THE DEVELOPMENT OF A SUSTAINABILITY STRATEGY TO MEET FUTURE SUSTAINABILITY REQUIREMENTS

Master`s thesis research report

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PREFACE

The thesis "The development of a sustainability strategy to meet future sustainability requirements" is the result of six months extensive research on possibilities for contractors to distinguish itself positively in terms of sustainability. This research is the final proof of competence for obtaining my Master of Science (MSc) degree in Civil Engineering and Management (CEM), from the University of Twente.

During my study at the university of Twente I developed an interest in sustainability. This was the reason to enrol in a minor on: "sustainable development in developing countries", and later travel across the world to conduct my bachelor thesis on energy efficiency in Curacao. When I was orientating on possibilities to conduct my master thesis, the decision was not that difficult. BAM, one of the largest contractors in the Dutch building sector, was looking for a graduate student which could conduct research on sustainability, and a couple of months later I was working in Gouda on my thesis.

This research was conducted on behalf of BAM Infraconsult under supervision of Klaas-Jan Visser and Born Goedkoop. I would like to thank my supervisors for putting time and effort in guiding my research during my graduation process. Additionally, I would like to thank all the inspiring people who I interviewed during my research and provided me with useful and interesting insights.

Conducting a research of this scale has been one of the most interesting, inspiring, educational, but at times also energy consuming challenges during my study so far. This research has been challenging at times. Fortunately, my supervisors from the university of Twente: dr. ir. A.G Entrop and prof. dr. ir. J.I.M Halman have been very helpful in guiding my research, and were always available for questions and discussions regarding my research. Therefore, I would like to thank my supervisors for their excellent guidance and support during this process.

This Master thesis marks the end of my graduation process, my time as a student at the University of Twente and an amazing period in my life. During this period I have found many friendships, developed myself as a person and had the opportunity to travel to many interesting places. I could not have completed this thesis without the help and support of my family and friends. I would like to take this opportunity to thank them all.

Guus van Eldik

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ABSTRACT

The building sector causes considerable impact on the environment, and reducing the environmental impact has become one of the most important goals within the building sector. The increasing environmental concerns, driven by regulations and market requirements, requires the building sector to reduce its impact on the environment. Although literature on sustainability in the building sector is flourishing, little attention has been paid to the relationships between sustainability performance and business competitiveness. BAM Infra bv acknowledges the relationship between sustainability performance and business competitiveness. However, BAM Infra bv is uncertain how sustainability requirements will develop in the future, and therefore, how BAM can align its business processes and products to improve its sustainability performance in order to gain a competitive advantage.

The objective of this research is to develop a competitive strategy for BAM to meet the future sustainability requirements. This research aims to identify sustainability requirements used in building projects, and future sustainability requirements from analysing sustainability goals of influential actors in the building sector. The combination of these sustainability requirements provides useful insights for the development of a competitive sustainability strategy to meet future sustainability requirements.

This research uses a combination of data collection and analysing techniques. For the identification of influential actors and their influence on sustainability in the building sector, several experts have been interviewed in order to select the most influential actors. The sustainability goals of the actors are identified and substantiated by conducting a desk research. Additionally, four cases have been selected and analysed to determine the sustainability requirements within BAM its projects. Two cases from the utility and infrastructural sector have been selected. In order to compare the in essence different infrastructural and utility projects with one another, a new "project sustainability assessment method" has been introduced. This assessment method is based on relevant project information, used sustainability assesment method, sustainability ambitions, sustainability offer, and drivers & barriers and enablers for sustainability. Lastly, the data from the cases and the sustainability goals of the actors have been analysed and discussed with experts within BAM, in order to identify possibilities for improvement.

This research shows that governments have a significant influence on sustainability requirements in the building sector. Governments are not merely providing legislation and policies regarding sustainability, but are also frequently involved as a client in the infrastructural sector. In the utility sector clients are more often commercial parties and require sustainability requirements to improve their corporate image. Moreover, trade associations in the building sector are identified as influential actors, and aim to reduce the impact on the environment by providing platforms of collaboration and knowledge sharing. Additionally, this research has indicated that BAM its own organisation has a significant influence on sustainability requirements in the building sector. This research shows that the sustainability requirements of the most influential actors in the building sector are mainly concerned with energy efficiency, CO_2 reduction, energy transition, a circular economy, managing waste streams and the preservation of building materials.

Sustainability related competition is most intensive during the tender phase of the building cycle. Clients use many different methods to assess the building performance of a bid. In the infrastructural sector the sustainability plan, CO_2 performance ladder, and the Environmental Cost Indicator (ECI) are predominant methods to assess the performance of a bid. Investment costs of projects within the utility sector are relatively lower compared to the infrastructural sector, which does not necessarily require clients to tender their project publicly. Sustainability is often included in the utility sector as a topic for collaboration rather than competition. Moreover, sustainability in the utility sector is often more assessed ex-post rather than ex-ante. The importance of sustainability themes also differs between the utility and infrastructural sector. Sustainability

requirements of the infrastructural projects were mainly concerned with: energy, material, ground and accesability themes. Sustainability requirements in the utility projects were also concerned with energy and materials but additionaly focused on well-being, social relevance and business climate themes. The assessment of project sustainability performance has showed that a clients willingness and ability to incorpoarte sustainability requirements within a project is a major enabler and driver for sustainability performance.

The analysis of sustainability goals of influential actors and sustainability requirements within BAM its projects have indicated some possibilities for improvement. Sustainability requirements within the building sector are predominantly concerned with materials and energy. Therefore, it is recommended to focus BAM its sustainability strategy on providing circular products and services, and contribute to the energy transition.

Circular business models should be aimed to minimise waste during the construction process. A circular business model should focus on 1) using circular supplies, 2) recovering useful resources, 3) extending product life, 4) sharing platforms and 5) retaining ownership and provide products as services (Haara, et al., 2015).

The energy transition focuses on increasing energy efficiency, upscaling renewable energy generation and energy autonomy of new projects. Indirectly, the energy transition aims to reduce GHG emission and reduce the environmental impact to the environment. Energy efficient products need to be developed and projects need to generate their own energy to become truly autonomous, and minimise the impact of a project on the environment. Many technologies are already available for the energy transition. However, the real challenge is to make these technologies as cost-efficient as possible to maximise their implementation rate and impact.

Moreover, the digitisation of the building sector has been identified as a major enabler and driver for improving the sustainability performance. In addition, BAM its sustainability performance largely depends on its suppliers and sub-contractors. Therefore, improved supply chain collaboration with BAM its suppliers and sub-contractors has been identified as one of the most promising driver to improve its sustainability performance.

When BAM anticipates early on the developments of sustainability requirements, and is able to perform highly on their future clients sustainability requirements, BAM can obtain a competitive advantage from its competitors. Early anticipation on developments of sustainability requirements does not necessarily provides a guarantee for successful future sustainability performance. However, it does provide BAM with an useful head-start.

Keywords: Sustainability requirements, Sustainability performance, Sustainability assessment, Competitive advantage.

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LIST OF ACRONYMS

BIM	Building Information Modelling
C2C	Cradle to Cradle
CBM	Circular Business Models
CSR	Corporate Social Responsibility
DBB	Design Bid Build
DBFA	Design for Manufacture and Assembly
DBFMO	Design-Build-Finance-Maintain and Operate
DBM	Design-Build-Maintain
ECI	Environmental Cost Indicator
EIA	Environmental Impact Assessment
EIR	Environmental Implementation Review
ETS	Emission Trading System
EU	European Union
GB	Green Building
GHG	Green House Gas
GPP	Green Public Procurement
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
MIE	Ministry of Infrastructure and Environment
NENB	Nearly Energy Neutral Buildings
SB	Sustainable Building
SDG	Sustainable Development Goal
SEA	Strategic Environmental Assessment
SME	Small and Medium-sized Enterprises
TCO	Total Cost of Ownership
UN	United Nations

1 INTRODUCTION

1.1 Dutch building sector

The Dutch building sector amounts to 4.5% of the GDP, employs 460.000 people and produced €55 billion worth of constructions in 2016 (Bouwend Nederland, 2017). In recent years the building sector is growing after a long period of economic decline. In 2015 the production volume of the building sector grew 7%, worth roughly €4 billion. This means that the Dutch building sector was the fastest growing industry of the Dutch economy. Forecasts expect the Dutch building sector to keep growing with 3% per year, which is expected to result in a production volume of 72 billion in 2021 (EIB, 2016).

The building sector consists of three components: the infrastructural, housing and utility sector. Infrastructure refers to the fundamental facilities and systems serving a country, city or area, including the services and facilities necessary for its economy to function. It typically characterises technical structures such as roads, bridges, tunnels, water supply, water protection, sewers, electrical grids, telecommunication, and so forth (Fulmer, 2009). The housing industry is concerned with the development, construction and sales of houses. Utility refers to all buildings which do not have a housing purpose including: work, schooling, commercial service, health service, recreation, electric utilities and water treatment utilities (ABN AMRO, 2017).

The building sector is characterised by uncertainty throughout the building process. The fundamental problem in construction management is the lack of information required to take decisions. This uncertainty has two major sources: complexity and predictability (Winch G. M., 2010). The building sector is characterised by relative complexity, which relates to structural elements, dynamic elements and the interaction of these elements across the broad categories of technical, organisational and environmental domains of construction (Gidado, 1996; Miller, 1995; Qazi, Quigley, Dickson, & Kirytopoulos, 2016). Additionally, the building sector is characterised by project-based work. A project consists of a temporary endeavour undertaken to create a unique product, service or result. The building sector is project-based because products are unique and site specific. The fact that construction is site specific and project based makes it less predictable because, the past cannot be used as a reliable guide to the future (Winch G. M., 2010).

1.2 Sustainability

Before focusing on sustainability in the building sector, a note on the general understanding of sustainability is required. Sustainability is one of the world`s most talked about but least understood words. Its meaning is often clouded by differing interpretations and by a tendency to be treated superficially. For most companies, countries and individuals who do take the subject seriously, the concept of sustainability embraces the preservation of the environment as well as critical development-related issues such as the efficient use of resources, continual social progress, stable economic growth, and the eradication of poverty (LHM, 2017).

Probably the most widely known definition of sustainability is the triple bottom line (Elkington, 1997), which was further developed into People, Planet & Profit (Fisk, 2010). This definition of sustainability focuses on economic prosperity, environmental quality and social justice in order to increase sustainability. Figure 1 illustrates the three dimensions, showing that the equilibrium between these three dimensions defines sustainability. The three dimensions are interrelated, but can individually be described as (Fisk, 2010):

1. People (social) dimension: is concerned with fair and beneficial business practices towards labour and the community and region in which a corporation conducts its business.
2. Planet (environmental) dimension: is concerned with minimising the negative impact on the environment by reducing the environmental footprint of businesses.

3. Profit (economical) dimension: is concerned with creating economic value and economic growth by the organisation, while these profits are fairly distributed between the actors influenced by the business.

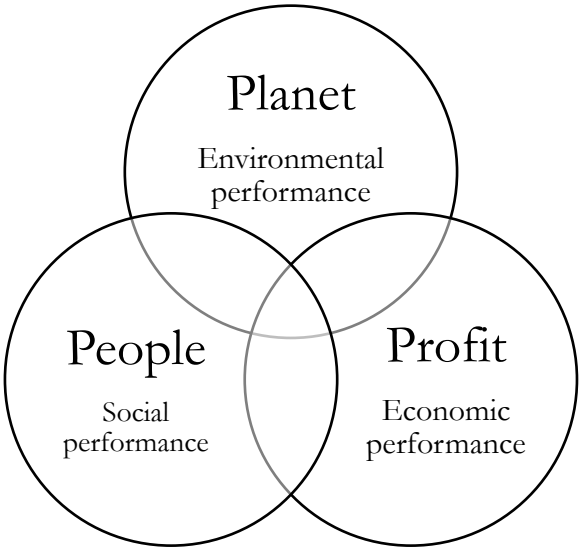

Figure 1. People Planet Profit (Voices of youth, 2017)

1.3 Sustainability in the building sector

Sustainable construction can be described as the contribution of construction towards sustainable development (Dickie & Howard, 2000). Literature about sustainable construction is often focused on preventing unnecessary use, using renewable sources and using sources as efficiently as possible (Duijvenstein, 1993). In order to better understand sustainable construction, a basic understanding of the building cycle is required. The building cycle is visualised in Figure 2.

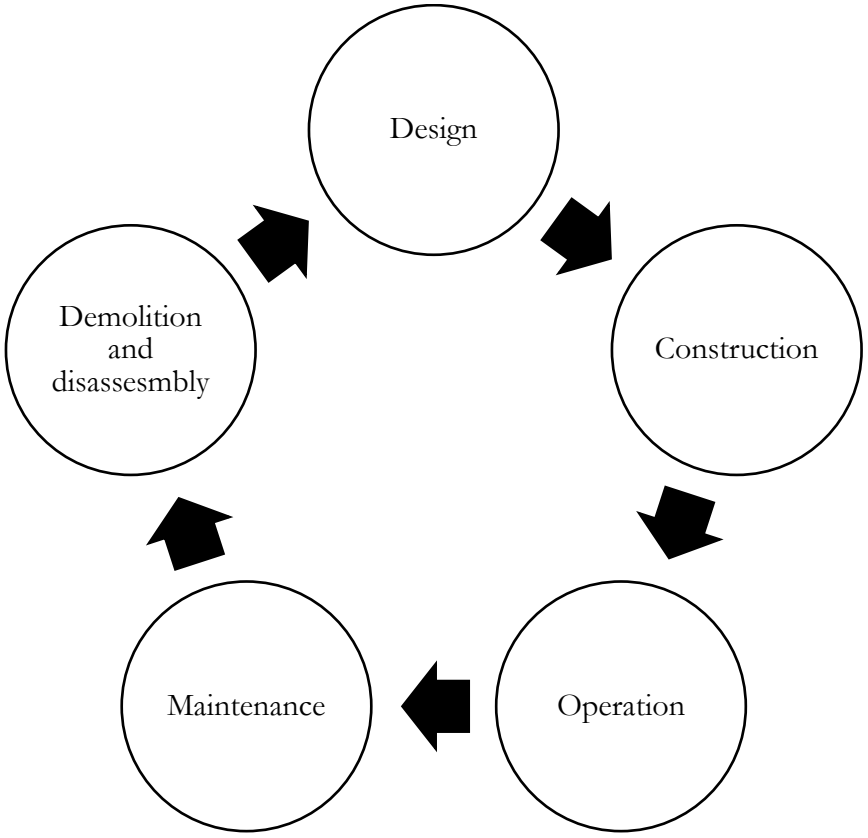

Figure 2. Building cycle (GDRC, 2017)

The building cycle consists of a design phase, construction phase, operational phase, maintenance phase and lastly the demolition & disassembly phase. All the phases in the building process are interrelated, which makes it more complex to implement sustainable measures. Sustainable measures have to be designed for the entire building process, and even beyond this process. This type of designing is called life-cycle designing or Cradle to Cradle (C2C) designing, and aims to make the building process circular, so that materials will be reused or recycled. Using recyclable materials, modular parts and durable parts is essential to reduce the environmental impact of the building process on the environment (Ljunberg, 2005).

The environmental impact of the building sector is high. Construction and operation of buildings consume 42% of all energy, 50% of all extracted materials, 30% of all water and produces 35% of all greenhouse gas emissions in Europe (EC, 2011). Moreover, the use of materials today has increased at least 20-fold per capita in many highly industrialised countries from the end of the 19th century until today. The natural environment cannot sustain today`s growth rate of up to about 5% in some countries, without serious impact in the long run (Ljunberg, 2005). Therefore, the European Union states that the building sector has one of the greatest potentials for reducing the environmental impact (EC, 2002).

Its increasing environmental impact requires the building sector to change towards becoming more sustainable and environmental friendly. Various push and pull factors stimulate the building sector to become more sustainable. Regulatory-driven trends, such as the obligation to reduce Greenhouse Gas emissions (GHG) and the Paris agreement (United Nations, 2015), are pushing the building sector to change. Market driven trends, such as environmental awareness and growing interest in Corporate Social Responsibility (CSR), pulls the building sector to change. This research aims to contribute to this change by providing direction on how BAM can meet regulatory requirements and exceed these requirements to positively distinguish itself from its competition in terms of sustainability.

1.4 Outline of the research

This research project is aimed at exploring the sustainability practice of BAM and specifically at providing understanding into the possibilities for BAM to distinguish itself from its competitors in terms of sustainability. An extensive preliminary literature study revealed that gaining a competitive advantage in terms of sustainability receives little attention in research, but is considered one of the most important reasons for a contractor to implement sustainability measures (Tan, Shen, & Yao, 2011). The research aims to identify the regulatory framework for sustainability in the building sector, and specifically on the development of this legislation in the future. Moreover, the research has focused on market trends, which have been identified from stakeholder related sustainability goals and requirements. Firstly, an organisational scope has been used to identify the most influential stakeholders, influencing the sustainability requirements in the building sector and identify their sustainability goals. Secondly, a more practical project-focus has been used to identify the current sustainability performance of BAM, and how BAM was able to distinguish itself from its competitors. The information from both these analyses has resulted in the development of a strategy on how BAM can positively distinguish itself from its competition in terms of sustainability.

The further outline of this report is organised in eight sections. In Section 2, the research methodology is explained. Section 3 explains the theoretical background of gaining a competitive advantage on sustainability. Section 4 describes the exploration of future sustainability requirements. Section 5 describes the assessment of the sustainability performance within four projects executed by BAM. Section 6 describes possibilities for BAM to improve their sustainability performance in order to be able to provide future sustainability requirements and distinguish itself from its competition in terms of sustainability. Section 7 discusses the scientific contribution, practical implications and research limitations. Concluding, Section 8 presents the final results of the research

2 RESEARCH SETUP

The aim of this chapter is to elucidate on the research design. This chapter discusses the background of this research, the problem description and statement, research objective, the relevance of the research, research questions, research scope, research methodology and the desired results of this research.

2.1 Background of research

This section describes the background and motivation for this research. The research has been conducted for the large Dutch contractor BAM Infra Nederland bv. BAM Infra Nederland bv is part of the Royal BAM group, which is active in the building sector in the north-west part of Europe. The Royal BAM group is operating in the Netherlands, United Kingdom, Germany, Belgium, Ireland and several other countries as visualized in Figure 3. BAM its business is divided in two business lines: Construction and property (Bouw en vastgoed in Dutch) & Civil (Infra in Dutch).

Figure 3. Organisation structure BAM (BAM, 2017)

In the annual report of BAM the business strategy is formulated as: 'building the present, creating the future' (BAM, 2015). This business strategy shows some similarity with the definition of sustainable development as discussed by Brundtland in the WCED report: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This is no coincidence because, BAM has increasingly aimed to improve health, safety and especially sustainability (BAM, 2015).

With the increasing requirement for resource efficiency and climate change adaptation in the building sector, there is a need for contractors to implement sustainable practices. BAM intents to increase sustainability because sustainability creates societal value for their clients and itself. BAM actively contributes to the realisation of sustainability objectives of clients by providing creative and innovative solutions for challenges perceived by itself and their clients. New market developments require innovative and sustainable solutions with low life-cycle costs. BAM aims to keep developing initiatives for an integral and efficient sustainability and life-cycle costing approach. In order to ensure sustainability, BAM works closely with clients, suppliers and sub-contractors. Since a couple of years BAM intents to improve its energy efficiency and intents to reduce carbon-emissions. Furthermore, BAM aims to reduce the impact on natural resources by carefully selecting materials, and using efficient methods to use the materials. In order to be as transparent as possible to their clients and the public, BAM annually publishes an integrated report to reflect on their sustainability performance (BAM, 2017).

BAM aims to lead the way in terms of sustainability performance now and in the future. In order to lead the way in terms of sustainability performance, it is critical to be aware of the sustainability requirements of today, and to identify the sustainability requirements of tomorrow (BAM, 2016). This research aims to connect the current sustainability performance of BAM and the future requirements for sustainability, by developing a strategy on how BAM can transform its current practices, regarding sustainability, in order to meet future sustainability requirements.

2.2 Problem description and statement

BAM aims to lead the way in terms of sustainability performance now and in the future. BAM aims to differentiate itself from its competitors by exceeding the sustainable performance of their competitors, and by providing the most sustainable solutions for their clients. However, the continuity of future construction work is uncertain, and if BAM is not awarded with future construction work they are not able to generate revenues. Additionally, the future sustainability requirements are uncertain which makes it difficult to anticipate on client`s sustainability requirements. Furthermore, the magnitude of sustainability requirements in the building sector is uncertain. The last decade sustainability evolved into one of the major concerns in the building sector (Crawley & Aho, 1999). However, it is possible that the number of requirements for sustainability will stagnate or even decline in the future. Because, the number of sustainability requirements is relatively uncertain, BAM does not know how they can competitively provide the sustainability requirements in the future. The problem can be summarised in the following statement:

"BAM is not certain how they can competitively fulfil the future sustainability requirements of their clients."

2.3 Research objective

Because BAM is uncertain how they can competitively provide sustainability requirements in the future, the objective of this research is to create a strategy on how BAM can competitively deliver future sustainability requirements. This main objective is accompanied by two underlying objectives. In order to create a strategy on how BAM can competitively provide future sustainability requirements in the Dutch building sector, firstly the future sustainability requirements need to be identified. Therefore, one of the underlying research objectives is to identify the future sustainability requirements in the Dutch building sector. Furthermore, in order to successfully develop a strategy on how BAM can competitively provide future sustainability requirements, it is essential to assess the current sustainability performance of BAM, in order to find ways in which BAM could improve in terms of sustainable building. Therefore, the second underlying research objectives is to assess the current sustainability performance of BAM. These two underlying research objectives will eventually contribute to reaching the main research objective:

"*The objective in this research is to develop a competitive strategy for BAM to meet the future sustainability requirements of its clients.*"

The desired result of this research is to develop a strategy for BAM which provides direction on how BAM can competitively provide the future sustainability requirements. This result can be achieved by first assessing the sustainability performance of BAM infra and BAM Construction and property, and compare this performance with the future sustainability requirements. Moreover, the assessment of sustainability performance of the two business lines itself is also relevant in order to determine the sustainability performance of BAM. Additionally, the identification of the future sustainability requirements is also relevant because it shows possibilities for change and improvement in order to meet the requirements for sustainability in the future.

2.4 Research questions

In the previous section the research objective is discussed. It is presumed that by answering the following general research question, the research objective can be achieved. The following question is leading in this research:

"How can BAM improve its sustainability performance, in order to competitively provide future sustainability requirements?"

This research question cannot be answered directly and therefore the main research question has been divided in several, complementary research questions, to ensure a structured research. It is

presumed that the combined answers to all the sub questions will answer the general research question. The main research question is divided in three research question, which are divided in sub questions.

1. What are the future sustainability requirements in the building sector?

The first research question focuses on the identification of future sustainability requirements. Actors are influential organisations which are involved in a certain process. The critical actors involved with setting sustainability requirements for the building sector, the way they influence the future sustainability requirements and their goals regarding sustainable construction in the future have been identified in order to determine the future sustainability requirements.

2. What is the current sustainability performance of BAM within its projects?

The second research question focuses on how the sustainability performance can be determined, which sustainability requirements are used and what BAM is able to deliver compared to the requirements. Lastly, possible drivers, barriers and enablers have been identified which influence the sustainable performance of BAM.

3. What are possibilities for BAM to distinguish itself positively from their competitors in terms of sustainable building?

The third research question focuses on possibilities for BAM to distinguish itself from the competition in terms of sustainability. Firstly, literature has been reviewed regarding possible improvement strategies. Next the major differences between the current sustainability performance of BAM and future sustainability requirements have been identified. Lastly, the gap between current sustainability requirements and future sustainability requirements have led to several possibilities for improvement.

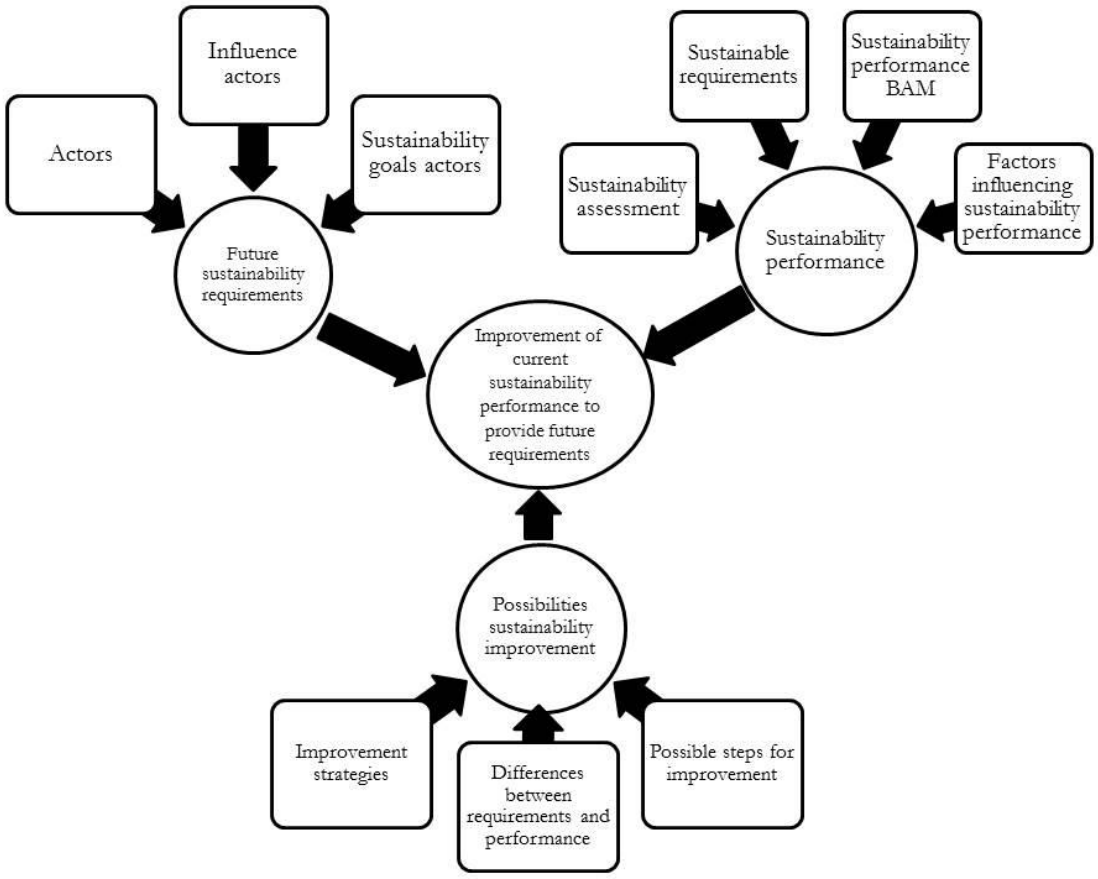

Figure 4. Visualisation synthesis between research questions

The relation between the three research questions is visualised in Figure 4. The combination of these three research questions, and the underlying sub-questions, will eventually lead to the

outcome of the main research question. Finally, combining the future sustainability requirements with the current sustainability performance and knowledge about possibilities for sustainability improvements will lead to the development of a sustainability strategy for BAM.

2.5 Research strategy

This section explains the research strategy that is applied for this research. First, the research framework is shown, followed by an explanation of the methods that are used to conduct this research.

2.5.1 RESEARCH FRAMEWORK

In order to answer the proposed research questions, the following research framework has been used. The research is divided in a theoretical phase, practical phase, analysis phase, and lastly the strategy development phase. The research framework is visualised in Figure 5.

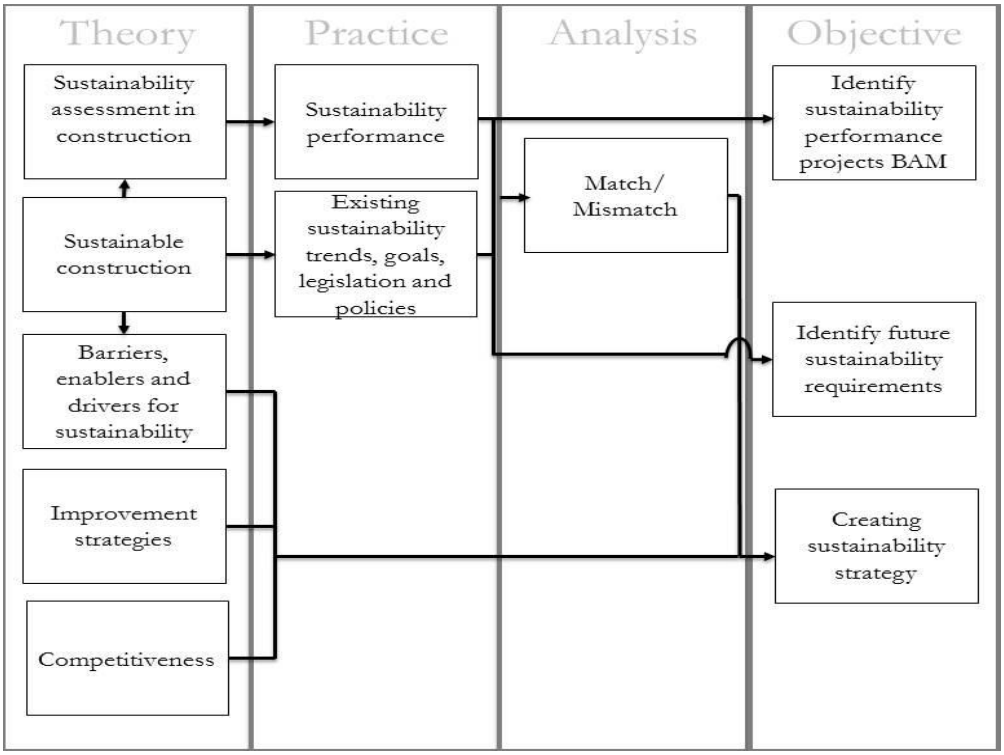

Figure 5. Research framework

2.5.2 RESEARCH METHOD

The research methods are discussed by briefly discussing each research question separately.

