Proactively dealing with climate change impacts in the construction sector.

A single-case study on proactive circular activities by a contracting company in the Dutch construction industry

Gert-Jan Troost

P5 Report

Colophon

Personal details:

Name: Gert-Jan Troost
Student number:
E-mail address:

Graduation details:

University:	Delft University of Technology
Master:	Architecture, Urbanism and Building Sciences
Master Track:	Management in the Built Environment
Document:	P5 – report
Date:	27 October 2020
First Mentor:	Prof. Dr. P.W. (Paul) Chan Professor Design and Construction Management, TU Delft
Second Mentor:	Dr. ir. E.W.T.M. (Erwin) Heurkens Assistant professor Urban Development Management, TU Delft
Delegate of the board of examiners:	S. E. (Salomon) Frausto Director of Studies Berlage Center for Advanced Studies in Architecture and Urban Design, TU Delft
Internship mentor:	R. (Rebecca) Leising Engineering deparment, J.P. van Eesteren.

Abstract

Climate change effects lead to a transformation of our environment. The building sector is considered to have the greatest potential in the clean energy transition. However, general consensus of climate change definitions, communication and cooperation on climate change knowledge and perspectives is underdeveloped in the industry. A review of previous studies shows that the construction industry is known to take a reactive stance rather than proactive towards climate change action. The aim of the study is to describe how the implementation of circular principles as part of climate change action, is managed by a construction company, and to explore how this can be done proactively. Through desk research and interviews with representatives of the case firm this description is developed. The findings show that both a proactive strategy by the company as individual proactive behavior by employees can have a big impact on the performance regarding circular activities. People who are showing proactive circular behavior need to be supported and given recognition by the organization. The other way around, these people can triumph and establish organization-wide implementation of their initiatives through issue selling and perseverance. People who are not showing proactive circular behavior will need to be made aware, informed and motivated to conduct circular practices.

key words:
climate change mitigation, climate change adaptation, circular economy, proactive behavior, construction firms

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Readers guide

This P5-report presents my final graduation research report. In the first chapter, an introduction to the topic of this study given. In the second chapter, the results of a systematic review of previous studies are presented, followed by the formulation of the problem statement in chapter three.

In the fourth chapter, the main research question is formulated, as well as four sub-research questions. For each sub-question the type of research and data source is given. The fifth chapter presents the methodology. Decisions on the type of research approach are explained and the research design is presented. To conclude, each part of the research design is elaborated on in-depth.

The sixth chapter presents the case company used for this study and explains how the methods for data collection are applied to this case. The seventh chapter presents the findings from the data analysis.

In the eight chapter, the findings are discussed and compared to existing theory, conclusions are drawn and recommendations are made. This report ends with a reflection on the work and the graduation process in the final chapter.

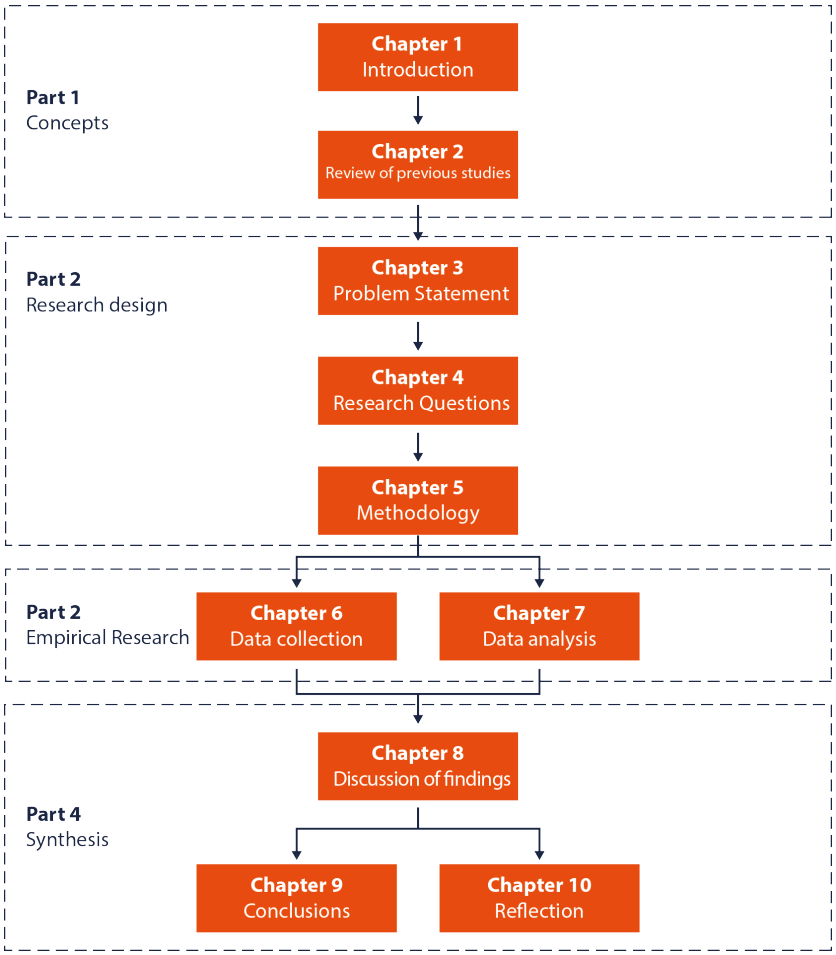

Figure 1: Reading Guide (own illustration).

1

Introduction

1 Introduction

1.1. Climate change and the built environment

Climate change impacts on natural and human systems can have damaging effects. Increases in extreme weather events, such as more warm temperature extremes, higher sea-levels and heavy rain events (IPCC, 2014) all affect the safety and livability of our built environment. This imposes many new risks to countries and the built environment, such as flooding risks, overheating in cities and low air quality, all threatening both ecosystems and human health. In their fifth assessment report of climate change, the Intergovernmental Panel on Climate Change (IPCC) made projections of future scenarios. Their definitive projection, which has been taken over by most of the international community, predicts that if no action is taken to reduce the emissions and adapt to inevitable changes, the likelihood of extensive and severe impacts has a very high confidence (2014). Hurlimann et al. assigns human population growth, industrialization and urbanization as the driving forces that are responsible for a big chunk of this transformation of our environment. “Especially urban areas are a key source for climate change” (Hurlimann et al., 2018, p.235).

In 2017, the building construction and building operations sector was accountable for 36% of the global energy use and 40% of carbon dioxide emissions (UN Environment and International Energy Agency, 2018, p. 10). Although progress by the building sector is made, knowledge on climate change action in the building sector is dispersed (Wilson & Rezgui, 2013, p. 303).

1.2. Difference climate change mitigation and adaptation

For the definition of climate change the one provided by Merriam-Webster is used: “significant and long-lasting change in the Earth’s climate and weather patterns” (Meriam-Webster, 2019). The previously mentioned climate change impacts are the manifestation of this long-lasting change on earth’s ecosystems and human systems. To soften the effects of these impacts, people can take mitigative and adaptative measures. This distinction in climate change action is of importance, as it constitutes two very different approaches to the issue at hand.

Climate change adaptation measures aim to adjust the system under impact to adapt to the new expected situation. It accepts that a change will happen and does not try to minimize the impact of that change. Example given, the average temperature rises and therefor buildings will need new cooling systems.

Climate change mitigation measures on the other hand aim to reduce the impact of the change. Example given, using materials or methods for construction that will lead to lower carbon dioxide emissions. Lower carbon dioxide emissions will lead to lower climate chance impacts than the original construction material or method would.

If mitigation and adaptation measures are taken successfully, the resilience of the system under impact is increased. The resilience of the system (which can be a social, environmental or economic system) is

its capacity to cope with the negative effects of climate change, maintaining its function and structure (Chalmers, 2014, p.18).

1.3. International Agreements on climate change

In the Paris Agreement of 2015, as a response to the projections made by the IPCC, 195 countries committed themselves to a number of goals to reduce the emission of greenhouse gasses. The main goal of the participating countries is to limit the rising of the average temperature on Earth to a maximum of two degrees Celsius compared to the pre-Industrial Age and preferably to a maximum increase of 1.5 degrees Celsius (Paris Agreement, 2015, p.21). The participating countries have also set their own goals in their nationally determined contributions.

The building sector is considered to have the greatest potential in the clean energy transition. According to the latest Global Status Report by the UN, the building construction and building operations sector accounts for 36% of the global energy use and accounts for 40% of carbon dioxide emissions in 2017 (UN Environment and International Energy Agency, 2018, p. 10). Despite this potential, the global building sector keeps growing and carbon dioxide emissions by the building sector keeps increasing by 1% each year (UN Environment and International Energy Agency, 2017, p. 4).

This does not mean there are no improvements made by the construction industry. The energy intensity of the built environment is improving, meaning the intensity of carbon emissions are reducing and many opportunities exist for energy-efficient and low-carbon solutions to be deployed (UN Environment and International Energy Agency, 2017, p.4). Thus, the construction industry is becoming more efficient in terms of emissions, but as the industry grows as well, the total amount of emissions has not decreased yet. This shows more action is needed.

Where reducing carbon dioxide emissions is a form of climate change mitigation, measures of climate change adaptation are equally necessary. As climate change impacts are inevitable and can only be partially mitigated, a combination of mitigation and adaptation measures is necessary. In the construction industry, inadequate adaptation can pose a serious issue, as a significant part of the existing building stock is expected to become obsolete due to damage from climate change impacts (de Wilde & Coley, 2012). The reason for this is the typical longevity of buildings. The long life-cycle of buildings not only makes them less resilient to climate change effects, but also leads to the risk of energy use ‘lock-in’, which means that any building for which its performance is not optimized will need energy for its whole life-cycle that could have been mitigated (Chalmers, 2014, p. 5). The long lifespan of buildings also implies a certain inertia for the construction sector’s ability to respond to changes. This calls for a need for the industry to take long-term climate change effects into account in their development and construction process (Hurlimann et al., 2018, p.235).

1.4. The Dutch construction industry

After signing the Paris Agreement in 2015, the Dutch government worked on their strategy to meet the goals set internationally. They set national goals and developed a set of measures to meet these goals. The complete package of measures is laid out in the “Klimaatakkoord” (trans. Climate Agreement), made definitive by the government in June 2019.

Central to the Dutch national Climate Agreement, is the target to reduce the level of greenhouse gas emissions in the Netherlands by 49 percent compared to the level in 1990 (Ministry of Economic Affairs and Climate, 2019, p.9). To achieve this, different targets have been set by the government for each sector of the Dutch society.

The required contribution of the built environment to the national reduction target of

49%, is a reduction of 3,4 Megaton of carbon dioxide emission by 2030. For the construction industry this implicates that about 1,5 million existing homes will need to be renovated and about 1 million extra Megaton of carbon dioxide has to be reduced in the non-residential sector (Ministry of Economic Affairs and Climate, 2019, p.18). The government has acted on these goals over the past years by introducing new legislation, such as a minimum energy label C for office buildings; every new-built dwelling has to be off the gas-grid and from 2020 on; and all new-built residential and non-residential buildings have to be in line with Nearly-Zero Energy requirements.

However, the latest edition of the yearly evaluation report by PBL Netherlands Environmental Assessment Agency, a government body that provides a yearly assessment of the current environmental state of the country and its prospective on the effects of the policies in place, states that the Netherlands currently has achieved a 15% greenhouse gas emissions reduction compared to 1990 (PBL, 2019, p.6). This means more than double of what has been done so far, needs to be achieved by 2030 to meet the 49%-reduction target. Thus also on the Dutch national scale, there is a need for more action.

There are various concepts for companies to draw from and act on climate change. One of these concepts that is gaining a lot of momentum over the past years is the Circular Economy. The Dutch government has set the goal for the Netherlands to be a fully circular economy by 2050, meaning no more waste is produced through its economic activities and all resources used are from renewable sources. By 2030, they aim to be at 50% of this goal (Ministry of Economic Affairs and Climate & Ministry of Economic Affairs, 2016, p.7). Currently the Dutch government pronounces their intentions, but has attached no regulations or laws that force industries or companies to take action (this is their intention in a later stage of their proposed transition). The government does stimulate innovations on towards a circular economy through financial packages. Thus, there are no prescriptions for the Dutch construction industry on how to become fully circular by 2050, only that they have to be it by 2050. This means some proactive behavior is required from the industry itself.

1.5. The Circular Economy

Our current economy is known as a ‘take-make-waste’ economy, meaning we extract (often non-renewable) resources, turn them into products through production processes and eventually use them until they are of no use and dispose them (Ellen MacArthur Foundation, 2019). As mentioned, these processes lead to enormous greenhouse gas emissions, as most of the economy depends on fossil fuels. Switching to a circular economy can be an important step towards the reduction of these emissions and thus to meeting the goals mentioned in the previous subchapters. This is also the reason the Dutch government has expressed their intentions to make this change.

The difference between a take-make-waste economy and a circular economy in which waste becomes resource again, can be illustrated by using the terminology of resource cycles. Resource cycles, or loops are currently still linear as explained. These loops can be closed, slowed and narrowed. Closing loops means that through recycling the loop of resource flow is closed as waste is recycled into a reusable product. Closing will eventually mean no new resources would be theoretically needed for the same amount of products. Slowing loops means prolonging the (functional) life of products through for example repairs or optimizing designs. This should result in a ‘slower’ need for new resources. Narrowing loops means that through optimizing resource efficiency of products, less resources are used

per product (Bocken et al. 2016, p.309). The narrowing of loops is already being applied in our current linear economy and is therefor a less distinctive feature of the circular economy model. Figure 2 depicts a visual representation of closing, slowing and narrowing loops, compared to the linear economy model.

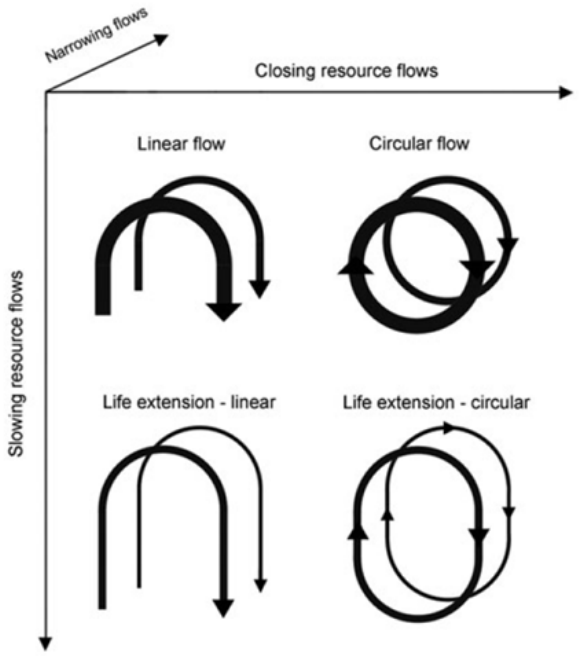

Figure 2. Comparison of resource loops between the linear and circular economy model, depicting the closing, slowing and narrowing of resource loops. (Adapted from "Categorization of linear and circular approaches for reducing resource use" by Bocken et al., 2016, p. 309).

The most widely seminal definition of the circular economy is the model developed by the Ellen MacArthur Foundation (Geissdorfer et al., 2017; Kirchherr, Reike & Hekkert, 2017). Based and incorporating 7 different schools of thought on circularity, they developed a concept of the circular economy as "an industrial economy that is restorative or regenerative by intention and design" (Ellen MacArthur Foundation, 2013, p.7). Kirchherr, Reike & Hekkert took on the challenge to derive one conceptualization of the circular economy. Their study started from the initial notion - and confirmed this notion - that there is an abundance of concepts of the circular economy and that this 'circular economy babble' poses as an obstacle for research (2017, p. 228). Their analysis showed that the definition provided by the Ellen MacArthur Foundation was indeed the most used, yet was used only 11 times in their sample of 114 definitions still. Combining the variety of definitions, they made an attempt to derive one general definition.

Therefor, for this study the definition given by Kirchherr, Reiker & Hekkert is used: "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations" (2017, p. 229).

Although a mouthful, this definition provides a comprehensive view of the circular economy concept, mainly three distinctive features: 1) the means of reducing, reusing, recycling and recovering; 2) the acknowledgement of the different levels involved; and 3) the environmental, economic and social aspect. These many aspects, and its complete difference from the linear economy that we are used to, make that this is such a complex concept. This complexity leads to often conflicting solutions. Therefor there is always a need to search for the right balance.

1.6. The relation between the circular economy and climate change

The adaptive nature of the circular economy is taken as an inherent 'trait', exemplified through this line in the paper by Gallego-Schmid et al.: "Increasing resource efficiency through slowing, closing, and narrowing material and energy loops, is key to mitigating change" (2020, p. 1). The researchers start of by pointing out the waste generation by the construction sector. It is not the depletion of raw or finite materials that mainly

causes climate change, but the emissions that are emitted when processing these materials.
This is confirmed by the Ellen MacArthur foundation who explain that our focus so far has mainly been on energy efficiency and increasing our use of renewable energy. This however can only account for 55% of the total amount of greenhouse gas emissions. The other 45% comes from the making of products, whether it is food, transportation or of particular interest for this study: buildings (Ellen MacArthur Foundation, 2019, p. 12).
Increasing resource efficiency therefor in the first place leads to the use of less materials, which is in the eye of this author, of an adaptive nature: responding to the future uncertainty of availability of these materials and thus become less dependent on the supply of these raw materials. Secondly, using less materials has the potential to reduce the emissions that come from the production of goods such as buildings, as is mentioned above. This reduction of emissions is of a mitigative nature towards climate change, as by reducing emissions the effects of climate change are tempered.
This can also be deducted from the conclusions drawn by Gallego-Schmid et al., who conclude that the different solutions from the circular economy (closing loops, slowing loops, narrowing loops) do not always result in emission reductions by default (2020, p. 12). This can be exemplified as follows: when construction waste has the potential to be reused, but this requires the expertise and facilities of a niche factory, then the transport of this waste to this facility might lead to more emissions then when the waste is disposed of. Or upgrading an existing air-conditioning machine might extend its lifespan, reducing the use of new materials as no new machine is needed, but if this is machine is much less efficient than the newest innovative model on the market, its energy consumption might outweigh the buy of a new model in terms of greenhouse gas emissions.
The circular economy therefor first and foremost has a focus on reducing the use of virgin materials, and secondly aims to reduce greenhouse gas emissions.

1.7. Sustainable performance and business competitiveness

Of what use is it for a construction company to focus on sustainability? Robinson et al. found that when an organization successfully incorporates sustainability in their business strategy, this can lead to advantages such as reduction in costs related to wastage, defects and rework, savings in costs related to fuel, disposals of waste and landfill charges and also it improves access to better employees, clients and an improved image and brand. The latter eventually might lead to an increase in market access and regular clientele (2006, p. 796).

The perspective a company has on sustainability will affect this business strategy. In one of the studies that was found in the systematic literature review, Tan et al. (2015) studied the relationship between sustainability performance and business competitiveness of international contractors. Their main question: “Does it pay to be sustainable?” (2015, p. 273). They point out that there are different perspectives on whether or not investing in sustainability impacts a competitiveness and revenue (growth) positively. Illustrated by a figure depicting the relation between economic success and sustainability performance, they present these different perspectives through three views: 1) the traditionalist view, in which investing in sustainability is seen as a burden that reduces economic success as the investment is done to meet environmental regulations that correct the negative impact a company has on the environment. 2) The revisionist view perceives investing in sustainability as a practice that improves economic success as the improvement in sustainable performance might lead to - amongst others - more efficient processes and new market possibilities. 3) The long-term view propagates that first movers, the ‘frontiers’ will be perform much better on the longer run as sustainable development is considered to become more important as a factor for competitiveness than other conservatist factors (2015, p. 274). This is underlined by Robinson et al., who conclude that the long-term performance of a construction organization is undermined and competitive

advantages and opportunities could be lost when the organization fails to integrate sustainability practices into their business strategy (2006, p. 806).

In contradiction to Tan et al, who suggest that first movers gain the most competitive advantage on the long run is the common notion that the first movers eventually get caught up. Silverberg et al. discuss this notion in their study, where it is explained that early adopters of innovative developments first suffer a loss after which they will get ahead of their competitors. But the group that adopts the innovation just after the first movers, suffers a smaller loss and therefor more easily catches up and potentially overtakes the early adopters (1988, p. 1046).

Thus in order to remain competitive, focusing on and investing in sustainable practices can be considered necessary, although timing and the amount of investing should be determined by the individual company to fit its specific context. Additionally, Robinson et al. point out that in order to adopt sustainability principles, “proactive management of financial, human, environmental and social capital” (2006, p.795) is needed. What precisely constitutes “proactive management” is not specified by the researchers.

1.8. Summary

Thus, based on global figures, an increase in both climate change mitigation and climate change adaptation measures is needed in the construction sector to meet national and international targets. However, there appears to be no clear overview of what knowledge on climate change the construction industry has developed and used successfully. Even on a smaller scale, the approach of the construction industry in the Netherlands to deal with climate change impacts seems to be dispersed.

A model gaining attention to take action against climate change effects is the Circular Economy model. Switching to a circular economy is not that easy. Many facets of the model can be conflicting when implementing the circular economy and switching to new business models as a company might be required. The Dutch government has also expressed its intentions to turn the Netherlands into a fully circular economy by 2050, but has tied no regulations or legislation to this yet at this point. This means that the Dutch construction industry will have to be proactive in getting their industry to meet this goal by themselves.

Before finding out how the circular economy model can help the construction industry, an overview of climate change action – of which the circular economy concept is a part of - is necessary. In order to gain an overview of what is known about climate change adaptation and mitigation in relation to the construction industry, a systematic review of previous literature has been conducted. Secondly, the review helps identifying missing knowledge in this research area, also known as the ‘gap in literature’. The approach and findings of this review are discussed in the next chapter.

2

Review of previous studies

2 Review of previous literature

Before studying how the Circular Economy model may aid a construction company in dealing with the climate change issue, the relation between the issue and the agent should be explored. By looking at what is currently already known from academic research about the relation between the construction industry and climate change action, unexplored areas may be identified. A literature review may guide this examination, as it can help in creating a clear picture of a research area in which the knowledge is scattered and interdisciplinary. It is a more or less systematic way of collecting and synthesizing previous research (Snyder, 2019, p. 333).

The review describes what related research has been conducted already, and how it can support the study (Creswell, 2014, p.28). The chosen type of literature review in this case is the systematic literature review. This type is the most fitting as it is a transparent, comprehensive method in gathering research already conducted. The strength of the systematic review are its comprehensiveness, as it aims to gather all the literature found on a certain topic (and not exclude any), and its transparency, as the reporting of the review should enable readers to replicate the process (Grant & Booth 2009). This way, an attempt is made to minimize doing flawed assumptions, as the boundaries of the review, the search terms used and the filters applied are all documented and communicated to the reader.

Thus, the aim of this literature review is to generate an overview of previous research related to this study's topic to discover what gaps might exist in the existing literature. To get the right results I posed the question: *"What research has been conducted about climate change effects in the construction industry?"*

1. TS=("Climate change adaptation") AND TS=("Construction industry" OR "Construction sector" OR "Building industry" OR "Building sector" OR "Real estate sector" OR "Real estate industry" OR "Real estate development" OR "property development" OR "Built Environment")

2. TS=("Climate change") AND TI=("Construction industry" OR "Construction sector" OR "Building industry" OR "Building sector" OR "Real estate sector" OR "Real estate industry" OR "Real estate development" OR "property development") NOT #1

3. TS=("Climate change mitigation") AND TS=("Construction industry" OR "Construction sector" OR "Building industry" OR "Building sector" OR "Real estate sector" OR "Real estate industry" OR "Real estate development" OR "property development") NOT #1 NOT #2

2.1. Methodology systematic review

Based on this question, the keywords for doing the searches were defined. The two key terms in this case are Climate change and Construction industry. Synonyms or more specified terms were added to ensure the comprehensiveness of the searches. For all searches, no time limit of publications was set. All searches were filtered on journal articles only. The three searches presented on the previous page have been conducted.

The searches were done in the first week of December 2019 using the databases of Web of Science, Scopus and the TU Delft Repository. Similar searches were done in the Google Scholar database, but as this database does not support the same extent of Boolean search options, the results were too large in size and therefore incomparable.

Two alterations have been made during the searches. For the second search only, the central term 'construction industry' and its synonyms had to appear in the title of the article, to reduce the amount of results from this search. The broad term 'climate change' and ' construction industry' (or one of its synonyms) often appear somewhere in an article which led to an extensive amount of results that were out of scope and unrelated to the question posed.

The second alteration is the exclusion of the term 'built environment' in the second and third searches. This was done for two reasons. First, the term led to an additional sum of results that made the workload unfeasible. Secondly, the results were fast-checked, most of the additional results dealt with topics unrelated to the question posed for this literature review, such as articles on the transmission risk of Lyme disease, dengue or malaria. In total, an additional 198 papers would need to be reviewed, for an estimated one dozen of additional results of value for the review. The impact of these additional results are considered to have a negligible effect on the results of the review.

2.2. The results

In total, 175 studies were found. These studies were first checked on their scope and on their study method. Papers that focused on a topic unrelated to the construction industry or climate change, despite the key search terms, have been marked as 'N/A'. Also, papers that did not contained an empirical study, such as review papers or opinion pieces, were also left out and marked by 'N/A'. In total, 80 out of the 175 results were either out of scope or non-empirical, leaving 95 papers meeting the search criteria.

The results are gathered in a synthesis matrix, which can be found in Appendix A. To improve the readability of the matrix, the 80 results that did not meet the criteria are left out. The matrix is split up in three groups, each for one of the keyword combination searches. For each result, the authors, year of publication and journal of publication are collected. Next, for each article three components of the study are identified: 1) the aim or research question of the study is identified; 2) the method applied in the study; and 3) the key finding of the study. Finally, each article is categorized along some preliminary assumptions made.

