatives and developments, that there is more room for sustainable development, and that outdated rules (that currently hinder innovation) will be removed. Additionally, the crisis and recovery law that has been discussed a number of times in this study is also being integrated into the new law along with countless other laws (Waterstaat, 2013b).

Knowledge gap in the construction sector

There seems to be a big gap in CE knowledge between architects, contractors, and workers which often results in cultural complexities. A possible explanation for this is that architects sometimes seem too distant from reality and contractors and workers are too attached to their current ways of production. However, the knowledge gap may also exist based on the fact that it still remains a search on what circularity is exactly. Even when developers or clients are open to circular construction, they wonder if there are guidelines or regulations for

circular construction. This makes it even harder for circularity to become normalized in the construction sector.

Recommendations: Governmental organizations should make sure that circularity will be defined properly and that policy documents that are already available about this topic also reach developers and construction companies to get them to understand the core principles of CE.

Be cautious with making material passports mandatory

Material passports are currently seen as a crucial part of bridging the 'information gap' between relevant actors in the building sector and they seem to be important criteria for certifications methods such as C2C and BREEAM. Most circular innovations in this study are making use of a material passport or aspire to develop such a system at their own pace because they deem it necessary for a CE to function. Also, the Dutch government has asked the RIVM and the Netherlands Environmental Assessment Agency (PBL) to develop such a system called the 'Raw Materials Information System' (GRIS). The GRIS system is currently under development step by step to determine which characteristics are necessary and how to use a system like this in practice. It is probably a good case that multiple initiators are developing such a system because all these pilots together could determine what kind of system will be most viable. The Dutch ministry will decide this year whether a material passport will be mandatory for the construction sector. It is proven that such digitalization can indeed speed up development and it might be important for the transition towards a CE. Moreover, material passports could protect national economies from a possible future economic crisis caused by running out of raw materials. However, we should be cautious with the way this will be deployed because generally speaking, buildings last for 50 years and it will consume a lot of energy to store all this data for such a long time. Moreover, it is extremely expensive and time-consuming to do such inventories, and we are already running on short capacity. Also, there is currently a lack of data regarding the exact composition of construction products, and methods such as C2C or LCA are not common yet.

Recommendations: Be hesitant with making material passports mandatory, there are still a lot of uncertainties to implement such a trajectory. However, it could be wise to start with applying for a materials passport as part of a precondition for a demolition permit. Also, see if it is possible to assign circular buildings an extra category in the BAG⁷ (Basic Registration Addresses and Buildings) to ensure the Dutch government has an overview of what has to be done to reach the goal of 100% circularity in 2050.

Subsidy trajectories are complex and often out of reach

For some circular innovations, being part of a subsidy program was important for successful development while for others it had no role at all. It was also observed that subsidy schemes were sometimes not accessible or too difficult to apply for. A possible explanation for this is that in practice, it seems that there are only a few developers who qualify or have the knowledge to initiate such a trajectory. Also, only a minority of municipalities will be able to get granted those subsidies because this can be a complex and time-consuming trajectory and in reality, only a handful of municipalities will manage. However, there may be an

⁷ The BAG (Basic Registration Addresses and Buildings) contains municipal basic data of all addresses and buildings in a municipality (BZK, 2014)

opportunity for municipalities to help get projects off the ground with their partners through European subsidy applications and regional investment funds, and this can often provide the extra resource for municipalities to hire additional staff. The issue however with these types of subsidies is that they are 'project based', so not structural. And structural funding is probably necessary to make the transition towards a CE possible.

Recommendations: Municipalities should be more coordinating and informing about subsidies. Moreover, municipalities can look at ways to stimulate cost recovery while circular construction is still more expensive so that developers are less in need of subsidy. For example, by stimulating eco-tourism. Not only to increase the revenue for the circular pioneers but also to inspire others to live sustainably or build circular, and strengthen the transitional path towards a CE. Also, if we want to make circular construction more accessible, we have to look at the current tax model. Currently, labor is disproportionately taxed in relation to (raw) materials. While labor is so necessary for using secondary materials as a crucial factor in CE.