Research question 1: What are the future sustainability requirements in the building sector?
In order to identify future sustainability requirements in the building sector, first the actors which are involved in the building industry have been identified, and secondly the way these actors influence the sustainability requirements in the building sector is discussed.

The most influential actors, and their contribution to the development of future sustainability requirements in the building sector, have been determined by identifying the actors which had a significant influence on the requirements for sustainable construction in the past, and by studying documents which describe how these actors can influence the future sustainability requirements.

After the identification of crucial actors and their influence, a desk research has been conducted on the sustainability goals of the actors. It is presumed that by identifying the goals of the crucial actors the future sustainability requirements can be determined. The goals of the crucial actors have been obtained from policy documents, websites, regulations, and several interviews with actors to create an in-depth understanding about the goals of the actors, which over time will become the new standard for project requirements.

Research question 2: What is the current sustainability performance of BAM within its projects?
In order to determine the current sustainability performance of BAM, case studies have been conducted to assess the performance of four building projects of BAM. These projects have been carefully selected and include two projects of the civil business line of BAM and two projects of the construction & property business line of BAM. Before the current sustainability performance of BAM could be assessed, a literature study has been conducted on how sustainability performance can be assessed, and additionally how the sustainability performance is determined during the projects.

Consequently, the sustainability requirements from BAM their clients have been assessed for each individual project in order to determine the current sustainability requirements. These sustainability related project requirements have been obtained from project related documents and interviews. Furthermore, in order to determine the sustainability performance, research has been conducted on what BAM was able to deliver in terms of sustainability, compared to the initial requirements. In other words, how was BAM able to distinguish itself from their competitors, and exceed their client`s requirements, in order to be awarded with the project contract. This information has also been subtracted from project related documents such as the tender documents. In order to fully understand the sustainability performance a literature study has been conducted on possible drivers, barriers and enablers for sustainability in the building sector

Additionally, interviews have been conducted to clarify the sustainability requirements, the sustainability delivery of BAM, and to identify possible factors which had an impact on the sustainability performance for each of the projects. These interviews have been conducted with the sustainability manager of BAM for each building project.

Research question 3: What are possibilities for BAM to distinguish itself positively from their competitors in terms of sustainable building?
In order to identify possibilities for BAM to distinguish itself positively from their competitors in terms of sustainability, first a literature study has been conducted on possible strategies for companies to improve their current practices. Secondly, differences between the future sustainability requirements and the current sustainability performance have been identified. The difference between the performance and future requirements provide a useful basis to identify possible steps which BAM could take in order provide the future sustainability requirements. These possibilities have been discussed with sustainability experts within BAM to determine if these possible steps might be valid in order to improve the sustainability performance. Lastly, these possible steps for improvement have been discussed with the Corporate Sustainable Responsibility (CSR) division to ensure that the proposed steps are in line with the corporate sustainability strategy.

2.6 Research scope
The scope of the research pinpoints the boundaries of this research. It is important to focus on gathering information which contributes to answering the research questions, while ignoring irrelevant information outside the scope of this research.

As briefly explained in the introduction, sustainability can be divided in three dimensions. Only the environmental dimension of sustainability has been included in the scope of this research. The environmental dimension is the most important dimension for BAM, because their clients most often have requirements concerning the environmental impact, and environmental legislation is often focused on reducing the environmental impact. This means that BAM can distinguish itself mainly by exceeding their competitors in terms of environmental impact. This research will focus on how BAM is able to provide their building services with a low environmental impact, in order to ensure work continuity. The social dimension of sustainability possesses other challenges and questions such as the impact on health (WCED, 1987), and have been left open for further

research. The economic dimension will not be discussed extensively during this research. However, it is inevitable that some economic parameters have been used to determine the current sustainability performance of BAM, because a lot of trade-offs exist between the environmental and economic impact.

As briefly explained in the introduction, the building sector can be divided in three subsectors. This research will only focus on the infrastructural and utility sectors. The infrastructural sector and the utility sector are researched individually, so that possible differences between the sustainability performances of the two business lines can be identified. The housing sector will not be included in this research because this sector includes many actors which are not active in the other sectors. Because, this research is conducted in a limited amount of time, the decision has been made to place the housing sector outside the scope of this research

As briefly explained in the introduction, the building process can be divided in six stages. Because all these stages are strongly interdependent, the decision has been made to include all of these phases in the scope of this research. This research is conducted for the contracting company BAM. The phases were BAM is active in the building process strongly depends on the type of contract used. For example a Design-Bid-Build (DBB) contract only requires construction activities from BAM, were a Design-Build-Maintain (DBM) contract also requires design and maintenance activities. Because BAM is involved in different type of contracts, the decision has been made to include all phases of the building process. However, most decisions to implement sustainable measures are taken during the design phase. BAM is able to distinguish itself from their competitors in terms of sustainability during the tender phase. Therefore, the centre of gravity in this research has been on the tender and design phase of the building process. The decisions taken during the tender and design phase, will heavily influence the environmental impact during other stages in the building process. The scope of this research is visualised in Figure 6.

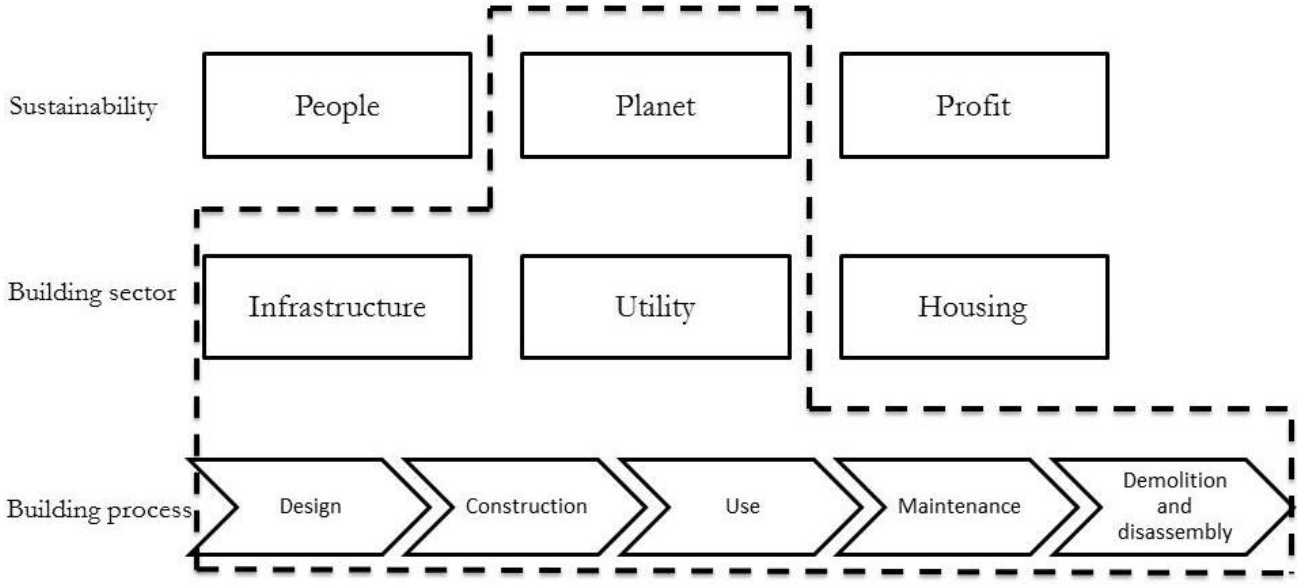

Figure 6. Research scope

Lastly, the focus of this research is mainly on the Dutch building sector. The Dutch building sector is influenced by global and European legislation. However, only Dutch building projects have been assessed, and therefore this research will mainly focus on the environmental impact of building activities in the Netherlands.

3 LITERATURE BACKGROUND

The concept of sustainable development is an attempt to combine the growing concern about a range of environmental issues with socio-economic issues (Hopwood, Mellor, & O`Brien, 2005). Sustainable building performance is now a major concern of professionals in the building sector (Crawley & Aho, 1999), and has emerged as a platform for extensive research. However, the research on the relationship between sustainability and business competitiveness in the context of the building sector is limited (Tan, Shen, & Yao, 2011). This research specifically focuses on combining the two concepts of sustainability performance and competitiveness. Additionally, literature on possible barriers, drivers and enablers for sustainability in the building sector will be discussed. Lastly, literature on sustainability strategies will be discussed which may lead to competitiveness.

3.1 Competitiveness in relation to sustainability

Competitiveness can be defined as the ability of a firm to offer products and services that meet quality standards of the market at prices that are competitive and provide adequate returns on the resources employed or consumed in producing them (Grzesiak & Richert-Kazmierska, 2014). Evidence has shown that good corporate governance of environmental and social issues enhances companies' shareholders value, or at the very least, protects their highly valuable reputations (SCTG, 2017). Moreover, proper designed environmental standards can trigger innovations that lower the total cost of a product or improve its value. Such innovations allow companies to use a range of inputs more productively - from raw materials to energy to labour - thus offsetting the costs of improving environmental impact and ending the stalemate. Ultimately, this enhanced resource productivity makes companies more competitive, not less (Porter & Van der Linde, 1995). Wagner and Schaltegger (2003) also proposed a phenomenological relationship between sustainability performance and economic success as shown in Figure 7. The decreasing curve in Figure 7 indicates the 'traditionalist' view of neoclassical environmental economics. They argue that the environmental protection activities would reduce economic success and the purpose of environmental regulation is to correct for negative behaviour which would consequently burden companies with additional costs. In contrast to this view, the 'revisionist' view (inverse U-shaped curve in Figure 7) argues that the sustainable practice by a company has a beneficial effect on its economic success. The reason is that improved sustainable performance is a potential source of competitive advantage leading to more efficient processes, improvements in productivity, lower costs of compliance and new market opportunities. However, these benefits will be decreasing after the peak point due to the increasing investment on sustainable activities. From a longer-term perspective (dotted line in Figure 7), the ability of innovation and developing new technologies and production approaches would be more important for sustaining competitiveness than traditional competitive advantage factors (Porter & Van der Linde, 1995).

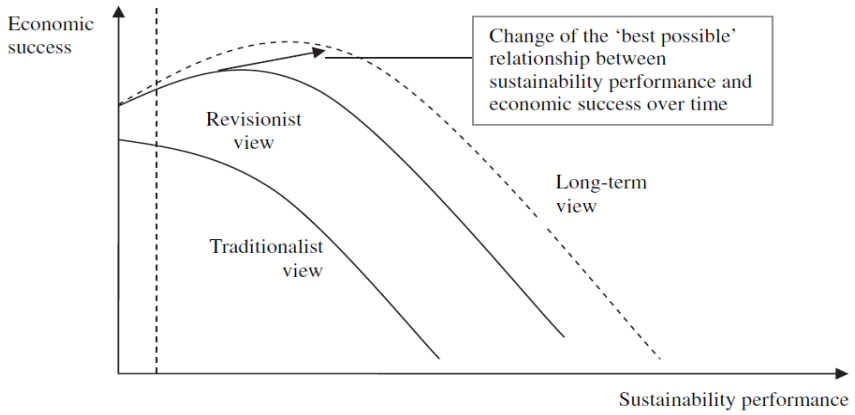

Figure 7. Phenomenological relationship between sustainability performance and economic success (Wagner & Schaltegger, 2003)

Tan, Ochoa, Langston & Shen (2015) examined the relationship between sustainability performance and business competitiveness of international construction contractors. The findings show that an inverse U-shape curve exists between sustainability performance and international revenue, and a U-shape curve between sustainability performance and international revenue growth. This roughly means that a relationship exists between sustainability performance and competitive advantage of most sustainable contractors. Sustainability is becoming a source of competitive advantage in the international building sector, and can lead to higher revenue growth and new market opportunities. To be winners in the market, international contractors need to have a better understanding of the relationship between sustainability performance and business success, integrate sustainability within their strategic management, and be the 'first-movers' in new technologies and innovations in compliance with sustainable development. Then, they can compete more freely in the global marketplace (Kim & Mauborgne, 2005).

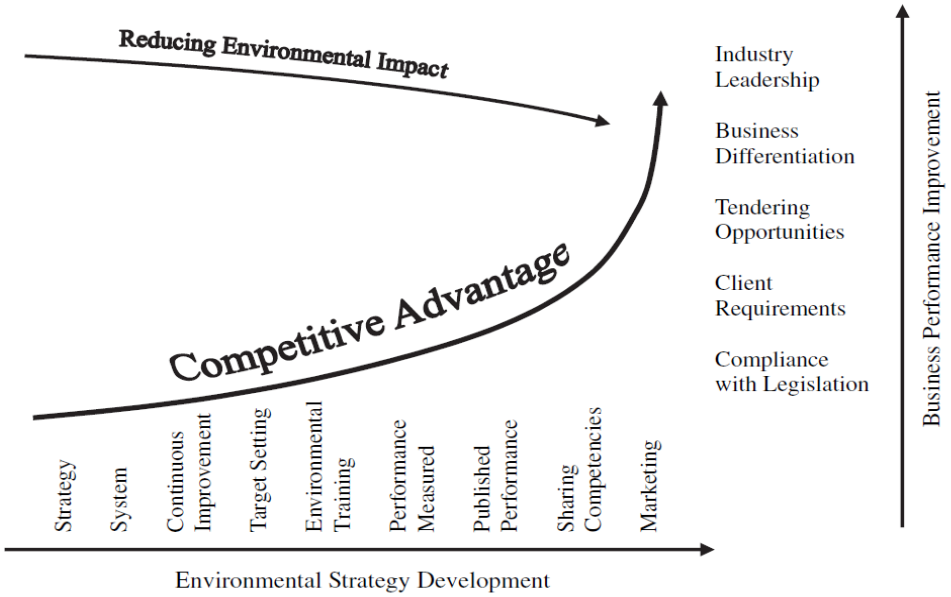

Figure 8. Relationship between environmental strategy development, performance improvement and competitive advantage (Fergusson & Langford, 2006)

Fergusson & Langford (2006) introduced a model for illustrating the relationship between strategy development, performance improvement and competitive advantage, as shown in Figure 8. The implementation of environmental strategies will improve contractors` competences in environmental management and consequently lead to improvements in business performance.

Tan, Shen & Hong (2011) developed a framework for improving contractors` competitiveness through implementing sustainable construction practice, as shown in Figure 9. There are two dimensions in the framework, representing sustainability performance and business competitiveness respectively. Understanding sustainability principles and legislation is the basis of the integration. Sustainability policy and strategy are guidelines for implementing appropriate sustainable construction practice. Review and correction is used to find the problems and make continuous improvement possible. With the implementation of sustainable construction practice in an effective way, an increase in sustainability performance will induce an increase in business competitiveness.

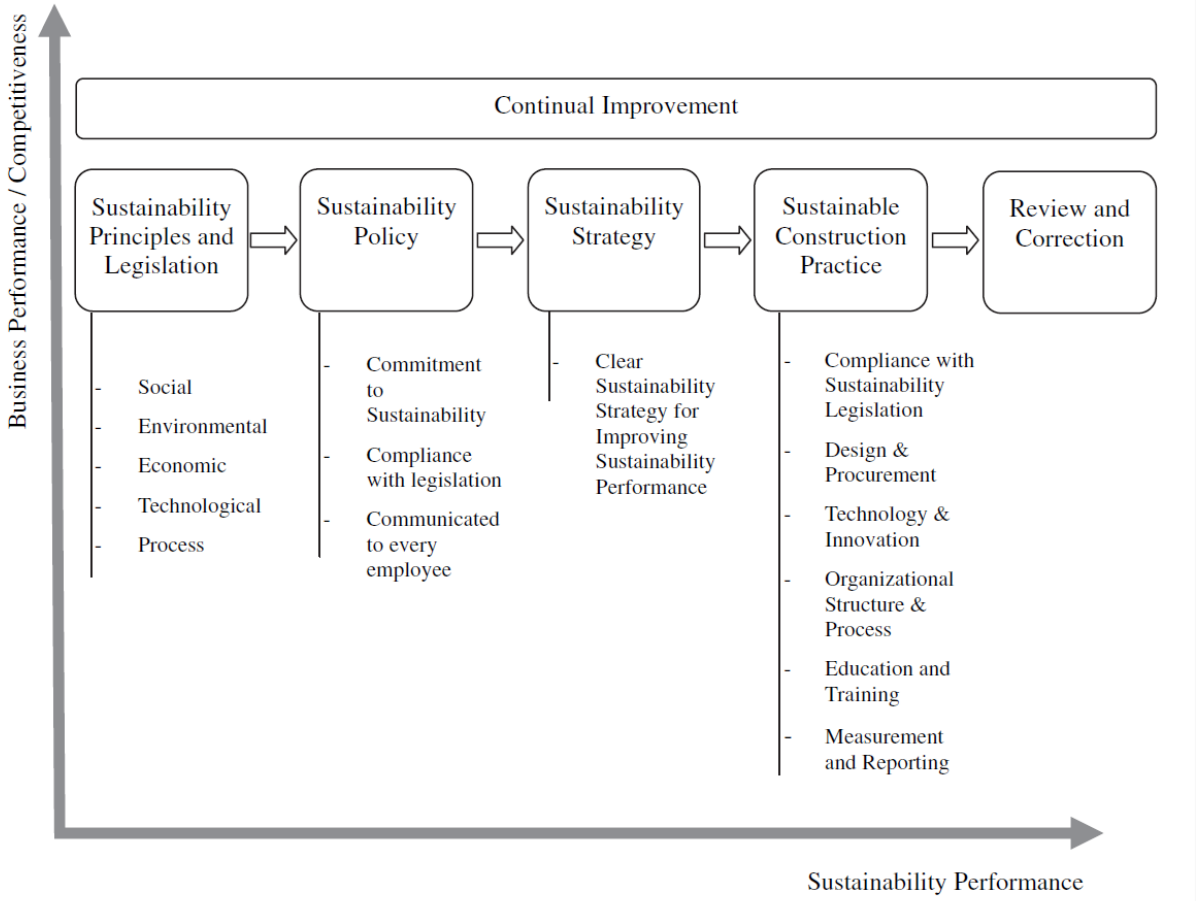

Figure 9. A framework to improve contractors` competitiveness by improving sustainability performance (Tan, Shen, & Yao, 2011).

According to the reviewed literature a relation exist between the concepts of sustainability and competitiveness. This relation has been less discussed in the exiting literature for the building sector. However, the empirical study of Tan, Ochoa, Langston & Shen (2015) indicates that such a relation exists. Moreover, the framework developed by Tan, Shen & Hong (2011) may prove a useful tool for contractors to become more competitive on sustainability, and harvest 'first-mover' advantages.

3.2 Barriers, drivers and enablers for sustainability

This chapter will discuss drivers and barriers for sustainable construction. Barriers for sustainable construction are all the factors which hinder the implementation and successful use of sustainable construction measures. Where drivers are defined as all the factors which positively influence the effect of the building sector on the environment.

3.2.1 BARRIERS FOR SUSTAINABILITY

Häkkinen and Belloni (2011) claim that sustainable construction is not hindered by a lack of existing information, technologies and assessment methods. But because it is difficult to adopt new processes and working methods, in order to apply new technologies. Resistance to new technologies occurs because they require process changes, entailing the perception of possible risks and unforeseen costs. These hindrances can be reduced and overcome with help of new efficient processes and by learning what kind of decision-making phases, new tasks, actors, roles and ways of networking are needed. Also van Bueren and Priemus (2002) state that non-technical barriers have the most drastic effect on the implementation and adaption of sustainable construction. Van Bueren and Priemus (2002) discussed institutional barriers to sustainable construction, by identifying the institutions in the building sector and the manner in which these institutions influence the decision of players whether or not to apply sustainable construction measures. According to van Bueren and Priemus (2002) gaps exist between: location development and building project development, construction and management, construction and operations and lastly asymmetric distribution of pluses and minuses. According to Mlecnik (2011) the building sector is not moving towards sustainable construction because the so-called 'circle of blame as visualized in Figure 10. In the circle of blame all stakeholders blame the lack of sustainable construction to other stakeholders, which results in a vicious circle. This circle of blame is a major barrier for sustainable development in the building sector.

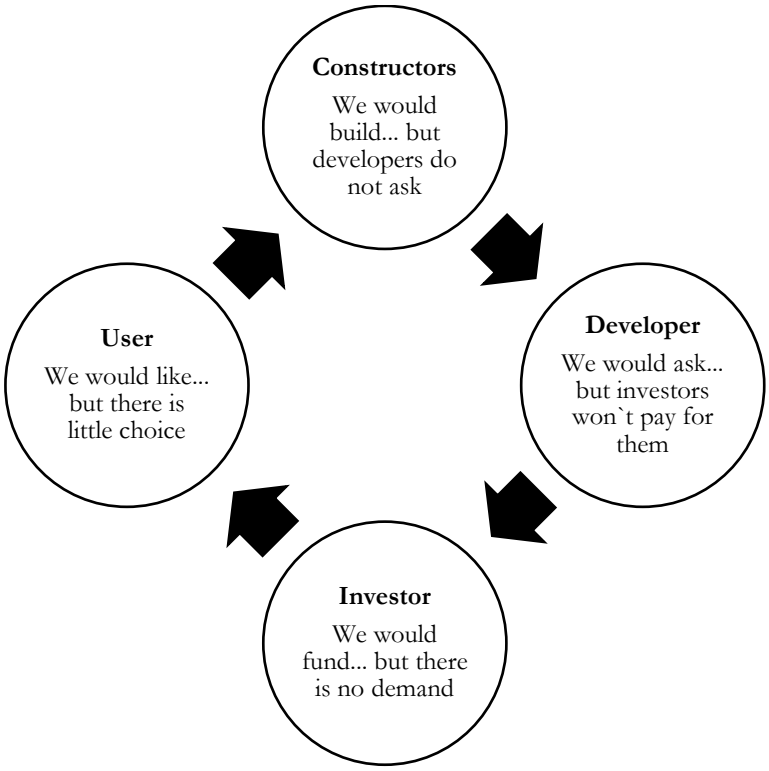

Figure 10. Circle of blame (Mlecnik, 2011)

Furthermore, Häkkinen & Belloni (2011) identify several barriers for several stakeholders in the construction process. These barriers are visualised in Table 1.

Table 1. Barriers for sustainable construction (Häkkinen & Belloni, 2011)

Who	Barrier
Client	Lack of assessment methods that enable the comparison in terms of sustainability
	Lack of methods that support Sustainable Building (SB) requirement setting
	New kinds of solutions are risks with regard to costs and quality
Contractors	The time perspective of property developers is only a couple of years: thus long term benefits are not essential
	It is not worthwhile to change the construction process(because relative low number of demanding buyers)
Buyers	Do not state requirements for SB because they have no information about the alternatives and possibilities of SB
	Do not have information about the effect of SB on operational costs
	Do not want to pay extra for SB performance
Users	Monitoring and allocation of the benefits of SB for tenants is rare
	Economic benefit of energy efficiency is relatively small

Häkkinen and Belloni (2011) identify five main barriers for sustainable construction: steering mechanisms, economics, lack of client understanding, process (procurement and tendering, timing, cooperation and networking) and lastly underpinning knowledge (knowledge and common language, availability of methods and tools, innovation).

Steering mechanisms include normative regulatory instruments such as building codes, informative regulatory instruments such as mandatory labelling, economic and market based instruments such as certificate schemes, fiscal instruments such as subsidies and incentives such as taxation and support. The lack of steering or the wrong type of steering may hinder sustainable construction. Additionally, the weakness of current steering mechanisms is that they are mainly directed at new buildings and not the existing building stock.

The economic barrier for sustainable construction is related with the fear of higher investments costs compared with traditional building and the risks of unforeseen costs. Because, of unfamiliar techniques, lack of previous experience, additional testing, lack of supplier support and a lack of performance information.

A lack of the client`s demand and understanding about sustainable construction can be a major barrier to implement sustainable construction measures. Ultimately the client decides which requirements its construction needs and how sustainable the construction needs to be.

Other major obstacles for sustainable construction are linked to process related activities such as: procurement and tendering, timing and cooperation and networking. One of the most important obstacles for successful sustainable construction is the difficulty to define measurable requirements during the procurement and tendering phase. Furthermore, the right timing and the presence of all needed actors are often addressed as key issues for the success of projects.

Moreover, successful implementation of sustainable construction measures requires good cooperation and effective communication between the members of the project teams.

The last group of major obstacles for sustainable construction is related to underpinning knowledge. Sustainable construction can be hindered by ignorance or a lack of common understanding about sustainability. Furthermore, the efficient use of all necessary information and the effective cooperation of all actors call for methods that enable the management and sharing of information. Furthermore, sustainable development requires changes compared with the current situation and therefore product but especially process innovations are required.

Pitt et all (2009) focused on what factors prevent sustainable construction practices and used a survey to identify the major barriers for construction. Each of the following factors were mentioned in the survey:

1. *Affordability:* amount of money which a sustainable construction measure cost
2. *Building regulations:* regulations that apply to a specific construction measures
3. *Lack of clients awareness:* awareness of client of possible sustainable construction measures
4. *Lack of business case understanding*: understanding about a specific project
5. *Lack of clients demand:* client is not willing to implement sustainable construction measure
6. *Lack of proven alternative technologies:* availability of sustainable technologies.
7. *Lack of labelling/measurement standard:* availability of sustainability measurement tools
8. *Planning policy:* How are sustainability construction measures planned over time

The factors which prevent sustainable construction the most according to the research of Pitt et all (2009) were affordability, building regulation and lack of client awareness.

In this chapter the major barriers of sustainable construction have been discussed. The reason why sustainable construction is not commonly used can be explained by "the circle of blame". Every actor in the building sector blames other stakeholders and no one takes initiative to move the building sector to become more sustainable. The identified barriers of sustainable construction in the reviewed literature correspond with each other, and the main barriers of sustainable construction are related with: affordability, building regulations, client awareness, steering mechanisms, process and underpinning knowledge. In order to successfully implement sustainable construction measures, these barriers need to be minimised.

3.2.2 DRIVERS FOR SUSTAINABILITY

As discussed in the previous section there are lots of factors hampering the broad implementation of sustainable building in the building sector. However, there also exist forces which are driving the building sector to become more sustainable.

Häkkinen and Belloni (2011) identify five main actions to promote sustainable construction: development of the awareness of clients about the benefits of sustainable construction, development and adoption of methods for sustainable construction requirement management, mobilization of sustainable construction tools, development of designers` competence and team working and lastly the development of new concepts and services.

Häkkinen and Belloni (2011) identify three issues that promote the adaptation of SB concepts: beneficial operating costs, improved well-being and productivity of occupants and users of the building due to improved building performance, and long-term benefits for the national economy because of reduced emissions and use of natural resources.

Darko et all (2017) presents a classification framework for Green Building (GB) drivers: external drivers, corporate-level drivers, prosperity-level drivers, project-level drivers and individual-level drivers. The classification framework for GB is visualised in Figure 11.

Furthermore, Darko et all (2017) have identified a list of potential drivers for implementing sustainable construction measures. The potential drivers are listed in Table 2.