The studies were conducted from all over the world, with China (12), the United Kingdom (8) and Australia (6) being the countries most under study. Table 1 shows the year of publication of each study. Of all the studies, over 61% was published in the past 4 years. This can be attributed to an increase in interest from governments, the construction industry and the academic community after the Paris Agreement of 2015. Almost all

Year	Number	Percentage	Cumulative percentage
2019	19	17%	17%
2018	17	15%	32%
2017	19	17%	49%
2016	13	12%	61%
2015	8	7%	68%
2014	4	4%	71%
2013	7	6%	78%
2012	7	6%	84%
2011	8	7%	91%
2010	3	3%	94%
2009	2	2%	96%
2008	0	0%	96%
2007	0	0%	96%
2006	1	1%	96%
2005	0	0%	96%
2004	3	3%	99%
2003	1	1%	100%
2002	0	0%	100%
2001	0	0%	100%
2000	0	0%	100%
1999	0	0%	100%
N/A	63		
	175	/175	

Table 1: Number of publications per year since 1999.

results were published in the past ten years (96%), indicating this research area is still in its infancy but also increasingly gaining attention.

In general, main findings show that studies aimed at public institutions tended to focus on assessments to control and stimulate behavior, while studies focusing at private actors tended to focus on strategies and barriers to overcome. Especially studies focused on private actors were often empirical studies using interviews and surveys as their research method, whereas the studies focused on public actors often used calculation models, weather forecasts or scenario analysis to derive at their recommendations.

Findings from each categorizations are now discussed. The categorizations made are:

- Reactive versus Proactive
- Adaptation versus Mitigation
- Written for Public versus Private actors
- The unit of analysis (public versus private)
- The unit of analysis (specified)

2.3. Reactive vs. Proactive

As all found articles are about the construction industry on the one hand, and climate change action on the other, the differences between the studies lie within this relation between the two. Therefore, as a first category, the studies are being examined on the position of the industry towards climate change. The questions asked here are: Does the study take a stance on the building sector's behavior as it is. Is the sector doing enough or not enough? Does it innovate itself or does it respond to regulations? And, are the cases used in these studies exemplary projects of proactive behavior or do they show what could be done, but due to reactive behavior has not happened yet.

Each paper has been scanned for statements about the stance of the building sector (or components of it) towards climate change action.

Type	Number	Percentage
Proactive	15	16%
Reactive	64	68%
Both	1	1%
None	14	15%
N/A	81	
Total	**175**	/175

Table 2. Categorisation by Reactive vs. Proactive

The results show a significant difference between studies that mark the sector as reactive and studies that mark it proactive. 68% Of the studies from this review mention the construction industry taking a reactive stance. 16% Of the studies describe proactive behavior in the sector. In most studies, the need for climate change action is noted, but the industry does not take the required action yet.

2.4. Adaptation vs. Mitigation

As mentioned, both mitigation as adaptation measures are required to deal with climate change impacts adequately. However, it appears in public debate, more attention has been given to mitigation than to adaptation. As the aim of this review is to get an overview of what research on climate change related to the construction industry has previously is conducted, insights into the distribution of research among mitigation or adaptation are an important contribution to that overview.

Type	Number	Percentage
Mitigation	**47**	49,5%
Adaptation	**28**	29,5%
Both	**14**	14,7%
None	**6**	6,3%
N/A	**80**	
Total	**175**	/175

Table 3. Categorisation by Reactive vs. Proactive

49,5% Of the studies were aimed at mitigation-related topics, while 29,5% of the studies were focused on adaptation-related topics. This supports the finding by Mazmanian, Jurewitz & Nelson (2013) that research about adaptation-related topics are relatively under-developed. Obviously, people rather prevent climate change events from happening rather than accept and adapt. However, as Krasny & DuBois point out, climate change mitigation alone will not be enough to deal with climate change and would create a sense of false optimism about our about our capacities (2019).

As might be expected if we look at the definition of adaptation as provided earlier, studies related to climate change adaptation focused on, amongst others, future weather scenarios, the effects of higher temperatures on buildings' cooling and heating demands and the effects of sea-level rises, such as flooding risks for the built environment.

Studies aimed at mitigation focus on carbon dioxide emissions and energy demand assessments. Studies agree that carbon intensity has been decreasing in the construction sector (Du et al., 2017) and that currently electricity has become the main source of emissions. Therefore, energy intensity decline could be a major contributor to climate change mitigation (Lin & Liu, 2015; Lai et al., 2019; Chedid & Ghajar, 2004). Also, many opportunities for climate change mitigation are identified, and many energy efficiency improvement options would produce net economic benefits for the firms implementing them (Timilsina et al., 2017).

Of the results, 14,7% took topics related to both mitigation as adaptation as their focal point. These studies addressed surprising topics, ranging from co-benefit theories towards the inclusion of biomimicry in architectural designs or the influence of federalism on environmental policies. This might be because addressing both implicates the scope of the research is more broad and therefor allows for more diverse topics.

Another surprising finding is all studies that have the education of climate change effects as their focal point, focus on adaptation rather than mitigation. This may be contributed to the earlier stated attention mitigation has already received outside the academic world. Krasny & DuBois, plea for the incorporation of climate change adaptation into environmental education programs, as most of these programs solely focus on preventing climate change (2019, p.2-3).

Written for	Number	Percentage
Public	**50**	52,6%
Private	**27**	28,4%
Both	**18**	18,9%
N/A	**80**	
Total	175	/175

Table 4. Categorisation by Written for public vs. private actors.

2.5. Written for Public vs. Private actors

Another distinction made in the synthesis matrix is the differentiation between the readers the studies are aimed at (Table 4). The distinction made is between public actors, such as policy-makers and decision-makers in governmental or municipal bodies, and private actors, such as contractors, project developers and interest groups of the construction industry.

Over 52,6% of the studies propose frameworks, assessment models, policy advice and other forms of knowledge for public actors. About 28% of the papers are written for private actors and provide tools for improving their organizations, buildings or strategies to gain better implementation of climate change measures, often combined with economic benefits.

2.6. Unit of analysis (public versus private)

Noteworthy is the opposite appears to be true in the categorization of the unit of analysis. The difference here with the previous categorization is that this category makes a distinction in the subject of the study rather than the reader. In 65% of the found studies, the unit of analysis was categorized as part of the private domain. This means that often, a private entity, such as a building, company or sector is analyzed to draw lessons for public actors. Example given, in over a third of these studies, the construction sector is the unit of analysis. The sector is considered to be part of

the private domain, but many of these studies are aimed at improving policies for the public domain. Similar to this, about one third of the studies focus on building life-cycle assessments, also aimed at improving regulations for governmental bodies (Mandley et al., 2015; Ghose et al., 2019; Pauliuk et al., 2013). Thus, only a small portion of the studies that have a private entity as their focal point, are actually also written for a private actor.

2.7. Unit of analysis (specified)

For a more refined distinction between the units of analysis, a more specified categorization of the papers was made. Table 5 presents the results of this category. Research focusing on firms in the construction sector specifically comprises a share of 13% out of the total studies.

level of analysis	**number**	**percentage**
policy	24	25%
local government	9	9%
national governm.	6	6%
building	15	16%
occupant	3	3%
sector	21	22%
firm	12	13%
portfolio	2	2%
school	3	3%
n/a	80	
total	175	/175

Table 5: Results categorized by Level of analysis

Firms:

The studies that specifically took construction firms as their focus point either looked at benefits of climate change implementation or at barriers to climate change implementation. This was done through analyzing a variety of firm-related topics, ranging from strategies, to perceptions of representatives and daily routines of employees.

First, the most remarkable overlap between these studies is the disparity of action between firms in the construction industry. Firms are seeking to align their company targets with (inter)national climate change mitigation targets. But multiple approaches to such alignment, based on different assumptions, lead to disparity between firms on how to achieve these targets (Giesekam et al., 2018). Wilson & Rezgui show knowledge regarding climate change in the construction industry is scattered and developed without cooperation nor communication, and thus misses the integration across stakeholders (2013). Also, different perspectives from decision-makers add another layer of uncertainty to the debate on climate change implementations (Roelich & Giesekam, 2019). For these reasons, Giesekam et al. (2018) call for an urgent cross-industry dialogue (in the UK) to come to a widely-accepted target trajectory.

Secondly, external barriers are identified that inhibit climate action by construction firms. Governmental constraints, financial constraints and sector constraints are the largest barriers. Lack of demand seems to have the lowest impact (Abuzeinab et al. 2017). Combined with assumptions of additional cost and a lack of understanding of the benefits of climate change measures (Aigbavboa et al., 2017), this leads to climate change being only one factor among many others that influence decision-making by firms (Hertin et al., 2003).

Third, within these firms themselves, multiple factors inhibit appropriate climate change action. For example inertia resulting from daily routines of employees make chances in favor of climate change difficult (Dooley, 2017). A survey amongst a employees of a large international engineering firm that is involved with the design and construction of building projects shows that there is a perceived need to develop new ways to

address climate change. Participants see the importance of the issue of climate change and recognize their current practice to be inadequate (Morten, Bretschneider, Coley & Kershaw, 2011). Although they found the aforementioned awareness amongst the participants, they also found that those with higher levels of seniority did not perceive the current practices to be inadequate (2011).

A final interesting finding are the changes the participants would suggest. The dominant response given to the researchers was “to embed the issue of climate change more firmly within the organization, its culture and identity.” (Morten et al, 2011, p. 1157). The participants find it easier to take action within the organization itself, instead of intervening in systems about the relation to clients or the products they create. The study also confirms the notion that adaptation measures are often overlooked. They did not specifically asked their participants to differentiate between mitigation and adaptation measures, but only a few mentioned adaptation measures when asked (Morten et al, 2011).

Local governments:

Studies on the local government level discuss climate change impacts on cities, municipalities or communities, barriers to climate change implementation and planning tools and assessment methods related to climate change for local governments. To overcome barriers to climate change implementation on a local level, continuous support from both policy-makers as industrial actors is needed. Especially since vertical interdependence by actors on different levels in society is increasing, since privatization and outsourcing are increasingly more common. (Fastenrath & Braun, 2018; Carlsson-Kanyama et al., 2013) To act in an adequate manner, policy-makers need to estimate emissions by the construction industry in their local communities, assess the mitigation and adaptation options they can implement on their local level and gain an understanding of the sectors and actions that are the most relevant to climate change implementation (Keenan & Oldfield, 2012; Kamei, Kurisu & Hanaki, 2019; Croci et al., 2017). After implementation, local governments also need evaluation frameworks to assess their spatial plans on energy use and emission footprints (Becchio et al, 2018).

National governments:

On a national governmental level, similar topics are studied, although most of them are very case specific. Progress of planning systems and carbon emissions on a national scale are reported on, specifically for the cases of the United Kingdom and China (Young & Essex, 2019 ; Du et al. 2017; 2018.) One interesting paper shows there is no equivalent to the (inter)national governing framework on climate mitigation to keep the global temperature rise at a max of 2 degrees compared to the pre-industrial age. This illustrates the underexposure climate change adaptation receives compared to mitigation in the public debate on climate change (Mazmanian, Jurewitz & Nelson, 2013).

Policies:

The policies-categorization is arguably not a unit of analysis, but represents an overarching group of studies that specifically focus on the assessment, implementation or development of public policies on any level. To a certain extent, the two previous categories of local- and national government levels fit within this category. However, studies in those categories are more focused on practice by the public bodies and are more scale-specific. With a 25% share, the policy-focused studies take up biggest share of the total results.

Most studies on policies provide either a framework for implementation of a climate change related tool, such as adaptation plannings tools and investment tools. The other share of policy-focused papers present an assessment tool, to calculate energy demand or carbon emission reduction potential of specific measures, sectors, or of the country as a whole. In general, the studies agree on one thing: often current policies do not address climate change targets adequatly, specifically the lack of implementing carefully targeted economic incentives (Georgopoulou et al., 2006; Gibbs & O'Neill, 2015) and educating people on climate change effects (Pisello et al., 2017; Murtagh, Gatersleben & Fife-Schaw, 2019; Kalu, Buang & Aliagha, 2016; Cheng, 2010).

2.8. Circular Economy

An additional check has been made to look if any of the literature reviewed mentions the circular economy or any methods that can be considered part of the circular economy view. The papers were scanned for the terms "material-"; "circular-"; "resource-"; "reduce/ reduction" ; "consumption"; "recycle"; "reuse" and "building methods".

Many of the studies focused on climate change adaptation focus on other adaptive measures than the main focus of the circular economy, which is its reduction of material/resource use. The focus of the studies lies mainly with adapting to extreme weather events caused by climate change. Zehra et al. (2019) focus on reducing flood impacts (Gibbs, 2013; Keenan & Oldfield, 2012), others focus on dealing with urban heat island and other heating impacts (Mabon et al., 2019), or ensuring building occupants' comfort within a changing environment (Dino & Akgül, 2019; Vardoulakis et al., 2015). Next to studying means to deal with these changing climates, some studies focus on assess these effects and act accordingly (Jones et al., 2017)

Of all the papers on climate change adaptation and the construction sector, almost none mentioned the circular economy or any notion of reducing material use (nor recycling or reusing). Next to the aforementioned focus on dealing with climate changes, their focus lies with reducing energy consumption of built assets. And although reducing material use in construction is a means that can contribute to this energy use reduction (at least in the construction phase of a buildings life cycle), this is not mentioned once.

There is one mentioning by Malek & Grierson, that Iran lacks a building code which leads to unnecessary use of energy-intensive materials and use of wasteful construction techniques (2016, p. 70), but other than a call for building regulations, no solutions are provided. Similarly,
Tan et al. (2015, p. 277) quote a sustainability yearbook to mention that in a world where the availability of resources is limited, firms with a reputation of being resource-conscious will have gain a competitive advantage, but their focus does not lie with providing sustainable solutions to climate change, let alone circular ones.

Owen et al. (2013, p.155) advocate the use of alternative materials, but as a goal for its buildings to have a higher resistance against water deterioration. Similarly, Houghton suggests using local materials, but with the goal of keeping easy access to replacement materials in case of hurricanes and other natural disasters (2011).

One author, Pedersen Zari, reviewed biomimicry strategies that can help to adapt buildings to climate change. In biomimicry, ecosystem processes are mimicked to increase the build environment environmental

sustainability. One of the ecosystem process strategies provided by the author in her overview, relates directly to the circular economy, which is “to cycle matter and transform energy effectively and to ensure that materials and energy have multiple functions” (2010, p. 179). Through existing methods such as design for deconstruction and reuse, cradle-to-cradle design, this can lead to a reduction in the extraction/mining/production of materials and energy, as well as to a reduction in waste eventually. This is clearly the same aim as he circular economy model aims. As Pedersen Zari puts it, the implications this has for climate change is that all of this leads to a reduction of greenhouse gas emissions and less disturbances in the earth’s ecosystems (Pedersen Zari, 2010, p. 179).

2.9. Other findings

Assessment tools:

In general, a large part of the studies analyzed in this review focus on assessment tools. Three main types of assessment tools can be distinguished:

1. Assessments of greenhouse gas emissions and energy usage, both on national and sector levels, that provide calculation methods for governmental institutions to calculate their emissions and usage themselves.

2. Assessments of building characteristics, advancing knowledge on building types, methods and materials that provide with adaptation and mitigation measures.

3. Assessments of the mitigation and adaptation processes, which provides policy-makers with knowledge on potential barriers and opportunities.

Lack of common definition:

A red thread found throughout the studies is a lack of common understanding of the climate change issue among different levels. Zuo et al. for example conclude there is no clear definition of a carbon neutral building (2012), and key actors in the study by Hurlimann et al. mention unclear and inconsistent definitions and language the most as a barrier to climate change implementation (2018). Simultaneously, policy-makers often do not fully understand the context in which their policy instruments operate (Spyridaki et al., 2016), while in addition to the uncertainty that comes with long-term decision-making, different perspectives from decision-makers have also contribute to uncertainty about climate change implementations (Roelich & Giesekam, 2019). Additionally, Wilson & Rezgui show sustainability knowledge in the construction industry is scattered and developed without cooperation nor communication, and thus misses the integration across stakeholders (2013). Combine these findings, and one can conclude that general consensus of climate change definitions, communication and cooperation on climate change knowledge and perspectives is underdeveloped in the construction industry.

2.10. Summary

The aim of the systematic review was to get a comprehensive overview of what research has been conducted about climate change effects in the construction industry. The results of the systematic review show the following main findings:

1. Most studies are focused on policies rather than practice

2. Most studies are written for public actors rather than for private actors, even though more subjects under study were considered part of the private domain.

3. Most studies focus on climate change mitigation related topics rather than adaptation related topics.

It should be noted that there are opportunities that may improve the robustness of the systematic review. More databases, such as the Google Scholar database could be included in the searches, as well as the searches themselves could be extended with more specific key terms found during this round of searches. Also, a third round of literature cited in the current studies might lead to some additional findings for this overview of previous studies.

3

Problem Statement

3 Problem Statement

Based on the findings from the review of literature on climate change and the construction industry, the following problem statement is formulated:

An increase in both climate change mitigation and climate change adaptation measures is needed in the construction sector to meet national and international targets. However, general consensus of climate change definitions, communication and cooperation on climate change knowledge and perspectives is underdeveloped in the construction industry. The industry is not known to be proactive in dealing with climate change, while knowledge on practice and aimed at private actors is scarce.

Therefore, this study fill this scientific gap by addressing climate change action by studying a contracting company from the construction industry, taking practice as the focal point and by taking both mitigation as adaptation measures into consideration.

Relevance of the study

To show the added value of this study, its relevance is discussed in terms societal relevance and scientific relevance.

The societal relevance of this study can be found in the need for climate change mitigation and adaptation. As shown in the introduction, the effects of climate change can be impactful on people's lives, health and their environment. Specifically the built environment will experience negative effects if no action is taken, while the building sector has also the most opportunities to reduces human's contribution to climate change. Currently, the climate agreement goals are not expected to be met. Action from the construction sector is needed to change this.
Secondly, as noted, knowledge appears to be shared only limited between firms in the construction sector. Development of new knowledge also does not happen in a sector-wide coordinated approach. This study can contribute to improve this knowledge-sharing. The study will not only help firms identify opportunities for themselves, but also can be used to identify common opportunities and barriers. This way, the sector as a whole can address these commonalities.
Third, this study contributes to the awareness by construction firms of their own organization and flexibility towards unexpected changes.
Fourth, this study provides specific recommendations for the case company, to improve their implementation of circularity as part of climate change action. The study does not prove whether these recommendations apply to other contracting companies as well, but can provide themes and areas of attention as starting points for further research or self-assessments by companies.

The scientific relevance of this paper can be found in the existing gap identified during the systematic review. Currently, there appears to be no clear overview of what action firms in the construction industry are already taking to address climate change. This study will provide new insights for the academic community by focusing on practice by firms rather than on policies for public actors. Additionally, the influence of the organisational structure of a firm on its decision-making will be analysed.

4

Research Questions

2.1 Research Questions

As stated, the construction industry will play a significant role in achieving the climate goals set out in the Paris Agreement of 2015. As most previous studies in this research area focused on policies, this study is directed at representatives of the construction industry's private sector. Many of the representatives of these private firms are aware of the need to act on climate change (Morten et al, 2011; Neprom, 2019). However, there seems to be no consensus on the approach on how to act. This study does not aim to create a perfect solution to this issue. Instead, it recognizes the uniqueness and context-dependency of each firm. Therefore, this study focuses on one contracting company as its unit of analysis and investigates the influences, opportunities and obstacles to act on climate change action by this specific company. The contracting company under study focuses on circularity as a means to act on climate change. The study aims for its findings to incite and support firms to assess their own context and develop their own approach and discover overlapping challenges with their colleagues to act on together.

Taking into account the problem statement and the identified gap in literature, the following research question is formulated:

"How does a contracting company manage the implementation of circularity principles proactively?"

In order to answer this research question, a set of sub-questions are defined. For each sub-question, the objective and proposed research method is given.

S1:
"How are decisions, related to the implementation of circularity principles, influenced by the context in which the contracting company operates?"

Objective: To gain insight in the context in which decisions by the firm are made.
Method: Desk research/Interviews

S2:
"What circular principles can be identified that can be proactively implemented by the contracting company?"

Objective: To gain insight in the type and number of opportunities there exist for the firm, and how these can be implemented.
Method: Case studies

S3:
"How is the implementation of circular principles within the contracting company related to its own current practices?"

Objective: To investigate the influences of a firm's organisational structure and current practice on the implementation of circular principles.
Method: Case studies and desk research

S4:
"How can a contractor company act on circularity principles to maximize their potential?"

Objective: To understand what is needed to proactively implement opportunities in a firm; how to overcome barriers to implementation; and from whom action is needed.
Method: Case studies and Game

Research design

The research questions are translated into a concept diagram which depicts the different parts under study (Figure 2). The first sub-research question addresses the context in which the contracting company operates. The second sub-research question addresses the actions on circular principles that can be or have been taken by the contracting company. The third sub-research question addresses the organization itself and how decisions within that organization are made. Between these different parts, obstacles and opportunities affect the relations between these parts and eventually whether or not action is taken. In general, a reactive stance is for a contracting firm to decide and act as a response to contextual factors. With the main research question, a proactive stance is taken, in which the parts affect each other in the opposite way.

Proactive management

For this study, the definition of proactive behavior given by Crant is used: *"taking initiative in improving current circumstances or creating new ones; it involves challenging the status quo rather than passively adapting to present conditions."* (Crant, 2000, p. 436)

Crant did an review of studies on proactive behavior in organizational contexts. Between the various explanations of proactive behavior he found some important commonalities between the studies that are of use for this study. Proactive people in organisations take an active role in their daily work. In contrast to passive, reactive people, proactive people initiate situations and create favorable conditions (2000, p. 437). Or as Crant puts it *"proactive people actively seek information and opportunities for improving things; they don't passively wait for information and opportunities to come to them."* – (2000, p.137)

Another common concept found by Crant was the concept of issue selling, in which individuals (often middle managers) call for attention for certain issues they encounter and through this, influence the strategy and strategy-making process of the firm (2000, p.437).

The focus of explaining what is adopted as proactive for this study lies mainly with the individual, the employees. They are the

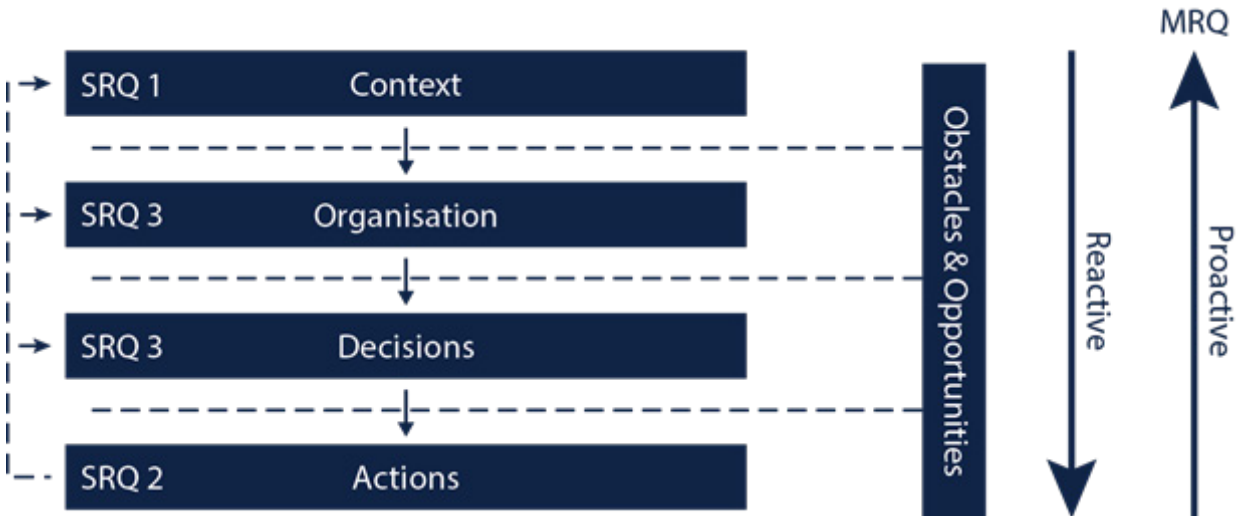

Figure 3: Concept diagram (own illustration).

representatives of the firm in the front-line and they eventually are the ones who have to bring the company's strategy into fruition. That does not mean that no proactiveness exists on any other level within the organization. The organization as a whole can set proactive environmental goals, a department or project team can take up proactive behavior. There is an interaction between proactive behavior by the individual and the larger organization (regardless of it being the team or the whole firm). Individuals can initiate proactive behavior by the firm and the firm in opposite direction can spark or support proactive behavior by the individual employees. This is now further elaborated on.

The idea that proactive behavior by employees can have a beneficial effect on the organization as a whole, is something that is researched before. It is a common theme studied in supply chain management studies. Specifically research on environmental sustainability in the supply chain found that eventually the implementation of environmental sustainable initiatives comes down to the employees who have to do the work (Montabon et al., 2016; Sarkis et al., 2010, p. 164). Proactive activities by employees can either be part of their job description, called in-role behavior, or be an additional effort to what their job description prescribes, called extra-role behavior (Crant, 2000, p. 436) In case of construction companies, the projects are the vehicle and the employees are the drivers of that vehicle.

That does not mean action is only required from employees in the front line. In order to get employees to commit to proactive environmental behavior, support and leadership is needed from top-management. This support ensures that environmental issues and the commitment to it are carried organization-wide (Sarkis et al., 2010). Montabon et al. point out that *"while examining environmental efforts at the firm level is important, concern for the environment should permeate the organization and directly involve individual employees in environmental activities."* (2016, p. 64)

It is thus essential for organisations to set up and adjust their their policies and systems in place to positively affect and maximize individual initiative (Crant, 2000, p. 435). Similar to the potential economic gains of circularity that can be attractive to organisations, the potential reduction in cost and waste reductions gained by environmental initiatives in the supply chain can function as drivers for organisations to pursue these initiatives (Montabon et al, 2016, p. 64). This is also another illustration of the overlap between the variable sustainable concepts that are out there.

The group of Montabon draw upon the notion of "organizational citizenship behavior" (OCB) (2016, p. 65), made known by Organ who illustrated it with the striking example of Sam, the good Samaritan: an employee who helped out a young Organ at a paper mill factory in need with showing him how to bind toilet rolls. Sam's behavior showed the following properties that define OCB: it was individual behavior, it was voluntarily, it was not directly or explicitly set out to lead to some kind of reward, and it contributed to the efficiency and effectiveness of the organization as a whole (Organ et al., 2005 , pp. 3 -11).