6.4 Small-wins

This study showed that there is room for improvement since most mechanisms that were observed are not performed by the municipalities themselves but are initiated by developers or commercial companies. However, it must also be noted that some activities can actually not be practically executed by municipalities but are always a collaboration between different actors in the industry.

Important factors for innovation (energizing)

Important factors for innovation seem when municipalities are flexible with laws- and regulations and for example, grant exemptions from the Building Decree. This can be considered a small win (energizing) since municipalities, through this form of cooperation are helping the circular innovations reach their 'circular targets' and let them be innovative. However, this call for exemptions in the search for circularity is mostly initiated by the developers themselves. So if the municipality is encouraging them to be innovative remains the question but they do 'enable' them to reach their targets. A possible explanation for this is that the current focus of municipalities is mostly on projects such as road construction, and regular housing that is part of their 'political' agenda. Also, with the 'conservative' awaiting and controlling municipal culture it only seems logical that if something like this happens, it must be from an external party. Moreover, it seems that when subsidy schemes play a role, they can amplify innovation potential since most subsidy conditions have strict requirements, ensuring that circular innovations will be completed in a truly circular manner and that cuts for circularity are not made in a later stage. However, it was also observed that this can, up to a certain ambition level, make requirements much more complex, resulting in unpractical ambitions or withdrawal of subsidy leading to financial issues.

Recommendations: In the coming decades' municipalities might have to change their attitude from a strictly controlling, to a more cooperative and inviting role to support developers that aspire to develop circular. The cooperating role which was observed might be a result of personal affinity with sustainability so we have to make sure that for municipalities of other governmental organizations, where there is a less personal affinity with these subjects, there will still be structural attention to these kinds of topics. Moreover, working with subsidy schemes and thereby raising the ambitions of developers seems like a positive thing for stimulating innovation. However, governments that grant those subsidies

should be careful when pushing developers and therefore look for the right balance in pushing for innovation, but also make sure that the destined innovations are executable.

The importance of exchange activities (learning by doing)

Municipalities seem to be aware of the importance of exchange activities but they appear to not have the time or are not sure if they are the right actor to initiate such activities. A possible explanation for this is again, due to the capacity issues. However, it also seems that the current culture on how municipalities act is changing. Instead of a controlling role, it seems to become more important to play an inviting and cooperative role, and this big institutional change just takes some time. However, at the municipality of Ooststellingwerf, the actual opposite was observed. The foundation Biosintrum was specifically developed to stimulate networking regarding circularity and sustainability because the municipality realized that these kinds of activities are too different from their initial planning but are still very much needed. This can be considered a small win (learning by doing) since exchanging innovations could lead to uncovering resources that were invisible before which can subsequently lead to new innovative ideas. Moreover, as part of the Communities for Future project, Ecodorp was part of some exchange activities that were organized by the EU. Also, the ministry organized an exchange activity on-site to inspire Dutch policymakers. However, projects from the EU are usually not structural, and the exchange activity from the ministry seemed to be exceptional.

Recommendations: To accelerate the transition towards a CE, governmental organizations will have to look for ways to make exchange activities more common. Maybe, governments can set up additional foundations such as the Biosintrum or even assign certain places as a testing ground for circular developments. In this way, developers will be stimulated to be innovative and those potential innovations possibly lead to new innovative ideas. Moreover, municipalities and other (local) governments should embrace the new culture in which governments will play a much more cooperative role. The policy should be redeveloped to make more time and possible knowledge available to make this happen.

Role of subsidies and awards in innovation (logic of attraction)

It seems that governments can have an important role in advocating circular innovations by subsidies. Nonetheless, the level of importance of subsidies seems to depend much on the sort of project and the type of developer. At 't Eemgoed, the developer did not attempt to get a subsidy because it would take a lot of extra time and the chances of success are relatively low. A possible explanation for this is that in practice, applying for subsidy is very complex and initiators 'almost' have to be a researcher or experts on relevant empirical knowledge to meet the subsidy requirements. Therefore, there are only a few developers who qualify or have the knowledge to initiate such a trajectory. Moreover, all circular innovations in this study have won prizes except for 't Eemgoed which is in its final stage of development. This can be considered a small win (logic of attraction) because it enables developers to become aware of their positive influence and it might make it more attractive for other developers to pursue similar projects. The organizations that have rewarded prizes however are all non-governmental organizations. A possible explanation for this is again, the capacity issues and priority of the governments. However, some companies that present awards seem to have collaborations with governmental organizations, and some governmental organizations are indirectly involved.