Pitt et all (2009) identified factors which are seen as key to the promotion of sustainable building and improved energy efficiency:

1. Creating awareness: public perception and awareness of the issues and better understanding of ways of addressing energy efficiency
2. Creating demand: from clients tenants users and investors for more sustainable buildings
3. Financial incentives: to help drive demand for stakeholders
4. Legislation and standards: consistent standards and enforcement
5. Labelling: of buildings with energy efficiency rating

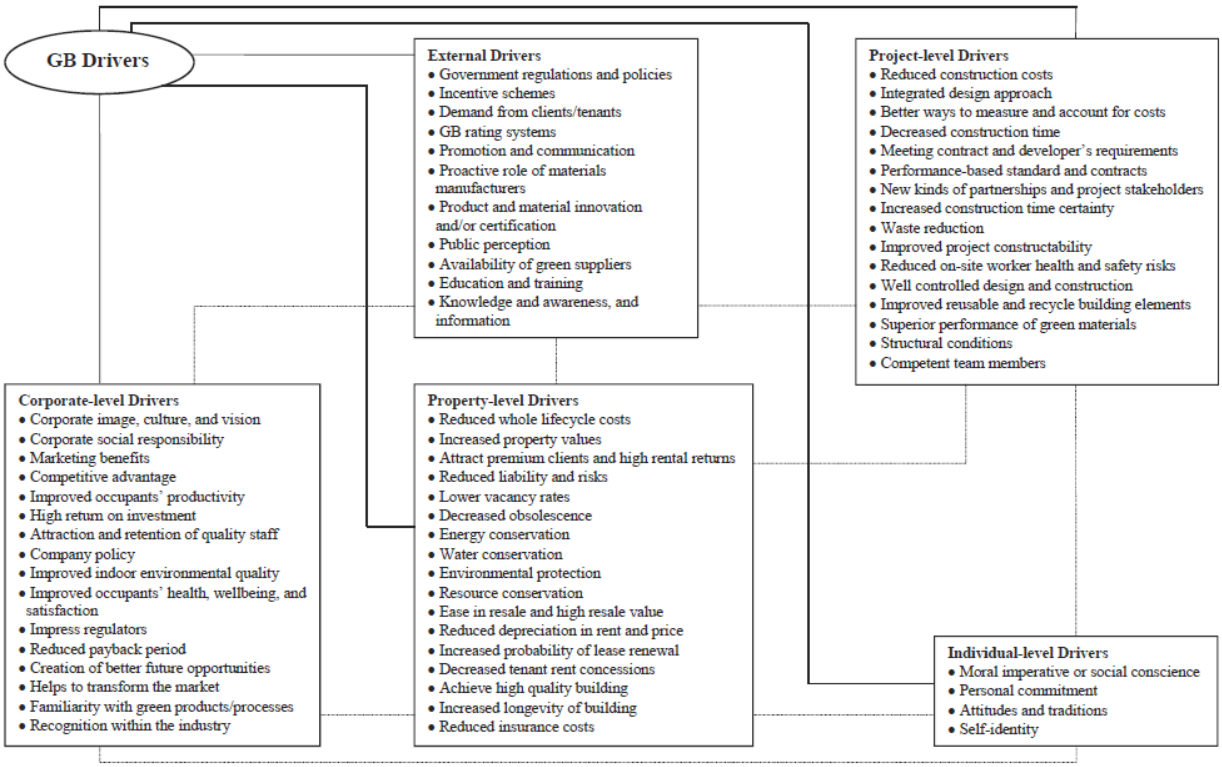

Figure 11. Classification framework for Green Building(GB) drivers (Darko, Zhang, & Chan, 2017)

Table 2. List of potential drivers of sustainable construction (Darko, Chan, Owusu-Manu, & Ameyaw, 2017)

#	Driving factor	#	Driving factor
1	Reduce the lifecycle costs of buildings	12	Attract premium clients and enhanced prosperity value
2	Greater energy-efficiency	13	Reduce construction and demolishing waste
3	Greater water-efficiency	14	Preservation of natural resources and non-renewable fuels/energy sources
4	Enhance occupant`s health, comfort and satisfaction	15	Set standards for future design and construction
5	Increase overall productivity	16	Reduce the use of construction materials
6	Reduce the environmental impact of building	17	Attract quality employees and reduce employee turnover
7	Better indoor environmental quality	18	Satisfaction from doing the right thing
8	Good company image, reputation or marketing strategy	19	Facilitate a culture of best practice and sharing
9	Better workplace environment	20	Efficiency in construction processes and management practices
10	Thermal comfort	21	Improve the performance of the national economy and create jobs
11	Better rental income and increased lettable space		

According to the research of Darko et all (2017) the five most important drivers for sustainable construction are: energy-efficiency, reduced environmental impact, water efficiency, occupant`s health & comfort and satisfaction, company image/reputation.

In this chapter a large variety of drivers for sustainable construction has been identified. Scholars mostly agree on the potential drivers for sustainability. Yet, they approach these drivers from a different abstraction level. For example: Häkinnen & Belloni (2011) state that drivers for sustainable construction are: the reduction of cost, improved well-being and reduction in environmental impact. Pitt et all (2009) focuses on promoting sustainable building as a driver, and

focus more on creating awareness, creating demand, providing financial incentives, creating good functioning legislation and standards and lastly use labelling techniques. Darko et all (2017) uses a more in-depth research to identify possible drivers for sustainable construction. Subsequently, they created a classification framework to categorize these barriers in order to be able to see interdependencies between these drivers. These three authors have identified many drivers for sustainable construction, which can stimulate sustainability in the building sector.

3.3 Sustainability strategy

This chapter discusses relevant literature regarding the development of strategy, and which factors influence the strategy development process. This section provides the theoretical basis for the sustainability strategy development of this research.

A strategy can be described as a plan that describes the method on how certain goals can be reached under conditions of uncertainty. Therefore a sustainability strategy is a plan on the fulfilment of sustainability-related goals under condition of uncertainty (Aarseth, Ahola, Aaltonen, Okland, & Andersen, 2016).

Table 3. Sustainability strategy perspectives: project organisation vs project host (Aarseth, Ahola, Aaltonen, Okland, & Andersen, 2016)

	Strategy	Description
Sustainability strategy adopted by project organisations	Setting strategic and tactical sustainability goals	Focusing explicitly on sustainability issues when developing project strategies, paying special attention to instances where sustainability issues align with other concerns.
	Developing sustainable supplier practices	Supporting suppliers in implementing sustainable practices such as e.g. use of ecological materials and prefabrication.
	Emphasizing sustainability in project design	Incorporating sustainability issues in early phases of projects and explicit project design documents. The methods are based on development of performance indicators and appraisal techniques such as life-cycle assessments and value management.
Sustainability strategies adopted by project hosts	Setting sustainability policies	Defining sustainable project policies that include the development of laws and regulations, norms, plans and guidelines to support sustainability on the project level, and executing governmental and regulatory tasks in a manner that emphasizes and promotes sustainability in projects.
	Influencing sustainability of project practices	Supporting the incorporation of sustainability into project practices and technical systems through e.g. construction tools, prefabrication and waste management systems.
Mutual sustainability strategies	Inclusion of sustainability-promoting actors in project organisation	*Project organisation:* selection and inclusion of actors that bring sustainability-promoting skills, capabilities and roles to a project. *Project host:* Inclusion of different authorities and NGO representatives to act as legitimacy actors in project organisation, supporting multidisciplinary in project organisation.
	Developing sustainability competences	*Project organisation:* Expending competences and skill sets of project managers by investing in formal training programs. *Project host:* developing sustainability related competencies of governmental actors as well as the public
	Sustainability management in project portfolio management	*Project organisation:* This relies on either using a framework for project selection or actively including sustainability as a dimension in early-phase appraisal *Project host:* Emphasizing sustainability issues when deciding which projects to fund and approve

Aarseth et all (2016) describe two perspectives on the development of project related sustainability strategies: one assumes the perspective of the project organisation delivering the asset while the second assumes the perspective of the host organisation. These sustainability strategies are visualised in Table 3.

Hart (1997) states that companies must look beyond their internal and operational focus to a more external and strategic focus on sustainable development. Such a vision is needed to guide companies through three stages of environmental strategy. This sustainable value portfolio is visualised in Figure 12.

Figure 12. The sustainable value portfolio (Hart, 1997)

Stage 1 pollution prevention: the first stage is concerned with companies making a shift from pollution control to pollution prevention. Pollution control means cleaning up waste after it has been created. Pollution prevention focuses on minimising or eliminating waste before it has been created.

Stage 2 product stewardship: the second stage focuses on minimising not only pollution from manufacturing but also all environmental impacts associated with the full life cycle of a product.

Stage 3 clean technology: the third stage is focused on the development of new and clean technologies. The simple fact is that the existing technology base is not environmentally sustainable. Therefore, new and more sustainable technologies are required in order to become truly sustainable.

Pollution prevention, product stewardship and clean technology all move a company towards sustainability. A vision of sustainability needed for a company is like a road map to the future, showing the way products and services must evolve and what new competences will be needed to get there.

According to Journeault (2016) organisations struggle to simultaneously integrate economic, environmental and social aspects in their corporate strategies. Journeault (2016) redeveloped the sustainability balanced scorecard which is one of the most promising strategic tools to help organisations face these challenges and support their sustainability strategy.

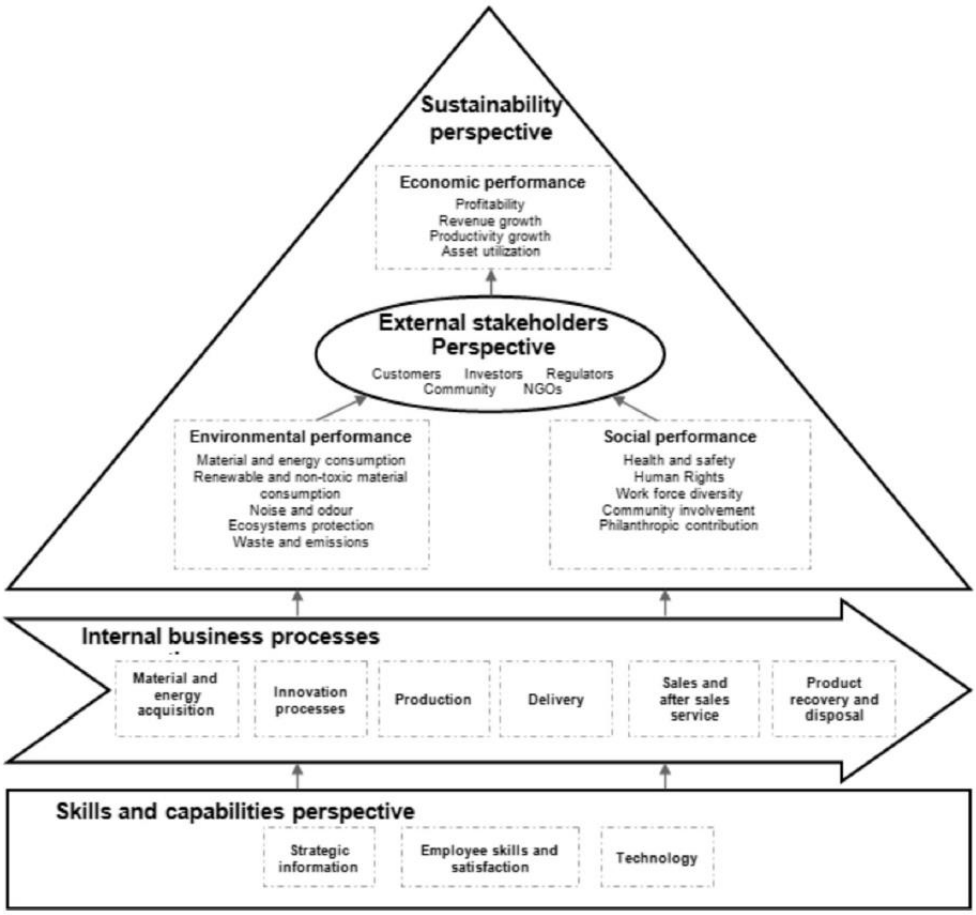

Figure 13. Integrated scorecard (Journeault, 2016)

The balance scorecard can assist companies to develop sustainability strategies by setting clear objectives for each perspective in the balance scorecard: economic performance, external stakeholders, environmental performance, social performance, internal processes and skills & capabilities. In order to ensure a clear and uniform method to determine the progress of these sustainability goals, performance indicators need to be used to measure the progress of the sustainability goals. The balanced scorecard is visualised in Figure 13.

According to Orsato (2009) four main sustainability strategies could be used to develop a competitive advantage. The appropriate competitive focus and the potential source of competitive advantage for a firm depend on: the industry in which a firm operates its position within that industry, the types of markets the company serves and its capabilities to acquire resource or to deploy radically innovative strategies. Orsato (2009) his four main sustainability strategies are visualised in Figure 14.

Previous literature discussed several sustainability strategies which can be used to become more sustainable and receive a competitive advantage. However, a limited amount of literature discusses, how these strategies could best be implemented. According to Percy (2000) the best approach to implement sustainability strategies is by:

1. integrate them fully with business strategies and hold the line accountable;
2. set visible targets and report progress;
3. take continual feedback from all constituencies and look for non-traditional partnerships for new ideas and learning;
4. build diversity of thought into your workforce and teams;
5. confront your largest environmental or social challenges as a company head on, in an open and forthright way.

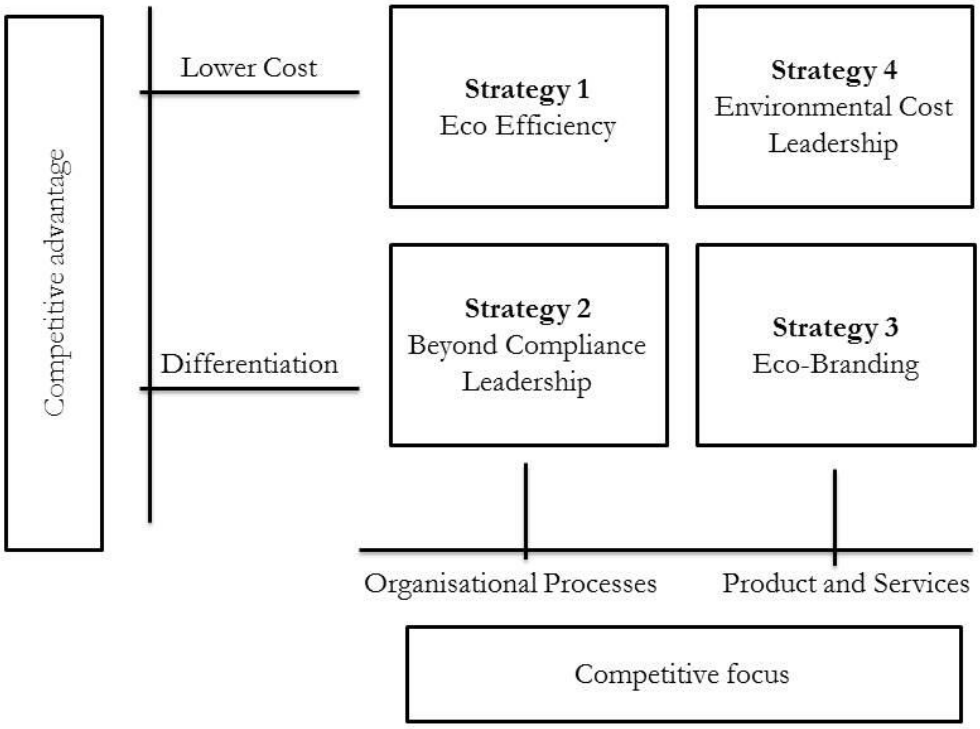

Figure 14. Competitive Environmental strategies (Orsato, 2009)

There exist many different sustainability strategies for companies to become more sustainable. The reviewed literature discussed several perspectives on sustainability strategies and showed different strategies on how companies can achieve a competitive advantage by implementing sustainability strategies. However, a strategy is just a plan on the fulfilment of a goal. Therefore, strategies need to be non-generic, and in line with organisation-specific sustainability goals.

4 FUTURE SUSTAINABILITY REQUIREMENTS

This section aims to answer the following research question:

What are the future sustainability requirements in the building sector?

In this section the future requirements for sustainability are identified. Firstly, the most influential actors and their influence on the future requirements for sustainability are identified. Consequently, a desk research and several interviews have been conducted to pinpoint the sustainability goals of the actors, which have a significant influence on the future requirements for sustainability. It is presumed that the sustainability goals of the most influential actors of today will evolve in the sustainability requirements of the future.

4.1 Identification of most influential actors

Many forces aim to move the building sector towards improvement in sustainability performance. Actors either push or pull on the sector to improve the sustainability performance as visualised in Figure 15. Governments push the building sector by enforcing laws and regulations, and with interventions such as subsidies, knowledge sharing, working programs and covenants. Next to the government pushing the building sector to become more sustainable, the market pulls the sector to become more sustainable by demanding a higher sustainability performance of their products. This pull is created by the increase of environmental awareness and growing interest in CSR. Clients are demanding higher sustainability performance and a reduced impact on the environment. Many actors have set their own sustainability goals, in order to improve their own sustainability performance, and the sustainability performance of the building sector. The sustainability goals of the most influential actors in the building sector can be considered as a good representation of the future sustainability requirements because, "current goals will eventually become future requirements".

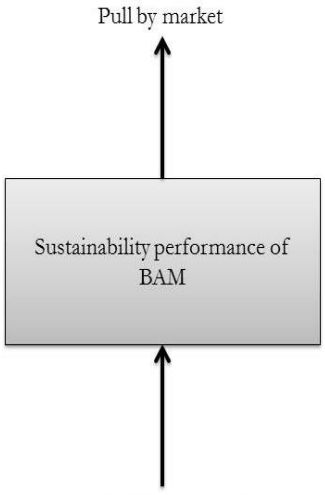

Figure 15. Push and pull actors

In this chapter the most influential actors which influence the future requirements for sustainability have been described. The most influential actors have been identified from related stakeholder literature from BAM, and by interviewing experts. The actors which have a major influence on the future requirements for sustainability in the building sector can be divided in four groups: governments, own organisation, clients and trade associations, as visualised in Figure 16.

The first group of actors which influence the future requirements for sustainability are governmental bodies, on global, intercontinental and national levels. This group focuses on setting goals and prescribing legislation in order to decrease the environmental impact. The governmental actors which will be included in this research are: the United Nations (UN), European Union (EU) and the Dutch government.

The UN is an international organisation founded in 1945 to promote international co-operation and it is made up of 193 member states. The organisation is financed by assessed and voluntary contributions from its member states. Its objectives include maintaining international peace and security, promoting human rights, fostering social and economic development, protecting the environment, and providing humanitarian aid in cases of famine, natural disaster and armed conflict. The UN influences the future requirements for sustainability because it is concerned with the promotion of sustainable development and reducing the negative impact on the environment to minimise the negative effects of climate change (UN, 2017).

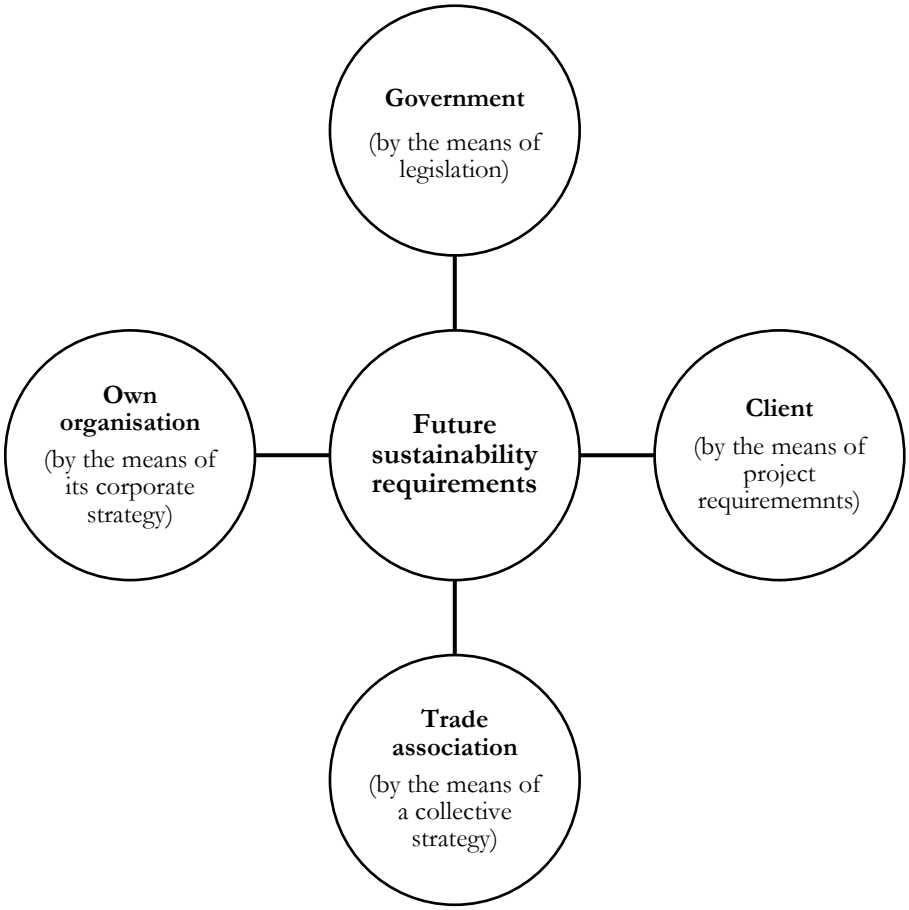

Figure 16. Most influential actors influencing the requirements for sustainability

The EU is a political and economic union of 28 member states that are located primarily in Europe. The EU is considered by some to have the most extensive environmental laws of any international organisation. Its environmental policy is significantly intertwined with other international and national environmental policies. The environmental legislation of the EU also has significant effects on those of its member states. The EU environmental legislation addresses issues such as acid, rain, the thinning of the ozone layer, air quality, noise pollution, waste & water pollution, and sustainable energy. The institute for European Environmental policy estimates the body of EU environmental law amounts to well over 500 directives, regulations and decisions (EU, 2017).

The Dutch government is responsible for national environmental policy directed to contributing to sustainable economic development and to the health and safety of people by maintaining and improving the quality of the environment. Preparing and coordinating national policy and strategies on the environment includes ensuring implementation of EU legislation and international treaties in national legislation. The responsible ministry for the preparing and coordination of national policy on the environment in the Netherlands is the Ministry of Infrastructure and Environment (MIE). The MIE is committed to improving quality of life, access and mobility in a clean safe and sustainable environment (Dutch Government, 2017).

The second group of actors are the clients. A client can be described as a person for whom a project is carried out. The client is a company with the controlling interest in the project. Generally the client will retain significant level of control over the assessment and appointment of designers and contractors for a project. The client is responsible for the requirements for a construction work, and therefore largely influences the level of sustainability of the product. Clients can be roughly divided in three categories: private, commercial and governmental. Private clients are comprised of either local or sole traders who need assistance with the construction, alteration, or maintenance of their private properties. It is common for such a client to enter into a private agreement with

just a builder to undertake the construction work. A commercial client is considered to be a company, factory or business that needs to undertake construction to aid their business processes or the production of products. The last category of client are governmental clients. Governmental clients are responsible for constructing and maintaining services. Because the government is responsible for the construction and maintenance of infrastructure, many infrastructural projects are procured by governmental bodies such as Rijkswaterstaat, Prorail and lower governmental bodies such as provinces and municipalities. In the Utility sector the client is more often a private or commercial organisation.

The third actor which has a significant influence on the future requirements for sustainability is the contracting company, in this research BAM. The contractor is a company engaged in work related to the construction of a project. This also means someone who manages or carries out the construction work or even a company who supplies labour or materials for a project. The contractor does not directly influence the requirements for sustainability in the future. However, if the contractor is able to provide sustainable products or services for an economically beneficial price, the demand for sustainability may increase.

The last group of actors influencing the future requirements for sustainability are trade associations. A trade association is an organisation founded and funded by businesses that operate in a specific industry. An industry trade association participates in public relations activities such as advertising, education, political donations, lobbying and publishing, but its focus is collaboration between companies. Associations may offer other services, such as producing conferences, networking, or charitable events or offering classes or educational materials. The main trade association in the Dutch building sector which is concerned with sustainable building is: Bouwend Nederland. Furthermore, an important platform for collaboration within the building sector are the greendeals.

Bouwend Nederland unites, connects and supports companies in the building sector. Bouwend Nederland aims to contribute to a more sustainable development of the living environment by representing interests of building companies, development of the building industry and providing services to their members (Bouwend Nederland, 2017).

Additionally, within the building sector a couple of platforms for partnerships exist between actors which focus on the development of a more sustainable building sector. The most important platform for partnerships aimed at reducing the environmental impact of the building sector are the greendeals, and one of the most successful example is Duurzaam GWW.

The greendeals approach is an initiative of the Dutch government and supports sustainable economic growth, or 'green growth', by stimulating sustainable innovation. The green deal approach in the Netherlands is an accessible way for companies, other stakeholder organisations, local & regional governments and interest groups to work with the central government on green growth and social issues. A Green deal is a mutual agreement or covenant under private law between a coalition of companies, civil society organisations and local and regional government. The deal defines the input by participants involved as clearly as possible. Green deals cover nine themes, including construction, bio based economy, bio diversity, food, water, materials, energy, mobility and the climate. In 2017 there are 43 construction green deals, with over 289 different involved parties (Greendeal, 2017).

The partnership Duurzaam GWW includes market operators, governmental clients and research institutes. Although the parties come from different backgrounds and operate in different construction works such as rail, ground, road and water, all these parties act congenial. The aim of this partnership is to actively contribute individually and jointly to reach the sustainability goals for the sector. The partnerships Duurzaam GWW consist of five basic principles to ensure a sustainable sector. [1] Translate corporate sustainability goals to individual projects. [2] Include sustainability as early and as fully as possible in the building process. [3] Focus on the sustainability themes, which have the most potential in a project. [4] Use innovative tendering methods and include sustainability award criteria. [5] The use of collective sustainability tools.

There are many actors which can influence the future requirements for sustainability. This research has narrowed the number of actors down, and identified the 8 most important actors which have a significant influence on the future requirements for sustainability. These actors have been selected by consulting with experts and reviewing the influence of actors on the development of sustainability requirements in recent years. The identified actors influencing the future requirements for sustainability in the building sector are visualised in Table 4.

Table 4. List of actors influencing the future requirements for sustainability

Actors	
UN	BAM group
EU	Bouwend Nederland
NL(MIE)	Greendeals
Clients	Duurzaam GWW

4.2 Influence of actors on the future sustainability requirements

In this chapter the influence of the identified actors on the future requirements for sustainability, will be discussed.

4.2.1 UNITED NATIONS

The UN is concerned with the promotion of sustainable development of its member states. In 2015 the UN adopted the 2030 development agenda which consist of 17 Sustainable Development Goals (SDG) and the associated 169 targets. Not all SDG`s can be directly linked with the building sector. In Table 5 the SDGs which are directly related to sustainable development in the building sector have been listed.

Table 5. Sustainable Development Goals (United Nations, 2017)

SDG #	Goal	Description
7	Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy for all
9	Industry, innovation and infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
11	Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable
12	Responsible consumption and production	Ensure sustainable consumption and production patterns
13	Climate action	Take urgent action to combat climate change and its impact by regulating emissions and promoting developments in renewable energy

The five SDGs listed in Table 2 are considered to be the strongest related with the building sector. SDGs and its targets are included in this research, when it is likely that the building sector has a significant influence on these SDGs and targets.

The 7th SDG is considered related to the building sector, because energy accesses are constructed by the building sector. Furthermore, construction and the use of buildings consume 42% of all energy in Europe, and therefore the impact of the building sector on affordable, sustainable and clean energy is considered high (EC, 2011).

The 9th SDG is also strongly related to the building sector, because the building sector constructs and maintains most infrastructures for the government. Additionally, the building sector is often considered as not-innovative or difficult to innovate (Winch G. , 1998). The relative poor performance on innovative behaviour provides an opportunity for the building sector, and is related to this SDG.

The 11th SDG is related with the building sector because it is responsible for the construction of safe, resilient and sustainable buildings. According to the UN the world`s cities occupy just 3% of

the earth`s land, but account for 60-80% of energy consumption and 75% of carbon emissions (EC, 2011). Therefore, cities have a significant potential for reducing the impact on the environment.

The 12th SDG is concerned with responsible consumption and production patterns. The building sector produces buildings, and uses relative high amount of resources during the construction and use of the buildings. Therefore, the building sector is considered to be related with SDG 12.

The last SDG which is related to the building sector is climate action. From 1880 to 2012, average global temperature increased by 0.85 degrees Celsius (IPCC, 2014). According to a study of the united nations global emissions of carbon dioxide (CO_2) have increased by almost 50% since 1990 (United Nations, 2015). Climate change is considered to be caused mainly by GHG emissions, because the building sector accounts for roughly 35% of the total GHG emissions, SDG 13 can be considered related to the construction industry.

4.2.2 EU

The EU aims to increase the sustainability of its member states. The sustainability policies of the EU cover two main topics: climate action and the maintaining of the environment.

The EU aims to become more sustainable, and decrease its impact on global warming. According to the EU, the emissions of GHGs are the main cause for global warming. The GHGs which are most commonly produced by human activities are carbon dioxide, methane and nitrous oxide, which are respectively 64%, 16% and 6% responsible for man-made global warming. According to the EU the main causes for global warming are the burning of fossil fuels, deforestation, the increasing livestock framing and fertilisers. The focus of the EU climate action policies depends on: [1] cutting GHG emissions, [2] energy from renewables and [3] improvement in energy efficiency (European Commission, 2017).

Next, to reducing global warming, the EU has created an environmental action plan on how to minimize the negative impact on the environment. It identifies three key objectives (European Commission, 2017):

1. To protect conserve and enhance the union`s natural capital
2. To turn the union into a resource-efficient, green, and competitive low-carbon economy
3. To safeguard the union`s citizens from environmental related pressures and risk to health and wellbeing

In order to reach these environmental goals, the EU has created several environmental policies such as: clean air, circular economy, environmental assessment, environmental implementation review, green public procurement, resource efficiency, raw material and many other policies (European Commission, 2017).

4.2.3 DUTCH GOVERNMENT

The Dutch central government is responsible for national environmental policy directed to contributing to sustainable economic development and to the health and safety of people by maintaining and improving the quality of the environment. The Dutch central government aims to increase sustainability in the Netherlands by preparing and coordinating national policy and strategies on the environment, ensuring implementation of EU legislation and international treaties in national regulations (Government of the Netherlands, 2017).