This behavior, in which employees voluntarily go beyond what is described in their job description or in their contractual obligations, is considered extra-role behavior and can be applied to environmental activities. Such behavior is proven to benefit employees, project teams and other types of groups, and organizations in various ways (Organ et al., p. 8; Montabon et al., 2016. P. 65).

In their study, Montabon et al. found the following points of attention to promote this behavior (2016, pp. 80-82):

- Supervisory support for environmental initiatives leads to more commitment by employees to such environmental activities
- Perception of support from the employees' supervisor is more important than that of top management support as they are more visible than upper management (also found by Crant, 2000, p. 443).
- Rewards such as praise of successes can motivate and lead to more commitment to environmental activities
- "Companies should strive to be more explicit about their environmental goals and the roles employees can play in achieving them"
- Personal beliefs, such as positive eco-world views, lead to more commitment to environmental activities.
- In pursuit of such environmental goals organisations might hire applicants who hold these eco-world views. In return, creating a culture of such a world-view will attract and retain more applicants and might lead to a competitive advantage over human resources (also found by Sarkis et al., 2010, p. 164).

The studies by Montabon et al. and Sarkis et al. - and many of the research they drawn on - have been conducted on supply chains in manufacturing industries, such as the automotive industry. Some important differences exist between the construction industries and manufacturing industries like the automotive industry, first and foremost the fragmentation of the construction process in the construction industry. Murtagh & Badi summarized the characteristic nature of the construction sector as follows: "The project-based nature, multiple dyadic relationships, high numbers of firms with suppy chains, the frequently one-off nature of contracts, and the potentially adversial relationships. […] slowness of change in the industry, reluctance of suppliers and contractors to invest in new approaches on the assumption that the benefit accrues only to the client, the uncertainty and instability inherent in the sector, and how the values embedded within the contractual relationships frequently vary considerably from the ideals of successful supply chain management." (2019, p. 77) These characteristics, also often mentioned as obstacles for innovative and sustainable behavior, should be taken into account when looking to address proactive behavior in the construction industry.

In (green) supply chain management specifically, but this can be applied to any approach to environmental activity by a construction company, the role of the firm in the building process influences its possibilities and activities. The researchers exemplify this with the difference between architecture firms and engineering firms on the one hand and the contracting firm on the other. Architects and engineers have a big impact on the 'green' design whereas the contracting firm has a big impact on the building site through managing transportation and waste (Murtagh & Badi, 2019, p. 77).

A difference should be made in the stakeholders with an influence on the environmental practices of an organization. First and foremost there is the difference between internal and external stakeholders. The employees can be considered the internal stakeholders, they initiate, receive and strive for the company its proactive environmental activities (Sarkis et al, 2010, p. 164).

External stakeholders have no control over the resources or actions of the organization, but can steer the organization by force (environmental legislation and regulations by governmental institutions) or through

public opinion and demand (protest groups, media, clients). Clients especially may require specific environmental performances from the product supplied by the organization. Another external group specifically mentioned by Sarkis et al. are the shareholders of the firm. The organization tries to maximize its value to these shareholders and therefor proactive environmental practices that lead to an increase in economic performance might please these shareholders. Something Sarkis et al. do not mention, is that stakeholders can hold back the organization in its proactive environmental initiatives. Clients, but surely also the shareholders might have no interest or see to much risk for certain proactive environmental practices.

In conclusion, proactive environmental activities take place on multiple levels: the individual and the group/organisational level. These levels influence each other. The individual's proactive behavior may incite proactive activities by the organization as a whole and vice versa. Pressure on the organization (and the individuals) comes from different stakeholders, both internally and externally. These pressures may drive the organization to proactive environmental activities, but can also hold the organization back.

Research framework

Based on the proactive management literature, the framework as presented in Figure 4. is developed for this study. First of all, the framework can be divided into two levels: the level of the individual and that of the group or organization. Between these two levels there is a bidirectional relation, meaning the individual and organization influence each other in various ways. The group level could be divided into more detailed levels, such as the project team, department and firm level, but for sake of simplicity these have been left out.

An organization can exhibit proactive behavior, for example by setting additional environmentally sustainable goals for themselves. There can be multiple intentions behind this, ranging from prospects of financial gain, to gaining competitive advantage or intrinsic motivations by top management. Often, these intentions are shaped by pressures from different stakeholders. Clients, society or the shareholders of the construction firm all have expectations and demands to which the firm should yield effectively. These pressures often serve knowingly or unknowingly the intentions. Although the firm on a strategic level might set these goals for them to proactively move towards, the achievement of these goals eventually should be made by the individual employees, on the projects of the construction firm. There is thus a need for the proactive strategy to trickle down to the bottom of the organization.

Therefor proactive management practices take place to enable and stimulate the necessary proactive behavior by the employees. This is one direction of the relation between the individual and the organization. The organization through its (top)management can support initiatives and proactive behavior or express intentions without providing exact descriptions how to get there.

As explained, proactive behavior can be exhibited by individuals. Just as the case with the organization, reasons to show such behavior can vary depending on the intentions of the individual, ranging from intrinsic motivation of doing good to the perception of gaining career advantages. Pressures that influence these intentions are not explored in this study, it is assumed these are shaped by one's personal and cultural background,

Figure 4: Conceptual framework (own illustration).

social network, age and all kinds of personal circumstances and characteristics.

Proactive behavior by the individual can also influence the organization. On the one hand by grabbing an opportunity to do something differently than is common and outside of the individual's role and through this initiative inspire the organization to implement this organization-wide. On the other hand through issue selling, bringing an issue in the practices of the organization to attention of upper management and even persisting until the issue is resolved.

It is no requirement for one of the two levels to show proactive behavior in order for the other to do so as well. Even though an organization sets a proactive goals, not all employees will have to show proactive behavior to get there. And the other way around the organization does not need to have proactive goals before the employee can proactively incite change in the organization practices. The types of stakeholders, intentions or ways of influencing in the framework are in no way complete and are depicted to illustrate the type.

There is some grey area within the determination of proactive behavior which becomes clear in the bidirectional relation between the organization and the individual. Drawing on the prerequisite that proactive behavior has to be voluntarily, one could say that demands by the client to be proactive - to go above and beyond the standard regulations and beyond the current practices of the construction firm on environmental issues - makes it automatically not proactive anymore. The result however is still the same as if you would have done it from your own voluntary will. As an example: "I want you to think along and challenge the status quo of common building methods by coming up with innovative methods that are environmentally sustainable". Although yielding to pressure from the client, proactive behavior is stimulated. The intention of the firm to take on the project may not only be to meet the pressure from the client, but also be the intention to learn innovative methods and use it for competitive advantages. Favorable conditions are then created for the individuals to be proactive. Although the line becomes more vague of when you are complying to your obligation to the client and when you are doing more, this vagueness is also the exact reason why it should be considered proactive. It is not of importance that the line is not clear for this research as long as it is also not clear for the individual as well, as he or she will then go above and beyond voluntarily and not from directives.

5

Methodology

5. Methodology

This chapter elaborates on the proposed methodology applied in this study. First, the chosen type of research approach (quantitative, qualitative or mixed-method approach) is discussed. Secondly, the philosophical view underlying this study and finally the research design, in which the specific research methods are explained. The aim of this chapter is to provide a clear overview of the different parts of this case study research and to explain how the study derives the answers to the research questions and fulfills the research objectives.

5.1. Selection of the research approach

In order to answer the research questions properly, the most appropriate research approach should be selected. Three general types of a research approach can be distinguished: quantitative, qualitative or a mixed-methods approach. The choice for either one of these approaches is dependent on the research aim, research question and the available data. For this study, a qualitative approach is chosen. A general notion of qualitative research is that it studies phenomena that are very dependent on their context, making it difficult to generalize findings. Also, qualitative research is often used in studies where the research question cannot be answered through a quantitative approach, which generally consists of testing a hypothesis with numeric data.

Edmondson & McManus provide aid in finding a methodological fit to a specific research. They specifically focus on research in management, which are studies that use qualitative or quantitative date from real organizations (2007, p. 1155). As is clear from the research question of this study, data from the specific contracting company will be required to find answers to the research question. They provide three archetypes of management theory, ranging from nascent theory to mature theory. Nascent theory contains research topics that have attracted little research so far, focusing on relatively new phenomena. Research questions for nascent phase-topics are open-ended and often the issues that may arise from data are not fully known (Edmondson & McManus, 2007, p. 1161). This study fits best with the archetype of nascent-phase research. Qualitative research, such as interviews and observations are the most suited for answering such open-ended questions as they leave room for the identification of important variables at a later stage (Creswell, 2014, p.20) and data collection and data analysis form an iterative process.

5.2. Research design

This study focuses on practice by a contracting company in managing the implementation of circular principles as part of climate change action. To answer the four research sub-questions defined, different types of data are required and gathered through different methods and from different sources. The research design provides an overview of the research steps that will be taken to adequately answer the research questions.

In table 6. the chosen research method is given for each research question, as well as the resources for data collection. As it concerns a qualitative research method, the types of data in this study are all qualitative.

Research Question	*Type of Data*	*Research Method*	*Data Collection*
1. "How are decisions, related to climate change, made by firms in the construction sector influenced by the context in which these firms operate?"	*Qualitative*	*Literature study*	*Academic literature found using Web of Science, Scopus, Google Scholar and other internet sources.*
2. "What opportunities for proactive climate change action are common amongst firms in the construction industry?"	*Qualitative*	*Case studies*	*Desk research on case firm documents; observations of case firm current practice; Interviews with employees of case firms;*
3. "How are decisions made by firms related to the current practices of those firms?"	*Qualitative*	*Case studies*	*Desk research on case firm documents; observations of case firm current practice; Interviews with employees of case firms;*
4. "How can firms act on identified climate change opportunities to maximize their potential?	*Qualitative*	*Case studies*	*Desk research on case firm documents; observations of case firm current practice; Interviews with employees of case firms;*

Table 6: The research objectives and accessory research methods.

The cumulation of answers to the sub-questions eventually lead to final conclusions and an answer to the main research question. To arrive at this point, multiple steps have to be taken, divided into different phases. The empirical research in this study consists of a single-case study method, for which observations, desk research and interviews are used to collect data. Finally, in the synthesis phase, the data is processed and analysed using coding. The data from the different interviews is compared to internally verify findings. The themes that arise from the data are also compared to existing theories on those themes. The logic here is that an inductive process takes place, where information is gathered from participants to the interviews which is then translated into themes. These themes are then compared to existing literature on the topics (Creswell, 2014). Based on the discussion of the findings, a final report is written and conclusions and recommendations drawn. Figure 5 shows the research design.

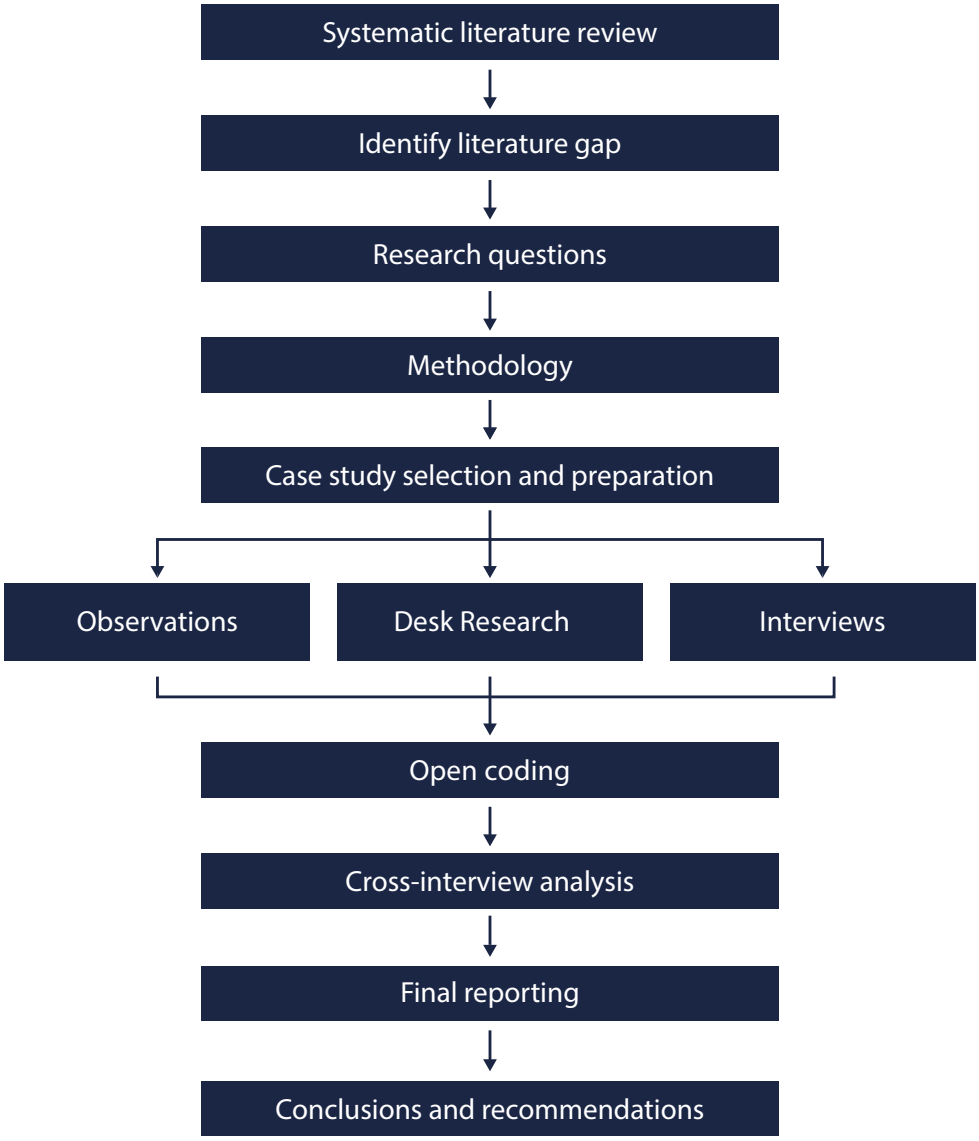

Figure 5. Research design (own illustration)

The research proposed here can be split up into two phases, each will be discussed in the next section:

Phase 1: Empirical research
Phase 2: Synthesis

5.3. Phase 1: Empricial research

In the second phase of the graduation research, the empirical study is conducted. For this phase, a single-case study method is applied. The case study is used to gather data to assess how circular principles as part of climate change action are managed by the case company. The single-case approach allows for a deeper exploration of the case in its own unique context (Gustafsson, 2017).

First, the choice for applying a case study method for this study is elaborated on. Second, a distinction between case study designs is provided to explain the specific case study design of this study. Third, the case company is introduced. Lastly, the three components used in the case study (desk research, observations and interviews) are discussed.

Case study research method

There are multiple research methods that can be used in a qualitative research approach. For this study, the case study research method is chosen. In order to match the method with the objectives of this study, three conditions by Yin were used for the decision (2009, p.8):

- The type of research question
- The level of control over behavioral events
- The level of focus on historic versus contemporary events

Table 7 shows the criteria per research method.

Method	Form of Research Question	Requires Control of Behavioral Events	Focuses on Contemporary Events?
Experiment	How, why?	Yes	Yes
Survey	Who, what , where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/no
History	How, why?	No	No
Case study	How, why?	No	Yes

Table 7. Criteria for research method selection (own illustration, based on Yin, (2009, p.8))

As the main research question consists of a How-question, requires no control of behavioral events (in this study firms and their employees are observed, not steered) and focuses mainly on contemporary events (exploring the current practice of the contracting company and its approach to implementing circular principles), the case study method is found to be the most appropriate for this study.

There seems to be misconception about case studies as a research method. It appears many researchers have a 'classical' view of case study research, where the research is considered to be appropriate for exploration of theory only and inadequate for testing theory. (Yin, 2009; Creswell, 2014; Ridder, 2017). As these authors have extensively opposed these misconceptions and provided many arguments to the contrary, I will not further extend on the legitimacy of case studies as a research method and consider its legitimacy as an explanatory research method proven.

There are different perspectives on what the case study method constitutes of. For this study, I follow the procedure of conducting a case study research by Robert E. Stake (The Art of Case Study Research, 1995).

He sees the researcher as an interpreter, as someone who gathers interpretations of others, and who writes for readers who represent a third level of interpretation of reality (Yazan, 2015). Yazan, in his comparison study on different approaches to case study methods, explains that Stake defines four characteristics of a case study (and qualitative research in general). The case study method is:

1. Holistic, meaning that not only the unit under study but also the interrelation to its context is investigated.
2. Empirical, meaning the study is based on observations and data gathered from the field.
3. Interpretive, meaning that there exists a research-subject interaction in which the researcher depend on their intuition in interpreting the data.
4. Empathic, meaning that the researcher is able to take the on the perspective of its subjects.

In an Stakian approach, a flexible research design is advocated, in which big changes can still be made when executing the research. Initial research questions provide guidance to the observations, interviews and document review, which he sees as the three methods for collecting data. This notion of flexibility comes from the idea that the course of the study cannot be predicted fully in advance.

This flexibility also comes back in the perspective on data analysis. Data collection and data analysis are not two separate phases but happen (partly) simultaneously iteratively. Processing of gathered data may lead to changes in the data collection process.

As a general notion for qualitative research, the importance of gathering data from multiple sources is emphasized. This ensures the case is investigated in its entirety and complexity. Validity and reliability are two important aspects that increase the credibility of the research.

It fits this study, as shown in the research design (Figure 3) to make use of different methods to collect data. These different methods are complementary to each other. This so-called triangulation minimizes biases because one method can be used to check the findings of the other methods used (Bryman, 2012, p. 392). In this case, observations can be used to check statements made in the interviews are true in reality. Vice versa, the interviews can be used to check whether observations were interpreted correctly by researcher.

Triangulation, by using different sources, using different theories and different researchers work on the study, increase the (internal) validity of the study. Explanation of the researcher's position and triangulation once more, increase the reliability of the study.

Flyvberg points out that choosing case studies as a research method for the study, is not merely a methodological choice, but mainly a choice about what is to be studied (2011). He elaborates on this by mentioning three important characteristics of a case study that apply to the choice made for this study. First, a case study method provides more detail and richness to the unit under study than other methods do. Second, the unit under study evolves over time, meaning that a series of events occur at a certain place and time and constitute the case as a whole. Last but not least is the relation of the unit under study to its environment. Defining the boundaries of the unit of analysis determines what is part of the case and what is context the case (Flyvberg, 2011).

In this study, climate change action by firms in the construction industry is a new, contemporary phenomenon. Previous studies on this topic have shown that action is dependent on many variables, such as external barriers, cooperation with different stakeholders and also alignment with the current practice of a firm. The phenomenon studied here relies heavily on its context; external factors, such as political, financial, environmental factors; people working at this firm, the decision-makers all have an influence. Thus in order to study this contracting company and their implementation of circular principles, a detailed examination which also takes into account the transitions of the company and the relation to its environment is needed. A case study method is the most appropriate to observe such a firm in its real-life context with the complexity of all these influences.

Unit of analysis

It is thus important to define the unit of analysis for this study, or as Stake calls it a "functioning specific" or "bounded system" (Stake, 1995, p2., as cited in Flyvberg, 2011, p.301; and in Yazan, 2015, p. 139). For this study, the contracting company as a whole has been defined as the unit of analysis. In this definition, the company encompasses its organizational structure, its employees, its current practice and its actions to implement circular principles. The larger concern the case company J.P. van Eesteren is a part of, the market in which the contracting company operates, other parties it interacts with and holds relations with, such as clients, suppliers and subcontractors, are considered outside of the boundaries of the unit of analysis, see figure 6.

Figure 6. Unit of analysis (orange) and its context (white) (own illustration)

Case selection (criteria)

As the unit of analysis is defined as the construction firm itself, an appropriate case has to be found. As the research focuses on how a construction company manages the implementation of circular principles, the most important thing is to find a construction company that actually has this implementation as an objective. Preferably, a company is

found that already has made progress on this implementation and takes an proactive approach to this.

Determining whether a company is proactive is hard to determine precisely. A proximity-measure is done to get as close to this criteria as possible. A search has been conducted for sustainability award-winning construction projects. The assumption is made, that if the more a construction company has worked on such award-winning projects, the more active and focused the company is on circularity.

By collecting the nominees of multiple architecture awards, preferring sustainability awards of others, a list of exemplary sustainable projects was compiled. Based on this list, contractors who worked on these projects were identified. J.P. van Eesteren was linked to multiple projects that won sustainability related awards, specifically the QO Hotel in Amsterdam and the Triodos Bank office in Driebergen-Zeist. J.P. van Eesteren their ambition and position in the market matched the selection criteria. Figure 7 visualizes the selection process.

Case company: J.P. van Eesteren

J.P. van Eesteren is a contracting firm active in utility construction projects within the Netherlands. In collaboration with them, this study takes their organization as the unit of analysis. Access has been granted to their policy documents, employees were available for interviews and the researcher was welcome to work at their office and get a grasp of the company through observations. The firm's structure, goals, vision and strategies. Project documents may be analysed to find effects.

Although it is implied so far, at the time of selection there was no certainty on whether J.P. van Eesteren was truly a proactive company towards circularity or not. It should be noted that the answer to this does not affect the possibilities to answer the main research question. Either the company is found to be proactive, and lessons will be drawn from how they do this, or the company is found to be reactive, and the emphasis of the research will lie on the obstacles and reasoning on why they are not proactive. Both ways, an answer to the main research question can be given.

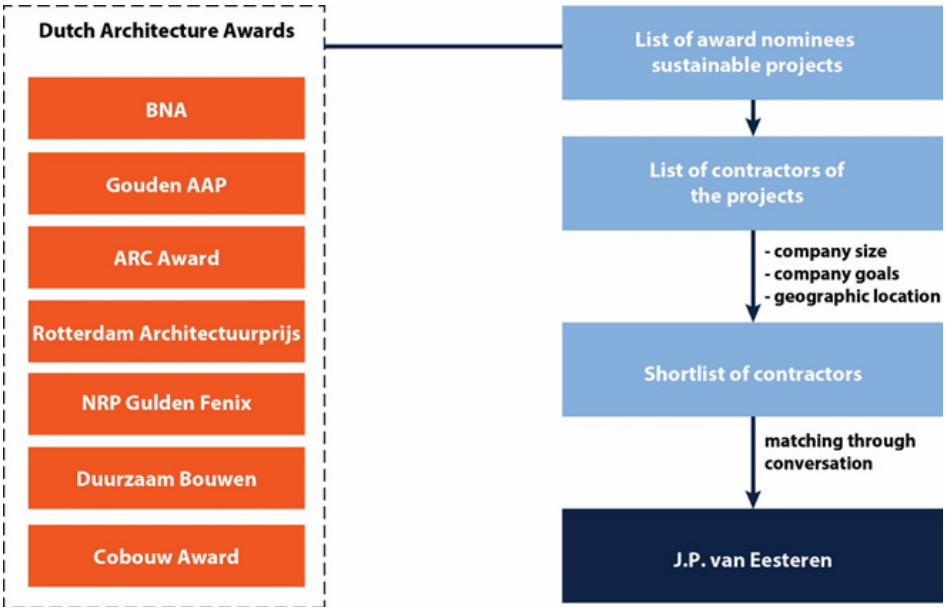

Figure 7. Company selection process (own illustration)

In order to fully grasp the organizational structure and current practices of J.P. van Eesteren, different levels within the company have been identified to study. Employees from each level and from different departments and functions are interviewed. This way, a broad range of perspectives are taken into account in this study. Experiences from this range of interviewees can help in both explaining the decision-making and organizational structure, as in showing differences in perceptions of obstacles and opportunities. The three levels distinguished are:

1. The project team level
2. The department level
3. The company level

The three different levels are depicted in figure 6 and can also be identified in the visualization of the organizational structure in figure 8.

Desk research

Policy documents of the firm (and larger collectives they are an active member of) are to be analysed to get an understanding of the firm's structure, goals, vision and strategies. Project documents may be analysed to find effects of the policy and vision of the firm on their projects.

Findings from the desk research may serve as input for the interviews and observations. Example given, a goal or strategy towards the implementation of circular principles might be set out in the firm its policy documents. Such goals may be used as a benchmark for the participants to indicate their perception of behavior and progress by the company.

Observations

The case is was to be visited on multiple occasions. Unfortunately, due to the impact of Covid-19 and the measures that followed in response, the company office has only been visited twice. The observations are unstructured participant observations. They primarily help the researcher gain a better understanding of the current practices of these firms. Also, findings from the desk research and interviews can be tested and potentially verified or falsified by these observations.

Working as an intern within one of the case-studies may pose some issues to be considerate of. It may lead to some bias in the processing of data, as I am participating in the processes I am observing myself. This requires some critical (self-)reflection when doing observations and analyzing the data.

Semi-structured interviews

For the interviews, a semi-structured approach is chosen. This means that the topics that will be discussed and the questions that will be asked are defined beforehand, but room is left for additional questions and discussions that come to the front during the interview. This allows room for participants to construct a meaning themselves and reduces control and steering by the researcher (Creswell, 2014, p.6). Also this allows for themes to be brought up that the researcher had not thought of yet. The approach to the case study used allows for such themes to be incorporate in later interviews, as well as discard themes that turn out to be irrelevant.

Employees from at least three different departments and the three identified levels within the firm hierarchy are to be interviewed. This way, a comprehensive understanding of

the structure, routines and effects of a change within the different parts of the firm. But most of all, this ensures a broad range of perspectives and interpretations are taken into account. The research by Morten et al. showed that people from different levels of hierarchy in their case study had different perceptions on climate change implementation into the firm's current practice (2011), illustrating the need to analyse the firm on all levels. Figure 8 shows an abstract depiction of the organizational structure of J.P. van Eesteren. The intention is to get a range of interviewees that represent as much of the different parts of the company as possible.