Recommendations: Municipalities or other governmental bodies should invest more time in making subsidy schemes more attainable for the general public. Perhaps municipalities

and provinces or the ministry can collaborate on this. The ministry or province (mostly responsible for granting the subsidy) could make the application process more 'practical' and municipalities should be more involved in the application of such subsidies. Moreover, municipalities and other governmental bodies should invest more time in rewarding successful innovative projects to stimulate circular development and thereby contribute to accelerating the transition towards a CE.

Informal- and formally sharing results (bandwagon effect)

It was observed that most municipalities have the conception that they do not share the results with other actors but they seem to do so internally or informally. The reason they are not aware of this seems because this is not a part of a formal procedure but mostly happens informally. However, it seems that other (governmental) actors are formally sharing the results of the circular innovations. This was observed at Ecodorp (by the ministry and RVO), at Recht op Wind (by many architectural magazines), at the 'Biosintrum Foundation', and at Alliander (by PBL and RVO). It seems that Ecodorp now is used by the province to inspire other municipalities to encourage similar projects and the initiator of Recht op Wind received many new assignments in the field of circular construction based on his project. Also, it seems that various parties now have concrete plans to follow Alliander its example, such as the Central Government Real Estate Agency (renovation of the Royal Library) and OVG Real Estate. This can, therefore, be considered a small win (bandwagon effect) because sharing this information could lead to more circular initiatives in the region as is already observed by the municipality of Duiven.

Recommendations: Municipalities notice the importance of (informally) sharing project results but they do not have any formal procedures for doing so. Therefore, they should evaluate whether this is already being done sufficient to determine if they could, for example, formalize this process to make this a more common mechanism.

Coupling projects and usage for political agenda (coupling)

It seems that municipalities, currently do not pursue to actively couple projects together. On an informal scale, however, it was observed at the municipality of Boekel. Also, whether the municipality of Ooststellingwerf is actively involved in bringing innovative projects together with the Biosintrum Foundation remains uncertain and for the time being, this foundation appears to be mainly used for exploitation opportunities. A possible explanation for the fact that municipalities do not actively couple projects together is again that there are no procedures for this and they are probably unaware of the necessity (for the initiators or CE in general) or the possible benefits it could bring them. However, the municipality of Duiven indicates that the construction of the Alliander office has resulted in a 'spin-off' for other 'circular-minded' companies. This can be considered a small win (coupling) because this means that the establishment of the Alliander office has contributed for circular companies to 'accumulate' in the municipality, therefore contributing to the transition towards a CE. However, it can only formally be marked as a small win when the government would have had an active role in the realization, and if that is the case remains unanswered. Also, it seems that none of the municipalities have used the project results for their agenda. A possible explanation for this is that for example, in the municipality of Boekel, this project was a rather sensitive subject and was 'politically' not popular. Moreover, at Lansingerland the municipality only noticed the importance of the project when it was realized, and therefore they were hesitant with actually using those results because they simply did not contribute. However, it seems that (thanks to these experiences) municipalities are aware

that when they would be more actively involved in such projects it would be more compelling to use such projects for their political agenda.

Recommendations: If municipalities would from day one be more involved with circular innovations, it would be much more convenient to see whether the project is in line with their ambitions. If projects are in line with the political ambitions, municipalities should therefore be more cooperative to support the concerning project but also to benefit from this themselves in a later stage by being able to share the project results and thus use these results for their agenda.