Almost all national legislation on the environment is incorporated in the Environmental Management Act (MHSPE, 2017). This act sets out an integrated approach to environmental management in the Netherlands and provides the legal framework by defining the roles of national, provincial or regional, and municipal government. The act stipulates the tools to be used in environmental management including:

1. Environmental plans: environmental planning is the process of facilitating decision making to carry out land development with the consideration given to the natural environment,

social, political, economic and governance factors and provides a holistic framework to achieve sustainable outcomes;

2. Environmental quality criteria for emissions and discharges of harmful substances such as greenhouse gases and heavy metals to air, water and soil;
3. Environmental impact assessment: the mandatory assessment of the environmental consequences (positive and negative) of a project by the government;
4. Environmental permit: approval of building activities by government because these comply with the environmental standards and laws;
5. Environmental reporting: public disclosure by the government of its environmental performance information;
6. Enforcement: enforcing the environmental law.

4.2.4 CLIENTS

The client is probably the most important actor influencing the future requirements for sustainability in the building sector. The client is eventually the organisation which sets the requirements for a project and determines whether they include sustainability requirements. The clients in the building sector can be roughly divided in governmental clients for infrastructural projects, and commercial clients for utility construction.

Governmental

The Dutch central government has implemented green public procurement (GPP) in 2010 which forces governmental bodies to include sustainability within the public procurement process. The two main governmental bodies responsible for the procurement of infrastructural work are Rijkswaterstaat and Prorail. Rijkswaterstaat is responsible for the execution of work planned by the MIE. Prorail is the organisation responsible for constructing and maintaining the rail infrastructure in the Netherlands.

Commercial

Commercial clients can also benefit from including sustainability requirements in their buildings. Energy efficiency measures can result in cost reductions during the operating of a building, and improve the indoor quality of the buildings. Additionally, the construction of green buildings can contribute to positive branding of companies because a sustainable building shows the company cares about the environment.

4.2.5 BAM

BAM is a contracting company which implementation of sustainability measures depends largely on the requirements set by their clients. Nonetheless, BAM aims to differentiate itself from their competitors by delivering high quality and sustainable products. BAM is already well-known for their sustainable building capabilities and is ranking high in various inter organisational sustainability studies such as the Carbon Disclosure Project (CDP) A list.

In order to improve its strategy and relevance with global issues, BAM appreciates the impact of aligning its sustainability strategy with the UN adopted SDGs. BAM has set its own sustainability goals, and has created a corporate sustainability strategy to ensure that these goals are met. BAM its sustainability strategy has three pillars: climate positive, resource positive and enhancing lives as visualized in Figure 17.

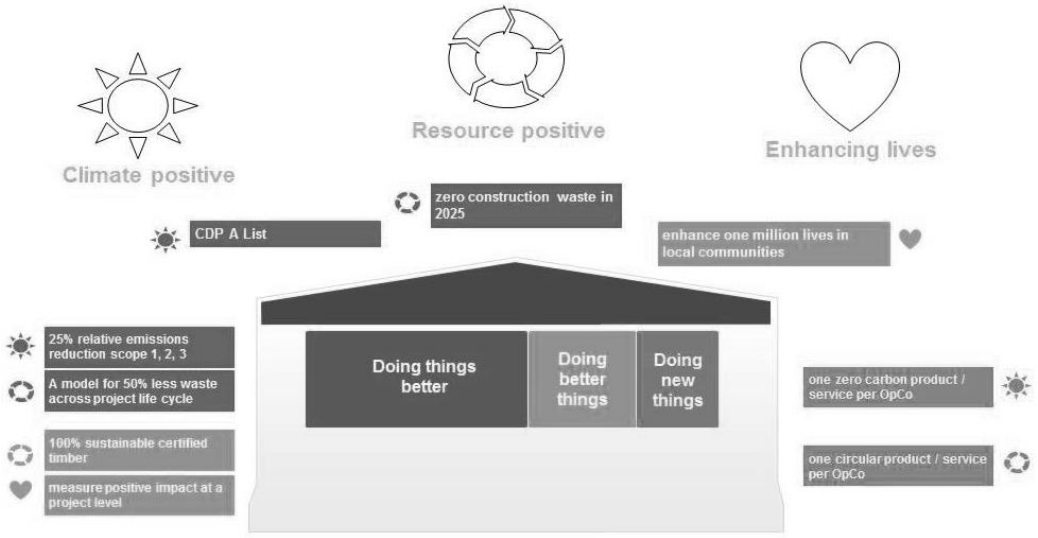

Figure 17. Sustainability vision and strategic objectives BAM (BAM, 2016)

The climate positive ambition of BAM is concerned with having a positive impact on climate change. The building sector has many fuel-intensive processes. BAM its carbon footprint and its carbon intensity largely depends on the type, the phase and the location of projects. The largest impact on climate change of BAM`s activities occurs in the operational phase of its products, after completion of construction.

The resource positive ambition of BAM focuses on reducing waste, during a product its entire life cycle. BAM focuses on construction and office waste as indicators of operational performance, since these outputs are based on BAM`s its own processes and procurement. BAM focuses its waste reduction on materials such as water, timber, asphalt, concrete and steel because these materials have the highest environmental impact.

The enhancing lives ambition of BAM consists of: acknowledging the benefits it provides to local communities, education and skills, charity partnerships and generally by enhancing the lives of its workforce.

4.2.6 BOUWEND NEDERLAND

Bouwend Nederland aims for a healthy, safe and affordable housing, utility and infrastructural sector with minimum effects on the environment (Bouwend Nederland, 2017). The building sector contributes to a couple of important societal challenges such as: reducing the use of primary materials, energy, harmful emissions and waste. The increasing demand for energy efficient buildings. Making the existing building stock more energy efficient and to reduce climate change.

Bouwend Nederland aims to contribute to some of these societal challenges by focusing on a couple of themes. The first aim of Bouwend Nederland is to ensure that new buildings are becoming more energy efficient and become nearly energy-neutral, which means that new buildings almost require no additional energy and the energy these buildings use comes from renewable sources. Furthermore, Bouwend Nederland aims to improve the energy efficiency of the existing building stock.

Bouwend Nederland also aims to incorporate sustainable requirements during tenders to ensure sustainable products and processes. In addition, Bouwend Nederland aims to increase the circular economy in the building sector and its supply chain, to reduce waste and to become more sustainable.

Lastly, Bouwend Nederland aims to make the building process more sustainable and provide the building sector with sustainability tools for actors to ensure the sustainability of their buildings.

4.2.7 GREENDEAL

Sustainable construction in the Netherlands is mainly controlled by international, European and national legislation. The Dutch government sets sustainability standards which the construction industry has to comply to. In the Netherlands the Dutch government supports sustainable economic growth, or 'green growth', by stimulating sustainable innovation. The green deal approach in the Netherlands is an accessible way for companies, other stakeholder organisations, local & regional governments and interest groups to work with the central government on green growth and social issues. A Green deal is a mutual agreement or covenant under private law between a coalition of companies, civil society organisations and local and regional government. The deal defines the input by participants involved as clearly as possible. Green deals cover nine themes, including construction, resources, bio based economy, biodiversity, mobility, energy, food and climate. In 2017 there are 43 construction green deals, with over 289 different involved parties (Greendeal, 2017).

The greendeals which are related with the buildings sector mainly focus on saving energy and using renewable energy sources in for the existing building stock. The largest share of the deals is concerned with the housing sector. Most building green deals focus on making the supply chain more efficient and sustainable, by integrating the entire supply chain and focusing on the full life-cycle of buildings.

4.2.8 DUURZAAM GWW

Duurzaam GWW is a good example of a successful greendeal. Duurzaam GWW is a partnership between building companies, governmental clients and knowledge institutes. The main aim of this partnership is to make the infrastructural sector more sustainable. Duurzaam GWW consists of the following five main principles (Duurzaam GWW, 2017):

1. Translate sustainable goals of the organisation to projects
2. Include sustainability as early and integral as possible in infrastructural projects
3. Focus each project on the sustainability themes which have the most potential
4. Focus on innovative procurement and include sustainability requirements
5. Use collective tools

The partnership Duurzaam GWW is a practical approach to include sustainability in infrastructural projects and to link these to organisational goals. The approach focuses on several steps such as: researching opportunities, weighing, specifying, including and pass down these opportunities to next project phases.

4.3 Sustainability goals of actors

In this chapter the sustainability goals of the identified actors on the future requirements for sustainability, will be discussed.

4.3.1 UN

The UN`s intergovernmental panel on climate change has warned of the increasing dangers of climate change and has spoken of the urgency to find solutions before it is too late. At the present rate, greenhouse gas emissions are rising and the world is on a path to raise the global average temperature by more than three degrees Celsius this century. The world is already experiencing the impacts of climate change, from sea-level rise to melting glaciers, to more extreme weather patterns (IPCC, 2014).

In 1992, 193 nations signed a treaty which required members to reduce greenhouse gas emissions in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system". This treaty is known as the Kyoto protocol (United Nations, 1998).

In December, in Paris, 195 nations negotiated a climate agreement, which declared that the temperature rise should be limited to 2 degrees above pre-industrial levels and should be tried to be kept under 1.5 degrees Celsius (United nations, 2015).

In order to reduce the global rise in temperature, the emission of greenhouse gasses needs to be reduced. In many European countries there has been a reduction in greenhouse gasses between 1990 and 2013 (United Nations, 2015). However this reduction is not enough to reach the goals set in the Paris agreement and therefore extra efforts will be required.

Therefore, the UN has set ambitious SDGs and targets to reduce the impact on the environment. The SDGs which are significantly related to the buildings sector and their targets have been visualised in Table 6. Furthermore, the progress of the Netherlands on these SDGs have been shortly discussed in the last column.

Table 6. SDG Targets 2030 (United Nations, 2017)& (CBS, 2017)

SDG #	Goal	Target	Dutch national performance
7	Affordable and clean energy	7.1 By 2030, ensure universal access to affordable, reliable and modern energy 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix 7.3 Double the global rate of improvement in energy efficiency	7.1 In the Netherlands electricity companies are required by law to provide everybody with electricity 7.2 The proportion of renewable energy has risen in recent years from 1.6% in 2000 to 5.8% in 2015. 7.3 Gross domestic energy consumption has fallen, in particular due to a reduction in industrial consumption. Overall consumption remains very high. Energy efficiency has improved over time
9	Industry, innovation and infrastructure	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all 9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	9.1 The density of the road network in the Netherlands is high: more or less everyone can be reached by roads. 9.2 The value added of the environmental sector as a percentage of GDP rose from 1.8% in 2001 to 2.2% in 2014. The environmental sector share of employment rose from 1.7% in 2001 to 1.9% in 2014. 9.4 The greenhouse gas intensity of the Dutch economy has slightly fallen since 2000. Additionally, greenhouse gas emissions have decreased somewhat while on balance economic activity has risen 9.5 The number of researchers is increasing in the Netherlands. In 1996 only 0.205% of the population was engaged in research what increased to 0.45% in 2012 (The world bank, 2017).
11	Sustainable cities and communities	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons 11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11.3 The urbanization rate in the Netherlands is very high, measured in area per inhabitant. The Netherlands is a densely populated country, and will remain that way. 11.4 government expenditure on environmental protection and culture has remained stable in the past 15 years: just under 2 % of GDP. 11.6/7 the volume of municipal waste per inhabitant has fallen since 2000, but the Netherlands still generated a relatively large amount of waste in 2014 compared to other EU countries. Emissions of particulate matter (PM10) in cities has fallen from approximately 30 micrograms per cubic metre in 2000 to just over 21 in 2013, and compared to other EU countries, things seem to be going well. This is a national figure, though; emissions at certain locations in the Netherlands are still high. Lastly, the proportion of victims of crime in the Netherlands has fallen somewhat (from 19.8 % in 2012 to 17.6 % in 2015). In 2014, the Netherlands ranked somewhere in the middle in Europe.
12	Responsible consumption and	12.1 Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries 12.2 By 2030, achieve the sustainable management and efficient use of natural resources 12.3 By 2030, halve per capita global food waste at the retail and	12.1/2 the proportion of organic agriculture is rising slowly, but the Netherlands is still ranked low within the EU. SDG 8 already shows that the Dutch material footprint has increased. However, per capita domestic consumption of resources has fallen, and seen internationally, the Netherlands consumes relatively few resources.

		consumer levels and reduce food losses along production and supply chains, including post-harvest losses 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle 12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities 12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.3/4/5 food-related waste (animal waste, mixed food waste and vegetable waste) has decreased somewhat since 2004, but compared to other EU countries, the Netherlands still generates a rather large amount per capita. On balance, the volume of hazardous waste per capita rose between 2004 and 2012, with the strongest rise between 2004 and 2006. Compared to other EU countries, in 2012 the Netherlands produced a lot of hazardous waste. Useful re-use (recycling and back-filling) as a percentage of total hazardous waste after treatment has risen somewhat, seen over the long term. The strong rise between 2004 and 2006 was in part nullified between 2006 and 2012. The Netherlands had an average EU ranking in 2012 for useful use of hazardous waste, and ranked in the middle range for recycling of municipal waste in 2014, although this is improving. 12.6 based on the number of the top 100 companies in the Netherlands that published a corporate social responsibility annual report, knowledge and awareness of Dutch companies is increasing: 26 of the top 100 in 2002 to 80 in 2015). The Dutch position is average in the EU. 12.8 sustainable production and consumption also starts with the knowledge and skills of young people. The PISA score for scientific skills of Dutch young people was quite high in 2012 compared to that of young people in other EU countries. However, the Dutch PISA score has remained stable since 2006 and the position of Dutch young people has fallen since then
13	Climate action	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries 13.2 Integrate climate change measures into national policies, strategies and planning 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.2 the climate conference in Paris in December 2015 led to an agreement, which although not legally binding, has resulted in more political commitment. The urgency to rapidly reduce global emissions of greenhouse gases is increasing. Dutch emissions of greenhouse gases have fallen steadily from 14.2 tons of CO_2 equivalent per capita in 2000 to 11.5 in 2014. However, CO_2 emissions per capita are still rising (from 6.8 tons of CO_2 per capita in 2000 to 7.4 in 2013). Seen internationally, the Netherlands had relatively high greenhouse gas emissions per capita (in 2014) and CO_2 emission per capita (2013). The greenhouse gas intensity of the economy has fallen slowly from 0.41 kg CO_2 equivalent per euro GDP in 2000 to 0.30 in 2014. Compared to other EU countries, the Netherlands ranked somewhere in the middle in 2014.

4.3.2 EU

As discussed in chapter 4.2.2 the sustainability policies of the EU cover two main topics: climate action and the maintaining of the environment.

Climate action goals

The EU has set itself targets for reducing its greenhouse gas emissions progressively up to 2050 (European Commission, 2017). The EU targets are visualised in Table 7, and can be divided in: cutting GHG emissions, increasing the share of renewable energy and improving the energy efficiency. The targets have been set for both the short and the long term, in order to create suitable and feasible sustainability policies.

Table 7. Goals EU (European Commission, 2017)

EU targets	2020	2030	2050
Cut in GHG emissions (from 1990 levels)	20%	40%	80-95%
Share of renewable energy	20%	27%	
Improvement in energy efficiency	20%	27%	

In the past, the sustainability goals of the EU have been claimed to be very ambitious and not feasible. In 2017 the EU and its member states have made a significant development in terms of sustainability. GHG emissions reduced by 18% between 1990-2012, renewable energy share reached 14.1% in 2012 up from 8.5% in 2005 and energy efficiency expected to improve 18-19% by 2020 (European union, 2017).

The EU has implemented the: EU emissions trading system (ETS), which is the key tool for cutting greenhouse gas emissions from large-scale facilities in the power and industry sectors. The ETS covers around 45% of the EU`s GHG emissions. The EU ETS works on the 'cap and trade principle', a cap is set on the total amount of certain GHGs that can be emitted by installations covered by the system. The cap is reduced over time so that the total emission falls. Within the cap companies receive or buy emission allowances which they can trade with another as needed (European commission, 2017). In addition to the ETS, the EU introduced national emission reduction targets for the sectors not included in the ETS, which account for the other 55% of the total EU emissions. EU countries have taken on binding annual targets until 2020 for cutting emissions in these sectors (compared to 2005). For example, the Netherlands national GHG reduction target for 2020 is 16% compared to 2005. In 2012, the national reduction in GHG emissions compared to 1990 was almost 10% (European commission, 2017).

Secondly, EU member countries have also taken on binding national targets for raising the share of renewables in their energy consumption, under the renewable energy directive. The national share of renewable energy must be 20% by 2020 and a 10% share of renewables in the transport sector must be realised. In the Netherlands, the overall renewable energy use grew from 4.3% in 2009 to 5.5% by 2014. However, this increase in renewable energy is so small that the Netherlands is regarded as amongst the most likely countries to miss the 2020 national renewable energy targets. The Netherlands has set itself a less ambitious target of 14% of their total energy consumption from renewable sources (European Commission, 2017).

Thirdly, the EU aims for energy efficiency of their member states, measures for increasing energy efficiency are set out in the energy efficiency directive. The EU has set itself a 20% energy savings target by 2020 (when compared to the projected use of energy in in 2020). The EU has adopted a number of measures to improve energy efficiency in Europe. They include: an annual reduction of 1.5% in national energy sales, EU countries making energy efficient renovations to at least 3% of the buildings owned by central governments per year, mandatory energy efficiency certificates accompanying the sale and rental of buildings, minimum energy efficiency standards and labelling of products and companies conducting energy audits. So far this policy seems to work because new buildings consume half the energy they did in the 1980s (European Commission, 2017). The EU has made considerable progress over the last years concerning energy efficiency. In 2014, its primary energy consumption was only 1.6% above its 2020 primary energy consumption target. Final energy consumption was even 2.2% below the 2020 target. The Netherlands performs well in terms of energy efficiency, because it reached the largest decrease (8%) in national final energy consumption in 2014 (European Commission, 2017).

Policies

In addition to the focus on climate change, the EU also focuses on the preservation of the environment. In order to preserve the environment, the EU implemented a couple of policies such as clean air, circular economy, environmental assessment, environmental implementation review,

green public procurement, resource efficiency, raw material and many other policies (European Commission, 2017).

The clean air policy aims to reach air quality levels that do not cause significant impacts on human health and the environment. Most areas in Europe already comply with the EU norm regarded PM_{10} and NO_2 emissions, reducing the problem to a few localized but densely populated areas (6% of zones for PM_{10} and 8% for NO_2). The goals of this policy is to reduce the impacts in 2020 by 36% for PM2,5, 23% for ozone, 17% for eutrophication and 61% for acidification, compared with 2005. The goal for 2025-30 will reduce impacts by 50% for PM2,5, 33% for ozone, 35% for eutrophication and 85% for acidification (relative to 2005) (European commission, 2017).

The EU commissioned a circular economy package, which aims to support the transition towards a more circular economy in the EU. This package included legislative proposals on waste, with long term targets to reduce landfilling and increase recycling and reuse. In order to close the loop of product lifecycles, it also includes an action plan to support the circular economy in each step of the value chain – from production to consumption, repair and manufacturing, waste management and secondary raw materials that are fed back into the economy. The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy**.** This package sets clear targets for the reduction of waste and establishes an ambitious and credible long-term path for waste management and recycling. This package includes: a common EU target for recycling 65% of municipal waste by 2030, a common EU target for recycling 75% of packaging waste by 2030, reducing landfill to a maximum of 10 % of municipal waste by 2030, and a ban on landfilling of separately collected waste. Based on volume, construction and demolition waste is the largest waste stream in the EU. The Waste Framework Directive 2008/98/EC establishes a target of 70 % of construction and demolition waste to be recovered by 2020. However the potential for reuse and recycling of this waste stream is not being fully exploited. One obstacle is the lack of confidence in the quality of construction and demolition recycled materials (European commission, 2017).

The EU has implemented a mandatory environmental assessment procedure. Environmental assessment is a procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made. Environmental assessment can be undertaken for individual projects, such as a dam, motorway, airport or factory, on the basis of Directive 2011/92/EU (known as 'Environmental Impact Assessment' – EIA Directive) or for public plans or programmes on the basis of Directive 2001/42/EC (known as 'Strategic Environmental Assessment' – SEA Directive). The common principle of both Directives is to ensure that plans, programmes and projects likely to have significant effects on the environment are made subject to an environmental assessment, prior to their approval or authorisation (European Commission, 2017).

In order to monitor the progress regarding environmental policies, the EU has developed the Environmental Implementation Review (EIR). The EIR is a tool to help deliver the benefits of EU environmental law and policies for businesses and citizens through better implementation. It aims to address the causes of implementation gaps and find solutions before problems become urgent and reach the stage of infringements. The European Commission published the first ever comprehensive overview of how EU environmental policies and laws are applied on the ground. The EIR package includes 28 country reports which map national strengths, opportunities and weaknesses; a Communication identifying common challenges across countries, and suggested actions for improvement for all EU Member States (European commssion, 2017).

In order to increase sustainability in Europe, the EU has implemented a Green Public Procurement (GPP) policy. Europe's public authorities are major consumers. By using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production. GPP can help stimulate a critical mass of demand for more sustainable goods and services which otherwise would be difficult to get onto

the market. GPP is therefore a strong stimulus for eco-innovation. To be effective, GPP requires the inclusion of clear and verifiable environmental criteria for products and services in the public procurement process. The European Commission and a number of European countries have developed guidance in this area, in the form of national GPP criteria (European Commission, 2017).

4.3.3 DUTCH GOVERNMENT

The Dutch central government is responsible for the implementation of EU legislation and international treaties in national regulations. The Dutch government aims to contribute to reducing the environmental impact, and has set itself mandatory targets to reduce the impact on the environment in 2020. These targets are a little less ambitious than the targets set by the EU. However, this can be mainly directed to the fact that the Netherlands produces energy for other European countries. The sustainability targets of the Netherlands for 2020 are visualised in Table 8.

Table 8. Dutch climate action targets and progress EU 2020 (Government of the Netherlands, 2017)

EU target 2020	Dutch national Target	Achieved in 2012
Cut CO_2 emissions by 20%	**16,1%**	**15.2%**
20% renewable energy	**14%**	**4,5%**
20% energy savings on average per year(since 2005)	**1,5%**	**1,1%**

The Netherlands are performing quite well in terms of reducing the impact on the environment. The Netherlands has been quite successful in reducing the emissions of CO_2. Already in 2012 the Netherlands has nearly reached its target for reducing CO_2 emissions. According to news reports, the Netherlands are on target to cut CO_2 emissions by 23% in 2020, compared to 1990 (Zuidervaart, 2016). The Netherlands are also performing very well in terms of energy efficiency. The Netherlands are performing especially well in the building sector and is falling behind in the transport sector. However, according to a new report of the EU on energy efficiency, the Netherlands are likely to reach its goal because, recent years energy savings up to 8% per year have been made, and the average between 2005 and 2014 was 1.9% per year (European Commission, 2017). The Netherlands are falling behind in producing renewable energy, in comparison to other European countries. The goal to reach 14% is not likely to be met in 2020 by the Netherlands. The major energy consuming sectors in the Netherlands are: heating and cooling, electricity and transport. In 2014 these sectors used respectively 5.2%, 10%, 5.7% renewable sources, with a total average of 5.5%. In order to reach the goals set by 2020, the Netherlands have to increase the share of renewable sources in all the sectors drastically (European Commission, 2017).

In order to reach these sustainability goals the Netherlands has implemented a lot of sustainability policies in the past, and is still focusing on new policies to reduce the impact on the environment. In Table 9 the most important policies of the recent and coming years have been visualised.

The policies of the Dutch government on sustainability can be roughly summarised in reducing the energy use and using renewable energy sources, and reusing material and minimising waste, in order to reduce carbon emissions and limit the impact on the environment.

In 1992 the Dutch government introduced the first national building decree with performance requirements for buildings. The most important themes in this building decree are: safety, health, usability and energy efficiency. The main requirements for energy efficiency were related with the insulation of buildings.

Table 9. Important past policies (Ministerie VROM, 2010)

Year	Policy
1989	First national environment plan
1992	Building decree
1995	Energy performance standard: new buildings

2001	National environment plan 4
2008	Energy label: existing buildings
2009	National waste management plan
2010	Green procurement governments
2012	New building decree existing buildings
2012	New norm energy performance buildings(residential and utility)
2013	Energy agreement
2013	Mandatory energy performance calculation for buildings and GWW
2017	National agreement on the circular economy
2017	Concrete agreement
2019	Environment and planning act
2021	New nearly energy neutral building (NENB) requirements

In 1995 the building decree was partly revised, and a new energy performance standard for new buildings was introduced. The energy performance of new buildings was compared to a reference value to determine the energy performance of new buildings. Requirements for the energy performance of new buildings were sharpened in the following years (1998, 2000, 2006, 2011, and 2015) and the goal for 2021 is to create nearly energy neutral new buildings.

In 2008 a mandatory energy label was introduced for existing buildings. This label is mandatory when a building is delivered, sold and rented. This energy label visualises the energy efficiency of the building, and aims to increase the environmental awareness of the building sector.

In 2017 the Dutch national government has reached an agreement on the transition of the Dutch economy to a circular economy. The Dutch government has set itself an ambition target to use 50% less primary resources in 2030. The Dutch government aims to reach this goals by: (1) raw materials in existing supply chains are utilised in an efficient and high-quality manner, (2) in cases in which new raw materials are needed, fossil-based, critical and non-sustainably produced raw materials are replaced by sustainably produced, renewable and generally available raw materials when possible, (3) new production methods and products will be designed for a circular economy , areas will be reorganised and new ways of consumption will be promoted in order to give an extra boost to the desired reduction, replacements and utilisation of raw material for strengthening of the economy (Rijskoverheid, 2017).

The Dutch government already implemented some sustainability policies with some success. Since the energy agreement in 2013 the Dutch central government committed itself to reach their sustainability goals in 2020, the government has made some progress in terms of sustainability. However, in order to reach all their goals, extra effort has to be made to reach the 2020 goals.

4.3.4 CLIENT

The number of potential clients for BAM is extremely high because BAM is involved in the infra, utility and the housing sector. Because it is not possible to conduct research on all these clients, the focus of this research will be on the two major governmental clients Rijkswaterstaat and Prorail.

Rijkswaterstaat

Rijkswaterstaat aims to contribute to the sustainability goals of the Dutch national government. Therefore, Rijkswaterstaat has identified its impact on the environment, and has set specific sustainability goals to reduce their impact. The specific goals of Rijkswaterstaat are visualized in Table 10.

Table 10. Goals Rijkswaterstaat (Rijkswaterstaat, 2015)

Theme	Goal
Energy	In 2020 Rijkswaterstaat their infrastructure uses 20% less energy than in 2009
CO_2 emission	In 2020 Rijkswaterstaat will emit 20% less CO_2 than in 2009
Sustainable mobility	Reducing the worst traffic jams with 20%, and reduce the travel time with 10% during these traffic jams.

CO_2 emission traffic	Reduce the CO_2 emissions of road traffic with 40% compared to 1990
Circular economy	In 2030 Rijkswaterstaat aims to perform 20% better in the reuse and recycling of materials compared to 2009

Because Rijkswaterstaat is responsible for the execution of policies and plan of the ministry of Infrastructure and the Environment, Rijkswaterstaat is forced to procure its projects green, which means that tenders have a compulsory sustainability aspect. Rijkswaterstaat provides opportunities for contractors to provide innovative solutions, by setting functional requirements to not limit the design freedom of its contractors. Additionally, Rijkswaterstaat focuses on Life Cycle Costing (LCC) and the Total Cost of Ownership (TCO) in order to ensure the most cost efficient and sustainable product. Depending on the specific project characteristics contractors can differentiate themselves on sustainability themes such as: CO_2 emissions, energy use, material use, water management, urban development, health, air quality, sound, safety and biodiversity.

Contractors of Rijkswaterstaat can differentiate themselves in two ways from their competitors: the CO_2 performance ladder and by delivering the lowest Environmental Cost Indicator (ECI) value (in Dutch: Milieu Kosten Indicator).

The CO_2 performance ladder is a certification system, which shows that a contractor is committed to implement measures which will result in reducing CO_2 emissions. The CO_2 performance ladder is a tool for companies to identify and reduce their emissions. The main goal of the CO_2 performance ladder is to stimulate companies to be aware of the CO_2 emissions of themselves and their supply chain and where possible, to reduce these emissions.

The ECI can be calculated using the DuboCalc tool. DuboCalc can be used to determine and compare the degree of sustainability of specific designs, and expresses this in Environmental Costs (€). DuboCalc calculates all effects of material and energy use from C2C, so from all the different phases of a material`s life-cycle. Competitors can differentiate themselves from their competitors by creating a design with the lowest ECI, and therefore the lowest impact on the environment.

Performing well in terms of the ECI and the CO_2 performance ladder can be rewarded with a fictional discount on the contract price. This fictional discount is based on the economically most advantageous bid (in Dutch: EMVI) principle.

Prorail

Prorail aims to make railway transportation even more sustainable. Prorail focuses on the following themes concerning sustainability: energy, materials, CO_2 emissions, sound, vibrations, spatial quality, nature and social sustainability. Prorail has set itself targets to become even more sustainable in 2030.