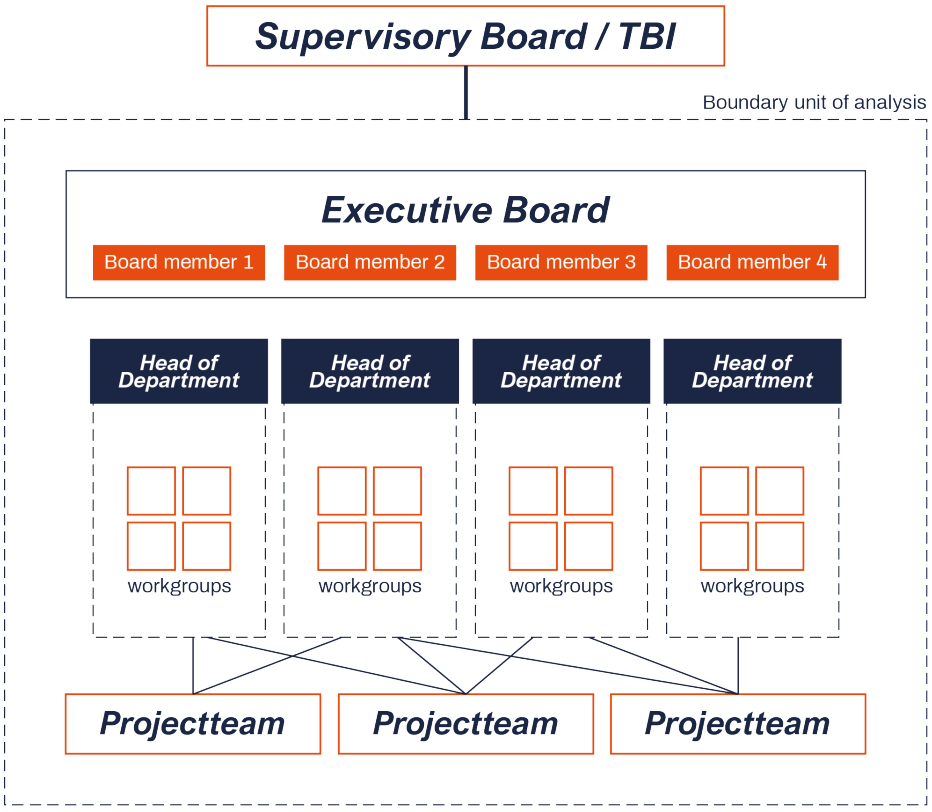

Figure 8. Organisational structure, depicting the project team, the departments and the executive board (company level) (own illustration)

5.4. Phase 2: Synthesis

During the second phase, as much information about the cases is gathered in order to answer each research (sub-)question. The different methods explained in the previous sub-chapter, all aim to gather this data. This data needs to be collected in a structured way, as well as processed and analyzed in a structured and ethical way. Based on the data, findings can be discussed and conclusions and recommendations are drawn. Finally, the phase is ended with a reflection on the process and findings.

During this phase, the goal is to make sense out of the data. Another perspective on qualitative research, which coincides with the ideas of Stake on this matter, is by Sherran Merriam. She considers the data analysis as consolidating, reducing and interpreting what is said (interviews) and what the researcher has seen (observations) and read (desk research), which combined makes up the process of making meaning (Merriam, 1998, p. 178, as cited in Yazan, 2015, p. 145). The means to do so are now further elaborated on.

Data collection

The different research methods all collect data in a different way. Table 8 shows the different phases, the questions answered during that phase, the methods applied and the way data is collected.

Data processing

Table 8 also shows the output to which the data collection and processing should lead to. Interview transcripts for example are the output from the data collection of the interviews held. These are then processed through Atlas.ti, a software program used to systematically uncover commonalities between the interview transcripts and other documents. This helps the researcher structure his findings from the interview transcripts.

The analytic process applied in this study is coding. For this study, the steps for the analysis are drawn from procedures for grounded theory research as describes by Corbin & Strauss (1990). They relate to the perspective by Stake as they consider data collection and analysis as an interrelated process as well. Relevant information that comes to the fore while analysing should be used in the next interviews and observations (Corbin & Strauss, 1990). They advocate that events and experiences as told in an interview do not shape a theory, they merely indicate a certain concept or theory. By labeling, categorizing and comparing quotes, claims or even theories can develop. Often, such categories and concepts become more abstract as the analysis reaches its end (Corbin & Strauss, 1990).

Thus, from the coding themes or patterns become visible in the data. These eventually shape the exposition of the findings. By means of cross-interview comparisons an overview of the different perspectives on these themes can be made. Here, a part of the internal validation is established. The overview shows where opinions match and where they differ. From this overview, the three levels within the organisation can be compared, as well as the perspectives from different areas of expertise.

The interpretation by the researcher is of importance here. As told before, the approach by Stake is followed here, in which it assumed that there is no perfect reality, but rather a range of interpretations of reality (Yazan, 2015). By including a wide range of these interpretations into the data collection, but also in the analysis by means of the researcher's awareness of his own interpretation and that of the future reader, the best possible approximation of reality is attempted to be derived.

Data plan

All the collected and processed data is handled with care. In order for the academic community to keep academic data available for everyone and for later moments in time, good infrastructure for storage and sharing of datasets is required. Different types of data, different software programs and different languages all lead to differences in the management of scholarly data, troubling reusability of these data. Wilkinson et al. have developed the FAIR principles, to ensure that this enormous bulk of data in the academic world can stay accessible and reusable for both humans and machines. FAIR stands for Findable, Accessible, Interoperable and Reusable (2016). To comply with these principles, the final version of this graduation research report will be registered and published on the publicly accessible TU Delft Repository, the paper will be written in English, the methodology is explained in a transparent manner and the referencing is done using APA Style rules.

Ethical considerations

As research involves collecting data from and about people, and in this case firms, ethical issues arise that need to be anticipated (Punch, 2005, as cited in Creswell, 2014). This subchapter elaborates on the ethical considerations that were made when developing the research design.

In general, these main ethical considerations should be taken into account when starting to execute this research: voluntary and informed consent by the participants; avoidance of harm to the participants; and careful and transparent handling of data.

Consent from participants is necessary. Each participant of the study has to sign an informed consent form in which they agree with the implications of the study and the processing of any data they release. This also encompasses that the purpose of the study the research has in mind should be communicated to and understood by the participant. Next to informed consent by the participants, the contracting company that is

Phase	Questions	Method	Data collection	Output
1. Empirical research	*Sub-research questions 1 – 4.*	Single case-study (following the approach by Stake): one contracting firm from the Dutch construction industry	Document review, unstructured observations, semi-structured interviews.	Desk research report; interview transcripts. All combined into one a chapter presenting the findings after analysis.
2. Synthesis	MQ: How can firms in the Dutch construction sector proactively identify and implement opportunities for climate change action, considering obstacles imposed by their own current practice?"	Cross-interview analysis; comparisons to existing theory	Based on findings from the first phase.	Conclusions and recommendations; specific set of recommendations for the case company.

Table 8: Overview of data collection and output per research phase.

used as the case company will have to give permission for the use of data, such as the processing of their policy documents; access to different departments and employees to successfully execute the study. The possibilities for participants to withdraw or rectify information they gave should also be clearly agreed upon.

Harming the participants should be avoided at all times. This means information that might harm them should never be disclosed. Their names and other personal information that could lead to the identification of the participants should remain confidential, unless approval is given by the participant for the disclosure of this information. This means also the privacy of the participants should always be secure. This could be dealt with by altering the names of the participants in the data processing and reporting.

The handling of data should be done with care. First of all the storage of data needs to be secured. But openness must be given, the data should be shared so others can check the credibility of the research (Creswell, 2014, p.98). Communicating who owns the data is also of importance. Participants should be aware to whom the information they will provide will belong, the researcher or, in this case, the TU Delft.

The TU Delft also has some sets of rules for their students and employees for conducting research within ethical boundaries. Therefore, the code of ethics of the TU Delft have been read and understood. Supplementary, I have read and understand the Dutch Code of Conduct for Research Integrity (trans. “Nederlandse Gedragscode Wetenschappelijke Integriteit”). The TU Delft university has established the Human Research Ethics Committee to assess all proposed research from university affiliates that involves human subjects on the ethical acceptability. The research proposal in this thesis report is assessed by the Human Research Ethics Committee, by means of an Ethics Review Checklist for Human Research.

6

Empirical Research

6. Empirical Research

The theoretical underpinnings have been determined through the review of previous studies, the theoretical framework has been developed through a literature review and the research design has been made based on the problem statement and research question. This part further elaborates on the case company and data gathered.

6.1. Introduction J.P. van Eesteren

J.P. van Eesteren is a contractor firm, specialized in utility building projects. Founded by Jacobus Pieter van Eesteren (brother of renowned urbanist Cornelis van Eesteren) in 1932, the company's geographic orientation at first was in the city of Rotterdam and it's vicinity. Projects such as the Euromast, the Kuip (the infamous home to soccer club Feyenoord) and the Groothandelsgebouw (trans. The Wholesale Building) next to the current central station, are all well-known buildings in the city.

Although they still work on projects in Rotterdam, their working area has extended to large parts of the Netherlands. The company was taken over by TBI Group in 1982. Their current headquarters is located in the city of Gouda.

J.P. van Eesteren is part of the larger conglomerate known as TBI Group. Each TBI-sub enterprise operates on its own, leaving J.P. van Eesteren fully in charge of their projects. This means for example that J.P. van Eesteren is not obligated to hire sub-contractors, advisors etc. that are a part of TBI for their projects. Many projects are done in collaboration with organisations external to the TBI group.

All companies that are a part of TBI Group have been requested to contribute to the goals set out by conglomerate. These goals are known as "the three of TBI". TBI wants to:

- Be a leading example within the building sector.
- Achieve fully circular business operations and realize a sustainable built environment.
- Create an attractive, inspiring and innovative work environment.

J.P. van Eesteren thus tries to contribute to these goals by setting similar goals for themselves. The company wants to become part of the top-three contractors in the Netherlands when rated on the knowledge and application of circularity. It is this goal that made this company an interesting organization to analyze for this study.

J.P. van Eesteren considers itself to be a small contracting firm that levels with the big players in the Dutch construction industry. They contract subcontractors, purchase all materials and coordinate all other parties to produce the end-product that J.P. van Eesteren as the main contracting firm is contracted for. Some might actually say they provide a service, which is to coordinate the construction/realization of the building, others say they sell an end-product.

Organisational Structure

In order to provide this service to their client, J.P. van Eesteren has organized its organization to support this service efficiently. Their primary

process consists of five parts: development, engineering, construction, maintenance and building management. Construction, also described as the realization of a project, is the primary service J.P. van Eesteren provides to their clients. Depending on the client's demands, they can extend their services to be more involved upfront, or to remain involved after the project has been delivered.

Different departments within the organization of J.P. van Eesteren are responsible for these parts of the primary process. These departments are: project development, engineering, project realization (which consists of two subgroups: big projects and small projects) and service & maintenance.

The rest of the organization is divided into three components. The managing board oversees the whole organization of J.P. van Eesteren and determines its course. The Project Support departments help the primary process departments out wherever they can. The Organisation Support departments are responsible for running the organization itself, for example the acquisition of new clients, the finances of the company and IT support. Figure 9 depicts the organization and their primary process. The specific linkages between the different departments are to be investigated.

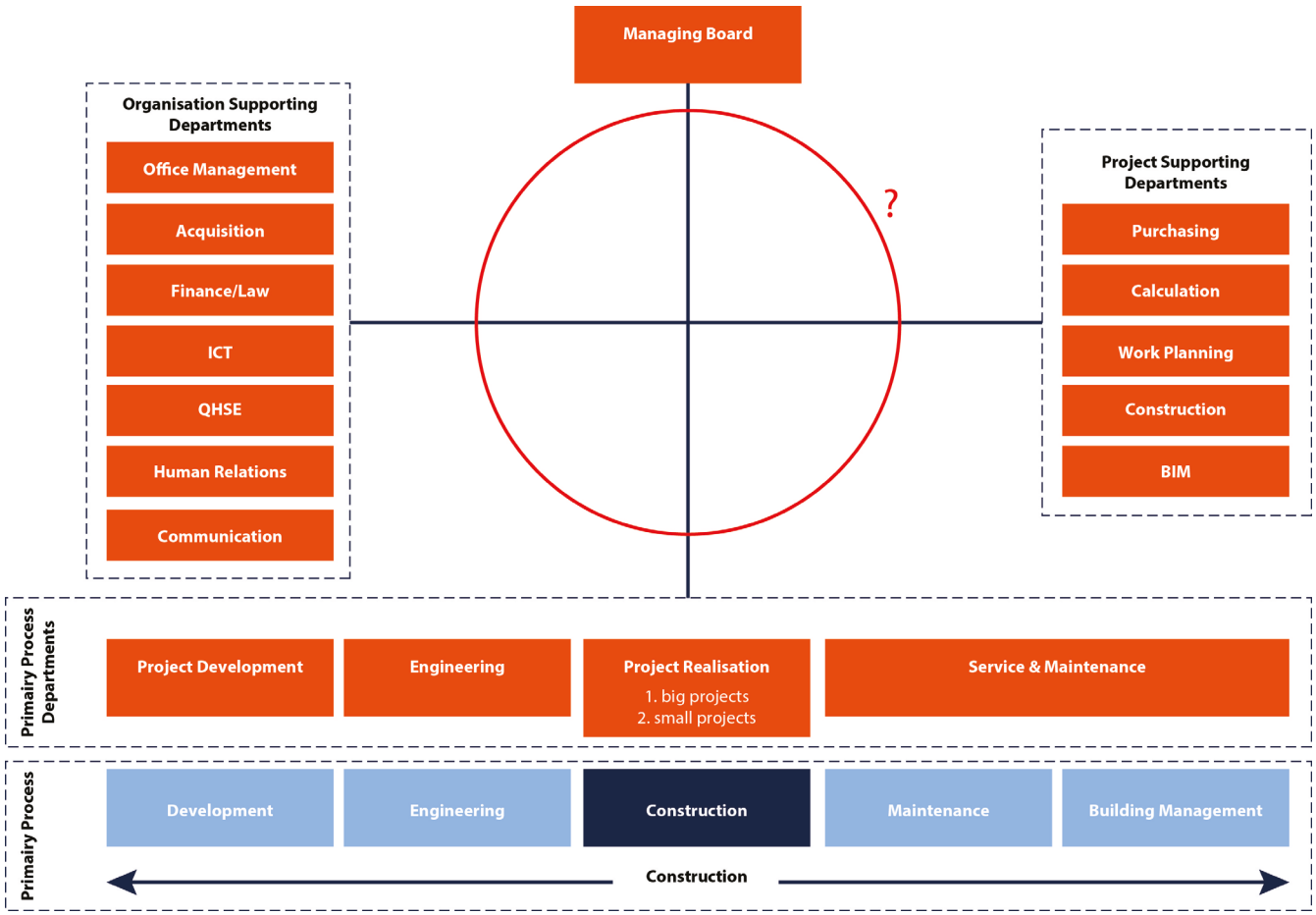

Figure 9. Organogram of J.P. van Eesteren and their primary process (own illustration, based on documents from J.P. van Eesteren.).

6.2. Introduction Triodos Bank project

It is one of the focus points of the company J.P. van Eesteren to become one of the front-runners of contractor firms with experience in circularity. Therefore, a project that implemented circular applications is picked to specially analyse. Preferably, the most "circular project" to date, as that is likely to differ from a "regular project" and the organization the most. This way, commonalities and differences from standard procedures can be identified.

In consultation with J.P. van Eesteren, the project "Triodos Bank" was chosen as the most appropriate.

6.3. Interviews

The interviews are divided into two rounds. First, people who worked on the Triodos Bank project have been interviewed. This round provides a deeper understanding of the project. It gives insight into the process, the opportunities taken and missed, experiences from individuals who worked on the project and possible obstacles that they have encountered.
For the second round, people from higher management of the organization of J.P. van Eesteren are interviewed. These include department heads and members of the executive board. As people who work on the project often have a different perspective, this round should provide a better understanding of the direction the company is heading as a whole. It gives insight into making use of experiences from one project for future projects, obstacles on the company levels for taking certain opportunities and how higher management enables people to make the best projects possible.

6.4. Coding

As discussed in the chapter 5 'Methodology', open coding is used as the method applied for data analysis, in order to analyse, categorise and compare comments from the interviews held. A full list of the codes can be found in Appendix B.

To illustrate the coding process, a quote from the interview with participant 1 is taken as an example:

Quotation 1:72 - "Things have actually become too cheap to be sustainable. Thus we have a wrong yardstick."

The first tier code for this is still rather specific: "Cost of sustainable alternatives". The second tier code is "Financial barriers", as this quotation is one of multiple mentions of other financial barriers. This tier is then brought under a larger group in the third tier code "Obstacles". There are all kinds of barriers which all cumulate to being the obstacles for managing the implementation of circular principles. Finally one more abstraction is made into the orientation of these groups. Obstacles relate to the transition from the current state towards the desirable future state (what obstacles need to be overcome?). Therefor the fourth and final tier code for this quotation is "transition".

7

Synthesis

7. Synthesis

In this chapter, the findings from the collected and analyzed data are presented. The first sub-chapter presents the findings from the desk research, elaborating on the policy documents from J.P. van Eesteren. The second sub-chapter presents the findings from the interviews after coding.

7.1. Findings Desk Research

In order to get a grasp on the organisation of J.P. van Eesteren and their current objectives and strategy, the empirical research started with a desk research on policy and operational documents from the company. A multiplicity of documents have been read, most which fed the understanding of this researcher in how the company works. The desk research mainly aided in the preparation of the interviews, which provided the biggest amount of data for this graduation research. Some documents however, are elaborated on here, as they are mentioned by participants during the interviews. The five documents discussed below are the strategic pillars of TBI Holding, the strategic note of J.P. van Eesteren, the operational plan of J.P. van Eesteren, the department plan of the Engineering department, and the roadmap for circularity by an intra-organisational work group.

The use of these documents have been elaborated on by one of the participants to the interviews. Each year, J.P. van Eesteren goes through a certain cycle when it comes to their policy documents. They start with the strategic note in which the board explores the latest market developments. They try to look 5 years ahead to see what the most important trends are, what is happening to the economy and what segments of the markets are showing growth. This strategic note is then used as a basis for the operational plan. Next to the board, the heads of departments are involved in this translation into the operational plan. Eventually, the operational plan is translated into department plans. For each department, SMART-actions are defined that altogether contribute to the goals set in the overall operational plan. These department plans are judged by the board. Together with the department heads, the plans are evaluated every quarter. The department heads involve their personnel into the department plans and also assign employees to specific objectives [4:58].

7.1.1. The three pillars of TBI

As mentioned, J.P. van Eesteren is part of a larger construction conglomerate called TBI Holdings. The strategy of TBI has been divided into three pillars:

1. Leading market position
2. Circular entrepreneurship
3. Attractive work environment

7.1.2. Strategic Note 2020

In J.P. van Eesteren's strategic note for 2020, a set of about five focal points have been determined. Of importance for this research are:

- Improving communication by stimulating employees to actively share information.
- The employee:
    - Safety first at J.P. van Eesteren.
    - Personal-, corporate, and

knowledge development
    - Stimulating an entrepreneurial culture within the company in which collaboration happens in good trust and there is room for feedback.
    - Improving health and well-being
- Circular entrepreneurship

These focal points are translated into steps of action in the operational plan.

7.1.3. Operational Plan 2020

The operational plan (OP) describes the strategy and its translation into an operational plan for the years 2020 till 2022 (J.P. van Eesteren, 2019). It starts off with an analysis of current market trends and the position of J.P. van Eesteren within that market. Based on this analysis it then delves into what this means for their own values and potential activities they can focus on. Eventually these are translated into operationalized objectives.

Trends

Especially what is written down in their strategy about sustainability and circularity in particular is of interest here. The document begins with an analysis of the current market trends that are of importance to the strategy of J.P. van Eesteren. Next to economic and demographic, technological and socio-cultural trends are mentioned. These last two relate to circularity and sustainability.

For technological trends, “lego-lisation” (referring to LEGO toys) and prefabrication are mentioned as a way to reduce construction time and nuisance to the neighborhood. The building site on this matter is increasingly becoming a site of montage rather than of construction. The benefits regarding sustainability of such a trend are not mentioned. Another technological trend is that of “logistics”, in which complex urban sites require stricter planning for logistics in which deliveries to the site are made just in time. Again, the potential benefits for sustainability, such as a reduction in transportation, are not mentioned. Within the socio-economic trends, Circularity and the energy-transition and use of sustainable energy sources are specifically mentioned.

In their operational plan, the organization of JP has identified multiple trends that affect the market in which they operate. Some of these trends can function as pressures for JP to move to circular practices. Others are also pressures but lead to a different change in behavior, such as demographic trends that will move JP to build other types of housing. Pressures can be seen as leading to proactive behavior, however a pressure itself is unlikely to have the sole purpose of making the organization act proactive, without any specific change as a result. Table 9 shows the trends identified by J.P. van Eesteren that could function as a pressure for change in circular behavior.

In addition to the pressure effects mentioned in the table, the technological trends all have the potential to lead to circular practices, but do not necessarily imply this. Digitalisation for example leads to higher efficiency, which could also just lead to financial gains. These trends, just like demographic trends, provide opportunities. The pressure here for a company like JP, is that they need to stay up to date or even ahead of the game to keep up with their competition.

The regulatory pressures on sustainability are also seen as an opportunity as it will lead to an increase in building production (JP van Eesteren, 2020, p.5): millions of homes need some transformation, as well as all offices who need to get energy label C.

Trend	Pressure
Low employment and reduction in available expertise lead to a scarcity in human resources.	Need to attract and keep the best new workers, who nowadays have expectations in sustainable behavior by their employer.
Emissions of nitrogenoxides and the related 'PFAS'-model in the Netherlands have led to new uncertainties.	This is an example of regulatory pressure (and potentially societal pressure new regulations on nitrogenoxide-emission will move contracting compani to reduce their emissions.
Technological trends: smart buildings, optimized logistics, prefabrication of building components and digitalization	Staying competitive, when applied right, technological innovations might lead to more circular practices.
Social-cultural trends: sustainability, circular economy and energy transition. These all are described as trends by JP and may lead to a combination of pressures.	1. Regulatory pressure as parts of the existing building stock do not meet new requirements. (And there is the potential of new regulations in the future) 2. Societal and political pressure, as there are ambitions to become a circular economy, there are expectations to companies like JP to contribute to this. 3. Financial pressure, as depletion of resources will lead to fluctuating material prices and uncertainty concerning the availability of materials.

Table 9. Trends identified by J.P. van Eesteren that could function as pressures for circular behavior.

Strategy

Core values

JP makes the acknowledgement in their Strategic Note that people are key to success. They emphasize the need for a self-critical/ reflective attitude to strengthen the learning capabilities of the organization as a whole (JP van Eesteren, 2020, p.7). Therefor core values have been determined that should support such a corporate culture. The operational plan does not provide further elaboration on how these core values are sustained or further developed, but the importance of corporate culture has been made known by this to its readers.

Distinctiveness in the future

One of the four points that have the potential for JP to distinct themselves from their competitors in the future, is on circularity specifically. It is written down as follows: "More and more people are looking for welfare in a way that the planet can sustain. Therefore, we are setting in on sustainable buildings and circular building methods to prevent the exhaustion of raw materials and fossil fuels." (JP van Eesteren, 2020, p.8). The objective here is clear, focusing on more environmental sustainable or circular practices. The intention behind it appears to be a commercial one: acting on a changing demand, but people could just as well be the people working at JP van Eesteren.

Thus, in the plan, sustainable buildings and circularity are briefly mentioned. These are not mentioned in the formulation of JP's goals, but are mentioned as potential areas for J.P. van Eesteren to distinct themselves on in the future. The strategy concludes with leading business principles the company and its employees should live by when doing their work. "Safety first" is the first principle. Of the remaining 13 principles, none mention sustainability or circularity. Two principles however relate to knowledge and the culture within the company, these are:

- *Strengthening and improvement of knowledge amongst employees. On the one hand by knowledge development within the organisation, on the other hand by attracting new employees with additional competences.*
- *Stimulating a corporate culture that is positive, self-reflective and self-learning, and in which knowledge is shared.*

Relating back to the problem statement of this study, learning and sharing of knowledge are considered to be important to manage climate change effects. It is therefore interesting to see how J.P. van Eesteren strengthens, improves and stimulates such knowledge-sharing. Promoting the culture, for which the core values have been determined above, is now mentioned as a business principle. The intention is clear, now the question becomes if it is also translated into strategic goals.

Strategic Goals

In the operational plan, J.P. van Eesteren has given their own meaning to the strategic pillars by TBI. For each pillar, themes to contribute to the TBI goals are given and goals for each theme are set. Concerning the second pillar by TBI "Circular entrepreneurship", J.P. van Eesteren has made a translation into their own ambition (2019, p. 12), committing themselves to more circular business operations. Their ambition is split up into three themes:

- Increasing sustainability of the built environment
- Demonstrable performances on circularity
- Minimizing own environmental footprint

These themes are further defined into sub-goals, ranging from specific targets such as reduction percentages for their own footprint as well as more intangible targets such as pilots or developing action items

The third pillar "an attractive work environment" by TBI has been translated by JP Into "Safe and healthy work". This is subdivided into four themes:

- Safe and healthy work
- Training and development of workers
- Integrity
- Typing organization

Of particular interest for this study are the training of employees and typing organization. Increasing the level of education and implementing particular skills into training programs for employees are examples of strategic goals. But the internal selection for job openings is particularly interesting as it is a means to effectively increase the influence of proactive employees.

One of the strategic goals defined for the typing organization is "a flat organization, short communication lines, entrepreneurship within the organization. Corporate culture that is self-critical/reflective and knowledge-sharing (see core values also)" (JP van Eesteren, 2020, p.12). Unlike some other strategic goals, here the overall goal of promoting the proposed culture is not specified any further for these strategic goals.

Action Plans

As a final step, actions are given to achieve these sub-strategic goals. For the "circular entrepreneurship" pillar, most of these steps

remain somewhat vague. The interviews should clarify how these steps are taken eventually and how these steps are experienced.

For the pillar 'attractive work environment', no attention is given to proactive circular behavior. Most points focus on creating awareness for safety or training programs on safety, which are means that could lead to proactive behavior, but none of these are focused on training or creating awareness on circularity.