Continuing institutional change (robustness)

It was observed that when the projects were developed in the period 2010-2015 (Recht op Wind and Alliander), there was no or little attention regarding circularity. Now, this seems to have changed with the innovative policy that was observed at the Biosintrum and 't Eemgoed that makes innovation and circular development possible. Therefore, it seems that the institutional change for CE in the construction sector is continuing. This can be considered a small win (robustness) because the strength of the institutional change, therefore, seems to be increasing. A possible explanation for this is that there is more attention nowadays for (the effects of) climate change (e.g. IPCC reports) and sustainability and nationwide programs are equipped to stimulate this circular or sustainable transition. Also, the fact that global agreements such as the SDGs became more compelling could explain why in the recent five years there seems to be more attention to this topic.

Recommendations: Municipalities sometimes seem unaware of each other their existence and sometimes see each other even as competition. This should change, and municipalities should make more use of collaborations so that not every municipality has to re-invent the wheel every time.

6.5 Further research

Future research should focus on the limitations of this study. For example, to make a transition possible towards a CE, developers and municipalities that are not yet familiar with circular construction should additionally be involved. This will enable us to determine if the institutional change that is observed by this study is the case for the whole sector. Moreover, there is probably still great gain to be made by, for example, approaching established entrepreneurs, and focusing on existing companies that are not personally motivated by CE. Therefore, future studies should find ways to identify entrepreneurs that are potentially interested in circular entrepreneurship. Moreover, it is unknown in what way the organizations that present the awards were involved with the concerning municipalities or other governmental bodies. Also, which actor initiates these awards, and what the reason is for those actors to present such awards is unknown. Therefore, future studies should identify in what way the actors are connected to and what their motivations are to determine if this particular governmental mechanism can be strengthened. It also seems that municipalities are not aware of the national- and international policy programs that are running to move towards a circular economy. Therefore, the following studies should determine what the knowledge is within governmental institutions about these types of policy programs, and in what way they are being implemented. Additionally, what exactly the share of the Green Deal was, at, for example, Alliander, that enabled them to collect and share knowledge regarding CE is currently unknown. Therefore, further studies should look into the role of

Green Deals at circular innovations to determine whether it is useful to make more use of Green Deals to remove barriers.

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Appendix 1, overview participants interviews

Table 5 Overview of the participants for the interviews

Circular innovation	Project initiator	Function	Date
Ecodorp	A. Vlems	Project initiator	12-11-2021
	H. van Zutven	Municipality Boekel (head of the department)	23-11-2021
Recht op Wind	J. Post	Project initiator	15-11-2021
	R. Crince	Head of urban planning (2011) municipality Lansingerland	29-11-2021
Biosintrum	A. Zwart	Project initiator	11-11-2021
	E. Veenhuizen	Team leader municipality Ooststellingwerf	30-11-2021
Alliander office	E. van Drumpt	Spokesman Alliander	24-11-2021
	J. Venema	Advisor Environmental Affairs	04-01-2022
't Eemgoed	S. Ruyter	Project initiator	24-11-2021
	-	-	-
Expert	Prof.dr.ir. V. Gruis (Chairman of the Transition Agenda)	Professor on Housing Management and Departmental Chair of Management in the Built Environment at the TU Delft	12-01-2021

Appendix 2, interview questions initiator

Table 6 Interview questions project initiator

No.	Question	Code	Category
1	Did local political attitude influence the succession of your project?	influence political attitude	Institutional drivers
2	Was the concerning municipality flexible with existing laws and regulations concerning your project?	flexibility laws and regulations	

3	Did you get support for recycling- and reuse efforts (e.g. in the form of incentives) for your project?	recycling- and reuse support		
4	Did the municipality coordinate and take a proactive stand to stimulate your project?	municipal coordination		
5	Did you notice any obstructing laws and regulations in the development of your project?	obstructing laws and regulations		Institutional barriers
6	Do you feel like your project (within CE) remains a niche discussion among developers?	CE niche discussion		
7	Do you have the idea that your project (within CE) is relatively complex to conduct?	CE relatively complex		
8	Did you experience troubles in marketing for your project due to the lack of consumer awareness?	lack of consumer awareness		
9	Do you have the idea that certification schemes are scarce and that existing certification is not fulfilling for projects like yours?	certification scarce/ not fulfilling		
10	Do you think that the users of your project have the idea that sustainability is a trade-off between price and performance?	consumer perception trade-off		
11	Was your project part of a living labs/pilot's experiment?	living lab/pilot	Technological drivers	
12	Did your project (being a part of a pilot) contribute to raising awareness about CE in the built environment?	raise awareness		
13	Did your project make use of an ICT system (material passport, GRIS) for future reuse?	ICT or material passport		
14	Did your project make use of open-source data to help speed up development?	open-source data		
15	Did your project notice signs of a favorable climate for R&D?	favorable climate R&D	Technological barriers	
16	Did a lack of data on circular business models lead to low pressure in removing obstructing regulation for your project?	low pressure removing obstructing regulation		