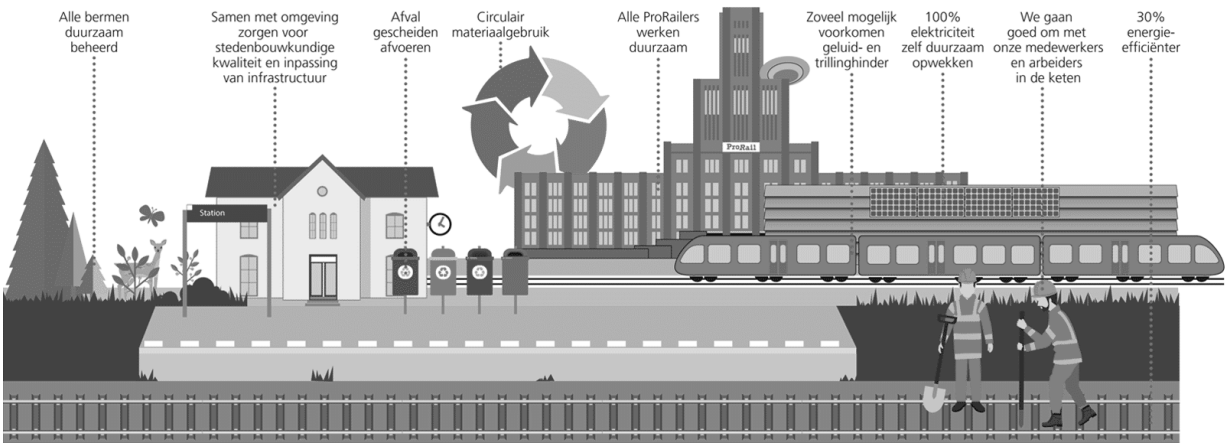

Figure 18. Sustainability goals Prorail (Prorail, 2017)

Prorail aims to approach the market by following the "aanpak duurzaam GWW" approach, which prescribes tools such as Dubocalc, CO_2 Performance ladder and the railstationscan. In addition Prorail aims to prescribe minimum criteria for materials and products in their specification. By describing these requirements as fictional as possible it is presumed that there will be a possibility for innovation. Over time Prorail will sharpen these requirements to ensure its sustainable development. The goals of Prorail are visualised in Figure 18 and listed in Table 11.

Table 11. Goals Prorail (Prorail, 2017)

Theme	Goal
Energy efficiency	In 2030 Prorail is 30% more energy efficient compared to 2015
CO_2 emission	In 2030 Prorail is CO_2 neutral in terms of their own energy use.
Sustainable energy	In 2030 all of the energy needs to be provided by sustainable sources, and the entire energy use needs to be provided by Prorail their own assets
Circular economy	The share of waste in 2030 which cannot be reused or recycled is maximum 5%, and 10% of materials needs to be reused

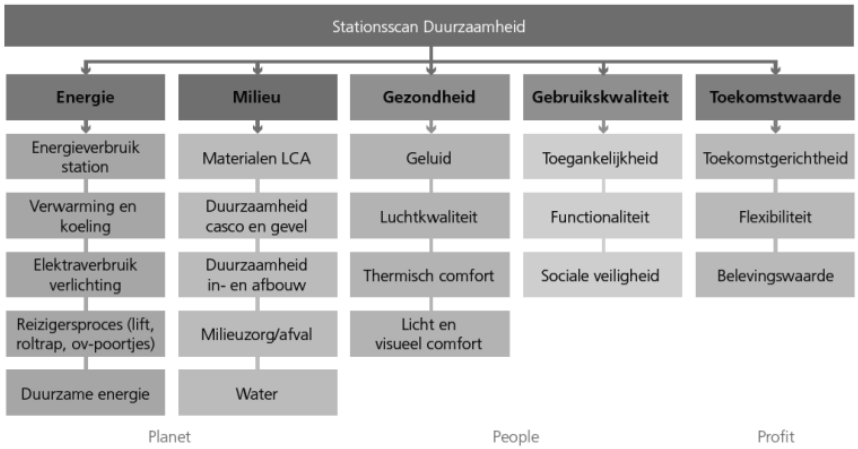

Figure 19. Rail stations scan sustainability (Prorail, 2016)

A large part of the environmental impact of Prorail is originating from their rail stations. In order to ensure that the future rail stations will become more sustainable Prorail developed a rail station scan, this scan is visualised in Figure.

4.3.5 BAM

BAM has aimed to increase its sustainability performance and has been quite successful. BAM is according to the Climate Disclosure Project (CDP) one of the global sustainability leaders in 2017. In order to stay a global sustainability leader and harvest first mover advantages from its position it has to set, and keep track of its sustainability goals. The main sustainability goals of BAM have been listed in Table 12.

Table 12. BAM goals and performance (BAM, 2016)

Theme	Goal	Performance(2016)
CO_2 emission	In 2020 BAM achieves 25% relative emission reduction in scope 1,2 and 3	BAM reduced CO_2 emissions by 12% compared to 2015
Global sustainability leader	To be included in the CDP climate A list leadership index by achieving performance band A	In 2016 BAM was included in the CDP climate A list, and achieved a performance score of A
Sustainable innovation	Deliver at least one product or service contributing to wider emissions reduction (zero carbon product)	

Construction waste	To aspire zero construction waste in 2025	BAM reduced construction and office waste with 8% compared to 2015
Circular economy	Deliver at least one BAM circular project, product or service in each operating company by 2020	
Sustainable material	Source 100% sustainable timber by 2020	BAM verified 98% sustainable certified timber

4.3.6 BOUWEND NEDERLAND

Bouwend Nederland is the trade association of the Dutch building sector and aims to lead the building sector to sustainable development. This sustainable development is focused on four main topics as visualised in Table 13: Nearly Energy Neutral Buildings (NENB) for new residential and small office buildings, energy neutrality, improvement in energy efficiency of residential dwellings and full implementation of GPP in the building sector.

Table 13. Bouwend Nederland goals (Bouwend nederland, 2017)

Theme	Goal
Energy use new buildings	In 2020 all new residential and utility buildings are energy neutral
Energy use existing buildings	In 2050 all existing residential and utility buildings are energy neutral
Energy use social housing	In 2021 all social housing has an average energy performance of B on the energy label
Green procurement	In 2020 all infrastructural tenders include sustainability criteria

4.4 Preliminary conclusions

The research question which has been discussed in this section is:

What are the future sustainability requirements in the building sector?

The results of this research indicate that the future requirements for sustainability in the building sector will be affected predominantly by the most important stakeholders in the building sector. The most influential stakeholders in the building sector have been identified in collaboration with experts within BAM as: the governments, clients, own organisation and trade associations. The future requirements for sustainability will be pushed by governments which enforce laws and regulations, and with interventions such as subsidies, knowledge sharing, working programs and covenants. Next to the government pushing the building sector to become more sustainable, the market pulls the sector to become more sustainable by demanding a higher sustainability performance of their products. This pull is created by the increase of environmental awareness and growing interest in CSR. Clients are demanding higher sustainability performance and a reduced impact on the environment. BAM its own organisation operates in the middle of these pushing and pulling forces, and creates opportunities for BAM to exceed the minimal requirements set by governments and provide in the sustainability requirements and ambitions of its clients. Trade associations and collaboration platforms provide opportunities, tools and collective goals for the building sector to become more sustainable.

The governmental push for implementing sustainability within the building sector originates from global, intercontinental and international treaties where member states commit itself to certain sustainability goals. The transformation of the Dutch building sector to become more sustainable is mostly concerned with the reduction of CO_2 emissions, use of renewable energy sources and the efficient use of energy. Most of these goals are somehow related with energy, which is logical because the building sector consumes roughly 42% of all energy (EC, 2011). The other major goal of governmental policies is concerned with the efficient (re)use of materials because the building sector roughly consumes 50% of all extracted materials (EC, 2011). The government is pushing

the building sector to contribute to a circular economy, where waste is minimised and materials are qualitatively reused. The governmental goals and policies which aim to improve the sustainability of the building sector affect the entire building cycle, and therefore an integral approach is needed to optimise the building sector its performance.

The demand for sustainability from actors has significantly increased over the last decade. This increase in sustainability demand is driven by environmental awareness and a growing interest in CSR. Many of today's organisations incorporated sustainability within their corporate vision, goals and strategies. Because the building sector has a significant influence on the environment (EC, 2011), the actors demand significant effort to reduce this negative impact and values organisations which put effort in sustainability. The introduction of GPP in the building sector was a major driver for sustainable construction because sustainability became a mandatory topic during tenders. This development pulled the building sector to incorporate sustainability within their organisation because it was demanded by its clients. Because sustainability is nowadays embedded within tenders, contractors are able to distinguish themselves in terms of sustainability and receive a fictional discount on the bid price. This development is advantageous for both clients and contractors because clients receive more sustainable products, and contractors are able to distinguish themselves in terms of sustainability and not merely on price.

In addition trade associations and collaboration platforms provide the building sector with useful tools and methods to implement sustainability as an important theme during a project, and to optimise the sustainability impact. One of the most important methods to maximise the sustainability of a project is to involve contractors early in a project. This way the expertise of contractors can be used to identify the most important sustainability themes, which provide opportunities for contractors to create sustainability measures which maximise the project its sustainability impact.

BAM is moving from providing the minimal requirements set by environmental regulations, to providing sustainable solutions which meet their client's requirements and ambitions. Therefore, BAM is focusing on its own organisation and is searching for possibilities to improve its current sustainability performance and to create new sustainable products. BAM has successfully identified the governmental and client requirements and focuses its sustainability strategy on climate and resource positivity, which are the most important sustainability issues in the building sector.

The development of sustainability requirements in the buildings sector is mostly influenced by four major actors: governments, clients, contractors and trade associations. The development of sustainability requirements is summarised in Table 14, and describes the most important barriers, drivers and enablers for the development of sustainability requirements

Table 14. Development of future sustainability requirements

		Governments	Client	BAM	Trade Association
Future sustainability requirements	Enablers	Governments mainly focus on CO_2 reduction, renewable energy generation and energy efficiency.	Increasing environmental awareness, growing interest in CSR and wide-scale implementation of corporate sustainability strategies.	Focus on resource & climate positivity and enhancing lives.	The availability of collaboration platforms, tools and methods for the implementation of sustainability within projects.
	Drivers	Introduction of GPP.	Increase in corporate sustainability branding.	Strong commitment to exceed sustainability performance of competitors.	Increasing commitment of building sector to commit to sustainability goals.
	Barriers	Large variety of governmental bodies.	Significant difference between commercial and governmental clients.	Uncertainty about the development of sustainability requirements.	Sustainability policies and goal are not compulsory.

The most important future sustainability requirements for the building sector can be divided in material requirements and energy requirements. These two categories of requirements combined will result in the most significant influence on the reduction of CO_2 emissions. Sustainability requirements can be divided in three steps and can be focused on both incoming and outgoing flows of materials and energy (Duijvenstein, 1993). Three steps for requirements concerning the incoming flows are:

1. Requirements which prevent unnecessary use
2. Requirements to use endless sources
3. Requirements to use sources which are not endless, as efficient as possible

Three steps for requirements concerning the outgoing flows are:

1. Requirements to prevent waste
2. Requirements to reuse waste
3. Requirements to dispose waste wisely

Combining all these requirements for both energy and material use to an optimum equilibrium will be the major challenge for contractors in order to become truly sustainable. During the last decade contractors are provided more often with a possibility to optimise the energy and material flows within project because, clients use more integrated contracts. Integrated contracts differ from traditional contracts where design, construction, maintenance and demolition activities are procured separately. The use of integrated contracts requires contractors to not merely focus on sustainability issues in only one building phase, but requires contractors to focus on sustainability during the entire life cycle of a product. The use of integrated contracts can be seen as a major driver for circular economy initiatives, waste reduction and sustainability.

The future requirements for sustainability are uncertain and difficult to predict. However, the most influential stakeholders in the building sector all identify energy and material related goals. It is presumed that the current sustainability goals of the stakeholders will evolve in future sustainability requirements and therefore the most important sustainability requirements in the future will involve material, energy and indirectly CO_2 emissions aspects.

5 PROJECT SUSTAINABILITY PERFORMANCE

This section aims to answer the following research question:

What is the current sustainability performance of BAM within its projects?

In this section the sustainability performance of BAM within its projects will be assessed. In order to determine the sustainability performance of BAM within its projects four case studies have been conducted. Two projects from the infrastructural business line, and two projects from the utility business line of BAM have been assessed. What are the requirements of clients, how is the sustainability performance of an offer assessed, and how was BAM able to positively distinguish itself in terms of sustainability, are questions which will be answered in this section.

5.1 Determining sustainability performance

In order to identify and quantify the impact of the building sector on the environment it is essential to assess a building`s performance. Building performance is now a major concern of professionals in the building industry (Crawley & Aho, 1999), and sustainability assessment has emerged as one of the major issues in sustainable building (Cole, 2005). Sustainability assessments, which reflect on the sustainability performance of buildings, are increasingly recognised as a useful tool for policy making and public communication in conveying information on countries and corporate performance in fields such as environment, economy, society, or technological improvement (Singh, Murty, Gupta, & Dikshit, 2009).

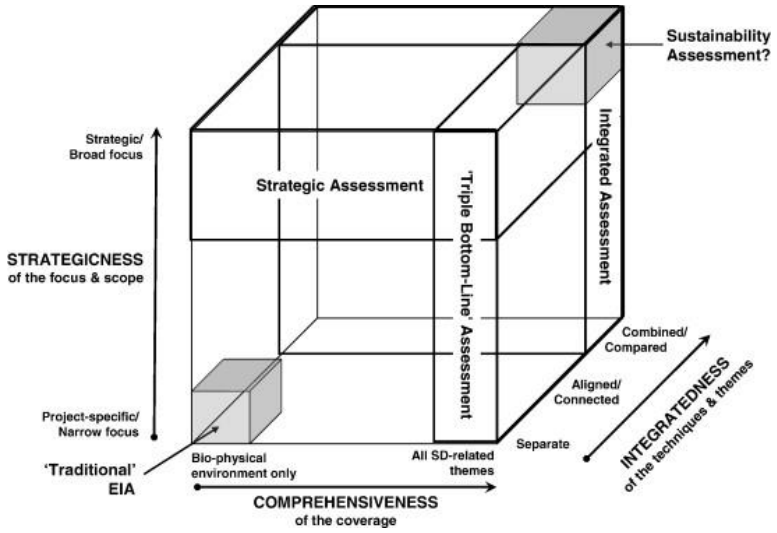

Figure 20. Spectrum of SD-directed features in the assessment process (Hacking & Guthrie, 2008)

Sustainability performance can be considered as relatively subjective, and varies from the perspective of the parties involved. For example, a building owner may wish his building to perform well from a financial point-of-view, whereas the occupants may be more concerned about indoor air quality, comfort, health and safety issues (Cole, 2005). Using a single method to assess a building`s sustainability performance and to satisfy all needs of users is no easy task. Therefore, an ideal sustainability assessment will include all the requirements of the different parties involved in the development.

Many methods, models, measures and sets of indices have been developed to assess the sustainability performance (Singh, Murty, Gupta, & Dikshit, 2009). Performance can be defined as the accomplishment of a given task measured against preset known standards of accuracy, completeness, cost, and speed. The term sustainability assessment is often described as a process by which the implications of an initiative on sustainability(both positive and negatively) are evaluated, where the initiative can be a proposed or existing policy, plan, programme, project, process, product or organisation (Pope, Annandale, & Morrison-Saunders, 2004).

There exist many different types of sustainability performance assessments and these assessments can be categorised based on three dimensions as visualised in Figure 20, namely: strategicness of focus and scope, comprehensiveness of the coverage and the integratedness of the techniques and schemes (Hacking & Guthrie, 2008).

The level of strategicness depends on the focus and scope of a performance assessment. An "impact assessment"' is generally applied to more specific projects and "strategic assessments" for general plans policies and programmes. When an assessment becomes even more strategically focused or scoped to the level of building products, components and construction materials over its lifetime, it is called a Life-Cycle Assessment (LCA) (Crawley & Aho, 1999).

As discussed in Section 1.2, sustainability is divided in social, economic and environmental dimensions. Thus, sustainability performance can also be divided in social, economic and environmental performance. The amount of sustainability themes taken into account in an assessment largely determines its comprehensiveness. The concept of sustainability covers a lot of different topics. The amount of topics integrated in an assessment determines the integratedness. When more techniques and themes are integrated in one assessment, it can be classified as an integrated assessment. So, in order to determine the sustainability performance, a sustainability assessment has to be conducted. In order to perform a correct sustainability assessment it has to be strategic comprehensive and integrated (Hacking & Guthrie, 2008).

The sustainability assessment methods shown above assess the performance on a single instance. In example, the focus on single construction technology, single building entity or singular processing efficiency (Ding, 2008). The aim of this research is to assess, in a simplified way, the sustainability performance of BAM its projects. However, BAM its sustainability performance involves the following complexities and diversities while assessing.

1. BAM is involved in two business lines: the infrastructural sector and the built sector. The complexity of comparing the performance of infrastructural projects with built projects is high. The processes, products, magnitude and sustainability effects will differ between projects which makes it difficult to assess the sustainability performance in a uniform way.
2. The organisational sustainability performance of BAM will largely depend on its processes and products during its projects. Because this research has to be conducted in a limited amount of time it is difficult to assess the entire sustainability performance of BAM as organisation.
3. The sustainability performance of BAM largely depends on the design and construction phase, because these phases are influenced by BAM its internal processes. During the construction and operational phase, relatively most materials and energy will be used which will affect the sustainability performance. The interdependencies between building phases makes it difficult to assess the sustainability performance of BAM.
4. This research focuses on how BAM can competitively distinguish itself from its competitors. The competitive aspect in the building sector is predominant during the tender phase. Unfortunately, assessing the sustainability performance of existing buildings is simpler than assessing the sustainability of offers during the tender phase which will result in a more complex assessment.
5. During BAM its projects, different methods have been used to determine the sustainability performance of an offer. The sustainability performance of BAM its offer is assessed by its clients. Because BAM its competitive sustainability performance depends on these assessment methods it is important to incorporate these different methods in the sustainability assessment.

Due to complexities and diversities, it is not possible to use one uniform existing sustainability assessment. All the discussed complexities and diversities result in the need for a specific assessment approach, which requires the development of a newly tailored "project sustainability assessment method".

5.2 Project Sustainability Assessment Method

Because sustainability assessment is very broad and the suitable type of assessment depends on many factors, it is important to tailor-made an assessment on a specific entity. This research focuses on assessing the sustainability performance of BAM its projects. Assessing the sustainability performance of such a large international organisation is difficult in a limited period of time. Therefore, this research has only included specific projects of BAM in the Netherlands. Projects are the combination of processes which will result in products produced by BAM. Therefore, projects can be a good small-scale visualisation of BAM its organisation. BAM its organisation can be divided in two smaller businesses namely: BAM Construction and property and BAM Infra. This research has included projects from both business lines in order to ensure a good understanding about BAM its entire organisation.

The "project sustainability assessment method" will consist of five successive phases, and is visualised in Figure 21. Five phases have been used because, the following five categories of data are minimal required to determine the sustainability performance of BAM within its projects. The reason that there are no more than five phases is because more phases makes the "project sustainability assessment method" more complex.

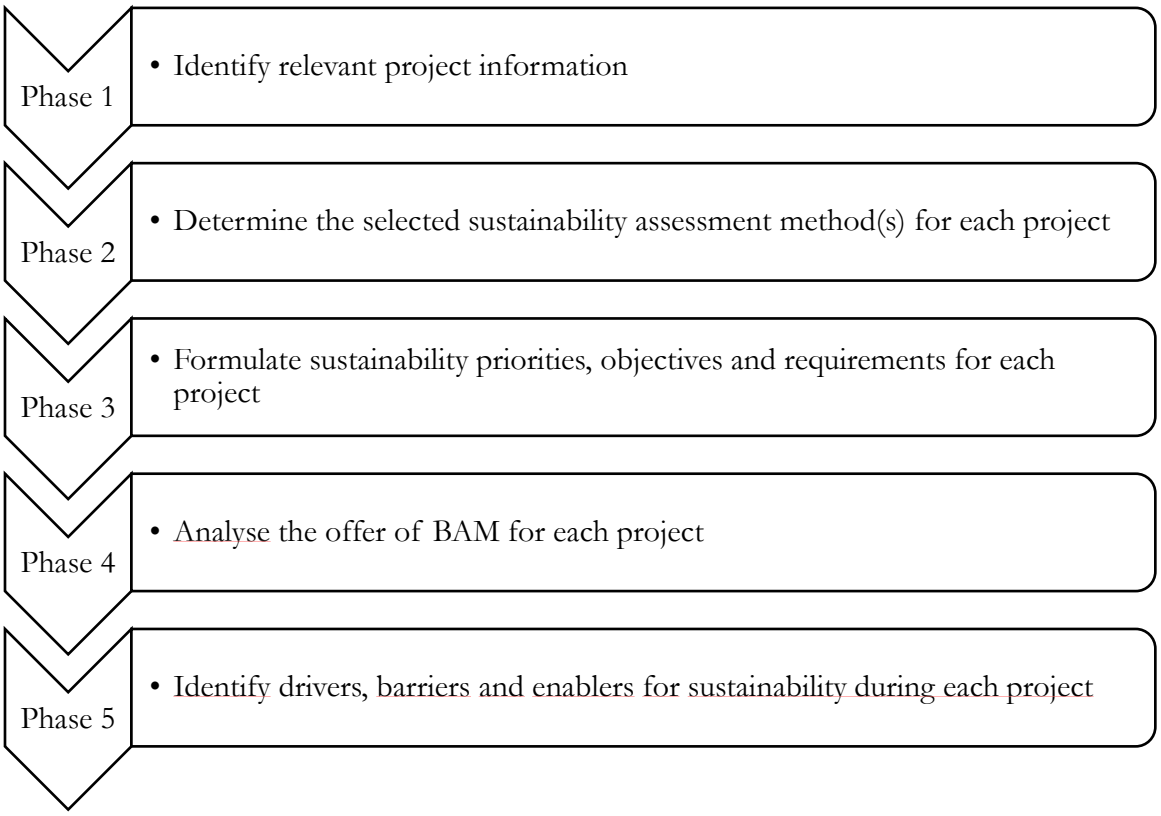

Figure 21. Project sustainability assessment method

5.2.1 PHASE 1: RELEVANT PROJECT INFORMATION

During the first phase of the "project sustainability assessment method", relevant information about a project which affect the sustainability performance will be described. The description of relevant project information includes: project location, investment cost, construction period, tender procedure, form of contract, investment cost and type of client(s). The relevant project information is summarised in Table 15.

Table 15. Relevant project information

Project information	Description

Project location	Project location can heavily influence the sustainability performance of a project and determines the possibilities for incorporating sustainability measures. The geographical distance from suppliers, user characteristics, local environmental plans (Dutch= Omgevingswet), soil composition, vegetation, natural shading and many other location specifications can influence the possibilities for implementing sustainable technique and measures (Entrop, 2013).
Investment cost	The investment cost can be an indicator for the size of a project. The investment cost of a project can also influence the possibilities for including sustainability in a project. Larger projects, with higher investment costs normally have more funds to incorporate sustainability measures. Implementing sustainability measures are often more expensive than non-sustainable measures. However, when a project is larger, the implementation of sustainable measures can become relatively less expensive because of scale-advantages which can make the implementation of sustainable measures more beneficial. For example, installing one photovoltaic panel will always be more expensive than installing 1000 of them because of installing costs, maintenance costs, collective storage etc.
Construction period	The construction period of a project can influence the implementation of sustainability measures because companies are often focused on short-term investments (Häkkinen & Belloni, 2011). Sustainability measures are often long term investments, with long pay-back period. The construction time of a project can therefore influence the decision to implement sustainability measures.
Tender procedure	The tender procedure largely determines how sustainability is incorporated during a tender. A tender is a procedure where contractors can enrol in order to acquire a certain product or service, which is granted, based upon the weighting of several factors such as price and quality (EC, 2002). The Dutch central government has implemented GPP in 2010 which forces governmental bodies to include sustainability within the public procurement process, and stimulates private companies to include sustainable requirements in their building projects. Sustainability is mostly not the only award criterion of a tender; and often other relevant topics such as safety, availability, risk management and price are incorporated. Therefore, sustainability is not the only criterion to win a tender, it may prove to be a good topic to distinguish yourself in a competition.
Form of contract	The form of contract largely determines when a contracting party is involved in a project. A project can be roughly divided in three phases: design phase, construction phase and a maintenance phase. The form of contract determines during which building phases a contractor is responsible. Traditionally a client was responsible for the design of a project after which the construction was tendered. After completion the project was delivered back to the client, which than became responsible for operating and maintaining the product of the project. This type of contract is called a DBB contract. In recent years, there has been a shift to more integrated contracts where design, maintenance, operating and sometimes even financing is tendered to a contractor. A good example of such a contract form is Design-Build-Finance-Maintenance-Operating (DBFMO). The type of contract can have a major influence on the sustainability of projects because when a contractor is responsible for maintaining a product, and is involved in the design of a project, it is more likely that a contractor involves sustainable techniques and measures to reduce maintenance and operating costs (van Waarden, 1996).
Type of client	The type of client is relevant project information because the clients has a significant influence on the decision to include sustainability measures in a project. Additionally, the reason to incorporate sustainability measures can differ between different types of clients. For example, governmental clients are more legislation driven, and commercial parties aim to improve its sustainable reputation. Therefore, the type of client can influence the sustainability performance of a project.

All these project related specifications can influence the sustainability performance of a project. Therefore, it is important to include these in the "project sustainability assessment method".

5.2.2 PHASE 2: SUSTAINABILITY ASSESSMENT METHOD

During the second phase, the selected sustainability assessment methods used by the clients, for assessing the sustainability performance of an offer during the tender phase of projects, will be identified and discussed.

In the infrastructural sector there exist three predominant methods to assess the sustainability performance of an offer during the tender phase, namely: using a sustainability plan, the CO_2 Performance Ladder and by using the Environmental Cost Indicator (ECI). In the built sector there are less predominant and uniform sustainability assessment methods. Moreover, in the built sector many projects are privately tendered and therefore sustainability is not necessary assessed during the tender phase. One of the most widely used assessment methods in the utility sector for new construction and renovation is the BREEAM-NL method.

Sustainability plan

One method to incorporate sustainability during tenders is requiring bidders to construct a sustainability plan. In a sustainability plan the contractor is required to provide a plan on how they plan to reduce the environmental impact of the project. Most often the client selects a couple of sustainability topics which they find the most important during a specific project, and requires the bidders to make a plan on how the bidders will ensure that they will deliver sustainable solutions for the selected themes. The sustainability plan is rated by the client who can provide a fictional discount to a bid.

CO_2 Performance ladder

The CO_2 performance ladder is a tool used by clients and contractors during tenders. The CO_2 performance ladder stimulates CO_2 reducing initiatives of companies by providing a fictional discount during tenders. The higher the effort of a company to reduce CO_2 emissions, the higher the fictional discount during tenders. The CO_2 performance ladder consists of five levels, and is divided in three scopes.

Table 16. CO_2 performance ladder certification scheme (SKAO, 2015)

Level	Description
1	The company has mapped its energy flow qualitative, and is aware of possibilities for energy saving and for using renewable energy. The company communicates its policies regarding possibilities for energy saving and the use of renewable energy both internal and external. Lastly, the company is aware of sector and supply chain initiatives regarding CO_2 reduction.
2	The company has mapped its energy flow quantitative, and set itself qualitative goals regarding energy saving and the use of renewable energy. The company communicates its policies and goals regarding possibilities for energy saving and the use of renewable energy both internal and external.
3	The company has inventoried its own CO_2 emissions (scope 1 and 2) according to the ISO standard. The company has set quantitative goals for its own CO_2 emissions (scope 1 and 2). The company communicates its CO_2 footprint and quantitative goals regarding possibilities for energy saving and the use of renewable energy both internal and external. Lastly, the company is actively involved in at least one sector or supply chain initiative related to CO_2 reduction
4	The company has roughly inventoried its supply chain emissions (scope 3), and has conducted supply chain analyses for at least two supply chains. The company has set quantitative goals for its supply chain emissions (scope 3). The company can prove it takes initiative in sector and supply chain related CO_2 reductions.
5	The company possesses CO_2 inventories of its most important suppliers. The company can prove that the formulated goals in the third and fourth level have been realised. The company is committed to participate in public CO_2 reduction programmes of the government and societal organisations, and the company can prove that it significantly contributes to these CO_2 reduction programmes

As stated in Table 16 the CO_2 performance ladder is divided in three scopes which are visualised in Figure 22 and discussed in Table 17.