7.1.4. Roadmap Circularity

In May 2019, a workshop took place at J.P. van Eesteren in which a range of people engaged in thinking about challenges of building circular. The output of the workshop was used by a work group to define a goal for implementing circular principles within the organization of J.P. van Eesteren and to determine steps to achieve this goal. This roadmap has been taken up into the operational plan as well. The following goal concerning the circular economy was determined:

"J.P. van Eesteren literally builds towards the circular economy. Central to this is to avoid spillage and to actively minimize the use of raw resources. Through education, collaboration and innovation J.P. is a front runner in the modern building sector."

This goal is elaborated on by explaining that the need for this roadmap is twofold. First of all, the sector in which J.P. van Eesteren operates requires the company to be distinctive and this should be achieved by being progressive in circular construction. Secondly, J.P. van Eesteren has the intrinsic motivation to become one of the most sustainable contracting companies of the Netherlands and wants to become this by becoming the catalyst within the circular economy.

One of the objectives of the roadmap therefor is to get circularity rooted within the organization of J.P. van Eesteren and to make it a leading principle within the company's policies. As already noted above, currently there is no mention of circularity nor sustainability in the business principles of J.P. van Eesteren. In the new Strategic Note for the upcoming year the objectives of this roadmap are integrated. As J.P. van Eesteren plays a central role in the construction process, working between organisations and connecting all involved actors to projects, they have the potential to make a difference.

The roadmap distinguished three areas of focus to manage the implementation of circular principles. These are:
1. Modular designing & usage of sustainable materials
2. Modular construction & logistics
3. Waste management & reuse

7.1.5. Department plans

In addition to the overall operational plan, each department has their own plan. In one of the interviews, the department head elaborates on the department plan as "all plans should be able to be reduced to the vision of TBI and J.P. van Eesteren, as those visions provide the structure to which all plans should relate" [6:1]. Each department makes this translation for themselves into an operational plan.

Example given, in the engineering department three or four employees are assigned to a work group that look after and carry the responsibility of one goal. The progress of these goals are discussed every six weeks within the department. This way, the department gives meaning to the objectives set out in the overall operational plan.

7.2. Findings Interviews

This sub-chapter presents the findings from the interviews. The findings are presented in four parts. The four parts presented are: the context of J.P. van Eesteren, circular principles, obstacles to implementation of these principles, and means for the implementation of these principles. References to the corresponding interviews are made by using the following annotation: [x:xx]. These references correspond with the codes overview in Appendix B.

7.2.1. Context

TBI

It is important for the case of J.P. van Eesteren to be aware that they are a part of a larger concern which is TBI. TBI as a whole is one of the big five construction concerns of the Netherlands, which means all the sub-companies have quite a clout all together.

Within TBI, J.P. van Eesteren is the contracting company focused on utility projects. None of the other companies within TBI does utility projects. J.P. van Eesteren intends to maintain this position. It is also what their business model is about. They make complex projects, clients hire J.P. van Eesteren because of their expertise and flexibility. They are often too costly for your dime-a-dozen projects.

The difference between TBI and the other big construction concerns is that those steer their subcompanies with more far-reaching policies. As a result their identity is stronger than that of their subcompanies, while at TBI the subcompanies have a stronger identity than the concern itself [2:27].

What this means for J.P. van Eesteren is that they are quite autonomous and they are free to set their own goals. There is a supervisory board to whom J.P. van Eesteren reports to and who give advice on the vision and plans of J.P. van Eesteren [2:31; 2:32; 2:33]. And J.P. van Eesteren tries to contribute to the overall goals set by TBI as well, as have been discussed in the desk research findings section.

Position in Market

Within the market for utility projects specifically, J.P. van Eesteren on its own is one of the big players as well. But according to participant 7, they should be aware to not think they are fully unique. What J.P. van Eesteren builds, can also be built by for example BAM (another Dutch construction concern).

It is noted that J.P. van Eesteren operates in a market that is dictated by demand and supply. They are still very dependent on market demand. Participant 8 makes a comparison to other types of companies, such as Apply or the car-industry. The difference with those type of companies is that they operate in a consumer market, whereas J.P. van Eesteren works in between organisations.

Their business model is that of costs-plus, meaning that they start from calculating the cost price, add their service costs to it and that is their business model. This is an important notion when thinking of their capabilities to implement circular principles. This is also stressed by other participants, who point out that they have to work with 1% or 2% of risk insurance, leaving very little financial room for addressing additional sustainable initiatives.
This however does not mean J.P. van Eesteren has no ambition regarding sustainability and circularity of their own. These are topics that are a trend in society and as J.P. van Eesteren they want to be a part of the leading group on this as well, according to participant 8.

When asked if this position of the contracting firm in the construction process would change if we are to switch to a circular economy, participant 8 replied that the contents might change, but there will still be a role for a contracting firm like J.P. van Eesteren in the building process. This is because of what J.P. van Eesteren does, they are flexible and have to be adaptive to changing circumstances. Participant 7 complements this by noting that they exist since 1932 and have always been able to recognize and tap into trends.

Market demand for circularity

When asked about the market demand for circularity, opinions seem to differ, even between members of the board. Participant 7 sees the increasing importance of circularity as twofold: as a market trend that is becoming increasingly important. Over a long period of time that is, but its importance keeps growing. Thus part is client driven. The other part is that TBI wants to make this move towards circularity from their own motivation, which is also driven by new young employees who have an intrinsic motivation to make a difference to the environment and society. Thus the growing importance comes from both the inside as the outside.

But mentioned before, the J.P. van Eesteren is still very dependent on the market demand. As one participant puts it: *"We are still in a world where we need those clients [clients who find short building time and lowest price more important than sustainability] to ensure our own continuity as a company. Thus we still need to listen carefully to what our clients want and how far they want to go with that."* [4:21].

Because not every project is like the Triodos bank project. That is a kind of progressive project, after which there will be five projects that are done the old-fashioned way. And that is strongly related to the changing companies J.P. van Eesteren works with on projects and with the clients, who might not find sustainability important, or who find it mostly interesting for good press but and in the end want the lowest price possible [4:19, 4:20].

Thus currently, what can be done or cannot be done about implementing circular principles is highly dependent on the market and more specifically the client. One other participant describes the role of J.P. van Eesteren as being the translator of the idea to a buildable construction. As this translator, J.P. van Eesteren cannot just say, we are now a sustainable contracting firm, because they construct what is asked. But: *"We want to concern ourselves with sustainable buildings because we see that is the future. And we want to become the specialist in that. With our knowledge we want to help make those buildings. Thus the situation is: we try to be leading amongst all contracting firms, but we are followers within the market"* [5:14].

Thus ideally, decisions about the implementation of circular principles are not dependent on the client anymore. Participant 6 explains the current situation as *"Ok Triodos bank, you want a remountable building, we will make this for you." And we do this very well. But, "Triodos bank, you want a traditional structure, oke fine we will do this." Thus the relation is very: U ask, we deliver. And then we try to fill it in as best and sustainable as we can. But it would be better if we could say "This is our vision, this is your request, but we would like to fill it in like this"* [6:15]. The problem with the current situation is, that a client too often does not like this and will simply choose another contracting company. Or as one member of the board puts it, "Yes, we could choose to not build or not take the job if it does not meets some minimum level of

sustainability. Whether that is a smart policy and whether we will exist for a long time with the size we have as a company right now, that is something should question then" [4:25].

The Triodos Bank project

One of the intentions of the client to move to this location, which is in the middle of a park, is that this is where they once started their business. They wished to go back to their roots and give the area an impulse. Additionally, they are known to be the most sustainable bank in the Netherlands/the World. Therefor their main office should fit within their own DNA [2.11; 5.20.].

The goals by JP were not specifically written down. The intentions were clear as mentioned above, but concrete measurable goals were not set. This was partly due to the uniqueness of the project and the unknown territory in terms of circularity that JP was entering. As an example, one of the intentions was to focus on reuse. But as there was no idea at all on what to expect, how much material reuse could be achieved on such a project, no measurable goals were set [5.24].

When asked what the main circular activities applied to the Triodos project were, the most answered activity was that the structure was made of wood. Although not very surprising, one might had expected to main answer to be its demountability as this is the main feature the building was featured in the news for: all the connections in the building are made from screws, meaning no fixed connections through gluing, cementing etc. But the interviewees had quite some critique on the environmental value of screwing it all together. The building with its many circular shapes does not have many conventional parts, meaning it is unlikely that whole components of the building can be reused directly in other projects if this building is ever taken apart. Secondly even if it would be taken apart then putting it together exactly the same in a new location would already pose problems. One interviewee put it as follows: *"The Triodos building is hold together by 165.000 screws. Try to get a viable business case to demount that"* [2.27]. However, for some elements it might not be known how to reuse it in the future, but if someone wants do it, it at least is possible. Additionally, it certainly provided a lot of lessons for JP (and the other actors in the building process) as this was the first time they build a building solely with screws.

The structure build in wood is considered the most circular element of the Triodos project. First of all because it is a renewable source, wood can grow back quite fast and therefor has a relatively low environmental impact [5.69]. Secondly, even though the building components might not be reusable one-on-one the wood can easily be reused by sawing it out of the building and producing new products out of it [2.29+2.30].

Intentions & Drivers

The Triodos project was seen as a testing ground for JP where they could learn more about circular activities. The main reason for this was due to favorable conditions: the client was open to innovative ideas and most importantly willing to make additional investments, time and effort to some extent [5.13.]. The client did not pressure JP to want to learn, but provided the opportunity for JP to do so.

The client, as part of the market as a whole, did contribute with their demands to the shift of the markt towards more environmental-conscious market. The shift works as a pressure for JP van Eesteren to act and be ahead of the game. (and for JP the intention to survive) And as one interviewee mentioned:

"Sustainability is also a topic for a contractor like us to distinct yourself from others" [5.14.].

An additional pressure found is regulatory, reference someone who mentions increasing demands such as BENG, for example NZEB-norms (Near Zero Energy Building) that are coming into effect in the Netherlands in the upcoming years will force the organization (and sector as a whole) to find more circular solutions as maximizing energy efficiency through PV-panels will not be enough [8.127].

One of the demands clients can set is to get a certain type of certification for their building. In case of the Triodos bank, the BREEAM certificate led to unnecessary additions of materials due to the certificate's strict acoustic norms. Interviewees seriously questioned the need to meet a norm of 62dB impact noise [6.75 + 6.76]. The client was stubborn in getting the BREEAM score they wanted and even pushed for more points. This was considered by one interviewee a missed opportunity in terms of circular performance. He wished to have had a discussion to see if there are options that perhaps do not up the BREEAM-score, but does make the design more sustainable [5.77]. The BREEAM certificate remains a quality label of which its score does not automatically mean it has got the best sustainable aspects.

Another participant agrees with the critique on the BREEAM-certificate shortcomings, but disagrees on the intentions of the client of the Triodos project. According to him the client did had the intention to go beyond the BREEAM certification, considering the environmental impact of every decision about materials applied and considering the residual value in 40 years for example.

One interviewee mentioned the client of an Erasmus university project who, opposite to the client at the Triodos bank project, did not require such a certification. *"They said: 'We do not need to get a BREEAM certificate, but these points are really important for us.' Thus for example material origins were of importance, the reuse of materials was very important and we would focus on those things we would not need to get a specific certificate"* [8.128]. As a result not only the client but also the project team from JP got the intrinsic motivation to do as much on circularity then when the client wants a certificate to up their value for investors [8.128].

7.2.2. Circular principles

Definitions of circularity by the participants focused mainly on materials, through either making it possible that a building can be reused/taken apart while maintaining high quality; and that us is made of available second-hand/renewable materials [5.59]. And by being of aware of the type of resources you are using and what you are using them for. Considering its impact on earth and the living environment in the long-run. Getting rid of fossil fuels and switching to renewable materials. [3.10].

When asked whether a different process or business model is needed to be able to implement circular principles well, the main critique on current procedures was the involvement of the contractor early on in the process. If you want to make a circular building, that should mean that you want the person who is going to build it and even the person who in years would have to take it apart, on board in the design phase [5.62]. Also, when a project is tendered through a competition, that currently already means that the process at the start is mainly focused on maximum value/price, not maximum sustainability or maximum environmental quality [5.60].

Even though some interviewees have clear ideas about what they think are circular

activities for a contracting firm to focus on, others have more difficulty with defining this or miss concrete directions from their superiors: *"I have ideas about it [innovation and sustainability] and I find it fun to do [have it as one of his task], but it is not like I can say 'today between 14:00 and 16:00 I am going to work on innovation'. But I can meet with the department Calculation between 14:00 and 16:00 to go through all the projects and tell them 'this needs to be done, that needs to be done'. So, that is much more concrete."* [2:70; 2:71].

Participants appear to find it hard to formulate concrete objectives for implementing circular principles. One participant makes the comparison with safety, which he sees as a black or white thing. Something is either safe or unsafe. His perception of sustainability is different from this: *"With sustainability there is certainly something like a little bit sustainable. Because you see that the level of sustainability in projects increases, but there is still something as a little bit sustainable"* [2:105].

Also other participants note the difficulty they have in defining what circularity means for them or what it is meant by it by the company [9:10].This lack of concreteness seems to be troublesome. Especially project managers interviewed, who concern themselves with the realisation phase of a project, call for more concrete measures from the top.

"It is of course very difficult if I as a project manager get a bag of money and a certain scope for the project. In the budget estimations, I don't see anything reserved for circularity, nothing at all. But then you are told 'Be aware though, because in our Strategic Note, we have to something about it.' That is of course a bad starting point." [9:2]

Currently, employees are still judged on whether they save money or spill money. This is due to the nature of the company, being a project-oriented company [9:4]. *"If I spend money on sustainability that is not reserved in the budget, they will look at me sideways. As in, 'Nice of you to do it, but who is going to pay for that?'"* [9:5] This lack of budgeting for circular goals in projects is something acknowledged by other interviewees [8.55].

This perception of lacking support was also found as the fear of making mistakes. This is fear is for a large part due to the business model of a contracting company. As explained earlier, a contracting company works from cost price plus service costs/profit margin. That margin is 2% maximum. That means that everything you do wrong in a project, will reduce that profit percentage [2:73].

Therefore, a contracting firm tends to plan everything into very detailed steps to predict the costs as best as possible and to minimize risks [2:73]. While experimenting, trying out new alternatives or trying things that come up during the realisation are hard to then still do. Thus it is the company's DNA to want to do everything right in one instance, because everyone knows that mistakes costs money. And therefore there might be some fear to make these mistakes [2:75].

He makes the comparison to safety. Naturally, people always have had to work safe on building sites. But about ten years ago, employees at J.P. van Eesteren would be scared to actually take that into account with the budget [9:3]. This is also pointed out participant 7, who notes that safety was something competed on to have the lowest bid [4:27]. Ever since safety has been put on "spot 1", this has improved. Money is now reserved in a project budget specifically for safety measures, this makes it easier to then secure the objectives concerning safety [9:3].

This lack of concreteness is exactly what one of the interviewees is aiming to change. Especially on JP's own development projects, but in general as well, he wants to formulate two goals that contribute to the circular roadmap of JP that are to be incorporated into the design of the project, into the budget of that project and into the evaluation of that project [8.55].

Products & Materials

The circular principle behind the focus on products and materials lies with some basic thoughts. What sources are being used, what is the long term impact of these materials on the environment. Therefor the aim lies at switching to renewable materials as much as possible, for example wood [5:10].

This principle is also something on which steps can be made not only in the preparation phase. Sustainable alternatives to products and materials are something you can still steer on in the later phases of the project, such as the realisation phase [1:106].

However, in order to make this work, there is also a piece of influence needed on J.P. van Eesteren's on employees to start to use these sustainable alternatives, as has been illustrated with the example of concrete [3:60; 3:61].

Additionally, there are some other obstacles to overcome when it comes to products and materials. First of all there is a financial barrier, most of the time sustainable alternatives cost more than traditional ones [3:57]. It might be so that the alternative is cheaper on the long-term, but the contracting company will not make that initial investment from his own motivation. It will require a client who is willing to pay the extra amount [3:58], which relates back to the dependency of J.P. van Eesteren on the client and market demand.

Secondly, there are also some legal barriers when it comes to sustainable alternatives. Often these alternatives do not have all certificates regarding sound, fire safety, structural regulations. By the time J.P. van Eesteren gets those certificates, it is too late for the project they wanted it for [3:59].

Waste management

The circular principle behind the focus on waste management is to reduce the total amount of materials used, and to enable waste that is produced to be recycled or reused as much as possible.

An important thing here is to remain aware of what the implications are of the demands you set. *"You have got to be careful that you do not all of a sudden exclude 90% of the market and you get yourself stuck in this transition you are trying to enforce. But by asking and by expressing what you find important, indicating where suppliers can score with, you can steer on this"* [4:51].

Thus currently J.P. van Eesteren, already indicates in the contract that suppliers and subcontractors have to come up with a plan on how they will reduce the amount of waste that they bring to the building site. Such demands eventually influence these suppliers and subcontractors to also optimize their process, what eventually benefits J.P. van Eesteren's own objectives as well [3:73].

Internally waste management goals are also pushed. The QHSE department of J.P. van Eesteren measures the waste reduction and separation goals on projects. *"Those aspects are measured, feedback is given periodically and it seems to become some kind of contest between the projects: who is the best? Who has the best waste separation and who has the least waste? So that is something good. It*

is a positive performance that is measurable" [5:25].

7.2.3. Individual behavior

"At about 25% of the preparation phase I took the material passport on, which was a request by the client. Eventually it was a client demand and I suggested to make the passport by using Madaster, which was positively received and from thereon I immediately was chef Madaster." – [5.30].

There are three elements that can be taken from this quote. First, is the client demand for making use of a material passport for this project. This is a relatively new (not completely new) innovation for which the architect of this project, Thomas Rau is also quite known. This demand forces JP and the project team to work with this new innovation and pushes them to think about the implementation it. Second is the suggestion made by the employee to make use of Madaster. Although known to be the circularity expert of the company (which possibly also had an influenced on how the suggestion was received), he stepped forward to take a next step in his proactive behavior introduce a new tool for the company to work with, as we will now learn. This was not his first time using Madaster and therefor he had some experience to support his suggestion. The first time was on a different project and the interviewee described that time as a "half-baked" experience [5.32]. The first time was potentially proactive behavior through initiative-taking by the interviewee. This time around, lessons were learned from the previous experience and although the first time was not a big success, the interviewee still thought it would be the right thing to bring to the attention of his superiors and to make this suggestion. That is the proactive behavior shown this time around. Thus, although making use of the material passport was a client demand, the easiest way for the participant would have been to simply make an overview in an Excel-file to meet the requirements, but the participant chose to take the extra step and successfully showed successful championing behavior.

Third is the behavior shown by the organization. They facilitate this behavior by positively responding and enabling the interviewee to champion this by also giving him the necessary responsibility for it. Eventually, Madaster indicated JP was the first contracting firm to make use of Madaster [5.36] for a material passport and thus in that way one could conclude that this also is proactive behavior as an organization.

7.2.4. Organisation

I took the liberty with the last paragraph of the previous finding to take a small leap to the organization. Once individual proactive behavior is considered a valuable means for an organization to make steps towards circular practices, then such behavior needs an organization that fits that behavior. Not only an individual can be proactive, a department or the firm as a whole can be proactive as well. Through proactive management, the organization can stimulate, inspire or support people to show proactive behavior.

Proactive management

Another objective of J.P. van Eesteren, "safety", provides some interesting parallels to sustainability. Safety is about the well-being of the people on the building site. This used to be thing that contracting firms compete on, and some still do. Thus, contracting firms that look for the minimum levels of safety can often make a lower bid for a project and got awarded more often.

"At some point we said, we want safety on spot 1. Thus we reserved money for it in our budget estimations. […] This means you are talking about tons of costs that a competing contracting firm does not account for. Thus that was something we had to highlight and you sometimes encounter parties that say: "those are your employees, we don't care about this. The other contractor will also get to work for a lower price." Which is a reality we still encounter today. So yes, we wanted it ourselves. But that means that sometimes you have to give and take in order to maintain continuity." [4:28] The parallel to the implementation of circular principles is found interesting because both are much about attitude and behavior [4:30]. *"Is it something that we really think should be on spot one and do we express that? Or is it something we say, but don't really feel like? This was a bit similar with safety."*[4:30]. Achieving some safety certificate is easy, but achieving a change of culture within the organization is much harder [4:31].

With safety, J.P. van Eesteren started at the top of the company, making them really becoming representatives of safety [4:32]. So what happens right now with safety, is that it comes back in all layers. As shown in the desk research, it is the first business principle. When board members visit a building site, the first question they ask is not about the budget or planning of the project, but about safety measures taken. And people are praised and success is highlighted when high scores on safety certificates are achieved. Safety is the first topic on the agenda of every meeting and it also is the topic that is addressed when contracting suppliers and subcontractors. It gets continuous (positive) attention [4:33, 4:34]. This particular participant thinks the same path should be followed when wanting to implement circular principles, especially because there are still people who do not have it in their mind yet. [4:36].

An importance difference should be highlighted between safety and circularity or sustainability in general, which is the lack of urgency. When comparing the implementation of safety, another objective of J.P. van Eesteren, with circularity, the difference in terms of urgency was brought to attention. With safety, everyone agreed and sensed that they did not want any more accidents or fatalities on the building site. *"Nobody accepts that you or your colleague does not come home from work. We said, none of us wants that anymore. We want a safe environment"* [2:92]. But with sustainability, there are simply too many alternatives that are still accepted by many [2:96].

The example was given of choosing between shopping at the outdoor market or at the supermarket. He goes by the grocery store and fills up his self-brought shopping bag with goods. But two days later when he drives home from work, he goes by the supermarket, where all goods are packed in plastics and cartons. Both options are there, and although he prefers one, he is not that strictly principled to not go the supermarket if its more convenient [2:116].

Sharing knowledge

An evaluation report is made of each project, half-way and at the end. That also includes the Triodos project [8.103], but when asked if knowledge is shared actively the main response was that the active sharing of knowledge within the organization is insufficient or even lacking [5.22].
Knowledge sharing mainly takes place on the project team level. This is already an improvement as some years ago people were used to do large parts of projects on their own and also within project teams the tendency used to be that once a project was finished everybody quickly moves onto the next project

and everybody takes their own knowledge with them [8.96].

Additionally, within some departments, success and failures are shared during department meetings in order to all learn from it. This is the case within the Engineering department [8.105], but not the case within the Realisation, where the project managers say they have too little time they spend meeting each other to be wasting time on discussing project evaluations [5.23]. Amongst foremen of the construction sites, also no knowledge is shared, apart from the rare occasional phone call [4.95+4.96]. But even knowing who to call can be an effective means of sharing knowledge, as no one can bear all knowledge and if you worked multiple years on a project it is quite hard to share it all within one session [8.107]. Another participant points towards the expectancy of some own responsibility by employees to share and ask for experiences of others themselves [2:119]. He tells that lessons learned are shared within each department, but it depends on the attention payed to it by each department, and the extent to which people are receptive to it, whether that is effective or not [2:122; 2:123].

Within the organization more tools facilitate finding knowledge for whomever in the organization searches for them. JP Link is an online intraorganizational platform in which updates on current JP projects are shared. A sustainability project map is made for employees to look up specific sustainable/ circular activities from past projects [8.97].

When looking at sharing knowledge on circularity, the aforementioned project evaluations fall short. One of the participants did not experience much knowledge sharing after the completion of the Triodos-project. He also does not really know where he should share this [1:114]. When a project is evaluated, the project team members from all involved departments join, even up to the responsible person from the board of directors. But circularity is not a standard topic on that evaluation. According to one interviewee, this would be the perfect time to address the topic of circularity and reflect on its implementation in the respective project. Currently it is mainly just brought to the attention to inspire and “show off” a bit. It has not become a reoccurring topic to be evaluated periodically yet [5.102. + 5.103].

Power of Repetition

The power of repetition is a means applied to both external actors such as the suppliers and subcontractors, as to internal actors such as project team members or employees in general.

The power of repetition used to influence suppliers and subcontractors is illustrated by the head of the purchasing department, who takes safety as an example. He explains that safety is not something J.P. van Eesteren had to teach itself, but what also needed to be taught to the subcontractors and suppliers that J.P. van Eesteren works with [3:42]. They represent a large part of the workers on a building site. He explains that every call with these external actors by the purchasers of J.P. van Eesteren start with “safety first”. They explain to them why they find safety important and explain that if the external actor wants to work on the project, he should find it important as well.

“By talking to you about it every day, you will start - in two weeks - to think ‘Oh right, that guy, he always talks about safety so he must find it important.’ That is the point we want to achieve, that Is the power of repetition.” [3:43].

Additionally, by making this part of standard procedure, employees are reminded to address safety in every call. This is also a

repeating measure for themselves [3:45]. This repetition also helps against slackening. When an objective is not given attention enough, people will forget it or become lazy in working on it [3:31; 2:111]. This relates to the comments made by the head of department of the realisation phase, who as quoted earlier, does not pay attention to circularity, if he is not judged or asked about it [9:15].

7.2.5. The Bidirectional relationship between the individual and the organization

Over the years there is a shift in the company's profile, which has a direct relation with the type of people working there. Whereas first there were only one or two people championing and believing in sustainable goals within JP, this group is now growing [8.88]. One participants notes that this is also a very conscious thing he takes into consideration when hiring new people. He looks for people who bring something new to his department. As the former company profile was more focused on technical aspects, time and money and thus most people had strong technical knowledge, he now looks for people who can challenge the conventional methods with new sustainable thinking [8.90].

Lack of Support and Awareness

Multiple interviewees indicate that they believe not everyone within the organization is convinced and intrinsically motivated to steer on the implementation of circular principles. Participant 8 adds that also due to the team/ project structure of the company, people who might be motivated be placed in a role where they work with someone with seniority who is perhaps less enthusiastic and prefers to everything the traditional way [4:46].

"Top management: the department heads, members of the board, project managers, general foreman… they find it [circularity] a thingy that we have to do, rather than seeing it as part of the primary process and important aspects of a project. With Triodos you see that this was different. It was one of the most important aspects in the project, next to planning and the budget" [4:38].