17	Did you have (technical) support during the development of your project (a project with a small network)?	technical support	
18	Did a lack of data on proven technologies or other large-scale demonstration projects lead to issues in your project?	lack of proven technologies	
19	Did you get the idea that the building sector was wary of innovation, uncollaborative, or risk-averse in realizing your project?	sector wary of innovation	
20	Did your project get any sort of financial support (e.g. reduction on VAT from the government)?	fiscal support	Financial drivers
21	Was your project able to save/recover costs in manufacturing and waste management or from a reduction in price from secondary materials?	cost savings and recovery	
22	Does your project make use of extra service or sales of products to meet low-cost competition?	extra service	
23	Do you think that your project (within CE) is more expensive than opposing similar projects?	CE is more expensive	Financial barriers
24	Was funding limited for your project (due to lack of data on for example avoided impacts)?	funding	
25	Did your project have high initial costs and market uncertainty (which led to high investment costs)?	high initial costs	
26	Did your project seem to have a poor business case (since sustainable innovations and their benefits are poorly understood)?	poor business case	
27	Did your project notice high costs of labor, or relatively higher costs of labor related to non-circular projects?	high labor costs	

Appendix 3, interview questions municipality

Table 7 Interview questions concerned municipality

No.	Question	Code	Category
1	Did the municipality encourage the project to be innovative?	Energizing	Small-wins
2	Did the municipality organize exchange activities (such as network activities)?	Learning by doing	
3	Did the municipality subsidize or reward the project in question (presentation of prizes)?	Logic of attraction	
4	Did the municipality share the results of this project to inspire other actors?	Bandwagon effect	
5	Did the municipality bring this project together with similar projects?	Coupling	
6	Did the municipality use the project results for their political agenda?	Coupling	
7	Did the government frame the circular innovation as an experiment?	Robustness	
8	Did the government frame circular innovations as experiments or rearrange existing policies to make innovations possible?	Robustness	

Appendix 4, codebook

Table 8 codebook

Primary code	Category
Local political attitude	Institutional drivers
Flexibility with existing laws and regulations	
Supporting CE initiatives	
Support for recycling- and reuse	
Governmental coordination	
Obstructing law and regulation	Institutional barriers
Supporting linear economy practices	
CE is still a niche	
CE is too complex	
CE is more expensive	
Lack of consumer awareness	
Certification schemes are scarce	
Existing certification is not fulfilling	Technological drivers
Consumer perception trade-off	
Living labs/pilots	
Raising awareness	

Availability of ICTs	Technological barriers
Open-source data	
Favorable climate for R&D	
Reduce risk associated with CE	
Lack of data	
Limited funding	
Low pressure removes obstructing regulation	
Lack of technical support	
Lack of proven technologies	
The sector is wary of innovation	
Sector is uncollaborative	Financial drivers
The sector is risk-averse	
Fiscal support	
Reduction in VAT for CE	
Cost savings and recovery	
Waste management	
Extra service or products (re- and upcycling)	
Improved margins	
Reduction price secondary materials	
Meet low-cost competition	
Limited funding	Financial barriers
CE is more expensive	
High investment costs	
Need for green financial innovation funds	
Poor business case	
Insufficient knowledge about benefits CE	
High labor costs	

Table 9 Primary codes based on the mechanism's conceptual framework

Primary code	Category
Energizing	Small-wins
Learning by doing	
Logic of attraction	
Bandwagon effect	
Coupling	
Coupling	
Robustness	