Table 17. Three scopes CO_2 performance ladder (SKAO, 2015)

Scope	Description	Includes
1	Direct emissions of the organisation	Gas-use: offices and projects Fuel-use: person transport and projects
2	Indirect emissions of the organisation	Energy-use: offices and projects
3	Other indirect emissions outside the organisation	Material production, recycling and all other work, services and deliveries Personal transport (car and plane)

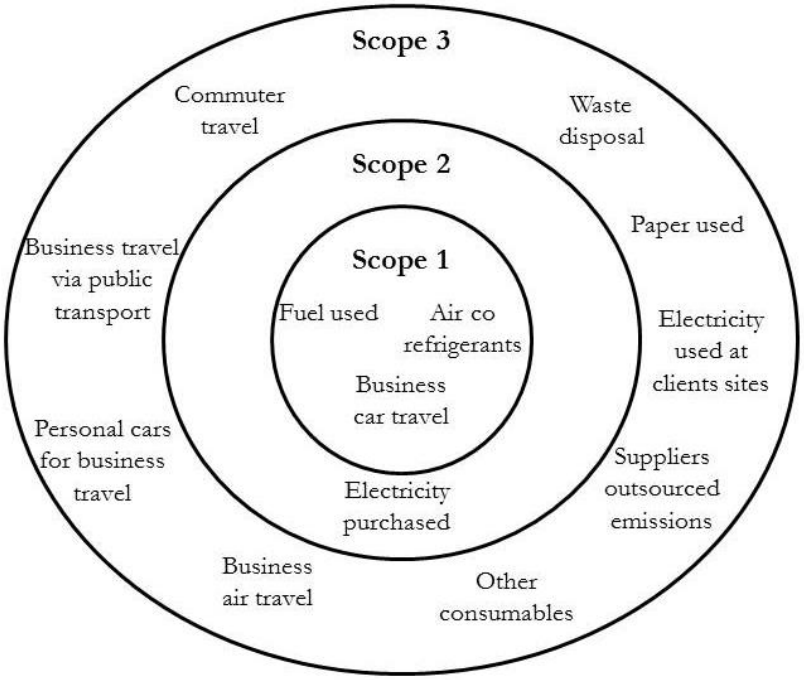

Figure 22. Three scopes of the CO_2 performance ladder (MVO, 2017)

Environmental cost indicator

The Environmental Cost Indicator (ECI) is used during tenders to quantitatively determine and compare the sustainability and environmental cost of different bids. The ECI can be used as an absolute requirement by the contractor or as an award criterion which can lead to a fictional discount on the tender price. To determine the ECI, a tool is used named DuBoCalc (Dutch=DuurzaamBouwenCalculator), which expresses the sustainability performance of a bid by calculating its environmental impact and translating the impact to cost in euros. DuBoCalc is based on the methodology of the Life Cycle Assessment (LCA), and calculates all material and energy use over a product its life-time. The aim of DuBoCalc is to achieve a significant reduction in environmental impact during design, tenders and construction of infrastructural projects. The great advantage of DuBoCalc is that the amount of required data is relatively low, because many data can be subtracted from an environmental database. The data which can be used to calculate a specific project its ECI include: type of material, quantity of material, transport distances of materials, quantity of dischargeable material, lifetime expectation of material and expected energy use during exploitation. This national environmental database holds many environmental values of materials and energy use during all life cycle phases: production and installation (A), use and maintenance (B) and demolition and waste-processing (C) (DuBoCalc, 2017).

BREEAM-NL

The BREEAM-NL assessment method for the construction and renovation of buildings. A BREEAM-NL assessment cover issues in categories of sustainability such as: management, health & well-being, energy, transportation, water, materials, waste, land use & ecology and pollution. Each category and theme has its own sustainability targets and requirements. The degree of sustainability measures taken to reduce the environmental impact will result in a specific score for each category.

5.2.3 PHASE 3: SUSTAINABILITY PRIORITIES, OBJECTIVES AND REQUIREMENTS

Each project has its own specifications which can lead to opportunities for including sustainability measures or techniques. For example, when a tunnel is being constructed, it is less efficient to

incorporate photovoltaic panels in a design than when a large office building is constructed with a relative high amount of roof surface. Next to the identification of project related specifications which may lead to sustainable opportunities, clients may have project related objectives and requirements. Some components of a project may have a higher sustainability priority, and therefore clients require bidders to focus on how they can influence the sustainability performance of these specific project related components.

A new tool to guide the incorporation of sustainability ambitions is the ambition-web (Duurzaam GWW, 2017). The ambition-web provides a visual representation of sustainability themes and links these to ambition levels. These levels represent to what degree certain sustainability themes are aimed to be incorporated in a project. The ambition-web has three levels and is visualised in Figure 23:

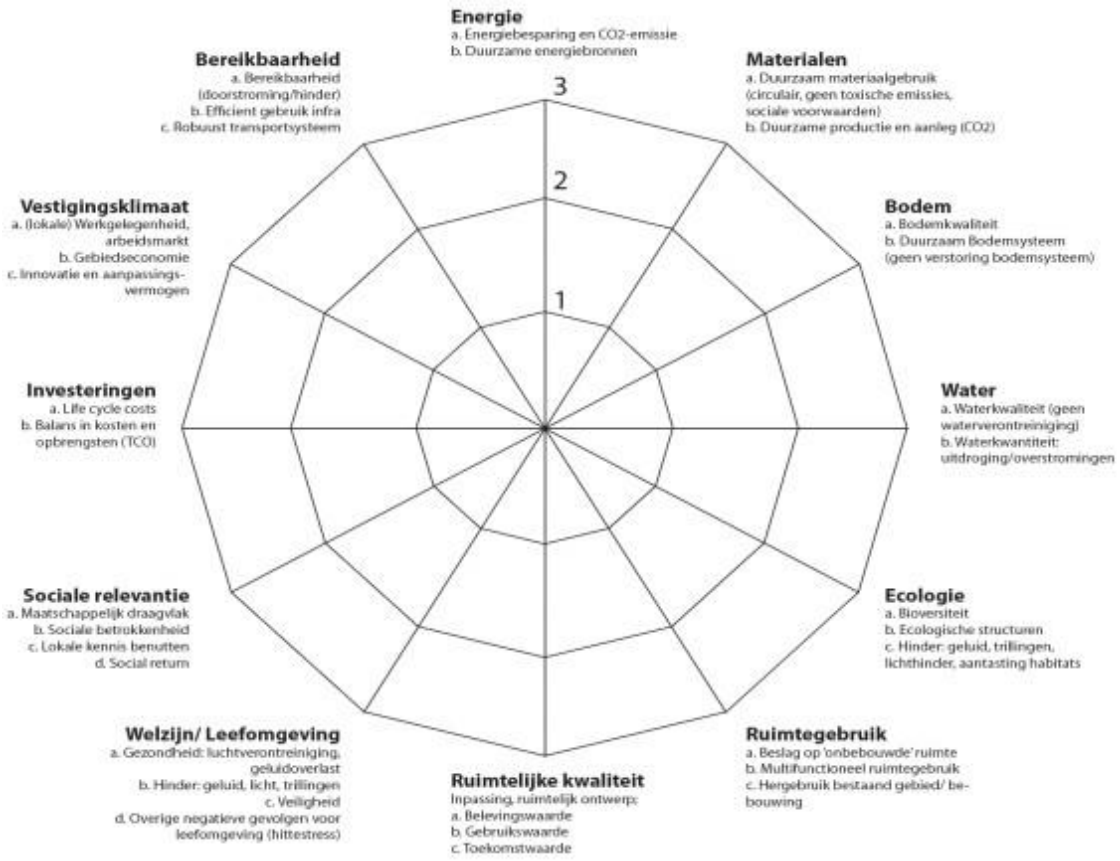

Figure 23. Ambition-web (Duurzaam GWW, 2017)

1. Level one means that the largest sustainability load on a specific theme has to be determined, and that this load may not exceed the minimum requirements.
2. The second level means that certain reduction goals will be set for a specific theme.
3. The third level means that a new added value is created: rather than "less bad" the negative impact on a certain theme has become zero or even a positive sustainable contribution is made on a certain theme.

The ambition levels provide a starting point for clients to set sustainability requirements for their projects. For each project an ambition-web will be constructed to visualise the opportunities, objectives and priorities. The ambition web can be considered as an useful tool because it is an uniform and structured method for the identification of sustainability priorities, goals and requirements. Moreover, the ambition-web can be considered as useful to compare the level of importance of different sustainability themes between projects; because it clearly visualises many

sustainability themes within one figure, and enables comparison. The sustainability themes are more extensively discussed in Appendix F: Ambition-web level explanation.

5.2.4 PHASE 4: OFFER OF BAM

After the client has set their list of objectives, priorities and requirements based on the specifications of the project and have determined the method(s) on how they can assess the offers of the bidders in terms of sustainability, it is time to focus on what BAM was able to provide. In Phase four the bid of BAM in terms of sustainability will be assessed. During this phase there will be focused on aspects of the bids which made it possible for BAM to distinguish itself from its competition. During this phase the data will be presented on how BAM was performing in terms of sustainability, and how BAM was scoring on the predetermined sustainability assessment method.

5.2.5 PHASE 5: PROJECT RELATED BARRIERS, DRIVERS AND ENABLERS

During the last phase, all factors which have influenced the possibilities for BAM to distinguish itself from its competitors will be discussed. Factors which enabled BAM to distinguish itself, driving factors which stimulated the sustainability performance of BAM and possible barriers which made it difficult for BAM to distinguish itself from the competition. In the previous phases we have seen how the sustainability performance of building projects is determined. In order to be able to learn from these past building projects it is essential to identify the most important factors which have influenced the sustainability performance of these building projects. Therefore, this phase will focus on identifying factors which have an impact on the sustainability performance of BAM its building projects. These factors influencing the sustainability performance of BAM their building projects can be categorized in different ways such as: push & pull factors, internal & external factors and barriers & drivers & enablers. In this phase the factors influencing the sustainability performance of BAM its building projects will be compared to factors influencing the sustainability performance in literature.

Many forces aim to move the building sector towards an improved sustainability performance. Actors either push or pull on the sector to improve its sustainability performance. Governments push the building sector by enforcing laws and regulations, and with interventions such as subsidies, knowledge sharing, working programs and covenants. In the first chapter a couple of these push factors have been discussed such as: Green Public Procurement (GPP), mandatory energy labelling for dwellings, maximum GHG emissions, mandatory environmental assessment procedure and many other policies to push the building sector to become more sustainable.

Next to the government pushing the building sector to become more sustainable, the market pulls the sector to become more sustainable by demanding a higher sustainability performance for their projects. This pull is created by clients who have set sustainability goals in order to improve their sustainability performance. Therefore, the client`s requirements can be considered as one of the major pull factors steering the building sector to a higher sustainability performance. Especially for a contracting party such as BAM, the sustainability requirements of their clients are heavily influencing the sustainability performance of BAM.

The factors influencing the sustainability performance of BAM can also be divided in internal and external factors as visualised in Figure 24. The internal business environment includes factors within the organisation that impact the approach and success of the operations. The external business environment consist of a variety of factors outside the company which it typically don`t have much control over.

When BAM is looking for possibilities to improve its sustainability performance it is important to focus on both internal and external factors influencing the sustainability performance of BAM. Internal factors can be influenced by BAM its operation and external factors need to be taken into account for successful operation. Factors influencing the internal business environment often

involve topics like: organisational culture, human resource, organisational structure, physical assets, profit & cash flows and management. Factors influencing the external business environment are often related with topics like: politics, economy, technology, actors, legal, competition, media, fashion and the environment (Leoisaac, 2017). Both group of factors will have an influence on the sustainability performance of BAM. However, the internal factors are controlled by BAM and therefore, can be steered in order to improve the sustainability performance. External factors also influence the sustainability performance, but these factors are more difficult to control. In order to improve the sustainability performance it is logical to focus on the controllable internal factors, while using the external factors to provide direction for future strategic planning.

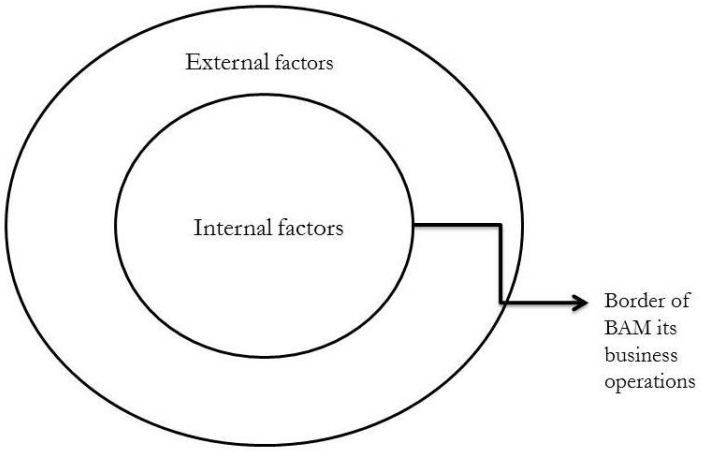

Figure 24. Internal and External factors

Lastly, the factors influencing the sustainability performance of BAM can be divided by their effect on the sustainability performance as visualized in Figure 25. Factors with a negative impact on the sustainability performance of BAM its projects can be considered as barriers. Factors which stimulate and improve the sustainability performance of BAM its projects can be considered as drivers. The last group of factors influencing the sustainability performance of BAM its projects can be considered as enablers and provide opportunity for improving the sustainability performance of BAM. The groups of factors can be approached individually by their effect on the sustainability performance of Bam its projects. However, it is possible that some factors show similarities and interdependencies between different groups. For example, one factor can be a major driver for sustainability for one actor, but can be regarded as a major barrier for another actor. In this research the barriers, driver and enablers will be discussed from the perspective of BAM within its projects.

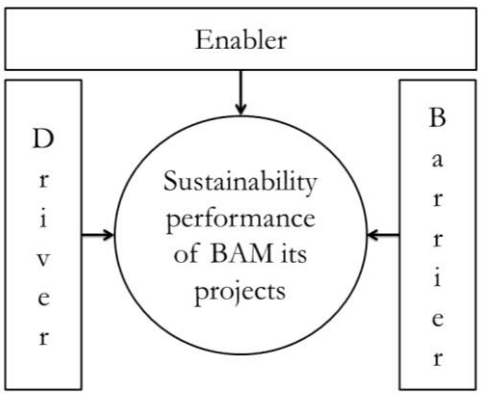

Figure 25. Barriers, drivers and enablers

5.3 Case study results

In this paragraph the selected cases will be introduced and assessed, by discussing the five phases of the "project sustainability assessment method". Moreover, in this paragraph the data from the projects will be presented. All data is collected from project related documents, or from interviews with experts of BAM. The extensive description and with-in analyses of the cases can be found in Appendix A-D.

The selected projects include two projects from the Infra business line, and two projects from the built business line of BAM. The two selected projects from the Infra business line include the transformation of the area around railway station Driebergen-Zeist, and the construction of a new underground motorway entrance for the city of The Hague named Rotterdamsebaan. The two selected projects from the Built business line include the construction of an office building of ABN AMRO named the Pavilion, and the office building of Royal Haskoning DHV in Amsterdam. The projects are listed in Table 18.

Table 18. Projects included in case study

# Case	Project	Sector
1	Driebergen-Zeist	Infra
2	Rotterdamsebaan	Infra
3	ABN AMRO pavilion	Utility
4	RHDHV	Utility

5.3.1 PHASE 1: RELEVANT PROJECT INFORMATION

In this paragraph the relevant project information will be presented. The relevant project information is summarised in Table 19.

Table 19. General project information cases

Project information	Case 1	Case 2	Case 3	Case 4
Project location	The Hague	Driebergen-Zeist	Amsterdam	Amsterdam
Investment cost	€250.000.000	€173.000.000	€10.000.000	€500.000(per year)
Construction period	72 months	48 months	16 months	10 months
Tender procedure	Public(EMVI)	Public(EMVI)	Private	Public(EMVI)
Form of contract	DBM	D&C	D&B	DBFMO
Type of client	Governmental	Governmental	Commercial	Commercial

The relevant project information is collected in order to test if any of the project specifications may have an impact on the sustainability performance of BAM. From this case study can be concluded that the investment costs and construction period of infrastructural projects are significantly higher than utility project. Moreover, infrastructural projects are more often public procured, and use a more traditional contract form. In the assessed projects the infrastructural projects were procured by governmental client, and the utility projects by commercial clients.

5.3.2 PHASE 2: SUSTAINABILITY ASSESSMENT METHOD

In this paragraph the selected sustainability assessment method will be presented. The selected sustainability assessment methods are visualised in Table 20.

Table 20. Selected sustainability assessment method

# Case	Award criteria	Sustainability Assessment method	Sustainability assessment topics
1	1. Price 2. Risk management 3. Nuisance reduction 4. Sustainability 5. Integral construction	Sustainability plan CO_2 performance ladder	Future value, Sound, Air quality, Material use, Energy use
2	1. Sustainability 2. Nuisance reduction	ECI CO_2 performance ladder	Ground work, Concrete work, Water closing layer, Steel work, Final hardening

3	(No public tender)	BREEAM-NL	Management, Health and well-being, Energy, Transportation, Water, Materials, Waste, Land-use, pollution
4	1. Housing concept 2. Process 3. Participation	Sustainability plan	Energy neutrality, Health and well-being, Resources and materials, Multi functionality

In the assessed project four types of sustainability assessment methods have been used to determine the sustainability performance of a bid or design. The sustainability plan, ECI and CO_2 performance ladder have been included during the tender phase to assess the sustainability performance of a bid. The BREEAM-NL method is an ex-post evaluation of the sustainability performance of a design. BREEAM-NL is not an assessment method which is used during a tender phase. Sustainability is included as one of many quality award criteria during a tender.

5.3.3 PHASE 3: SUSTAINABILITY PRIORITIES, OBJECTIVES AND REQUIREMENTS

In this paragraph the sustainability priorities, objectives and requirements will be presented. The sustainability priorities, objectives and requirements have been determined by using the ambition-web. The project ambition levels of twelve sustainability themes are summarised in Table 21. The explanation of ambition levels can be found in Appendix F.

Table 21. Ambition level of sustainability themes

Sustainability theme	Case 1	Case 2	Case 3	Case 4
	Ambition level	**Ambition level**	**Ambition level**	**Ambition level**
Energy	3	3	2	3
Materials	3	3	3	3
Water	2	2	1	1
Ground	3	3	1	1
Ecology	2	2	2	1
Space use	2	2	3	2
Spatial quality	2	3	3	2
Well-being	2	3	3	3
Social relevance	2	2	3	3
Investments	2	2	2	3
Business climate	2	2	3	3
Accessibility	3	3	2	2

The ambition level of sustainability themes differed in the assessed projects. Every project has other specifications which lead to different sustainability priorities, objectives and requirements. It can be concluded that energy and materials have been important sustainability topics in all the assessed projects. The ambition level does not necessarily has to correspond with the sustainability performance. The ambition level merely indicates the amount of effort invested in a single sustainability theme. This data can be used to determine which sustainability themes are most important in the assessed projects, and provide useful insights for possible future sustainability focus.

5.3.4 PHASE 4: OFFER OF BAM

In this paragraph the sustainability performance of BAM its offer will be presented. The sustainability performance is determined by the selected assessment method. The sustainability performance of BAM its offer is presented in Table 22.

Table 22. Sustainability performance of BAM its offer

# Case	Assessment method	Score of BAM
1	Sustainability plan CO_2 performance ladder	Level 4/5(Extreme good quality) Level 5 (Maximum discount)
2	ECI CO_2 performance ladder	>100% reduction(Maximum discount) Level 5 (Maximum discount)
3	BREEAM-NL	75.75%(4/5 star rating)
4	Sustainability plan	Level 4/5(Extreme good quality)

BAM its offers of the assessed projects have been assessed relatively good. BAM has achieved the highest score on the CO_2 performance ladder, which results in the highest possible fictional discount during tenders on CO_2 reduction. Moreover, BAM was also successful in developing sustainability plans, and was assessed with a score of 4/5. In the second assessed project BAM was able to achieve the maximum reduction target for the ECI calculations. However, all the other contractors did also achieve the highest level, so these calculations did not offer a possibility for BAM to distinguish itself in terms of sustainability. In project three, there was no sustainability assessment included during the tender. However, the sustainability performance of the third project was assessed using the BREEEM-NL method. BAM received a 76% score. The main reason that the score was not higher, was because the building was mainly aimed to be circular, and the BREEAM-NL method also focuses on other sustainability themes.

5.3.5 PHASE 5: PROJECT RELATED BARRIERS, DRIVER AND ENABLERS

In this paragraph the project related barriers, drivers and enablers which have been identified during the case study, will be presented. The project related barriers, driver and enablers influencing the sustainability performance are summarised in Table 23.

Table 23.Project related barriers, drivers and enablers influencing the sustainability performance

	Case 1	Case 2	Case 3	Case 4
Enablers	1. Urban location provide opportunity for nuisance reduction. 2. Use of competitive dialogue. 3. Long life time.	1. Multifunctional area provides opportunities for synergy advantages.	1. Synergy advantages by simultaneous constructing bike basement. 2. Early supplier involvement.	1. New innovative business case, from owning to using 2. Integrated contract
Drivers	1. Functional requirements set by client. 2. Ambitious client. 3. Prestige project.	1. The surrounding rural landscape stimulated the demand for sustainability. 2. GPP.	1. Ambitious client 2. Prestige project 3. Use of material passports.	1. Flexible project location 2. Functional requirements set by client. 3. Renovating existing building
Barriers	1. Little storage space due to urban location.	1. Lack of client`s ability to set ambitious sustainability requirements. 2. Lack of client`s ability to scope the sustainability themes to provide fair competition. 3. Use of traditional contract.	1. No sustainability based competition. 2. Only sustainability requirement of client was circularity.	1.Period of exploitation 2. Finding investment parties 3. Many responsibilities contractor

5.4 Cross-case analysis

In Section 5.3 the data from the case studies is presented and every case is extensively analysed and discussed in Appendix A-D. However, relationships, trends and differences between the cases have not yet been discussed. It is important to state that some major differences have been caused by the principle differences between the infrastructural and utility sector. The cross case analysis will be divided in 5 sections which correspond with the 5 phases of the "project sustainability assessment method".

5.4.1 PHASE 1: RELEVANT PROJECT INFORMATION

Within the assessed infrastructural projects the client was always a governmental agency, while in the assessed utility project the clients were commercial parties. The involvement of sustainable requirements in the infrastructural projects were therefore more regulation driven, where the commercial utility projects were more pulled by the client's ambition for positive branding and reputation development.

Moreover, the quality and quantity of sustainability requirements set by the client in the infrastructural sector and utility sector strongly differs. In the infrastructural sector sustainability requirements are uniform and quantified. In the utility sector the client is often less familiar with setting sustainability requirements in advance, because commercial parties often have limited in-house knowledge about sustainable construction. In the case study no governmental client has been selected for the utility sector because the number of governmental agencies in the utility sector is significantly lower than in the infrastructural sector. Additionally, governmental clients are not forced to procure their project "green" as in the infrastructural sector, and therefore sustainability based competition is rare. It can be concluded that the type of client has a significant influence on the quality and quantity of sustainable requirements, and that sustainability requirements setting is more mature in the infrastructural sector than in the utility sector.

It is observed that the relation between investment costs and the willingness to implement sustainability requirements was stronger in infrastructural projects than in utility projects. Governmental clients in the infrastructural sector were more willingly to invest more in sustainability measures, where the commercial clients often used a maximum for their investment costs. Moreover, sustainability measures for utility project were more aimed at reducing cost during its operational phase than merely reducing the environmental impact.

The environmental impact of projects in the utility and infrastructural sector strongly differs during the phases of the building cycle. In infrastructural projects the environmental impact is the highest in the construction phase, relatively lower in the operational phase and higher during its maintenance phase. In utility projects the highest environmental impact is during its operation (BAM, 2016).

The recycling of building materials is relatively simple in the utility sector, because the building components are easy to demount compared to the infrastructural sector. For example, demounting doors, windows and facades is easier than demounting the most important components of infrastructural projects such as steel, concrete and asphalt.

In the assessed cases the relationship between the form of contract and the sustainability performance was significant. A higher level of integratedness of the contract lead to a better sustainability performance. This can be explained by the fact that when a contractor has more responsibilities during the entire life-cycle of a project it is forced to manage its activities over a long period of time. This long term-focus forces a contractor to deliver higher quality products, because the contractor is also responsible for maintenance and reusing the products. Therefore, the level of integratedness of a contract can be regarded as a good indicator for sustainable performance.

5.4.2 PHASE 2: SUSTAINABILITY ASSESSMENT METHOD

Within the infrastructural projects sustainability is always included during the procurement of a project, because of mandatory GPP. One of the utility projects was privately tendered which made it difficult for contractors to distinguish itself in terms of sustainability. During the infrastructural projects sustainability was used as a platform for optimising the design in terms of sustainability. In both cases the client stated its sustainability ambitions, and the contractor was asked on how it could improve the sustainability performance of the design, and quantify these sustainability improvements. Within the utility projects sustainability was incorporated earlier in the building cycle. The contractor was asked to help set sustainability ambitions for the project. This enables contractors to use their expertise and design the most sustainable solution for their clients.

During the projects several sustainability assessment methods have been used to determine the sustainability of a design, and to quantify the environmental impact. In the utility sector exist many assessment methods, labels and certification schemes which assess the sustainability performance of a project. In the infrastructural sector there exist three major sustainability assessment methods: CO_2 performance ladder, sustainability plan, and DuBoCalc. Less assessment methods result in a more uniform and objective way to assess the sustainability performance of a certain bid, and a higher competence level of the contractors with these specific methods. Nonetheless, less assessment methods means that it becomes more difficult for a company to distinguish itself in terms of sustainability. Moreover, sustainability is less included during tenders of utility projects. Sustainability is often an important topic of discussion. However, sustainability commitment of a contractor is often enough to include a company in a utility project.

The CO_2 performance ladder can be used in both the utility and infrastructural sector. However, far less clients use the CO_2 performance ladder in utility projects. Because a small number of contractors require CO_2 performance ladder during procurement procedures, it is not worth to invest large sums of money, to achieve the highest CO_2 performance. Therefore, BAM has decided to merely achieve the third level of CO_2 performance, because this level is already quite ambitious, and no other contractor in the utility sector has a higher CO_2 performance. In the assessed utility projects CO_2 ambitions have been less ambitious than in the infrastructural sector. In utility projects energy transition topics have been identified as one of the most important topics.

5.4.3 PHASE 3: SUSTAINABILITY PRIORITIES, OBJECTIVES AND REQUIREMENTS

In Figure 26 the ambition webs of the assessed project have been collectively visualised. It can be concluded that themes such as: accessibility, energy, materials and ground are the most important themes in the infrastructural projects. In the utility sector themes such as: business climate, investments, social relevance, well-being and spatial quality have been identified as the most important themes.

In the assessed infrastructural projects the components, which have the most harmful impact on the environment, have been identified such as: ground work, concrete work, steel work and final hardening. Moreover, other sustainability ambitions have also been used as a basis for sustainability competition such as: future value, sound, air quality, material use and energy use.

In the assessed utility projects sustainability is not always included in the tender, and was not always a platform for competition. Sustainability in the utility projects was more often a topic which was addressed together with the client and the contractor and proved a platform for collaboration. The willingness to involve in sustainability based cooperation has proved the be a major driver to be selected as contractor. Moreover, reporting on the CSR of these clients has proved to be one of the most important reasons to include sustainability requirements and forms the basis for branding and reputation development.

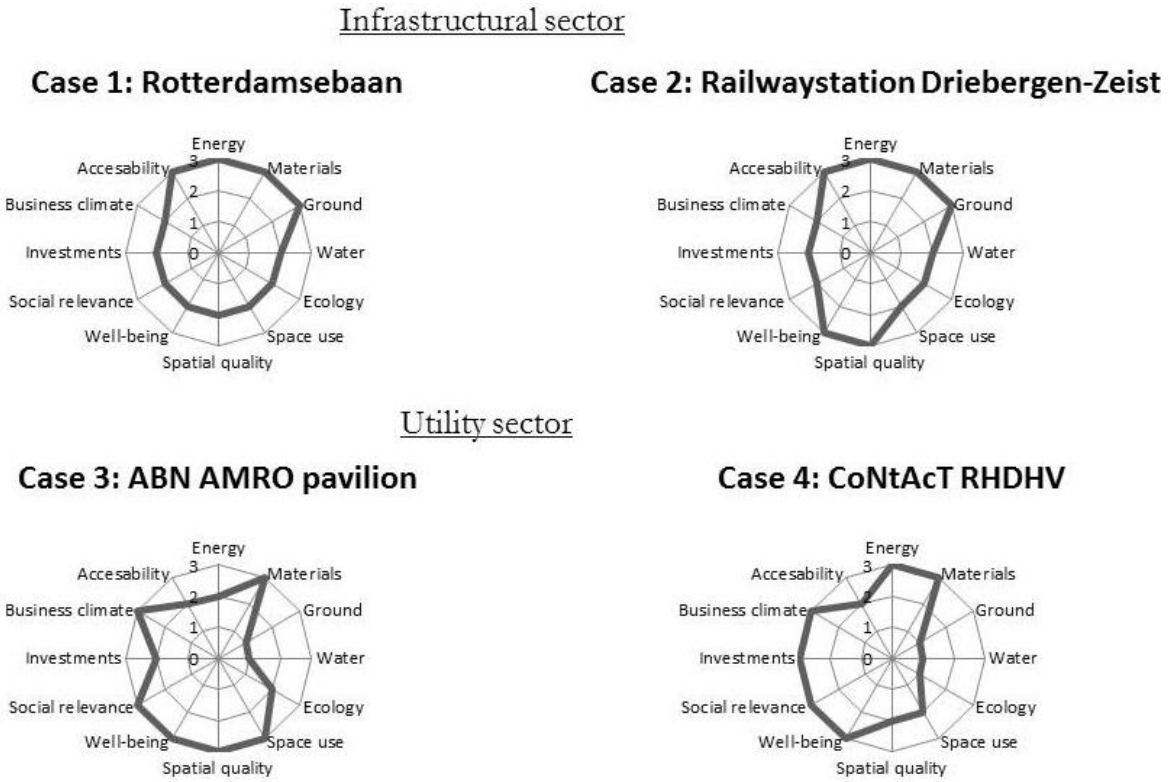

Figure 26. Cross case theme analysis

An explanation for the difference in sustainability themes can be found, in the focus on different key environmental impacts. Key environmental impacts are the most influential factors which have an impact on the sustainability of a certain project. Within the infrastructural sector the key environmental impacts are: rolling resistance, congestion, material production and transportation, ground work, maintenance & rehabilitation and traffic flow (EC, 2016). The key environmental impacts for the utility sector are: energy use during occupation, production of construction product, transportation of aggregates, lifespan of building and elements, healthy and attractive working environment (EC, 2016). This principle difference in key environmental impacts requires a different sustainability approach. For each individual project the key environmental impacts need to be identified. Combined with the sustainability ambitions of the client the key environmental impacts should result in a tailor-made sustainability strategy to maximize the sustainability performance of a project.