This relates to comments made by participant 9, the department head of the realisation department and also project manager on some projects as well, who admits that sustainability is on perhaps the fifth place on his priorities list. He attributes this to the aforementioned lack of concrete project goals on sustainability. He also makes the comparison to Triodos bank, where there were concrete project goals on sustainability. In such a case people will start to spend energy and time on it [9:13]:

"If I don't get clear project goals, then I always start with time, money, safety, quality and if my team has a bit of air left, I try to think along on other topics as well. But you probably see this coming, due to the issues of the day, that is just not going to happen, you will not make any progress. That is simply how it is" [9:14].

Participant 7 notes that it is mostly new young employees who bring this intrinsic motivation to the company. This means the motivation amongst employees slowly increases. But the current people who do have the motivation often feel held back.

Another part that relates to this lack of support base is a lack of awareness concerning circular solutions or activities. An example is given of another project build by JP, the QO Hotel in Amsterdam, where the project team managed to achieve successes concerning waste management. And although the successes were shared, people would not be convinced: *"Everybody hears about it, but thinks 'Ah it will probably cost a lot money' or 'It seems too difficult. I will just bring all the*

panels to the building site and cut them into the right size there.'" [8.70]. The colleagues of this participant simply are not informed well enough and thus unaware of the potential benefits and easy applicability of circular solutions, even if they have already been proven to be a success.

One part that contributes to this also is not even a lack of awareness or of being convinced, but simply being unwilling to change. People tend to stick with things they are used to. This is not only the case for clients, who do not want "second-use" materials, but also very much for employees.

This is illustrated by the use of sustainable concrete, in which the component gravel is replaced by concrete granulate. The participant experiences unwillingness by foremen from the realisation department. Even although this type of concrete does not cost more than regular concrete, they are not using it [3:61]. *"And why not? Because they will have notify the construction engineer, or the material is a bit more viscous than regular concrete. Some people don't trust anything they don't know. […] In short, a hundred-and-one excuses to not do it and it is not in their DNA."* [3:61;3:62].

The power of repetition plays a role here. When asked how to deal with such employees who do not want to use this sustainable type of concrete, participant 10 replies: *"by talking about it, talking about it, talking about it."* [3:63]. Up until the point that someone will use it and spread positive word about it to others.

Influencing actors

J.P. van Eesteren does try to influence parties, by suggesting alternatives and providing input from their expertise. This is something they constantly do in their relation to the client. They can attempt to steer a bit through these discussions, but in the end J.P. van Eesteren is not in the position to impose these alternatives [2:107]. This relates to the earlier comments made on their position in the market.

So where does J.P. van Eesteren can have a decisive impact on the implementation of circular principles? When asked, participant 3 pointed to possibilities to give meaning to the design. In the end, J.P. van Eesteren has to follow the design that they are given. This means that they should focus on how to fill in the design. The main areas for this are waste reduction, waste separation, logistics, products & materials and the tools used [5:19]. When asked how J.P. van Eesteren has the most influencing in implementing circular principles, the suppliers and subcontractors were often mentioned [1:98]. Where J.P. van Eesteren has to follow market demand and the wishes of the client, the suppliers and subcontractor want the work J.P. van Eesteren has to offer.

And this is something that happens already. The purchasing department works together with the suppliers and subcontractors to both look for sustainable alternatives as to work on waste reduction and separation [3:26]. A specific focus here lies with blanket orders: long-term contracts with suppliers for products that return on every project, such as concrete or wooden plate materials [3:27]. On such returning products, most impact can be gained.

Another group that J.P. van Eesteren has an influence on are its own employees. At the Triodos project for example, the project manager would regularly hold brainstorm sessions to think about how they could make the project more sustainable [1:120]. This meant people would start to own it and have fun in it. This motivation means they would invest time and energy in it. These brainstorms were specific for the Triodos project and are

not generally applied.

Exemplary person

One of the means to address implement circular principles within the culture of J.P. van Eesteren, is to have exemplary persons, representatives of this objective who are responsible for it and who thus own it. This suggestion is also made by the head of the realisation department: *"Someone who comes to me to have a cup of coffee. And who tries to test certain objectives with me, like 'Hey, we agreed upon these objectives for your project, how is it going? Why is it not working?' Then it will move on up on my list of priorities and you will end up making more steps."* [9:15]

The board member who has sustainability and innovation assigned as a task and who thus carries the responsibility, is aware of the leading role he fulfills [2:70]. He also mentions the importance of giving the right example. He explains that if someone comes to him and tells him he tried something now, something sustainable and it went wrong, then there are two options that the board member could do: punish him and or try to not make it too negative. *"I could saw him by the legs, but then he will never try anything new ever again. It has a lot to do with exemplary behavior, but also with highlighting good results. If someone managed to do something that is new successfully, we will put it in the spotlights and it will have a positive effect on that person and others. If the person fails, we have to be careful that we do learn from it, but do not make it too negative"* [2:80].
One of the interviewees actually was the board member who has "innovation and sustainability" assigned to him as a responsibility. He emphasizes that innovation and sustainability are no real departments within the organization and are not part of the primary process. *"It is a part of your organization or its not"* [2:49], referring to the DNA of the company. He finds sustainability and innovation to be inherent to the work J.P. van Eesteren does, not a set of tasks [2:69]. When asked what his goal is then for innovation and sustainability, he answered that he wants it to be something that is a topic that is described in a set of tasks, but that has become part of the whole system of J.P. van Eesteren [2:72].

He suggests that what needs to be done first, is to create a culture within the company, where it is ok to think about innovation and sustainability. That people are open for it [2:50]. In order to do so, he intends to challenge people to think about it, and to start small [2:51].

Related to influencing employees is the means of people management or coaching. This means was brought forward as a way to also counter the obstacle of slackening. Participant 10 deals acts on this by hiring an external company to coach his department on a regular basis and to go through their objectives and progress [3:30; 3:31]. This continuous attention given ensures that people do not lose focus and the objectives do not become forgotten. It therefor also closely relates to the power of repetition.

7.2.6. Summary

In summary, contextual factors that influence J.P. van Eesteren in their implementation of circular principles were discussed. J.P. van Eesteren is still very dependent on market demand, but also functions as a client to suppliers and subcontractors. Their position as a subsidiary to TBI gives them more clout, while remaining autonomous in their decision-making. TBI has a positive influence on their objectives regarding circularity.

The main idea interviewees linked to circularity, was material-related: reducing the use of materials, maximizing reuse of materials and designing for demountability. In standard building projects, the contractor has the most influence, as mentioned in literature as well, on logistics, waste streams and what happens on the construction site. In order to also influence the design, they need to be involved early in the process. Due to the fragmented nature of the construction process, this is not always the case unfortunately.

Top-down action is called for by some of the interviewees, but not everyone from top management seems to be convinced of this need for top-down action and rather sees the implementation of circular principles grow naturally from bottom-up.

In general you can see that there are people who are more critical of the circular achievements by the company than others. They see that progress is made but also see that there is still a lot of improvement and also are capable of expressing and explaining this. Others with seemingly less knowledge on the topic of circularity are just happy and proud of what is done and are less critical what could have been done better. This can be because of numerous reasons: their job description/ position does not require them to get involved much with circular principles (such as the foremen), they simply don't care too much, they have not been enlightened yet as they have not been involved much with circular projects.

What is certain is that these people could gain from training/awareness into this topic from the organisation. Opposite the critical persons, these people are seemingly more reactive and are likely to adapt to the culture expressed by the organization.

8

Discussion of findings

8. Discussion of findings

In this chapter, the findings are discussed by answering each sub-research question.

S1: "How are decisions, related to the implementation of circularity principles, influenced by the context in which the contracting company operates?"

As mentioned in the theoretical framework, proactive strategies and proactive behavior are often driven by certain intentions. These intentions are often shaped by pressures from different internal and external stakeholders. Decisions to adopt circular goals or to implement specific circular solutions in projects are driven by these strategies, these intentions and indirectly by these pressures. From the data some of these influences or drivers were found.

Some important external stakeholders were found to be influencing the adoption of circular practices by JP. Stakeholder theory states that in general growing pressure from stakeholders leads to firms yielding to the pressure and adopting environmental practices voluntarily (Seroke-Stolka & Fijorek, 2020, p. 2341). External stakeholders do not have control over the actions of the organization, but deliver pressure through things as public opinion, market demand or shareholder wishes (Sarkis et al. 2010). In the case of JP van Eesteren, this pressure for adopting circular practices comes from client demands such as the client of the Triodos bank project; the future prospects of more similar client demands; which are also fed by potential new regulations that will also deliver pressure on clients and contractors; a need stay competitive to satisfy shareholders; and even to attract the best human resources.

An important stakeholder group that requires highlighting next to clients, are the shareholders, which in this case is TBI, the concern that J.P. van Eesteren is a part of. TBI has made circularity as one of their three main objectives. Although J.P. van Eesteren can set their own goals and targets, they are expected to contribute to the goals of TBI. TBI therefore functions as a driver for J.P. van Eesteren to take adopt circular practices.

At the same time, currently most of the market does not demand circular solutions yet and therefor put different pressure on JP, holding back their adoption of environmental practices. JP van Eesteren's business model is to offer the lowest bid possible by calculating the cost price of the construction of a project, and then add a 2% margin which covers their risks and represents their profit. This makes them extremely focused on avoiding money spillovers. This competition on price makes them more dependent on what the client wants and does not allow room for additional circular principles that J.P. van Eesteren finds important unless it does not cost more than the conventional application.

Thus when it comes to implementing circularity principles, J.P. van Eesteren seems to be highly dependent on its context. The market in which the company operates, and the role they play within the construction process, makes them dependent on the demand of the market as a whole when it comes to their overall

company strategy, and on the demand of the client when it comes to projects specifically.
Henriques and Sadorsky, as cited in Seroka-Stolka & Fijorek identified four environmental strategies to categorize firms into. The strategies were based on the level of commitment to environmental issues (2020, p. 2339):

a) The reactive strategy, used by organizations where neither top management nor employee support and involvement for environmental issues exists.

b) The defensive strategy, in which the organization only aims to meet environmental regulations and no to little support and involvement for environmental issues exists

c) The accommodative strategy, in which there is environmental issues gain some support and involvement by the organization and environmental management becomes an important function within that organization.

d) The proactive environmental strategy, in which the organization takes environmental issues into account for every management decision and deploys advanced environmental practices.

JP van Eesteren currently follows the accommodative strategy, in which initiatives are supported when individuals behave proactively, but the strategy of the company is still heavily dependent on external stakeholder pressures. Ideally, JP van Eesteren moves to the proactive environmental strategy, making environmental issues part of every decision.

S2: "What circular principles can be identified that can be proactively implemented by the contracting company?"

The possibilities for circular principles depends in what stage of the building process JP becomes involved. If it is early on in the design phase, there are more (influential) circular activities possible, as big decisions as construction material (wood instead of concrete for example), design for deconstruction etc. are yet to take place.

When looking at the part of the process where the contractor is fully responsible for, the realization phase, the most discussed circular principles that were identified are using sustainable alternatives to applied materials and products, and reducing and separating waste streams.

Looking back at the closing, slowing and narrowing of loops as described by Bocken et al. (2016), especially the circular practices that can be opted for in the design phase have the potential to close the loop (design for deconstruction), but even practices that are only thought of after the design phase can still contribute to closing or slowing loops, such as making use of a material passport in the Triodos project.

Another important notion is that their role in the building process is that of being in between organisations. J.P. van Eesteren takes the idea of one organization and translates that by using knowledge from other organisations. The supplier or subcontractor does not have the capacity to construct the project directly for the client, while the client does not have the knowledge or capacity to organize the whole construction process. There is little influence on the client, as the contractor has to build what the client wants, but there is much

influence on the suppliers and subcontractors, who have to deliver what J.P. van Eesteren wants.

Taking the difference in influence over actors into account, important aspect in identifying what principles can be implemented by J.P. van Eesteren, is to know what is within their control. Their area of influence in which they can manage the implementation and where they are not dependent on the demands or actions by other parties. The area of influence in terms of actors is twofold: J.P. van Eesteren has an influence on their suppliers and subcontractors, to which they can communicate their interest in circularity and even set demands. And J.P. van Eesteren has an influence on its own employees, of which not everyone is convinced or willing to actively work on circular principles yet.

Combining their accountability in the realization phase of a building project, with their influence over the subcontractors and their own workers, makes the building site and everything that happens on it the main area to fully control circular practices by JP.

S3: "How is the implementation of circular principles within the contracting company related to its own current practices?"

The current practices by J.P. van Eesteren, how they manage projects and how their organization is organised, strongly influence the implementation of circular principles. Eventually it all comes down to people. Most of the comments made in the interviews are related to the organizational culture. Culture, the DNA of J.P. van Eesteren, people management, these are all aspects, objectives, obstacles or means that relate to people. It is not surprising that the Employee is specifically mentioned as an important entity in the strategic note of the company. As this paper set out to research, the proactive behavior by the employee was described as having a lot of potential for implementing circular practices.

Participant 10 mentions that in his role specifically as a department head perhaps the most important thing is bringing people together, making co-workers get along well and get the same norms and values in the DNA of the group [3:20]. *"If you can achieve that, all the rest will follow."* [3:20]. It is important to get everyone facing the same direction and that is not something that is easily done. It takes a long time, years, to get there. [3:21; 3:22]. This describes the underlying message of most of the findings. Proactively, and effectively implementing circular principles first and foremost requires the creation of a culture that supports this.

This is also found in literature, where Crant (2000, p. 449) found that (the perception of) a supportive organizational culture helps promoting issue selling behavior, whereas conservative organizational cultures makes people hesitant to issue selling. Sarkis et al. (2010, p. 165) specially points towards organizational culture as a potential barrier to environmental practices. Lack of capabilities in knowledge and training can lead to the company responding inaccurately to pressures for the adoption of environmental practices.

S4: "How can a contractor company act on circularity principles to maximize their potential?"

Taking into account the answers to the previous three sub-research questions, J.P. van Eesteren should be aware of their position

in the market and their role within the building process. The interviewees all seem to be quite well informed about this. It is then the area of influence from their position and role that should guide how to act on circular principles. Influencing suppliers and subcontractors, but most importantly influencing their own employees is how they can manage this implementation.

By stimulating proactive behavior by individual employees, top and middle management can steer on innovations regarding circular practices. By setting switching to a proactive environmental strategy, as mentioned above at S1, company goals regarding the circular economy can be communicated clearly and taken up by mid management to turn into specified concrete goals tailor-fit for each building project.

In the other direction, when an individual within the company shows proactive behavior this should actively be stimulated and supported by management. This enables the individual to become a real champion in his or her specific initiative.

The potential impact of each circular principle differs. But for each principle counts that getting the involved people on board is the most important step if J.P. van Eesteren wants to maximize the impact of these circular principles. Overcoming the presented barriers and making use of the means is all about ‘people management’. As people management is a relatively soft aspect, this might be more difficult to act on. As mentioned in one of the barriers and in the desk research, actions on the implementation of circularity are not very concretely defined. Therefore, the role of top management is more important than with very tangible actions, as they should give direction when the steps for implementation become vague.

As one participant said, it this has to happen in small steps. What constitute these small steps, is something that the perspectives of the interviewees differ on. Defining what these small steps are, making them concrete, would be the first step into implementing the circular principles.

9

Conclusions

9. Discussion, Conclusions & Recommendations

In this chapter, the research is discussed, after which conclusions are drawn and recommendations are made. The discussion elaborates on specific choices made in the study that might have affected the results. After potential influences on the results have been discussed, conclusions of this study can be drawn and the main research question is answered. The chapter concludes with a set of recommendations for future research.

9.1. Discussion

A single-case study approach has been applied in this research. This brings some limitations, especially in the possibilities to generalize findings. As only one contracting company has been analyzed, no comparisons to other companies can be made. It is therefor difficult to determine whether found obstacles and means, and the way to be proactive in general, are also applicable to other contracting companies. The benefit of focusing on one company only, is the amount of depth into the company. When studying multiple cases, time has to be divided over each case and as a result, each case would be explored less in depth. Perhaps the findings would be very different and would be generalizable. But looking at the topics that came up in this single-case study, which are very much about culture and DNA, the ability to go in-depth had a positive effect.

Additionally, the approach by Stake to qualitative research was followed in developing the research process. There are some comments to make about Stake's approach which can be troublesome. As Stake builds upon the notion that the course of the research cannot be predicted in advance (Yazan, 2015), there remains a lot of uncertainty and there is a risk of ambiguity from the researcher as there is no clear protocol to be followed. This lack of protocol makes it harder for other researchers to reproduce or validate the findings of this study.

This can also be seen in the analysis of the data. In the open coding and eventually in the reporting of the data, there is a lot of room for interpretation by the researcher. The reliability and validity of the results therefore depend highly on the skills of the researcher, who has to try to be empathic and present all different perspectives from the data within the reporting.

Validation in this study currently has been achieved in only one way: by using different sources for the data, namely documents and interviews. The validation therefore is rather shallow. This means the risk of other researchers reaching other findings and drawing different conclusions if they would do the same research is bigger than one would wish for. This affects the reliability and substantiation of the findings.

9.2. Conclusions

In this graduation research, the implementation of circular principles within the organization of a construction company is studied. The aim of the study is to describe how this implementation of circular principles is managed by a construction company, and to explore how this can be done proactively. The sub-research questions have been answered

in the discussion of findings. These answers cumulated provide the basis to answer the main research question of this study:

"How does a contracting company manage the implementation of circularity proactively?"

As a means to answer this question, a single-case study into the Dutch construction company J.P. van Eesteren has been conducted. In order to answer the research question, a determination should be made on whether or not the company is showing proactive behavior towards the implementation of circular principles. It can be concluded that the case contracting company is currently neither proactive nor fully reactive in managing the implementation of circular principles. The company takes on an accommodative strategy. Overall they show mainly reactive behavior, waiting for market to make changes through client demands. But they show some signs of proactive behavior on projects where the conditions are right. This proactive behavior however is not a standard within the organization of J.P. van Eesteren and present at all projects. Ideally, J.P. van Eesteren switches their strategy to a proactive environmental strategy, making environmental issues part of every decision.

It then becomes the question why J.P. van Eesteren does not show this proactive behavior as a standard and how they could achieve this. A part of the answer to this why question comes from the context in which J.P. van Eesteren operates. They are dependent on market demand and therefor cannot proactively determine all circular implementations in their projects. Especially clients as external stakeholders will have to deliver pressure by demanding more circular practices for their designs. But there remains an area where J.P. van Eesteren does have an influence and where they are in control in every project. This influence lies with the room in which they can give their own meaning to the translation of the design into the construction. In case of J.P. van Eesteren, making use of sustainable alternatives to products and materials, and the management of waste are two important circular principles that J.P. van Eesteren can use for this translation.

In order to do so proactively, the second part of the main research question is of importance. The characteristics of the company and its current practice are found to have a big impact on the behavior and performance of the company in implementing circular principles. Culture, motivation and the facilitation of knowledge-sharing are examples characteristics that either can enable or obstruct proactive behavior by individual employees and as a result the effective implementation of circular principles. An organization supportive of proactive behavior by individuals, increases initiative-taking and issue selling by employees who can positively influence the organization by triumphing innovative circular practices. When done successfully such initiatives could lead to organization-wide implementations.

Thus, most attention should be given to the people within the company. It are these people that will need to be aware, informed and motivated to carry out this proactive behavior. To get these people to act accordingly, the right culture needs to be developed, which is something that requires close attention from top-management. Top-down action could speed up creating such favorable conditions.

9.3. Recommendations

This subchapter presents recommendations for future research, for practice, and for the case company J.P. van Eesteren specifically.

9.3.1. Recommendations for J.P. van Eesteren

It is recommended for J.P. van Eesteren to make the objectives and actions concerning circularity more tangible. Their roadmap to circularity is a good step towards this. This document describes the tangible aspects of the circular principles the company wants to focus on. In order to also make sure that the current practice and culture of the company can facilitate these actions, the tangible aspects of the circular principles (for example applying an sustainable alternative concrete material) should be matched to the intangible aspects (awareness of the importance of such sustainable alternatives).

Therefore, steps should be formulated on how J.P. van Eesteren intends to reach this match, by creating the right culture that supports the proactive behavior. The recommendation here is made to do this top-down, as the vagueness of the intangible aspects leads to much confusion and might demotivate people to be proactive.

9.3.2. Recommendations for practice

Due to the research method, no generalization of the findings has taken place. It is therefore not sure that the findings from this study also apply to other contracting firms. However, it seems that contracting firms who work within the same market will experience the same external influences. Potentially they will find some of these findings to overlap with their own situation. This is not guarantueed, as for example a contracting company might have more construction capacity in-house compared to the case company of this study.
As noted in the problem statement, there appears to be a lack of knowledge-sharing within the construction industry and no consensus on what circularity, or climate change action in general is nor how contracting companies should act on it. Although the findings are largely focused on internal aspects of the company, some common areas might be found by firms. Hopefully this can spark a discussion amongst contracting companies to collective take action.

9.3.2. Recommendations for future research

It would be interesting to make a comparison to a developer-contracting company, who's largest sum of work comes from its own project development. J.P. van Eesteren also has a project development department, but this is relatively young and only accounts for a small portion of the primary process. Findings from this study suggest that there were more possibilities to steer on circular principles during project development and that actions or decisions made in this phase can have a bigger impact than actions and decisions in later phases. Studying a developer-contractor who mainly develops its own projects could provide new insights in how circular principles can be implemented if the contracting firm can act in this early phase of a project.

Looking into the far future, moving to a circular economy can impact the role the contractor plays within the construction process. It would be interesting to see what changes are made to that role and how this affects the area of influence the contracting company has. It is then also interesting to see what organizational structure would fit the new role and business model of the contracting company. A comparison could be made to this study to see how this will change.

10

Reflection

10. Reflection

In this final chapter, I will reflect on my process which started 13 months ago in September 2019. A lot has happened since and my graduation research transformed from some personal ideas and interests about the construction sector into a full qualitative study. I would first like to thank Paul, Erwin and Rebecca, who guided me throughout this process and always were able to provide the right feedback and suggestions for me to continue exploring both the academic and societal side of the sector and its many facets.

Research design, research method and lessons learned.

The choice of taking a qualitative research approach for my research was made quite early on. It was not that I specifically wanted to do a qualitative method, but my intentions with my study from early on were to study the opinions and perspectives of people from the construction sector. Combined with the topic climate change action(first and circular principles later), I never really found quantitative measures fitting. This is further elaborated on in my report, but I also think an additional thing played a role here which is my personal affinity with the qualitative research method. Although far from easy, I doing a case study and conducting interviews fitted more with my personal skills rather than surveying and doing statistical analyses for example.

The original plan at time of my P2, was to study three cases: three different contracting companies from the Netherlands. By interviewing a couple of employees of each firm I would be able to get some idea of how these companies were structured and worked. This way I could compare them and see how they dealt with climate change effects. I followed the approach to case study research developed by Yin and wanted to do a cross-case analysis to derive at my findings and answers to my research questions. Throughout the second part of my graduation research, thus the period since P2, some of these things changed.

Instead of studying three companies, I switched to a single-case study, in which I studied one contracting company more in-depth. As a consequence, the analysis switched from cross-case analysis to open coding and cross-interview analysis. And I switched from following the procedures prescribed by Yin to the approach of Stake. Although this last change might sound very theoretical, it actually meant a lot in how thought and approached my research. I struggled for quite some time with things like my interview protocol, as I felt like I wanted to go in the interviews with an open mind and little structure, to be surprised. But the approach I set out at P2 did not fully support such an approach. Changing to the approach by Stake fitted my idea of my research much better and also resulted in me having more confidence in what I was doing.

Altering the proposed method was not a bad thing, instead I think it was a sign that I made progress. I discovered that there was a disalignment between what I wanted to find out and the plan I had thought of to derive at those answers. The tough part here was to make those changes, as I often clinged on to decisions and steps I already took, even when it became evident that I had taken a wrong

turn. This meant I sometimes felt lost at to where my graduation research was going, but in all cases I eventually made the necessary changes and was able to continue and make new steps.

Also, the change towards a single-case study proved to be the right choice, because culture, the DNA of the company, and its employees turned out to be extremely important for proactively implementing sustainable principles. Getting a feeling for this culture takes time. I wonder if I even have been able to really understand these things for this one company. If I would have studied three companies I would have only scratched the surface of these companies and I think especially these things like culture would remain underhighlighted.

Part of this learning curve was incited by the feedback of tutors. Paul, my first mentor, has surely steered me on multiple occasions in a certain direction. Especially in finding my interests, defining my research topic and in selecting my research method, Paul has been of much support through his feedback. This happened for example by him or Erwin suggesting certain areas of research or certain theorists for me to look into. I think I have been quite eager in taking all this new information up and really digging into it. Sometimes I perhaps took this too far as I would just take the direction of the suggest topic or theorist blindly and I would find myself a bit lost on how everything connected to each other. But I think that I became more nuanced in using these sources. During the research I found out that nothing is either black or white, instead there are many shades of grey. This graduation process therefor also has been quite an adventure for me to find out what fits me as a researcher (what research methods and philosophical views on these methods do have affinity with) and what fitted my graduation research.

An example of this is the previously mentioned switch from Yin to Stake. Another example is my research focus on “proactivity”. This focus or motivation for my research into proactivity sprouts from a certain personal incomprehension or almost indignation of why the construction industry in the Netherlands appears to do so little about climate change (and why they seem so conservatist in everything). This was to be honest quite a prejudice which was not proven and unfairly generic. To some extent I showed in my review of previous studies that the industry does show mainly reactive behavior and little proactive behavior towards climate change effects and that little is known about proactivity in the sector. But during the empirical part of my study, I slowly kept coming across a more essential question: is it at all desirable to be proactive towards climate change effects as a contracting company? (I leave the discussion on the difficulties of determining whether or not my case company was an exemplary company that showed proactive behavior out of this reflection.) Logically, from the perspective of Mother Nature, every company should be proactive in dealing with climate change. But during my interviews I discovered that it is not that black or white. Being proactive as a contracting company could also mean it eventually breaks you up and you end up with nothing. Sometimes it might be better to wait for clarity from for example the government on sustainability requirements. Especially when there is no general consensus on what things really are sustainable or circular. This is quite a turn from my original starting point in which I had the view that everyone should be a pioneer instead of waiting for others to take action. This turn however does not mean that the current behavior or stance towards climate change action by many is the right one and the one that achieves the maximum potential. Proactivity establishes itself in many shapes and sizes, thus also in small steps that might be less drastic but cumulatively can still make

a difference over time. People or companies are never 100% proactive or 100% reactive. Again, it is not black or white and thus the goal should be to strive for the perfect balance between the two. I think this is one of the lessons that I slowly became aware of during my graduation process.
Relation research topic towards the master track Management in the Built Environment.
In short, the master track MBE has a focus on sustainable development and management of buildings and urban areas, taking into account end-users and other stakeholders. This study ties in to both the focus on sustainable development, as the building sector will not achieve the national climate mitigation targets with its current trajectory. There is a need for firms in the sector to proactively address climate change mitigation and adaptation, which relates to the aim of this master to strive for sustainable built environments. Secondly, this study has a very social aspect to it as well, as it focuses in part on the people that are a part of the contracting company under study. The MBE master track pays specific attention to the management of people in building processes, to which this study delivers a contribution.

Scientific relevance.

The scientific relevance of this paper can be found in the existing gap identified during the systematic review. Currently, there appears to be no clear overview of what action firms in the construction industry are already taking to address climate change. This study will provide new insights for the academic community by focusing on practice by a contracting firm rather than on policies by public actors.

Secondly, the influence of the context and of the organisational structure of the contracting company on its decision-making was studied. Themes that arise on these relations have been linked to existing theories in order to contest or support the findings.

Societal relevance and transferability of the results.

The societal relevance of this study can be found in the need for climate change action. As shown in the introduction, the effects of climate change can be impactful on people's lives, health and their environment. Specifically the built environment will experience negative effects if no action is taken, while the building sector also can also contribution the reduction of climate change effects. Currently the climate agreement goals are note expected to be met. Action from the construction sector is needed to change this. Although it focuses on a small part, the contracting company, this study can help the construction industry (and the contracting firms that are part of it) to identify themes of importance and hopefully take action. Secondly, knowledge appears to be only shared limited between firms in the construction sector. Development of new knowledge also does not happen in a sector-wide coordinated approach. This study might contribute to improve knowledge-sharing. This study first and foremost helps the case company to identify areas of attention for itself, but the findings might also be used to identify commonalities with other contracting firms. This way, the sector as a whole can address these commonalities. Third, this study contributes to the awareness by the construction company of its own organisation and flexibility towards unexpected changes.

The second and third point made above might be hard to achieve in reality, as a single-case study method was applied in this graduation research. There might findings that are recognisable for other contracting companies, but even then there are differences in the type of contracting companies. The case

company in this study builds utility-type projects. Contracting companies that only built residential projects might experience different things. Transferability of the results to other actors is even harder or even impossible, as my findings specifically relate to the role of the contracting firm in the building process. The areas of influence for example of a contractor is very different than that of the client, architect or even subcontractor.

Ethical issues and dilemmas encountered.

In the execution of the research, the main ethical issues that arose where related to the sensitive information that some of the documents by the case company contained that I had access to. In agreement with the person who tutored me on behalf of this company, I ran information I took from these documents by them in order to ensure no sensitive information was disclosed. Other ethical issues mainly related to the execution of the interviews, which are described in the report.

Potential issues that arise in the application of my results in reality would be that eventually the case company itself has to take the most important step, which is implementing my recommendations. Most certainly there are reasons that did not came up or fell out of scope in my research that might drive the case company to not take action. In the end, it depends on the willingness of the decision-makers at the company. If this willingness is not there, they would need to do something about this and. The final step to proactivity lies with themselves, which I think is actually a nice concluding observation for this reflection.

Thank you.

Gert-Jan

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Appendices

Appendix A - Synthesis Matrix

Author	No. Total	#search	Year	Title	Journal	What is the study about (RQ)	What Method?	What is the key finding?	Theme/topic	Adaptation/Mitigation?	Reactive/Proactive?	Level of analysis	Subject is Public/Private?	Aimed at Public/Private
Zehra et al.	1	#13	2019	Rapid flood risk assessment of informal urban settlements in Maputo Mozambique	International Journal of Disaster Risk Reduction	The aim of the paper is to understand how flooding affects day-to-day life of residents of Maxaquene A	Case study; desk-basesd research, literature reviews and observations in the field. Data collection through interviews, workshops and transect walks.	Flooding has an impact on daily life of residents affecting mobility, health and well-being. The most urgent concerns of the case' neighborhood are solid waste management and drainage infrastructure (which go hand-in-hand). Infrastructure should be part of CCAdaptation plans, due to its direct impact on livelihoods.	Flooding; risk assessment	Adaptation		Local government	Public	Public
Mabon et al.	2	#13	2019	Fukuoka: Adapting to climate change through urban green space and the built environment?	Cities	Assessing how the city of Fukuoka has integrated climate adaptation-related issues into its local policies to draw lessons for other Asian subtropical cities facing climate-related risks.	Policy document review and interviews	Most distinctive is that there is a robust body of scientific evidence produced by local scholars and institutions on which municipal policymakers may draw to support their decisions.	Climate change governance; urban planning	Adaptation	Reactive	Local government	Public	Public
Dino & Akgül	3	#13	2019	Impact of climate change on the existing residential buiding stock in Turkey: An analsyis on energy use, greenhouse gas emissions and occupant comfort	Renewable Energy	Evaluating the consequences of climate change in Turkey, and to assess possible adaptation measures on a building scale.	Impact analysis for turkeys climatic regions; assessment of residential building with three cooling scenarios, on multiple climate change impact types (CO2 emission; energy use; comfort etc.)	Overheating will be experienced in the future, which will have a strong effect on cooling energy use and/or occupent comfort.	Impact assessment; scenarios; cooling of buildings; building energy performance	Adaptation		Building		Both
Murtagh, Gatersleben & Fife-Schaw	4	#13	2019	Occupants' motivation to protect residential building stockfrom climate-related overheating: A study in southern England	Journal of Cleaner Production	Examining the motivation of householders and tenants in the UK to modify their homes to protect against overheating.	Survey amongst home occupiers	Enhancing people's perception of their capacity to take action and of effectiveness of the action, could increase the contributions of householders to societal resilience in the face of rising temperatures.	Overheating; occupants motivation	Adaptation	Proactive (precautionary measures)	Occupant	Private	Both
Boezeman & de Vries	5	#13	2019	Climate proofing social housing in the Netherlands: toward mainstreaming?	Journal of Environmental Planning and Management	What factors influence the mainstreaming of dimate change adaptation measures in development and renovation projects in the social housing domain in the Netherlands?	Embedded case study approach. Content analysis of housing association documents; desk study on social housing policies; and in-depth semi structured interviews with H.A. policy makers and other experts.	Anticipatory and deliberate adaptation action to date was very scarce and attention limited in the social housing domain. (multiple factors are given; limited awareness; low priority i.r.t. other issues; financial constraints; regulatory constraints; lacking cooperation and nomaterialisation of adaptation concerns in procedures and perfromance agreements.). Also, adaptation is weakly institutionalised.	Housing associations; barriers; policies	Adaptation		Policy		Public
Young & Essex	7	#13	2019	Climate change adaptation in the planning of England's coastal urban areas: priorities, barriers and future prospects	Journal of Environmental Planning and Management	To explore what progress has been made by the planning stystem in England in addressing climate change adaptation in coastal urban areas.	Mixed-methods approach	The adaptation produced through the planning system remains incremental rather than transformative	spatial planning; planning policy	Adaptation	Reactive	National government	Public	Public
Krasny & DuBois	8	#13	2019	Climate adaptation education: embracing reality or abandoning environmental values	Environmental Education Research	How can the field of Environmental Education engage in climate adaptation education in a manner that is consistent with Environmental Education values?	Literature review	EE needs to continue its traditional role in education that supports efforts to mitigate the human environmental footprint; however we need education for adaptation and by carefully choosing our approached, we can integrate adaptation education in a manner consistents with EE values.	Environmental education	Adaptation	Proactive	School	Public?	Public
Hurlimann, et al.	12	#13	2018	Barriers to climate change adaptation in the Australian construction industry - Impetus for regulatory reform	Building and Environment	The aim of the paper is to identify and explore barriers to climate change adaptation in the (Australian) construction industry.	Twenty-one interviews with key actors (managers from different sectors, different company sizes and different cities) in the Australian construction industry.	17 issues (both barriers as opportunities) related to climate change were identified. Most were seen as both a barrier and an opportunity. The five most mentioned issues were: inconsistent or unclear language; limitations of the regulatory framework; perceived unaffordability of CC initiatives; lack of CC awareness and lack of client demand. Also, building codes need reviewing to ensure CCadaptation is addressed and incorporated by contractors.	Barriers; opportunities	Both	Reactive	Sector	Private	Both
Fastenrath & Braun	14	#13	2018	Ambivalent urban sustainability transitions: Insights from Brisbane's buiding sector	Journal of Cleaner Production	Examining How and Why green building practices develop and what barriers exist at the city level.	Case study of Brisbane; based on an interactive workshop, policy document analysis and interviews.	Continual support from both policy makers and industry actors are crucial when economic market mechanisms do not drive sustainability transitions.	Sustainability transitions; pathways	Both	Proactive?	Local government	Both	Both
Steurer & Clar	16	#13	2018	The ambiguity of federalism in climate policy-making: how the political system in Austria hinders mitigation and facilitates adaptation	Journal of Environmental Policy & Planning	What effects did the Austrian federal system have on climate change mitigation and adaptation? Are the policy effects similar or different for the two aspects of climate policy-making?	Two case studies, build up from document analyses and semi-structured interviews.	It is not federalism on its own but federalism combined with various contextual factors that shape environmental policy-making.	Policies; federalism	Both		Policy	Public	Public
Pisello et al.	18	#13	2017	The role of building occupants' education in their resilience to climate-change related events	Energy and Buildings	Can the education and cultural background of citizens affect their awareness about climate change events, consequently increasing/decreasing their vulnerability to extreme hot conditions while at home?	Survey	Participants' educational background represents a clear way to drive environmentally aware behaviors minimizing the consequent health risk imputable to urban overheating and other environmental hazards.	Overheating; building occupant education	Adaptation	Proactive?	Occupant	N/A	Public
Forino et al.	19	#13	2017	Climate Change Adaptation and Disaster Risk reduction integration: strategies, policies, and plans in three Australian local governments	International Journal of Disaster Risk Reduction	The paper aims to explore how Australian Local Govs promote CCadaptation and disaster risk reduction integration into strategies , policies and plans.	Document analysis of three Local Govs		Policies; risk reduction; local governments	Adaptation	Proactive	Policy	Public	Public
Jones et al.	23	#13	2017	Built asset management climate change adaptation model	International Journal of Disaster Resilience in the Built Environment	The paper reports the development of a staged process of including CCadaptation into built asset strategy for social housing in London, based on an already existing framework.	Workshops and semi-structered interviews; building surveysl building simulation models and life cycle costing analysis were analysed. Final stage: dicussions and meetings with professionals.	A 10 step approach to adaptation planning is proposed, that should help facility managers to improve the climate change resilience of their built assets in the social housing sector	Asset management; social housing	Adaptation	Proactive?	Portfolio	Private	Private
Malek & Grierson	25	#13	2016	A contextual framework for the development of a building sustainability assessment method for Iran	Open House International	To develop the basis of a framework that will inform the development of an assessment method for incorporating sustainability in the built environment in Iran.	Review of current assessment tools	The paper has profiled the basis of a contextual framework that will inform the development of a regional tool for Iran.	Building sustainability assessment	Adaptation	Reactive	Policy	Public	Public
Moazami et al.	26	#13	2016	Energy retrofit of a day care center for current and future weather scenarios	Conference paper	To evaluate the behavior of a net-zero energy day care center udner future weather scenarios, in terms of energy and thermal comfort	Case study	In the long-term, the retrofitting concept of the zero-energy building may require the installation of a cooling system. Design strategies should include future weather scenarios.	Future weather scenarios; net-zero energy buildings	Adaptation	Proactive?	Building	Private	Private
Shearer et al.	28	#13	2016	How the structure of the Australian housing development industry influences climate change adaptation	Housing Studies	How does the institutional structure of the Australian private housing development industry influence its risk profile and its ability to innovate?	Survey; interviews and focus groups	The industry is highly heterogeneous, with diverse company structures, and a preference for diversification as a risk-reduction strategy. Diversification can drive sustainable development, but is largely unrecognized by policy-makers.	institutional structure	Adaptation	Reactive	Sector	Private	Public

Author	No. Total	#search	Year	Title	Journal	What is the study about (RQ)	What Method?	What is the key finding?	Theme/topic	Adaptation/Mitigation?	Reactive/Proactive?	Level of analysis	Subject is Public/Private?	Aimed at Public/Private actors
Walker et al.	29	#13	2016	Application of insurance modelling tools to climate change adaptation decision-making related to the built environment	Structure and Infrastructure Engineering	To propose and test a probabilistic method for undertaking cost-benefit analyses of proposed building adaptation measures.	Hypothetical case study	This study highlights the importance of including insurance, the nonlinear characteristics of disaster losses and temporal changes to community size and asset value in undertaking mitigation cost–benefit analysis	cost-benefit analyses	Adaptation	Proactive?	Policy	Private	Public
Fahrion, Horn & Weller	32	#13	2015	Glass façades of the Eastmodernism - Construction and Climate Change Adaptation	Aufsatz	To investigate the effects of higher summer temperatures on buildings of the 1960s and 70s.	Case study of typical german industrial building: calculations with climate data	Heating demand remains the main challenge for these buildings, although cooling demand rises significantly.	heating and cooling; existing stock	Adaptation	Reactive	Building	Private	Both
Tan et al.	34	#13	2015	An empirical study on the relationship between sustainability performance and business competitiveness of international construction contractors	Journal of Cleaner Production	To test the relationship between sustainability performance and contractors' competitiveness.	Correlation analysis and regression analysis	The U-shaped relations exists. This may help international contractors to evaluate their position and to maximize their profits with innovations in sustainability	Business competitiveness; sustainability performance	None	Reactive	Firm	Private	Private
Forino et al.	36	#13	2014	Disaster risk reduction and climate change adaptation policy in Australia		To analyse the local, regional and national policies in Australia regarding disaster risk reduction and climate change.	Document analysis of policy documents.	Impacts of climate change on Australia's economy, society, and environment over the coming decades will be significant. DRR and CCA strategies are essential in order to limit these impacts and reduce the probability of much greater and more destructive consequences in the future.	policy analysis; australia	Adaptation	Reactive	Policy	Public	Public
Carlsson-Kanyama et al.	38	#13	2013	Barriers in municipal climate change adaptation: results from case studies using backcasting	Futures	To investigate barriers to successful local climate change adaptation due to lack of support from decision makers in other organisations than the municipality iself.	Backcasting? Together with civi servants from 2 municipalities, visions fo the ideal adapted local society were developed. Based on these visions the authors identified a range of external decision makers upon whose input these municipalities depend in achieving this ideal adaptation.	The study finds a vertical dimension to the analysis of barriers of climate change adaptation. It highlights the interdependence between organisations at various levels in a society; local, regional, national and international. They advocate a systems perspective on adapatation. (especially now in a situation where there is an increasing degree of out-sourcing, privatisation etc.)	Barriers; external stakeholders; vertical alignment	Both	Reactive	Local government	Public	Public
Mazmanian, Jurewitz & Nelson	39	#13	2013	A governing framework for climate change adaptation in the Built Environment	Ecology & Society	To develop a governing framework for climate change adaptation similar to the already existing framework for climate change mitigation (to keep the global temperature rise at a max of 2 degrees).	The authors only draw arguments from existing literature? It seems a bit like a conceptual paper, not empirical?	The authors developed a governing framework for the built environment in which projects approval include minimum standards that integrate forecasted climate change impacts, and where the framework is updated every 6 years	Governing framework	Adaptation	Proactive?	National government	Public	Public
Owen, Fisher & McKenzie	40	#13	2013	Beyond reduction: climate change adaptation planning for universities and colleges	International Journal of Sustainability in Higher Education	To outline a unique six-step process for the inclusion of climate change adaptation goals and strategies in a University Climate Change Plan	Mixed-method: literature review; meetings; surveys and a workshop.	The majority of literature surrounding climate change adaptation planning is aimed at larger levels of organization than a University campus (f.e. nations). The poper provides a new planning process.	Climate change adaptation Planning; university campus; adaptation assessment	Adaptation	Proactive	School	Public	Private
Keenan & Oldfield	42	#13	2012	The Urban Impacts Toolbox: An initial assessment of climate change flood adaptation options for Westport	Weather & Climate	To investigate the potential for undertaking an assessment of strategic flood mititgation options.	Case study	The key finding was a demonstration of the process of an initial options assessment.	Flooding; assessment of adaptation options	Adaptation	Proactive	Local government	Public	Public
Eakin et al.	44	#13	2011	Public Sector Reform and Governance for Adaptation: Implications of New Public Management for Adaptive Capacity in Mexico and Norway	Environmental Management	To analyze the potential tentions between New Public Management and adaptive-capacity buiding.	Two case studies: Norway and Mexico	The success of NPM reforms presumes the existence of core elements of governance that have often been found lacking. Some key attributes associated with governance for adaptation therefor have been eroded by NPM reforms.	Adaptive capacity; governance New public management	Adaptation	Reactive	National government	Public	Public
Pedersen Zari	48	#13	2010	Biomimetic design for climate change adaptation and mitigation	Architectural Science Review	The paper examines biomimicry as a means to both climate change adaptation and mitigation in the built environment.	Comparative cross-disciplinary review.	Incorporation of a thorough understanding of biology and ecoogy into architectural design will be significant in the creation of a sustainable and healthy built environment.	Biomimicry; architecture	Both	Proactive	Building	Private	Private
Hasegawa	51	#13	2004	Climate change, adaptation and government policy for the building sector	Building Research & Information	The paper comments on papers from a special publication of this same journal to develop a discussion on ways to develop government poicies to encourage the required Ccadaptation in the building sector	n/a	n/a	designing adaptation policy	Adaptation	Proactive	Policy	Public	Public
Martinez et al.	52	#23	2019	Organization Environmental Footprint through Input-Output Analysis	Journal of Industrial Ecology	To evaluate the Organization Environmental Footprint of a construction company in Spain, using a multiregional input-output approach.	Case study	The quantification of the Organization Ecological Footprint with the input-output approach will grant the organisations a reduction in expenses and an environmental advantage over competitors.	Ecological footprint; assessment	Mitigation	Reactive	Firm	Private	Private
Chen & Chen	53	#23	2019	Potential impacts of coal substitution policy on regional air pollutants and carbon emission reductions for China's building sector during the 13th Five Year Plan period.	Energy Policy	To evaluate the coal substitution policy during the 13th Five Year Plan period of China.	Literature review; testing of framework through scenario design and factor analysis.	A policy-driven increase in natural gas consumption could be helpful for some less-developed areas in achieving greater health benefits and faster low-carbon transformation.	Emission reduction; evaluation of low-carbon policy impacts	Mitigation	Reactive	Policy	Private	Public
Rajkovich & Okour	55	#23	2019	Climate change resilience strategies for the building sector: Examining existing domains of resilience utilized by design professionals.	MDPI	To better understand how resilience is defined in the building esctor and adopted by building professionals in their work.	Document review	Few documents incorporated an ecological or social science-based logic. There is a need to translate resilience from academic domains into building strategies.	climate change resilience strategies	Adaptation	Reactive	Sector	Private	Both
Kamei, Kurisu & Hanaki	56	#23	2019	Evaluation of long-term urban transitions in a megacity's building sector based on alternative socioeconomic pathways	Sustainable Cities and Society	To estimate and quantitatively analyse future changes in building stock and carbon emissions in tokyo's building sector.	Socioeconomic scenarios and Quantitative analysis.	Results show two alternative pathways that can reduce carbon emissions by approximately 15 percent compared to the current pathway in 2050.	assessment of future carbon emissions; pathways	Mitigation	Reactive	Local government	Public	Public
Lai, Lu & Liu	57	#23	2019	A sythesized factor analysis on energy consumption, economy growth, and carbon emission of construction industry in China	Environmental Science and Pollution Research	To explore the relationships and trends among carbon emission, energy consumption, and GDP growth rate and carbon emission intensity of the Chinese construction industry.	Kaya model	Energy consumption was the main driver to the increase of carbon emissions.	Relation energy consumption and carbon emission	Mitigation	Reactive	Sector	Private	Public
Hurlimann, et al.	58	#23	2019	Is the Australian construction industry prepared for climate change?	Building and Environment	To explore the preparedness of the Australian construction industry to adapt to climate change risks.	Interviews	Increased awareness of the impacts of climate chaneg, better translation of existing solutions into practice, and regulatory reform are needed.	adaptive capacity; preparedness	Both	Reactive	Sector	Private	Private
Gokarakonda et al.	60	#23	2019	Decoupling in India's building construction sector: trends, technologies and policies	Building Research & Information	To analyze decoupling resource consumption and environmental impacts from growth in the Indian building construction sector.	Document analysis	Technological 'leap-frogging' is needed to ensure decoupling, to minimize damage to the environmetn while maintaining human welfare.	decoupling; building materials	Adaptation	Proactive	Policy	Private	Public
Graham & Rawal	61	#23	2019	Achieving the 2 degree goal: the potential of India's building sector	Building Research & Information	To report on the progress of India's contribution on global building sector climate actions.	Global Status Report analysis	The adoption of consistent national energy and GHG emission reduction goals could further align national, subnational and private-sector climate action commitments facilitate climate change transition.	progress reporting; India	Both	Reactive	National government	Public	Public