5.4.4 PHASE 4: OFFER OF BAM

BAM Infra has reached the highest level on the CO_2 performance ladder and received the maximum fictional discount with this assessment method. However, achieving the highest maximum discount with this assessment method does not necessarily mean that BAM was able to distinguish itself from its competition. Almost every large contractor in the Netherlands has reached the fifth level on the performance ladder. Therefore, the CO_2 performance ladder is not an effective tool for sustainability related competition.

The ECI is an effective quantitative assessment method to compare the ability of contractors to reduce the environmental impact of a building project. This assessment method requires significant expertise from both client and contractor. The client is required to scope the sustainability themes of a project in such a way that contractors base their calculations on the same quantities of materials. In the assessed case BAM was able to receive the maximum fictional discount. However, all contractors were able to reach the maximum reduction target and therefore the ECI was not a successful assessment method for contractors to distinguish itself.

The sustainability plan has proved a more effective platform for competition because the scores of the bids differed more from each other. Moreover, the sustainability plan is focused on topics

which are most relevant for a specific client. However, the assessment of a sustainability plan can be considered as relatively subjective. The assessment of a sustainability plan can be made less subjective by clearly stating the scope of sustainability themes, and reduction measures. In the assessed cases where a sustainability plan was used, BAM was able to score 4/5 points. The sustainability plan proved to be a more effective assessment method for sustainability related competition, and for BAM to distinguish itself.

In one of the utility projects sustainability was not included during the tender. BAM has been selected for this project mainly because of its corporate sustainable reputation. After the selection of BAM as contractor the sustainability ambitions were discussed and set. The performance on the BREEAM-NL assessment method was four out of five stars. The performance could have been improved on this assessment method if the design was more focused on the sustainability themes of the BREEAM-NL method. However, the focus of the project was on circularity what made it difficult to reach a higher sustainability performance on the BREEAM-NL method.

In the other utility project the contractor was also selected before clear sustainability requirements have been set. The expertise of the contractor was used to implement sustainability ambitions of the client within their project. The selection criteria within the assessed utility projects is less formal and is aimed on the willingness and competence of a contractor to collaborate on sustainability themes.

5.4.5 PHASE 5: PROJECT RELATED BARRIERS, DRIVER AND ENABLERS

The main barriers to include sustainability as a topic for competition was the lack of ability of clients to set clear sustainability requirements or provide a clear scope for sustainability related competition. Both in the infrastructural and utility projects clients were not capable to set a clear scope for sustainability related competition.

A major driver to include sustainability as a topic for competition was the willingness of clients to include sustainability. Governmental clients were pushed by legislation to implement GPP and commercial client implemented sustainability to improve their sustainable reputation. In both sectors the willingness of a client can be regarded as the most important driver to implement sustainability. Additionally, setting functional requirements has been identified as a driver in the assessed projects. Providing design- space to contractors on how sustainability is implemented in a project, provides contractors with the possibility to use their expertise and maximise the sustainability performance. Another driver for sustainability is the implementation of material passports. Storing specifications about the building materials is an important step towards a circular economy. The possibilities for materials passports are considered larger in the utility sector than the infrastructural sector because of the type of building materials.

One of the largest enablers for improving the sustainability performance of projects in the utility and infrastructural sector has been the multifunctional use of spaces. Multifunctional use of spaces and materials provide an opportunity for synergy advantages. Additionally, early supplier involvement can be regarded as a major enabler for improved sustainability performance. Providing suppliers an opportunity to be involved early during construction processes, enables them to adapt their products to maximise its sustainability performance. Lastly, integrated contracts can be regarded as an major enabler for improving sustainable performance. If a contractor is responsible for all phases of a project its life cycle, the contractor will be more assertive to optimise a project its sustainability performance. The identified barriers drivers, enablers and barriers are visualised in Table 24, and discussed for every phase of the "project sustainability assessment method".

Table 24. Barriers, drivers and enablers influencing the sustainability performance

		Phase 1	Phase 2	Phase 3	Phase 4

Phase 5	Enablers	1. Long construction period 2. Ambitious client 3. High investment cost	1. GPP 2. Growing interest in CSR	1. Main focus on material and energy	1. High amount of in-house capabilities 2. Functional requirements from clients
	Drivers	1. Integrated contract 2. Urban project location 3. Multifunctional project location	1. Growing database of materials and processes (LCA`s)	1. Investing in sustainability become more desirable 2. Supply chain collaboration	1. Uniform corporate sustainability strategy 2. BIM
	Barriers	1. Unexperienced client	1. Scope of assessment is often not clear 2. Lack of ex-ante assessment in utility sector 3. No possibility to distinguish on CO_2 performance ladder	1. Reduction targets are too easy	1. Limited availability of circular business models 2. Limited availability of energy transition business models

5.5 Preliminary conclusions

The research question which has been discussed in this section is:

What is the current sustainability performance of BAM within its projects?

In order to answer the research question, and to assess the sustainability performance of BAM within its projects it is important to use a "ruler". This "ruler" is different in every project because each project has different sustainability ambitions, and each ambition needs to be assessed differently. However, in the infrastructural sector there exist three commonly used, sustainability assessment methods which are used as a "ruler", to assess the sustainability performance of BAM: the CO_2 performance ladder, ECI and the sustainability plan.

The (sustainability) performance of BAM within the assessed projects can be considered as relatively good compared to its competition, because BAM was able to win all four considered tenders. BAM received the highest fictional discount on the CO_2 performance ladder and the ECI calculations, and received a 80% rating on its sustainability plans and BREEAM-NL certifications. However, this does not necessary means that BAM was able to distinguish itself by exceeding in sustainability performance. Sustainability is often included as a relative small share in a tender (7-20% of the tender price in the assessed cases), and includes roughly 15% of the total tender price of all tenders between 2015 and 2017, as discussed in Appendix E. Nonetheless, because the margins are relatively low in the building sector, and bids are often relatively close to one another, sustainability can be considered as an excellent platform for competition and for contractors to distinguish itself from their competitors.

BAM Infra has reached the highest level on the CO_2 performance ladder, and BAM Construction & Property reached the highest performance level within their market (level 3). However, many of the large infrastructural contractors have reached the highest possible performance level of 5, which means that contractors are not able to distinguish itself merely by reducing their CO_2 emissions.

DuBoCalc is used to quantify the effect of certain sustainability decisions. Because, DuBoCalc is a uniform method to determine the sustainability performance of a certain design, in theory it should provide a fair basis for sustainability related competition, because all the bidders use the same environmental costs values for their calculations. This results in competition based on quantity reduction and optimisation. Additionally, conducting additional LCA`s have proved to be a

successful strategy to reduce environmental costs of certain key environmental impact materials. However, clients often do not possess the expertise required to provide fair competition based on DuBoCalc. The scope of DuBoCalc calculations are often vague, and it is unclear which components must be included in the calculations, and which components need to be disregarded. This results in unfair competition in terms of sustainability. Moreover, clients often set ambition targets for environmental cost reduction which are relatively simple to accomplish, and many bidders receive the highest fictional discount on their DuBoCalc calculations. This trend results in a reduction of the ability of contractors to distinguish itself in terms of sustainability during a tender.

The sustainability plan is used, when a client knows which sustainability themes it wants to include in a project, and requires the contractor to reduce the negative impact on these themes. Unlike the ECI this assessment method does not has a standardized calculation method, and the contractor is required to realistically quantify their sustainability measures. This provides contractors with lots of design-freedom to implement different sustainability measures. However, because there is no standardized method to quantify the impact of these measures, it is important to set clear requirements to minimize the subjectivity of the assessment.

Overall BAM is performing quite well in terms of sustainability performance within the assessed projects. However, BAM its performance is limited by some barriers, and BAM does not utilize some major enablers and drivers to their fullest potential as visualised in Table 24. In order for BAM to be able to distinguish itself in terms of sustainability there exist some possibilities for improvement.

6 POSSIBILITIES FOR IMPROVING SUSTAINABILITY PERFORMANCE

This section aims to answer the following research question:

> **What are possibilities for BAM to distinguish itself positively from their competitors in terms of sustainable building?**

In this section the possibilities for BAM to improve its sustainability performance will be discussed. In Section 4, possible future sustainability requirements for the building sector were identified. In Section 5, the current sustainability performance of BAM has been assessed, and barriers, drivers and enablers for sustainability have been identified. This section will focus on the synthesis between the previous sections, and aims to identify the possibilities for BAM to improve its sustainability performance and positively distinguish itself from its competitors. This section, firstly, focuses on BAM its current sustainability strategy to improve its sustainability performance. Secondly, the major gaps between the future requirements for sustainability in the building sector and BAM its current sustainability performance will be discussed. The gaps between the future sustainability requirements, and the current performance of BAM within its projects, will provide an useful basis to identify steps which could be taken by BAM in order to positively distinguish itself from its competitors in terms of sustainability.

6.1 BAM its sustainability strategy

It is BAM`s mission to build sustainable environments that enhance people's lives by enabling the right people to capitalise on state-of-the-art knowledge, resources and digital technologies, providing solutions across the total construction life cycle for BAM its clients and generating maximum value for its stakeholders.

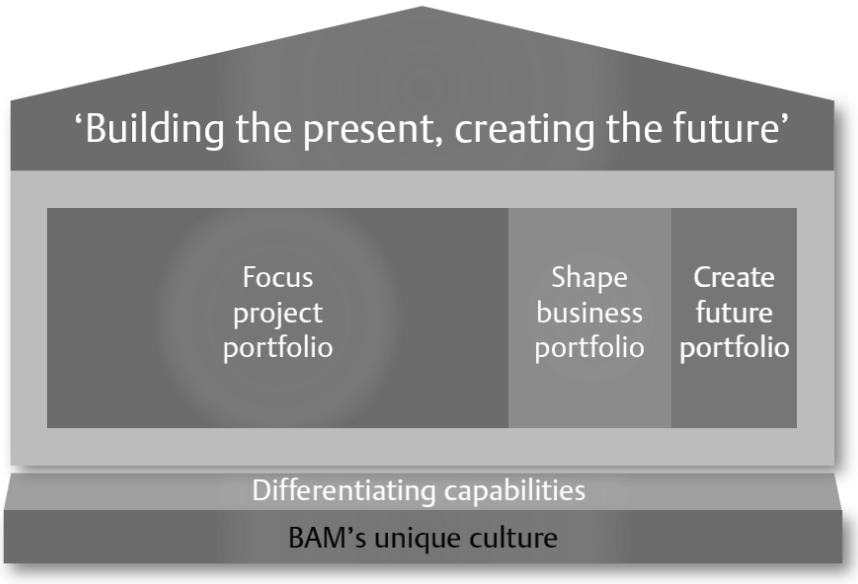

Figure 27. BAM its strategy 2016-2020 (BAM, 2016)

According to BAM its annual report (BAM, 2016), three external forces are shaping prospects for the construction industry. Firstly, economic growth is still vulnerable and will have a low to modest impact on construction volumes. Secondly, digitalisation is increasingly transforming the construction industry and the built environment. Thirdly, sustainability and mega trends such as energy efficiency and a circular economy are creating areas of higher growth. This research focuses on all external forces because it is possible that synergy advantages can be harvest from combining these external forces.

BAM its strategy has three pillars: to focus the project portfolio, to shape the business portfolio and to create the future portfolio. These are supported by a strong foundation consisting of two layers: culture and capabilities, as visualised in Figure 27.

In line with BAM its strategy 2016-2020 'building the present, creating the future', sustainability is used as the overarching term to include the broader focus on sustainable innovation and being solution driven in order to exceed clients expectations. CSR is an important aspect of BAM`s sustainability journey. CSR best describes the impact BAM will have as a business on the environment and its social responsibility towards both internal and external stakeholders.

BAM its sustainability strategy is focused on three key themes: climate positive, resource positive and enhancing lives (BAM, 2016). By collaborating with the supply chain, encouraging innovative thinking through its products, and realising the benefits of circular economic business models, BAM aims to have a net positive approach on climate, resources and local communities.

BAM its sustainability agenda has been incorporated in its business principles. BAM recognises its responsibility to future generations and focus its business principles on three main environmental sustainability topics (BAM, 2017):

1. *Energy:* BAM strives to reduce its impact on climate change. BAM will improve its energy efficiency, reduce its CO_2 emissions and work with its clients to develop CO_2 neutral solutions.
2. *Raw materials:* BAM is becoming more efficient in the use of materials. BAM believes in in reducing its impact on the supply of natural raw materials used in its products. BAM will work with its clients and suppliers to use alternative materials and methods in order to optimise the use of raw materials. BAM also promotes measures to promote measures to recycle and restrict waste.
3. *Environment:* BAM will limit its environmental impact. BAM takes all possible reasonable measures to ensure that its activities are conducted in a way that minimises the impact on the local environment. BAM promotes environmental friendly operations and seeks opportunities to promote biodiversity on its construction sites.

As discussed in Section 3.3 a sustainability strategy is a plan on the fulfilment of sustainability-related goals under condition of uncertainty (Aarseth, Ahola, Aaltonen, Okland, & Andersen, 2016). The sustainability goals of BAM can are summarised in Table 25.

Table 25. Sustainability goals BAM (BAM, 2016)

Goal	Key theme	Strategy pillar
In 2020 BAM achieves 25% relative emission reduction in scope 1, 2 and 3	Climate positive	Doing things better
To be included in the CDP climate A list leadership index by achieving performance band A	Climate positive	Doing things better
Deliver at least one product or service contributing to wider emissions reduction (zero carbon product)	Climate positive	Doing new things
To aspire zero construction waste in 2025	Resource positive	Doing things better
A model for 50% less waste across project life cycle	Resource positive	Doing better things
Deliver at least one BAM circular project, product or service in each operating company by 2020	Resource positive	Doing new things

This section will focus on possibilities for BAM to improve its sustainability performance in order to meet its sustainability goals. Additionally, possibilities will be discussed on how BAM is able to distinguish itself during projects in terms of sustainability.

6.2 Comparison future sustainability requirements and current performance

This chapter discusses the main differences and similarities between the expected future sustainability requirements in the building sector, and BAM its current sustainability performance. The main differences and similarities are listed in Table 26.

Table 26. Main differences and similarities between future sustainability requirements and current sustainability performance

Current	Future
Governments have mainly focused on CO_2 reduction, renewable energy generation and energy efficiency.	The environmental impact of materials will become more important for governmental agencies.
Commercial clients have mainly focused on creating circular buildings and highly efficient energy use of buildings.	Commercial clients will maintain their focus on circular buildings and highly efficient energy use of buildings.
The predominant sustainability assessment methods for the infrastructural sector are: the sustainability plan, the CO_2 performance ladder and the ECI.	The predominant sustainability assessment methods for the infrastructural sector will maintain: the sustainability plan, the CO_2 performance ladder and the ECI.
In the utility sector many sustainability assessment methods exist, although none of them was predominantly used during tenders.	Because, circular building is a predominant topic for commercial clients it is possible that a circular assessment method will become dominant in the utility sector.
The most important sustainability themes within the infrastructural sector are: energy efficiency, material efficiency, accessibility and groundwork.	The efficient use of energy and materials will maintain the most important sustainability topics in the infrastructural sector.
The most important sustainability themes within the utility sector are: energy efficiency, material efficiency, business climate, social relevance and well-being.	New circular business models require a shift in procuring construction services. Therefore, the investment topic will become more relevant in the future

These differences provide an opportunity for BAM to improve its sustainability performance and distinguish itself from its competition in terms of sustainability. The expected future sustainability requirements will mainly focus on efficient use of materials and energy.

The building sector is pushed by governments which force the building sector by enforcing laws and regulations, and with interventions such as subsidies, knowledge sharing, working programs and covenants. The most important sustainability topics addressed by government legislation and policies are focused on reducing CO_2 emissions and increasing energy efficiency.

The building sector is pulled by the increase of environmental awareness and growing interest in CSR. Clients are demanding higher sustainability performance and a reduced impact on the environment. The market pull for sustainability requirements is nowadays most related with the transition to a circular economy and reducing construction waste by reusing and recycling building materials and components.

In the assessed projects energy and material efficiency have been identified as the most important sustainability themes in the infrastructural sector. In the utility sector these sustainability themes are also identified as important. However, in the utility sector other sustainability themes are also perceived as important such as: business climate, social relevance and well-being. It is presumed that the current focus on sustainability themes in the infrastructural sector and utility sector will not differ from future projects. Yet, it is presumed that the investments topic will become more relevant in the utility sector due to new circular business models. The level of important of sustainability themes now and in the future are visualised in Figure 28.

It is presumed that CSR and corporate branding and reputation are some of the major drivers for sustainability within utility projects. Within infrastructural projects, reducing the environmental impact has been identified as the main drivers for sustainability. An important explanation for this difference can be found in the role of the client. Infrastructural projects are mostly procured by governmental agencies, where utility projects are commissioned by commercial parties.

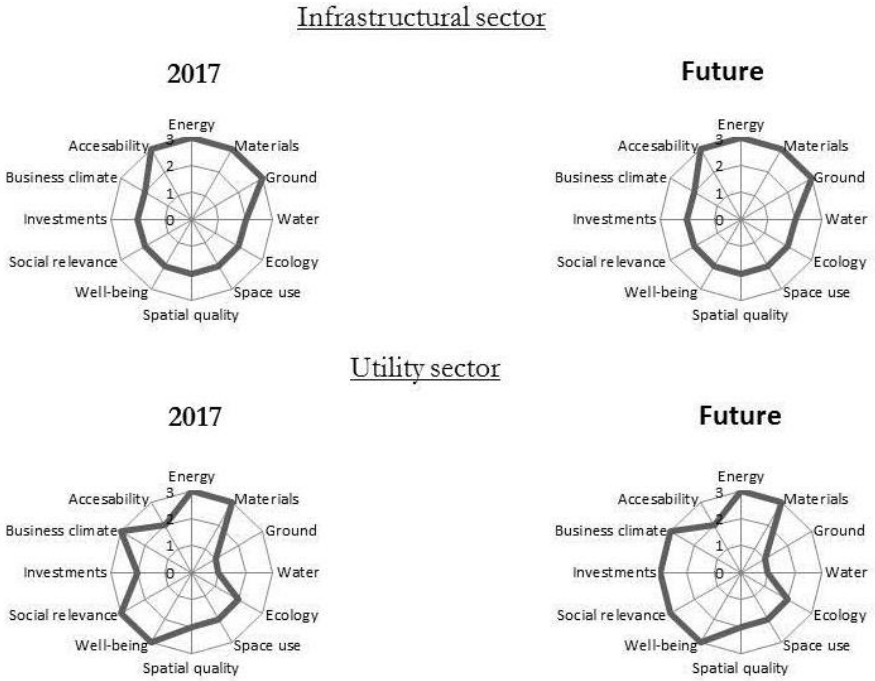

Figure 28. Importance sustainability themes: now vs future

In order for BAM to distinguish itself from its competition in terms of sustainability, it is essential to take client their sustainability goals into account and incorporate these requirements in their projects. Sustainability related competition is often based on CO_2 reduction (performance ladder), material optimisation (DuBoCalc) or reduction targets based on additional sustainability themes. BAM has many sustainable building solutions to offer their clients. It is essential to keep developing and improving sustainable solutions in order to be able to differentiate itself from its competition and achieve industry leadership in terms of sustainability, and harvest first-mover advantages rather than merely adopt sustainable solutions.

The building sector is still focused on short term efficiencies rather than long effectiveness, because of relative low profit margins for contractors. Yet, this is no excuse for the lack of innovative behaviour, because sustainability provides an useful platform for new business models and competition. Many actors in the building sector have ambitious goals regarding sustainability, and sustainability has been successfully implemented during most project tenders. However, sustainability has not always provided a good platform for contractors to successful distinguish itself. Clients are not experienced in sustainability related competition and struggle to set clear boundaries. Additionally, sustainability targets are often not very ambitious and reaching these targets is not very difficult, what decreases the opportunity for sustainability related competition.

Summarizing, in order for a contractor to successfully distinguish itself from its competition: 1) clients should provide fair, challenging and clear sustainability competition. 2) contractors should keep developing and improving sustainability measures which align with client their requirements and goals. The most important sustainability requirements are concerned with CO_2 reduction, energy efficiency, energy from renewable sources, reducing material waste and a circular economy.

6.3 Possibilities for improvement

As discussed in Section 4 & 5 most sustainability requirements in the building sector are related with a circular economy and energy transition, in order to reduce CO_2 emissions. If BAM wants to improve its sustainability performance it is important to focus on these sustainability themes. These sustainability themes are also identified by experts of BAM as critical sustainability themes and focusing on these themes is therefore in-line with BAM its corporate and operational strategy.

Additionally, the development of digitisation is often identified by internal and external experts of BAM as a key platform to increase the sustainability performance of BAM. Therefore, the possibilities for improvement will be divided in three main topics:

1. Circular economy: A circular economy is a regenerative system in which resource input and waste, emissions and energy leakage are minimised by slowing, closing, narrowing material and energy loops.
2. Energy transition: The transition from fossil energy sources to renewable energy sources.
3. Digitisation: The conversion of building information into a digital form that can be processed by a computer.

6.3.1 CIRCULAR ECONOMY

The world`s economy is based on the definitions of a linear economy, 'take-make-dispose'. Linear industrial processes and the lifestyles that feed on them deplete finite reserves to create products that end up in landfills or in incinerators. Because many resources are finite, it is essential to prevent waste and reuse materials before we run out of resources. The linear economy and scarcity of resources can result in strong price fluctuations of resources and energy, pollution of ground soil and water, climate change and an increase in GHG emissions.

Many authors describe circularity as an important precondition for sustainability. A circular economy can be defined as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. (Geissdoerfer, Savaget, Bocken, & Hultink, 2016).

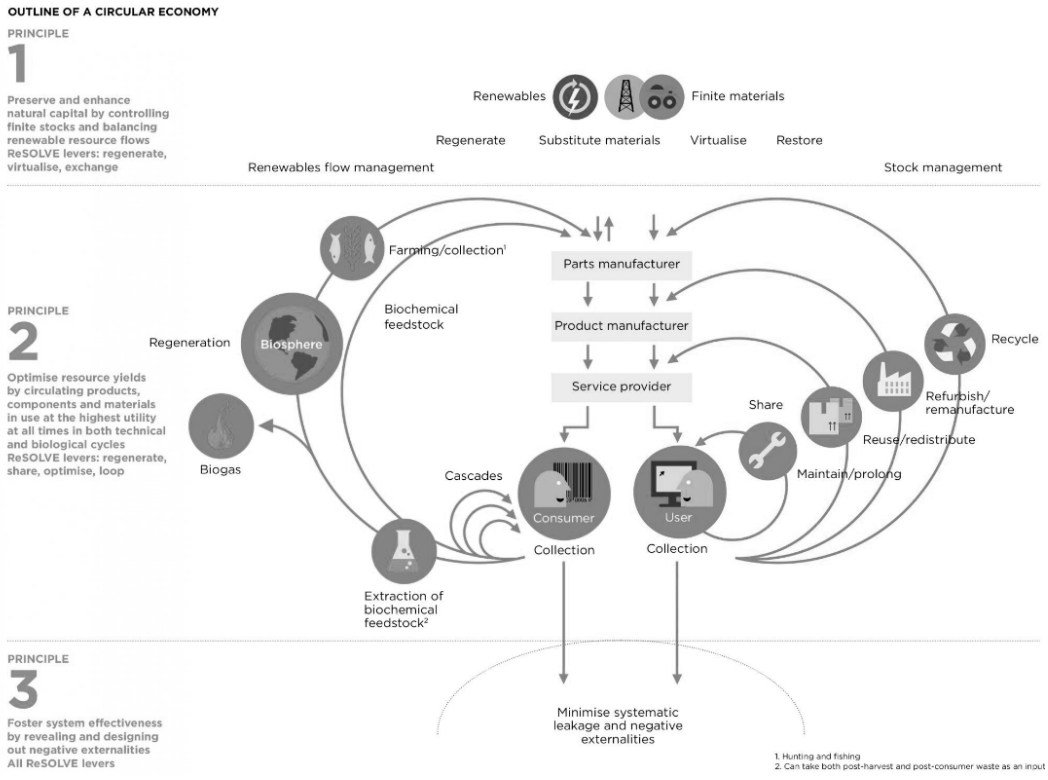

Figure 29. System diagram 'Circular Economy' (Ellen Macarthur Foundation, 2017)

A circular economy is a continuous positive development cycle that preserves and enhances natural capital, optimises resource yields, and minimises system risks by managing finite stocks and renewable flows. A circular economy is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times. A circular economy seeks to rebuild capital, whether this is financial, manufactured, human, social or natural. This ensures enhanced flows of goods and services. The system diagram visualised in Figure 29

illustrates the continuous flow of technical and biological materials through the 'value circle' (Ellen Macarthur Foundation, 2017).

In a circular economy products are designed for resource efficiency and to maximise the value of its resources. Moreover, a circular economy is focused on a shift from ownership to use. This means that products are used over their lifetime and are taken back by their manufacturers. Because the manufacturers know exactly which materials are used in a product, the manufacturers can reuse, refurbish or recycle the product most efficiently. Many circular principles already exist, varying widely depending on the problems being addressed. The following elements are identified and required within a circular economy (Ellen Macarthur Foundation, 2017):

1. Prioritize regenerative sources: ensure renewable, reusable, non-toxic resources are utilized as materials and energy in an efficient way.
2. Use waste as a resource: Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.
3. Design for future: Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetime and to design for extended future use. Meaning that a product is designed to fit within a materials cycle, can easily be dissembled and can easily be used with a different purpose.
4. Preserve and extend what`s already made: While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.
5. Collaborate to create joint value: Within a circular economy, one should work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create joint value. For the business sector this calls for collaboration within the supply chain and cross-sectorial, recognising the interdependence between the different market players.

Table 27. Key features of Circular Business Models (Haara, et al., 2015)

CBM	Key features
Circular supplies	Providing fully renewable, recyclable or reusable resources inputs to phase out the use of scarce resources, and reduce waste and inefficiencies.
Resource recovery	Recovering useful resources of energy from disposed products or by-products to eliminate material leakages. C2C designs.
Product Life extension	Extending the life of assets and products through maintenance, repair, upgrade and remanufacture.
Sharing Platforms	Maximising utilisation via a platform for product users to facilitate the sharing of overcapacity/underutilisation
Products as services	Retaining ownership, whilst providing product access ensuring that longevity, reusability and sharing are no longer perceived to be cannibalisation risks

The shift towards a circular economy provides business opportunities for BAM to distinguish itself in terms of sustainability. Several circular business models already exist. Linder and Williander (2015) describe a circular business model as: 'a business model in which the conceptual logic for value creation is based on utilizing the economic value retained in products after use in the production of new offerings'. Additionally, a circular economy focuses on opportunities to create greater value and align incentives through business models that build on the interaction between products and service. Basically, this means that a circular business model is not focused merely on selling products, but encompasses a shift in thinking about value proposition, bringing forward a whole range of different business models to be used. The key features of these Circular Business Models (CBM) are listed in Table 27.

Possibilities for CBMs can be implemented during all the stages of the building cycle: design, procurement, distribution and assembly, use and maintenance and end-of-use.

Building design: Opportunities include applying nonconventional design processes such as involving end-users and facility managers; designing for efficient construction and longevity as well as designing for flexibility and resource recovery.

Procurement: Choosing suppliers that offer circular solutions such as leasing models and buy-back schemes requires higher levels of value chain integration. Product passports may provide a solution as well as the development of circularity indicators to facilitate decision-making.

Distribution and assembly: In this stage, prefabrication provides benefits in terms of a CE, as it reduces waste on site, offers higher quality finish and facilitates resource recovery.

Use and maintenance:

1. Minimising environmental footprint during use is crucial as CO2 emissions far outweigh the embodied emissions.
2. Providing a comfortable work environment would enhance employee productivity.
3. Opting for suppliers with service-models would facilitate the development of a circular built environment, but occupier receptivity may be a barrier.

End-of-use:

1. Reuse is an important component in a circular built environment and should be considered before buildings are dismantled.
2. Reverse logistics need to be developed to ensure that material loops are closed.
3. Recognising exit value is a key requirement for reclaiming materials.

6.3.2 ENERGY TRANSITION

Government agencies are increasingly compelling the building sector to reduce GHG emissions. In order to drastically decrease GHG emission, an energy transition is required. The energy transition will focus on increasing energy efficiency, upscaling renewable energy generation and energy autonomy of new buildings. Moreover, clients are demanding more energy efficient buildings because of corporate reputation, branding, lower operational costs, improved well-being and productivity of users of the building due to improved building performance, and long-term benefits for the national economy because of reduced emissions and use of natural resources (Häkkinen & Belloni, 2011). The energy transition provides opportunities for BAM to distinguish itself in terms of sustainability.