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Du et al.	63	#23	2018	Club convergence and spatial distribution dynamics of carbon intensity in China's construction industry	Natural Hazards	To examine whether carbon emissions have the characteristic of convergence across provinces in China's construction industry or not.	Markov chain approach. (quantitative)	Provinces with high carbon emissions have a negative influence on their neighbor, whereas the provinces with low carbon emissions have a positive influence.	Spatial distribution; carbon emissions	Mitigation	Reactive	National government	Private	Public
Ma et al.	64	#23	2018	Assessing co-benefit barriers among stakeholders in Chinese construction industry	Resources, Conservation & Recycling	To provide an effective theoretical basis to assist stakeholders to evaluate co-benefits performance and tackle conflicts of interest in sustainable development in the construction industry.	Case study	Stakeholders of suppliers, firms and the sustainable community are deemed to have priority to achieve co-benefits.	Co-benefits; stakeholder theory	Both	Reactive	Firm	Private	Private
Cellura et al.	65	#23	2018	Climate change and the building sector: Modelling and energy implications to an office building in southern Europe	Energy for Sustainable Development	To analyse the potential impact of climate change on the energy uses for heating and cooling in southern Europe.	Morphing for weather projections; energy simulations on a case study	The results show an overall increase in total energy consumption with a decrease in heating demand and an increase in cooling demand.	weather effects; cooling and heating demand	Adaptation	Reactive	Building	Private	Both
Karavai, Lütken & Puig	69	#23	2018	Could baseline establishment be counterproductive for emissions reduction? Insights from Vietnam's building sector.	Climate Policy	Is the optimal balance between the costs and benefits of baseline setting currently being realized? (in Vietnam)	Case study: Document analysis; interviews and observations.	Emissions reduction measures are not only driven by a cost-efficiency or development rationale, but are also influenced by the institutional feasibility of baseline setting.	Baseline setting; energy efficiency policy	Mitigation	Reactive	Sector	Public	Public
Akan, Dhavale & Sarkis	71	#23	2017	Greenhouse gas emissions in the construction industry: an analysis and evaluation of a concrete supply chain	Journal of Cleaner Production	To develop a method to measure the impact of greenhouse gas emissions when concrete material is used in construction	Case study	Results show various emissions for the use of various types of concrete.	sustainable concrete; greenhouse gas emissions	Mitigation	Reactive	Building	Private	Private
Ibn-Mohammed	72	#23	2017	Application of mixed-mode research paradigms to the building sector: A review and case study towards decarbonising the built and natural environment	Sustainable Cities and Society	To illlustrate how an agenda within the building sector can be formulated from initiation to fruition using mixed-mode approaches.	Case study	There is no right or wrong approach to realising a research aim. Nevertheless, a mixed-method approach offers a number of advantages.	Research paradigms; mixed-mode approach	None	n/a	School	Private	Public
Abuzeinab, Arif & Qadri	74	#23	2017	Barriers to MNEs green business models in the UK construction sector: An ISM analysis	Journal of Cleaner Production	The aim of the study is to identify barriers to Green Business Models.	19 semi-structured interviews with selected UK construction sector experts. Results were obtained through thematic analysis. Then interpretive structural modelling was used on the found barriers to find their collective impact.	Five major categories were identified: government constraints; financial constraints; sector constraints; company constraints; and lack of demand. The government constraints are driving the rest ofthe barriers followed by financial and construction sector constraints equally. Lack of demand appears to have the least significance compared to the rest of the barriers.	Barriers; Green Business Models	Both	Reactive	Sector	Private	Both
Timilsina et al.	75	#23	2017	Development of marginal abatement cost curves for the building sector in Armenia and Georgia	Energy Policy	To develop a methodology to estimate marginal abatement cost for energy efficiency measures.	Case study	Most energy efficiency improvement options considered in the study would produce net economic benefits, even without taking the value of the reduced carbon into account.	Energy efficiency measures; abatement cost curve	Mitigation	Proactive	Building	Private	Private
Lai et al.	76	#23	2017	Driving forces for low carbon technology innovation in the building industry: A critical review	Renewable and Sustainable Energy Reviews	Identifying the relevant driving forces of low carbon technology innovation and their interaction in the construction industry.	Case study China: Survey; deductive method en simulation model.	It will take a long period of time to transform traditional projects to low carbon projects.	System dynamics; low carbon technology innovation	Mitigation	Reactive	Firm	Private	Private
Yang et al.	77	#23	2017	CO2 emissions in China's building sector through 2050: A scenario analysis based on a bottom-up model	Energy	To gain an comprehensive understanding of carbin emissions in China's building sector.	Cabon-calculation methodology; scenario analysis	It is critical to simultaneaously control floor space, energy cosumption and energy structure to limit the growth of carbon emissions in the building sector.	carbon emissions; scenario analysis	Mitigation	Reactive	Sector	Private	Public
Li and Jiang	78	#23	2017	Moving low-carbon construction industry in Jiangsu Provice: Evidence from decomposition and decoupling models.	MDPI	To measure the total CO2 emissions of the Jiangsu Province construction industry.	IPCC cabon emission accounting method.	During most of the years covered by the study, an expansive negative decoupling state existed between the level of CO2 emissions ad the output value of Jiangsu's construction industry.	carbon emissions; decoupling analysis	None	Reactive	Sector	Private	Public
Cho & Jeong	80	#23	2017	Is energy policy on the right track for the climate target in the Korean building sector?	Journal of Asian Architecture and Building Engineering	To determine whether Korea's climate mitigation targets are in line with energy and climate policies.	linear modelling method; scenario analysis	There is a discrepancy between current energy policy and climate change policy.	alignment of climate change policies	Mitigation	Proactive	Policy	Public	Public
Du, Wu, Wang & Bai	82	#23	2017	Spatiotemporal characteristics and influencing factors of China's construction industry carbon intensity	Policy Journal of Environmental Studies	To investigate the spatiotemporal characteristics and the dominating factors of China's province-level carbon intensity in the construction industry from 2005-2014.	Spatial econometrics: spatial dependence analysis and use of econometric model	Carbon intensity has been decreasing in the past 10 years in each province;	spatial economics; carbon emission intensity	Mitigation	Reactive	National government	Public	Public
Xing et al.	84	#23	2017	A study on mitigation potential in service building sector: efficient technology implications of China's intended nationally determined contribution.	Conference paper	To estimate the achievability of the CO2 reduction target in China's service building sector.	Cost optimization model (called AIM)	The service building sector has potential to succeed a no-regrets CO2 reduction target by 2030.	mitigation potential; service building sector	Mitigation	Reactive	Sector	Private	Both
Aigbavboa et al.	86	#23	2017	Sustainable construction practices: "a lazy view" of construction professionals in the South African construction industry	Conference paper - ICAE2016	To determine the challenges hindering the adoption of sustainable construction practice in South Africa.	Survey	Foremost challenges are: the assumption of additional costs; and limited understanding of the benefits of sustainable construction.	Sustainable thinking	Both	Reactive	Firm	Private	Both
White	90	#23	2016	The conditions of practical action: Neoliberalism and sustainability in the Australian road construction industry	Environment and Planning C: Government and Policy	To examine the historical conditions within which industries' focus on construction efficiency emerged as the basis of practical action.	Historic analysis	The efficiency-based approach to sustainability by the Australian road construction industry is unsufficient to meet carbon targets. A different approach is needed.	neolibarlism; environmental impact	Mitigation	Reactive	Sector	Private	Both
Zhang & Wang	93	#23	2016	Hybrid input-output analysis for life-cycle energy consumption and carbon emissions of China's building sector	Building and Environment	Development of an hybrid input-output approach to account for supply-chain energy and emissions by China's building sector.	Scope-based & stage-based analyses	Although the operation stage appears to be the one with the largest consumption and emissions in the lifespan of a single building, attention should also be paid to the construction stage.	Life cycle assessment; input-output analysis	Mitigation	Reactive	Sector	Private	Private
Lai et al.	94	#23	2016	Low carbon technology integration innovation assessment index review based on rough set theory - an evidence from construction industry in China	Journal of Cleaner Production	To develop an evaluation system framework for the low carbon technology integration innovation from the perspective of system management.	Survey; exploratory factor analysis	Evaluation of low carbon technology innovation should be conducted by a smarter managing of system resource input, the process control and the system comprehensive performance as an output.	Integration innovation; system management; assessment	Mitigation	Proactive	Building	Private	Private
Spyridaki, Ioannou and Flamos	95	#23	2016	How can the context affect policy decision-making: the case of climate change mitigation policies in the Greek building sector	Energies	Transition dynamics are mainly driven by the choices of the agents involved. The study proposes a methodological framework that considers important contextual trends to be the ones that are expected to have a great impact over policy intended effects by key related actors.	The proposed framework is tested on the case of energy conservation in the Greek construction sector; and strenghtened through a stakeholder survey among key actors in the Greek building sector, and interviews with 17 experts with both closed- and open-ended questions. Cluster analysis method was applied to the results.	To improve compliance and participation in claimate change PIs, policy makers need to understand the context in which PIs operate. They should take into account both economy-related exogeneous trends and specific national needs and characteristics. Suc hconditions can be translated as effective instruments to help improve the effectiveness and efficiency of policy instruments.	Policy decision-making; contextual factors	Mitigation	Proactive	Policy	Both	Public

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Dobrovolskiine & Tamosiuniene	101	#23	2016	An Index to Measure Sustainability of a Business Project in the Construction Industry: Lithuanian Case	MDPI	The study proposes a composite sustainability index of a construction project.	Literature review and pilot case study	The index may be useful in assessing the sustainabilty of a business project when making decisions regarding project portfolio selection and financial resource allocation.	Sustainability index; project portfolio management	None	Proactive	Portfolio	Private	Private
Eleftheriadou, Sfetsos and Gounaris	102	#23	2016	The suitability of high resolution downscaled seasonal models for the energy assessment of the building sector.	Energy and Buildings	To investigate the suitability of high resolution downscaled seasonal climatic regional model.	Analysis of heating and cooling data?	The model has potential to provide refined inputs for assessing building vulnerabilities to climate change.	Climatic forecasting model	Adaptation	Reactive	Building	Private	Private
Spyridaki, Banaka & Flamos	103	#23	2016	Evaluating public policy instruments in the Greek building sector	Energy policy	To shed light on the implementation of currently employed policy mechanisms that aim to achieve the 2020 energy savings targets.	Multi-criteria analysis	Greece is still missing significant energy saving opportunities that could be reached through more streamlined implementation practices and political support.	Policy evaluation	Mitigation	Proactive	Policy	Public	Public
Lam et al.	104	#23	2015	Applicability of clean development mechanism to the Hong Kong building sector.	Journal of Cleaner Production	To explore the applicability of Clean Development Mechanism in the building sector.	Case study; survey and interviews.	Major hindrances found in CDM projects are the lack of financial incentive, inadequate knowledge about emission trading and insufficient governmental support.	emissions trading;	None	Reactive	Building	Private	Public
Lin & Liu	105	#23	2015	CO2 mitigation potential in China's building construction industry: a comparison of energy performance	Building and Environment	What is the relationship between CO2 mitigation potential and energy performance in the building industry?	Counterfactual analysis	Electricity has become the main source of emissions; energy intensity decline is the major contributor to CO2 mitigation.	Relation energy consumption and carbon emission	Mitigation	Proactive	Sector	Private	Public
Gibbs & O'Neill	106	#23	2015	Building a green economy? Sustainability transitions in the UK buiding sector	Geoforum	The paper explores UK government attempts to engender a shift in the mainstream building and construction sector towards adopting green building methods and techniques.	In-depth interviews	The current legislation fails to adequatly encourage, or recognise, green building forms that will contribute to substantial reductions in carbon emissions, nor does it respect locally appropriate building methods.	UK policy; socio-technical transitions	Mitigation	Proactive	Policy	Public	Public
Chun, Hwang and Byun	107	#23	2015	Green Supply Chain Management in the Construction Industry: Case of Korean Construction Companies	Social and Behavioral Sciences	The paper investigates green business activities of small-medium enterprises and aims to find differences across Suppy Chain Management processes.	Survey among 132 enterprises	There are correlations between upstream and downstream processes...?	Business strategies	None	Proactive	Firm	Private	Private
Mandley, Harmsen & Worrell	108	#23	2015	Identifying the potential for resource and embodied energy savings within the UK building sector	Energy and Buildings	What reduction measures are most suited to reduce material and energy consumption in the full life cycle of a building?	Case study	Four reduction measures strategically focusing on hotspots of excessive consumption are proposed.	Resource efficiency; life cycle analysis	Mitigation	Reactive	Sector	Private	Both
Wilson & Rezgui	113	#23	2013	Barriers to construction industry stakeholders' engagement with sutainability: towards a shared knowledge experience	Technological and Economic Development of Economy	To identify a range of perceived barriers, which operate broadly at 'individual' and 'organisational' levels.	Mixed-method approach	Sustainability knowledge in construction is fragmented, diverse, embedded in various documents, and developed in a non-concerted and integrate way across stakeholders, localities, regions and countries.	stakeholder perception; barriers to engagement	Both	Proactive	Society	Both	Both
Moynihan & Allwood	115	#23	2012	The flow of steel into the construction sector.	Resources, Conservation & Recycling	To develop a method to estimate steel use in the construction industry.	Self-developed method	The use of steel in the construction industry appears to be higher than previously estimated.	material flow analysis	Mitigation	Reactive	Sector	Private	Private
Asimakopoulos et al.	117	#23	2012	Modelling the energy demand projection of the building sector in Greece in the 21st century.	Energy and Buildings	Projecting the energy demand of the building sector in Greece.	Calculation methods combined with three building typologies and 13 climate zones.	Energy demand for heating the building sector in Greece could decrease by 50%, while energy demand for cooling could increase by 248% until 2100.	energy consumption; heating and cooling	Adaptation	Reactive	Sector	Private	Both
Zuo et al.	118	#23	2012	Achieving carbon neutrality in commercial building developments - Perceptions of the construction industry	Habitat International	To investigate the current situation of carbon neutral commercial developments.	Literature review and interviews	There is a lack of clear definition of what a carbon neutral building is, which is a barrier in pursuit of achieving carbon neutral commercial building development.	Carbon neutral, commercial buildings	Mitigation	Proactive	Building	Private	Private
Park & Ahn	119	#23	2012	Strategic environmental management of Korean construction industry in the context of typology models.	Journal of Cleaner Production	To analyze strategic environmental management types within the Korean construction industry.	Model by Auster and Hunt to analyze 99 Korean local construction companies. + interviews and survey	Strategic environmental management by these contractors was found to still be in its infancy. Only 11 out of 99 contractors was actively implementing strategic environmental amnagement policies at corporate levels.	strategic environmental management	Both	Reactive	Sector	Private	Private
Eriksson et al.	121	#23	2012	Climate change mitigation through increased wood use in the European construction sector - towards an integrating modelling framework	European Journal of Forest Research	Estimating the effects of an increase in use of wood as a building material on the carbon balance in Europe.	Modelling approach	The paper suggests increased wood construction will have a minor impact on forest management and forest carbon stocks.	wood substitution	Mitigation	None	Sector	Private	Both
Morton, Bretschneider, Coley & Kershaw	122	#23	2011	Building a better future: An exploration of beliefs about climate change and perceived need for adaptation within the building industry	Building and Environment	The aim is to better understand how representatives of the building industry understand climate change and how this relates to the perceived need for innovation within the industry.	A survey was held amongst all employees of a large international engineering firm involved in the design and construction of building projects.	Participants perceived climate change to be an important issue, current practices to be inadequate, and a need to develop new ways of addressing climate change. Despite this, there was notable and consequential variability in how participants thought about climate change. Higher levels of seniority were associated with greater satisfaction with current practices, and the belief that climate change was a natural rather than man-made phenomena was associated with a reduced support for the idea that changes to current practices were necessary.	Perception of climate change; inovation; organizational change	Both	Reactive	Firm	Private	Private
Wedawatta et al.	129	#23	2010	Building up resilience of construction sector SMEs and their supply chains to extreme weather events.	University of Salford Repository	To identify the importance of being resilient to the effects of extreme weather events in a wider supply chain context.	Literature review	SMEs are increasingly affected by extreme weather events leading to significantly negative as well as positive organisational consequences. -> Recent studies suggest that SMEs are less proactive in beign prepared to face the threat of EWEs and other natural hazards.	extreme weather events; supply chain resilience	Adaptation	Reactive	Firm	Private	Private
Georgopoulou et al.	138	#23	2006	Evaluating the need for economic support policies in promoting greenhouse gas emission reduction measures in the building sector: the case of Greece	Energy policy	To analyze economic attractiveness of potential emission reduction measures in the building and tertiary sector from the point of view of the end-user that makes the decision for implementation of these measures.	Case study	Emissions reduction potential of win-win cases is significant. Individual measures can provide significant reductions if carefully targeted economic support policies are applied.	Support policies; greenhouse gas emissions reduction measures	Mitigation	Proactive	Occupant	Private	Public
Chedid & Ghajar	139	#23	2004	Assessment of energy efficiency options in the building sector of Lebanon	Energy policy	The paper aims to assess energy efficiency measures in the building sector in Lebanon.	Case study	A multitude of energy efficiency options; guidelines and solutions to barriers are suggested. (no general conclusion)	Energy efficiency; Lebanon; policies	Mitigation	Proactive	Policy	Private	Public
Hertin, Berkhout, Gann & Barlow	141	#23	2003	Climate change and the UK house building sector: perceptions, impacts and adaptive capacity	Building Research & Information	To explore how climate change could affect the UK house-building sector: "How climate change impacts translate into technical, financial, commercial and organisational challenges for companies in the house-building sector, and how firms could adapt their operations in response to these challenges.	Case study, interviews	*From the view of companies, climate change is only one factor that influences strategic decision-making among many others.*	Adaptation by companies; innovation	Adaptation	Proactive	Firm	Private	Private

Author	No. Total	#search	Year	Title	Journal	What is the study about (RQ)	What Method?	What is the key finding?	Theme/topic	Adaptation/Mitigation?	Reactive/Proactive?	Level of analysis	Subject is Public/Private?	Aimed at Public/Private actors
Ghose et al.	143	#13	2019	Refurbishment of office buildings in New Zealand: identifying priorities for reducing environmental impacts	The International Journal of Life Cycle Assessment	What is the relationship between energy and resource management policies, and building-specific characteristics on environmental impacts of refurbished office buildings in New Zealand	Life Cycle Assessment of 17 buildings under four policy scenarios. Influence of 15 building specific characteristics are evaluated icm with each scenario. Regression analysis applied	1. the study highlighted the importance of policies on increasing renewable energy supply from national grid electricity to substantially reduce most of the impacts related to buildings.	Life Cycle Assessment / policies	Mitigation	Proactive	Policy	Public	Public
Bollo & Cole	145	#15	2019	Decoupling climate-policy objectives and mechanisms to reduce fragmentation	Building Research & Information	The efficacy of climate-change mitigation policy within the building sector is examined in terms of how fragmentation can limit the extent of mitigation actions.	Analysis of existing policies; data collection through interviews and focus group sessions with local and provincial stakeholders	The paper proposes a framework. The framework makes two proposals for formulating and impementing climate policy: 1. an intentional and rigours decouping of policy objectives and mechanisms; 2. a renewed focus on advocacy for climate policy by the policy-makers themselves.	Implementation of climate policy; stakeholders	Mitigation	Proactive	Policy	Public	Public
Roelich & Giesekam	146	#16	2019	Decision making under uncertainty in climate change mitigation: introducing multiple actor motivations, agency and influence	Climate Policy	A number of tools and approaches exist to help manage and support long-term decision making in relation to climate change mitigation. However, intercation between decision makers with differing perspectives and agency is an additional uncertainty that is rarely addressed. This paper aims to extend existing decision support methods with the perspectives and agencies of mulitiple actors	Case study of the UK construction sector.	The findings demonstrate the importance of considering alignment between perspectives, agency and potential actions when developing plans; the need for mobilizing and advocacy actions to build momentum for radical change; and the crucial influence of interaction between actors.	Decision support approach / multiple actor perspective	Mitigation	Proactive	Policy	Private	Public
Becchio et al.	147	#17	2018	Decision making for sustainable urban energy planning; an integrated evaluation framework of alternative solutions for a NZED (Net Zero-Energy District) in Turin	Land Use Policy	To investigate the use of integrated evaluation frameworks for urban energy planning, with specific attention to Cost-Benefit-Analysis.	Case study	The proposed methodology to NZED was succesfully applied to the case.	evaluation framework of alternatives; urban planning	Mitigation	Proactive	Local government	Public	Public
Padilla-Rivera, Amor & Blanchet	149	#19	2018	Evaluating the link between low carbon reductions strategies and its performance in the context of climate change: a carbon footprint of a wood-frame residential building in Quebec, Canada.	MDPI	Evaluating the potential of reducing greenhouse gas emissions from the building sector by evaluating carbon footprint of four hotspot approaches.	Case study; carbon footprint calculation.	The use of prefabricated techniques in buildings can reduce the CFP of builgins. Beneftits of low carbon strategies included, timber structures can generate 38% lower climate change impact than the average building.	carbon footprint reduction	Mitigation	Proactive	Building	Private	Both
Peñaloza et al.	151	#21	2018	Future scenarios for climate mitigation of new construction in Sweden: Effects of different technological pathways	Journal of Cleaner Production	To evaluate the climate mitigation effects of increasing the use of biabased materials in the construction of residential buildings.	Collection of life cycle assessment data; scenario analysis	Increased use of harvested wood products results in lower climate impacts, but reductions decrease if the use of low-impact concrete expands more rapidly.	life cycle assessment; climate scenarios	Mitigation	Proactive	Sector	Private	Private
Giesekan, Densley Tingley & Cotton	152	#22	2018	Aligning carbon targets for construction with (inter)national climate change mitigation commitments	Energy & Buildings	Identification of the unique challenges in aligning construction targets of construction companies and possible sectoral decarbonisation trajectories	Review of commitments and progress of companies in the UK construction sector.	A cross-industry dialogue is urgenty required to establish an appropriate response that delivers both a widely-accepted target trajectory and a plan for its delivery.	Carbon mitigation commitments; target alignment	Mitigation	Reactive	Firm	Private	Both
Martinez et al.	153	#23	2018	Organization environmental footprint applying a multi-regional input-output analysis: a case study of a wood parquet company in Spain	Science of the Total Environment	The aim of this study is to quantify the organization environmental footprint of a wood parquet business by means of an input-output model.	MRIO analysis; path decomposition	The highest impact category was ozone depletion. The structural path decomposition related t ozone loss revealed that the indirect impacts in the supply chain are higher than the direct impacts.	structural path analysis; organization environmental footprint	Mitigation	Reactive	Firm	Private	Private
Croci et al.	157	#27	2017	Urban CO2 mitigation strategies under the Covenant of Mayors: An assessment of 124 European cities.	Journal of Cleaner Production	To understand which sectors, subsectors, actions and policy levers are the most relevant to mitigate climate chaneg.	Analysis of city sample; cities' strategies and regression analysis.	Buildings and Transport stood out as the sectors where cities intend to deliver the largest emission reduction. In the Building sector, the category 'integrated actions', which combine several types of intervention as to maximise the energy efficiency of buildings, delivered the highest share of CO2 emission reductions.	Mitigation strategies; covenant of mayors	Mitigation	Proactive	Local government	Public	Public
Balasbaneh & Marsono	158	#28	2017	Strategies for reducing greenhouse gas emissions from residential sector by proposing new building structures in hot and humid climatic conditions.	Building and Environment	Whether or not wood is currently used as building material and presents an alternative solution that can be applied in real scenario buildings.	Life cycle assessment	Timber prefabricate is the best choice due to having lower emissions toward climate change mitigation of building construction.	life cycle assessment	Mitigation	Reactive	Building	Private	Private
Dooley	159	#29	2017	Routines, Rigidity and Real Estate: Organisational Innovations in the Workplace	???	How does routine rigidity inhibit environmentally focused, organisational innovations in the corporate real estate industry?	Case study of an office building (to examine the impact of the strategy on the building's energy consumption)	Inertia is to be expected as the daily routines of employees are highly patterned, repetitious, and have become familiar over an extended duration. This is the reason why breaking these patterns and discarding routines in favour of a new process is difficult.	Organisational innovation; corporate real estate strategy	Mitigation	Reactive	Firm	Private	Private
Liu & Lin	160	#30	2017	Cost-based modelling of optimal emission quota allocation	Journal of Cleaner Production	The study proposes a novel cost-effective allocation model to explore the optimal carbon emission quota allocation among multiple decision-maing units.	The model is tested on the Chinese building construction industry, among 30 provinces.	With the proposed model, they find regions in China where more quotas can be imposed or where more emission reduction can be undertaken. Eventually this leads to financial cost reductions.	Carbon emissions; quota allocation model	Mitigation	Reactive	Policy	Public	Public
Kalu, Buang & Aliagha	161	#31	2016	Determinants of voluntary carbon disclosure in the corporate real estate sector of Malaysia	Journal of Environmental Management	The aim is to understand what various determinant-factors are that motivate voluntary corporate carbon disclosure by corporate real estate companies.	Structural equation modelling technique, based on 2013 annual reports of 126 property sector companies listed in Malaysia stock exchange market.	Increase in public education and awareness will enhance community demand for disclosure from companies and they will increase level of disclosure; also as financial institutions consider sustainability practice as a viable investment and term for credit financing, companies will increase disclosure	Carbon disclosure; corporate real estate	Mitigation	Reactive	Policy	Private	Public
Casado-Asensio & Steurer	162	#32	2016	Mitigating climate change in a federal country committed to the Kyoto Protocol: how Swiss federalism further complciated an already complicated challenge	Policy Science	Based on earlier research, the assumption is made that federal states have an advantage in mitigating climate change over unitary ones. This paper aims to test this assumption for the case of Switserland. --- "Did the Swiss federal system facilitate or hinder climate change mitigation?	Qualitative case design focusing on policies aimed to green the building sector. In addition, 15 semi-structured interviews with federal and cantonal policy-makers and experts were held.	The 15% emissin decline achieved in the Swiss building sector between 2008-2012 compared to 1990 levels happened despite, not because, of Swiss federalism. This warrants caution against having to high hopes of decentralised governance compensating for failed national climate policies	Effects of federalism on climate change mitigation	Mitigation	Reactive	Policy	Public	Public
Steurer & Clar	163	#33	2015	Is decentralisation always good for climate change mitigation? How federalism has complicated the greening of building policies in Austria	Policy Science	To what degree federalism is responsible for Austria's poor climate change mitigation performance?	Analysis of policy documents (and other documents) on EU, federal and provincial policies that aim at GHG emissions in the building sector. Secondly, 14 semi-structured interviews with policy-makers from relevant federal authorities and provinces, and climate policy experts.	Austrian federalism did not facilitate but hinder climate change mitigation because it added a vertical dimension to an already complex horizontal integration challenge. Also, it is only one of many independent variables that spae climate change mitigation (thus not the only reason for Austria's failure in mitigation)	Effects of federalism on climate change mitigation	Mitigation	Reactive	Policy	Public	Public

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Fujimori et al.	*164*	*#34*	2014	The effectiveness of energy service demand reduction: a scenario analysis of global climate change mitigation	Energy Policy	To quantify the effectiveness of energy service demand reduction.	AIM/CGE model for the analysis and scenario analysis	A 25% energy service demand reduction in the building, transport and basic material sectors would reduce the GDP loss induced by climate mitigation from 4.0% to 3.-% and from 1.2% to 0.7% in 2050 (in 2 scenarios).	energy service demand reductions	Mitigation	Reactive	Policy	Public	Public
Fahmy et al.	*167*	*#37*	2014	Prediction of future energy consumption reduction using GRC envelope optimization for residential buildings in Egypt	Energy and Buildings	To evaluate usage of GRC walls as a new construction method in the housing industry in comparison to using traditional brick walls and materials.	Simulations of residential buildings in different climatic zones	Both buildings showed gradual energy consumption reduction using the 10 and 12 cm GRC-foam sandwich material.	material energy consumption simulations	Both	Reactive	Building	Private	Private
Pauliuk et al.	*169*	*#39*	2013	Transforming the Norwegian Dwelling Stock to reach the 2 degrees celsius climate target.	Journal of Industrial Ecology	To determine sectoral emission reduction potential of the dwelling stock in Norway.	Material flow analysis and life cycle assessment	Full transformation of the stock is not sufficient to achieve an emissions reduction of 50% or more, because hot water generation, appliences and lighting will dominate the sectoral footprint once the stock has been transformed.	emission reduction potential; transformation of the dwelling stock	Mitigation	Proactive	Sector	Private	Both
Hrabovszky-Horvath et al.	*170*	*#40*	2013	Generalized residential building typology for urban climate change mitigation and adaptation strategies: the case of Hungary	Energy and Buildings	What should city developers focus on in order to plan a sustainable and safe city in a changing climate?	Case study	For city developers it is essential to estimate the amount of the produced CO2 by the buildings in the city and the distribution among the districtrs in order to set-up mitigation reference goals.	urban planning; carbon emissions	Mitigation	Proactive	Local government	Private	Public
Morrissey, Moore & Horne	*171*	*#41*	2011	Affordable passive solar design in a temperature climate: An experiment in residential building orientation	Renewable Energy	To investigate the low cost new regulation option of orienting in order to maximise their passive solar benefits.	Scenario modelling	Higher standards are easier to apply to smaller dwellings, and costs are lower. Passive solar design is a concept that can readily be incorporated into house plans at the design stage.	passive solar design; building regulations	Mitigation	Reactive	Building	Private	Public
Cheng	*172*	*#42*	2010	A new NAMA framework for dispersed energy and end-use sectors	Energy Policy	Development of a new framework to fulfill the demand for public policies and public sector investment to boost private sector investment through market mechanisms.	Case study: the building sector	The new NAMA framework has the ability to interface efficiently with Kyoto Protocol mechanisms and to facilitate a systematic uptake for greenhouse gas emission reduction investment projects.	NAMA framework; boost private sector investment	Mitigation	Reactive	Policy	Private	Public
Li & Colombier	*175*	*#45*	2009	Managing carbon emissions in China through building energy efficiency	Journal of Environmental Management	To analyse the role of building energy efficiency in China in addressing climate change mititgation.	Analysis of current situation and scenario analysis of future situation	Improving building energy efficiency can generate considerable carbon emissions reduction credits with competitive price under the CDM framework.	carbon emission reduction; policies	Mitigation	Proactive	Policy	Public	Public