Energy autonomy of new buildings creates a decentralised generation of energy which requires a flexible and smart energy grid. Additionally, new buildings should use less fossil fuel for heating such as gas, and should use renewable energy sources to become truly autonomous. Energy neutral buildings should be designed to minimise the energy use, by using energy efficient systems and appliances, and should maximise its energy generation.

The best way for BAM to distinguish itself in terms of sustainability is by reducing and monitor its CO_2 emissions. Energy use can be converted to CO_2 emissions and therefore provide an uniform unit for measuring all forms of energy use. The CO_2 performance ladder provides an useful uniform method to determine CO_2 emissions and enables clients to compare the CO_2 reduction performance of contractors. However, the CO_2 performance ladder is mainly focused on the CO_2 reduction performance of a company and does not directly include the CO_2 reduction of its products and projects. The infrastructural sector is far more CO_2 intensive (80%) than the construction and property business line of BAM (20%). In order to reduce CO_2 emission on a corporate level the biggest opportunities for BAM is to reduce its emission from car travel, which account for roughly 30 percent of its total emissions. Yet, the construction sites are still the largest emitters of CO_2 and account for almost 50% of the total emissions (BAM, 2016).

In order for BAM to reduce its CO_2 emissions it is important to move away from fossil fuels. Transportation of resources and manpower, and construction of building materials and components can be considered as the most CO_2 intensive construction processes. Unfortunately,

many of these processes are outsourced to subcontractors and suppliers. Therefore, it is critical to include and collaborate with the entire supply chain to minimise the environmental impact in order to become more sustainable.

BAM needs to focus on products and services which reduce carbon emissions. Recent years the building clients were demanding many neutrality concepts such as: energy and carbon neutral buildings. It is expected that in the nearby future these concepts will still be predominant in the building industry. During the assessed projects, most buildings have a larger impact on the environment during their operational phase than during construction. However, when a large number of buildings have become energy or carbon neutral, a new shift will occur. When buildings do not use any additional electricity because these building are energy neutral, the most environmental harmful component of the building sector becomes the building materials. In other words, when building are energy autonomous and no additional energy will be used during its operational phase, the centre of gravity of sustainability will shift from the energy use during the operational phase to the materials used during the construction phase.

The energy transition is already happening, and many energy efficient measures are available to increase the energy efficiency of the building stock. It is believed that the sustainable development of the building sector is not hampered by the lack of available sustainable measures, products and services but by the lack of willingness of clients to implement them in their projects. Energy efficiency has received increasing attention over the last decades and has been a major concern of both governmental agencies and private organisations. In order to successful facilitate the energy transition, BAM needs to use its expertise and offer tailor-made energy efficient solutions for their clients which are affordable, reliable and safe.

6.3.3 DIGITISATION

Digitisation can be regarded as a key driver for sustainability and provides several opportunities for BAM to improve its sustainability performance, and therefore distinguishing itself from its competition. Digital construction can be divided in the digital construction process and the digital built environment.

The digital construction process is concerned with the digitisation of all activities in the building process. Building Information Modelling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of places. BIM provides a useful platform for information sharing across value chain and control of requirements, costs, planning and even sustainability. All building specifications and quantities of materials are available in one single model, which enables EIAs and LCAs to be conducted more efficiently using BIM. Next to more efficient sustainability analysing, BIM has proved to stimulate collaboration and eliminates construction waste by a more efficient design process. BIM enables Design for Manufacture and Assembly (DFMA). During the design process decisions can be made to use materials and components which are easier to assemble and disassemble, which can improve their reusability. Because most design activities are finished before the start of construction, the construction time can be significantly reduced, which reduces nuisance, and use of energy and materials. Moreover, using BIM enables decision making based on cost-value analysis of sustainable designs. Therefore, BIM can be considered as a major driver and enabler for sustainability in the building sector.

Next to the digital construction process, the digital built environment provides additional opportunities for the building sector to become more sustainable. The digital built environment is concerned with the use of digital services and products which aim to improve a buildings performance. Smart digital devices for example provide an opportunity to customise a building during its operational phase by using available and measured information. Building related information can be collected by sensors, and combined with smart devices can result in energy savings. For example, in an office building a sensor can measure the attendance of people, and when nobody is in a certain room automatically turn of the lighting and air condition units.

Furthermore, sensors can be used to measure road or rail traffic intensity, which can be used for travel planning and management purposes. This can reduce congestion, and therefore, improve the sustainability of a certain (rail) road section.

Probably, the most promising possibility of the digitisation of the construction industry is the possibility to collect, store and analyse (big) data. The collection of data enables monitoring of building performance and process control, more efficiently. Especially, the collection of data concerning building materials and components can be a major opportunity for sustainability. Data regarding durability, end of life and other material specifications can be used for maintenance, reusing and recycling of building materials.

6.4 Preliminary conclusions

The research question which has been discussed in this section is:

> **What are possibilities for BAM to distinguish itself positively from their competitors in terms of sustainable building?**

The possibilities for BAM to distinguish itself positively from its competitors in terms of sustainability are endless. Nonetheless, the findings of this research indicates that BAM should focus on three major sustainability topics which have been identified by clients, governments, trade associations and during projects of BAM. The most promising sustainability themes for BAM in the assessed projects were energy and materials, as visualised in Figure 30. These sustainability themes correspond with the circular economy and energy transition ambitions of the most influential actors. Other sustainability themes have also been important topics during the assessed projects. However, the most influential actors have not incorporated these themes extensively in their sustainability goals. Therefore, the findings of this research indicate that requirements concerning a circular economy and the energy transition will maintain predominant in the building sector. Additionally, the digitisation has been identified as a major enabler and driver for improving the sustainability performance of BAM.

In order for BAM to distinguish itself from its competitors, a strong basis for competition is required. Competition in the building sector is the most intensive during the tender phase. Since the introduction of GPP, sustainability has been incorporated more extensively during tenders and has been a basis for competition in the building sector. The mostly used methods to assess a contractor its bid in terms of sustainability are the CO_2 performance ladder, which classifies the effort of a company to reduce its CO_2 emissions, and the ECI which determines and compares the sustainability and environmental cost of different bids. Most large Dutch contractors have achieved the highest score on the CO_2 performance ladder and therefore the ladder cannot be used for BAM to positively distinguish itself from its competition. However, not focusing on achieving the highest score on the ladder may lead to a disadvantage during tenders, and therefore BAM needs to keep investing in achieving the highest score on the ladder. The ECI is used during tenders of projects and aims to quantify the environmental impact of a project using a LCA-approach. DuBoCalc is a tool which is used to calculate the ECI of projects and proves to be a useful platform for competition because every bidder is required to use the same calculation method and use the same values to determine the environmental cost. Yet, the scope provided by the client to determine the environmental cost are often vague, and do not promote fair competition. Nonetheless, pushing the boundaries and keep developing new innovative solutions to reduce the environmental cost of projects remains a key process in sustainable construction in the infrastructural sector.

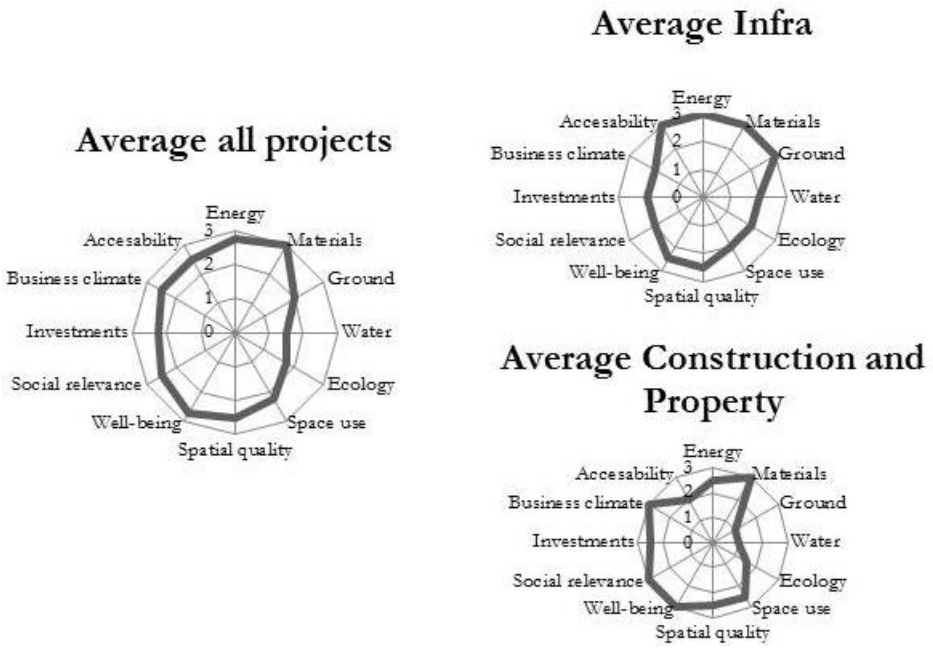

Figure 30. Average ambition scores on sustainability themes

In order to reduce the environmental impact of BAM its building activities, there exist many different opportunities. This research has showed that ambitions and requirements of different clients and stakeholders vary between projects, and therefore a tailor-made solution is required for every project. Nonetheless, a couple of sustainability themes have occurred more frequently during this research, and therefore a focus on these themes may prove to be beneficial for BAM.

The first opportunity for BAM is to contribute to a circular economy. A circular economy preserves and enhances natural capital, optimises resource yields, and minimises system risks by managing finite stocks and renewable flows. The environmental impact of the building sector is high. Construction and use of buildings consume 42% of all energy, 50% of all extracted materials, 30% of all water and produces 35% of all greenhouse gas emissions in Europe (EC, 2011). Therefore, the building sector has an enormous impact on the environment. Finite energy sources and material scarcity are demanding the building sector to reuse and recycle buildings, building components and materials more efficiently. BAM can contribute to a circular economy by using several circular business models, and incorporate these in their sustainability strategy. Firstly, BAM can use circular supplies in their building projects to provide their clients with fully renewable, recyclable or reusable resources. Secondly, BAM can contribute to recover useful resources from existing building and reuse these materials in new buildings or renovations. Thirdly, BAM can extend the product life of its projects by efficient managing of their products through maintenance, repair, upgrade and remanufacture. Fourthly, BAM can provide sharing platforms to ensure maximum utilisation of buildings to facilitate the sharing of overcapacity or underutilisation. Lastly, BAM can remodel their business by not merely focusing on the construction of buildings as products, but to focus on offering buildings as services and retain ownership to ensure the reusability of the building or its separate building components.

The second opportunity for BAM is to facilitate the energy transition and to keep reducing its GHG emission. The use of renewable energy sources and the efficient use of energy has been a process of the last decades. Within the building sector there has been a focus on energy autonomous buildings and concept such as energy and carbon neutrality. Providing NENB has proved to be a successful business model of BAM. The knowledge and expertise developed during these projects can be used to win future tenders. One of the largest emitter of CO_2 by BAM is car travel, and transportation of building components. In order for BAM to reduce its CO_2 emissions BAM needs to more intensively collaborate with the conveyors throughout its supply chain.

The last opportunity for BAM is provided by the digitisation of the building sector. The digitisation is a major enabler for sustainable building. BIM provides major opportunities for sustainability design, assessment, monitoring and cost-value analysis. Additionally, the use of (big) data can be considered as an enormous opportunity for BAM. Material specifications can be stored in digital databases, and can contribute to the reusability of materials through material passports. Moreover, the use of big data can improve the precision of monitoring the energy use of building, which can increase the predictability of a buildings energy demand, and early anticipate on this demand.

Early anticipation on sustainability requirement development will contribute to gaining a competitive advantage. Because governments, clients and trade associations are currently not requiring contractors to deliver highly circular and energy efficient buildings, does not necessarily means that actors demand higher sustainability requirements in the future. The goals of all the reviewed actors indicate a development towards higher sustainability requirements. By offering new innovative sustainable products and services BAM is able to create demand, and harvest its first-mover advantages. Especially creating an equilibrium between all the sustainability themes will maintain one of the largest challenges for contractors. Focusing on the most frequent sustainability themes and exceeding the sustainability performance on these topics will result in the most distinguishing ability, and the highest overall sustainability performance.

Concluding, this research has identified the circular economy, energy transition and the digitisation of the building sector as most promising opportunities for BAM to distinguish itself.

7 DISCUSSIONS

This section covers the interpretation of results, the scientific and practical contribution and formulation of limitations.

7.1 Interpretation of results

This research has showed that the demand for sustainability within the building sector will remain an important topic for future building projects. Sustainability has been incorporated in many tenders as an important platform for competition as discussed in Appendix E. Because of the relative small margins within the building sector, and fierce competition, sustainability can be regarded as an excellent topic for contractors to distinguish itself from its competition. In order to break the vicious circle of blame discussed by Mlecnik (2011), BAM should offer a wide range of sustainable concepts and services to its clients (Häkkinen & Belloni, 2011).

Within the assessed projects of BAM there was a significant difference in sustainability requirements and assessments between projects in the utility sector and the infrastructural sector. Firstly, the importance of several sustainability themes differed between the two sectors. In the infrastructural sector themes such as: accessibility, energy, materials and ground are the most important themes. In the utility sector themes such as: business climate, investments, social relevance, well-being and spatial quality have been identified as the most important themes. Furthermore, the level of sustainability is assessed differently in these sectors. In the infrastructural sector the most common used assessment methods are the sustainability plan, CO_2 performance ladder and the ECI. Within the utility sector sustainability assessment methods are often not included during the tender phase, and are far less standardised than in the infrastructural sector. Sustainability assessment in the utility sector is often performed ex-post by certification schemes such as BREEAM-NL. Because of the significant differences between the utility and infrastructural sector it is difficult to identify common drivers, barriers and enablers. Nonetheless, client understanding about sustainability and a client`s willingness to incorporate sustainability as a key requirement for a project is essential in both sectors, these results are in-line with the findings of Häkinnen & Belloni (2011). Furthermore, circularity has been identified in both sectors as a promising business model. Especially, the utility sector is suited for the implementation of circular product and services because the infrastructural sector is more dependable from environmental harmful materials such as concrete, asphalt and steel. In order for BAM to reduce its impact in the infrastructural sector, and to increase its sustainability performance, it is essential for BAM to closely collaborate with its key-suppliers to reduce the environmental impact of its building projects (Darko, Chan, Owusu-Manu, & Ameyaw, 2017).

BAM has possibilities to distinguish itself from its competition in terms of sustainability on a corporate level as well as on a project-level. BAM is quite successful to distinguish itself on a corporate level in terms of sustainability and scores high on several corporate sustainability benchmarks, which results in positive corporate sustainability branding and reputation development (Darko, Zhang, & Chan, 2017). However, many infrastructural projects are required to be tendered public by law, and therefore BAM needs to distinguish itself also on a project-level. It is difficult for BAM to distinguish itself merely on price because BAM has higher overhead expenses than Small and Medium-sized Enterprises (SMEs). Because BAM is a large company it has possibilities to distinguish itself otherwise. BAM can distinguish itself by focusing on complex projects, because of the relative high amount of in-house knowledge. Additionally, BAM can rely on its past-performance, and corporate image. Because of its economies of scale BAM can procure products and services more beneficial than smaller construction companies. Moreover, BAM has much experience in the Dutch building sector and has worked together with many co-makers (subcontractors). Because BAM works closely together with its co-makers BAM can ensure the reliability of their performance and can guarantee high performance. Because, BAM is a relatively large company, sustainability-based competition enables BAM to distinguish itself not merely on

price. Therefore, the results of this research align with the phenomenological relationship between sustainability performance and economic success described by Wagner & Schaltegger (2003), and with the relationship between environmental strategy development, performance improvement and competitive advantage discussed by Fergusson & Langford (2006).

7.2 Scientific contributions

Although literature on sustainability in the building sector is flourishing, little attention has been paid to the relationships between sustainability performance and business competitiveness. The development of sustainability requirements in the future is uncertain, and therefore the ability for building contractors to be competitive is uncertain. This research has proposed an empirical investigation of the problem, and analysing four cases in the light of sustainability performance and competitiveness.

Prior studies have recommended the building sector to incorporate sustainability related requirements. However, the development of these sustainability related requirements has not been a topic of extensive research. Through examining the role and goals of the most influential actors in the Dutch building sector namely: clients, governments, trade associations and BAM its own organisation, an insight is created in the development of sustainability related requirements.

Sustainability performance has developed as one of the most extensive research topics within the building sector. However, the building sector is diverse and consists of various subsectors such as utility and infrastructure. Little researches has been conducted on the differences between the utility and infrastructural sector in terms of sustainability. This research partially fills this gap, because a cross-case analysis has been conducted on sustainability performance in the utility and infrastructural sector

Sustainability assessment has emerged as one of the major issues in the building sector. Many different sustainability assessment methods exist and all focus to assess a building`s sustainability performance. However, the sustainability assessment of whole projects has received less attention in literature. This research aimed to assess and compare the sustainability performance of projects and developed the "Project Sustainability Assessment Method". This method provides a simple but effective method to assess the sustainability performance of projects by focusing on client requirements, used sustainability assessment method and the offer of the bidder. This method distinguishes itself because it does not focus on a set of predetermined sustainability indices, but merely focuses on client and project-specific sustainability themes. Moreover this method can contribute to determining key factors for contractors to positively distinguish themselves in terms of sustainability.

7.3 Practical contributions

The findings of this research provide valuable insides for contractors in the building sector, and especially for BAM because its projects were involved in the case studies. The cases highlight topics having a high impact on the environment, and provide possible solutions to improve the performance. This research contributes to reducing uncertainty of sustainability related requirements for future building projects. Therefore, BAM can more accurately focus its sustainability strategy and develop sustainability related policies.

Moreover, this research has contributed to the validation of sustainability practice of BAM. Several projects have been assessed and indicated that BAM its sustainability strategy is quite successful. Within the projects several factors have been identified which can stimulate or hamper the sustainability performance of BAM, and provide the basis for possibilities to improve the sustainability performance.

Lastly, this research has provided guidance for BAM on how it can competitively provide future sustainability requirements and set direction for possible sustainable business models.

7.4 Research limitations

As within any research project, there are some limitations acknowledged. This research has focused on how a building contractor can competitively provide future sustainability requirements.

A first limitation of this research is the fact that the building sector is not researched as a whole, but only the utility and infrastructural sectors have been included in the case studies. The main reason to exclude the housing sector in this research is because many additional actors are involved. This research has focused on future sustainability requirements by studying the roles and goals of actors. If the housing sector was included in this research the number of actors was significantly higher. Because of significant differences between these sectors and limited available time, the decision has been made to place the housing sector outside the scope of this research.

A second limitation of this research is concerned with the fact that it has been conducted in the Netherlands, and focuses on the Dutch building sector. The conclusions of this research are not necessarily valid for other countries. One of the main reasons that the results of this research can differ from other countries is the fact that the Dutch economic system follows the principles of the Rhineland model. This means that the Dutch government is actively involved with legislation regarding environment, spatial planning and other topics. The Dutch building sector is therefore more legislation pushed than market pulled, and the research results can differ in other countries.

A third limitation of this research is concerned with the limited number of cases and the case selection criteria. Because, only four of the hundreds of annual projects of BAM have been included in the research the external validity is hampered. However, the cases have been selected in such a way that the cases represent the entire project portfolio. Nonetheless, because of the limited number of case studies not all case selection criteria could be met. The clients of the infrastructural projects represent the two most important governmental clients: Rijkswaterstaat and Prorail. Yet, lower governmental-bodies such as provinces and municipalities could not be included in the research due to time-constraints. Furthermore, in the utility sector two commercial clients have been selected because of the relative large sustainability component within these projects. Therefore, it was not able to include a governmental client within an utility project. Governmental and commercial clients are inherently very different, which makes it difficult to compare the sustainability requirements of these projects.

A fourth limitation of this research is the number of actors involved. This research has identified four main groups of actors concerned with sustainability in the building sector. These groups have been carefully selected in consultation with sustainability experts within BAM. However, due to time-constraints and difficulties to extract information from actors some of the actors with less influence have been neglected. In order to improve the internal validity of this research more actors could be involved such as lower governmental-agencies and large private clients.

A fifth limitation of this research is the reliability of the data gathering method. The data collection of this research has partially been depended on interviews with sustainability experts within BAM. The building sector and especially sustainability within the building sector is a dynamic topic and develops quickly over time. Therefore, the answers of sustainability experts collected during interviews can differ in a couple of years. It is possible that if a researcher uses the data gathering strategy of this research, other data and answers will be given over time.

The last limitations of this research are concerned with the Project Sustainability Assessment Method used to assess the sustainability performance. This method has been tailor-made for BAM in order to compare the two business lines. This method focuses on projects as a whole and not merely on reducing the environmental impact, but how a contractor can positively distinguish itself from its competitors. Furthermore, the methods is mostly qualitative except the ambition web, focuses on the tender phase and includes several other project assessment methods.

8 CONCLUSION

The main research question of this research is:

"How can BAM improve its sustainability performance, in order to competitively provide future sustainability requirements?"

BAM is aiming to improve its sustainability performance, and compeitively provide future sustainability requirements. The future sustainability requirements are uncertain and BAM does not exactly knows how it can improve its sustainability performance in order to distinguish itself from its competition, and ensure its future project portofolio. This research project has contributed to this problem by identifying future sustainability requirements, assessing BAM its current sustainability performance, and identifying possiblities for improvement as visualised in Figure 31.

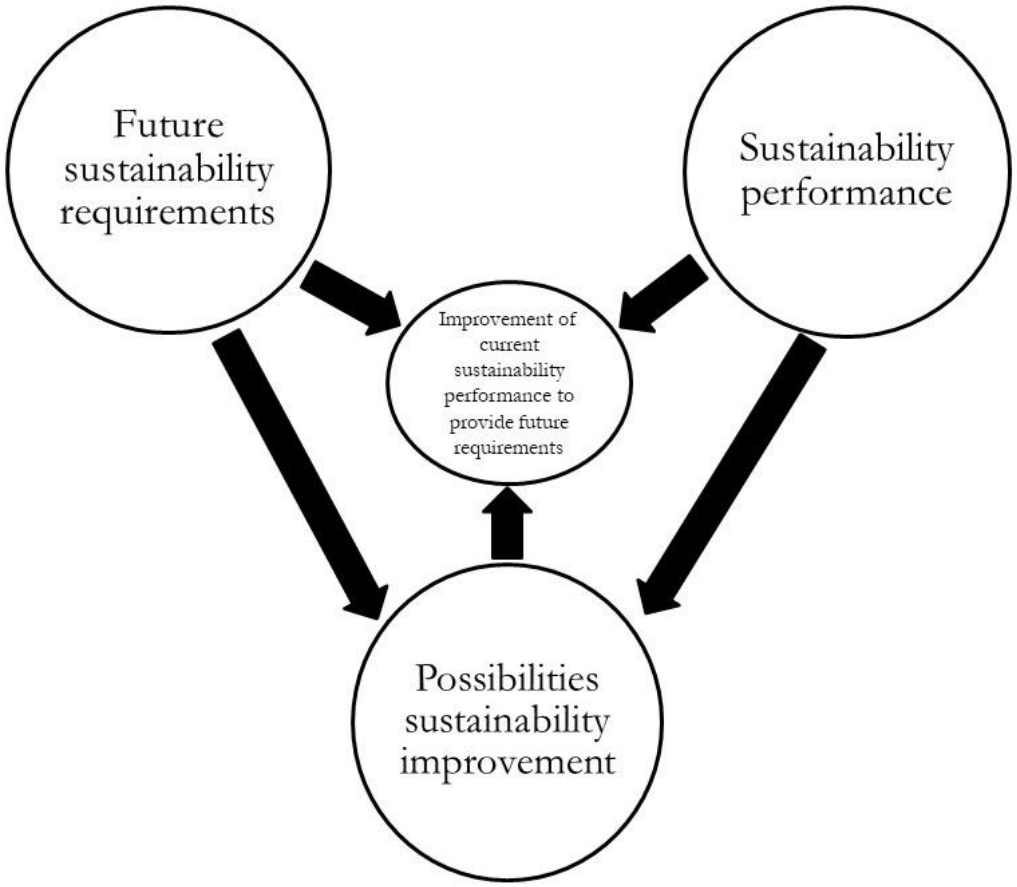

Figure 31. Synthesis between research questions

Future sustainability requirements

This research has showed that governments, clients, trade assocations and BAM its own organisation have a significant influence on the future sustainability requirements. Governmental agencies and trade assocations are compelling the building sector to become more sustainable. Building clients are demanding more sustainable products and services. Providing sustainable requirements is considered as a usefull strategy for BAM to distinguish itself from its competition.

This research has showed that future sustainability requirements will be mainly related with energy efficiency, CO_2 reduction, energy transition, a circular economy, managing waste streams and the preservation of building materials.

Sustainability performance assessment of BAM its projects

In many building project sustainability performance is assessed differently. In the infrastructural sector the sustainability plan, CO_2 performance ladder, and the ECI are predominant assessment methods, and in the utility sector there exist no predominant assessment method.

Because, the sustainability performance of projects are assessed differntly a new sustainability assessment method was required to assess the sustainability performance of projects. This "project sustainability assessment method" is based on relevant project information, used sustainability assesment method, sustainability ambitions, sustainability offer, and drivers, barriers and enablers for sustainability.

Sustainability requirements of the infrastructural projects were mainly concerned with: energy, material, ground and accesability themes. Sustainability requirements in the utility projects were also concerned with energy and materials but additionaly focused on well-being, social relevance and business climate themes.

The assessment of project sustainability performance has showed that a clients willingness and ability to incorpoarte sustainability requirements within a project is a major enabler and driver for sustainability performance.

Main possibilities for improving sustainability perforamance of BAM

BAM its corporate sustainability strategy is focused on being climate and resource positive, which is in line with current and future sustainability requirements. The research shows that BAM can improve its sustainability performance significantly, by focusing on the most important sustainability themes and requirements. The first possibility for BAM is to focus on materials and creating circular business models. The second possibility is to focus on energy and the energy transition. Thirdly, the results of this research indicate that the digitisation of the building sector can be considered as a major enabler and driver for improving the sustainability performance. Furthermore, BAM needs to collaborate more intensively with its conveyors throughout its supply chain in order to minimise its environmental impact.

9 RECOMMENDATIONS

The evaluation of four of BAM its projects in terms of sustainability is not sufficient to settle the debate on creating an appropriate sustainability business strategy. However, it does provide a first step towards additional assessments of sustainability within projects. In order to improve the validation of this research it is recommended to expand the Project Sustainability Assessment Method, and include an ex-post evaluation of the construction phase and compare these results with the ex-ante forecast of sustainability impact. This research has showed that clients attach significant value to the guarantee of environmental impact reduction. Therefore, an uniform and simple monitor system of sustainability during the construction phase may prove to be a good business model for BAM to distinguish itself from its competitors.

The ambition web has proved to be an useful tool to identify and compare sustainability ambitions of projects. However, the limited number of ambition levels hampers the ability to distinguish sustainability ambition between projects. The ambition web involves three levels which indicate if a sustainability ambition is incorporated: minimally, extra effort has been put in the topic, or significant extra effort has be put in the topic. It is suggested to expand the number of ambition levels to five, in order to make a more substantiated decision for a certain ambition level.

As a large contracting construction company it is inevitable to sub-contract several construction activities or processes, and to be dependable on suppliers. This research supports the findings of previous researches which state that supply chain collaboration is a key enabler for sustainable building. The findings of this research recommend future research on the relationship between sustainability and supply chain collaboration. Additionally, it is recommended to conduct an ex-post analysis on successful supply chain collaboration which resulted in more sustainable construction processes or materials, in order to identify possibilities for sustainable supply chain collaboration.

This research has identified a strong relation between digitisation and possibilities for BAM to distinguish itself in terms of sustainability. Next to more efficient construction processes and digital products, digitisation may prove to be a valuable business model to improve BAM its sustainability performance. It is recommended to conduct future research on the relationship between digitisation and sustainability, in order to create new innovative business models and sustainability products and services.

Contributing to a circular economy, and the managing of waste streams and preservation of building materials has been identified as one of the largest possibilities for BAM to create future business value. BAM has already committed itself to the contribution to the circular economy by delivering at least one circular project, product or service in each operating company by 2020. This research recommends future research on circular business services for BAM. This future research should provide insight in possibilities for BAM to manage materials and waste-streams in order become truly sustainable.

The last recommendation for future research is concerned with business models for energy transition. In the housing and utility sector several successful business models have been implemented during the last years. However, the infrastructural sector is slightly falling behind, and more attention needs to be paid to this energy transition. Therefore, it is recommended to conduct additional research on energy efficiency business models in the infrastructural sector. Moreover, a clear shift has been identified from fuel-intensive forms of transport to more efficient and electric modes of transport. Incorporating, measures to contribute to the energy transition may prove to be a successful sustainability strategy by providing additional future value for infrastructural projects.

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APPENDICES

Appendix A: Case study 1 Rotterdamsebaan

The first case study is focused on an infrastructural project in the city of The Hague. The case study will be described according to the five steps of the "project sustainability assessment method".

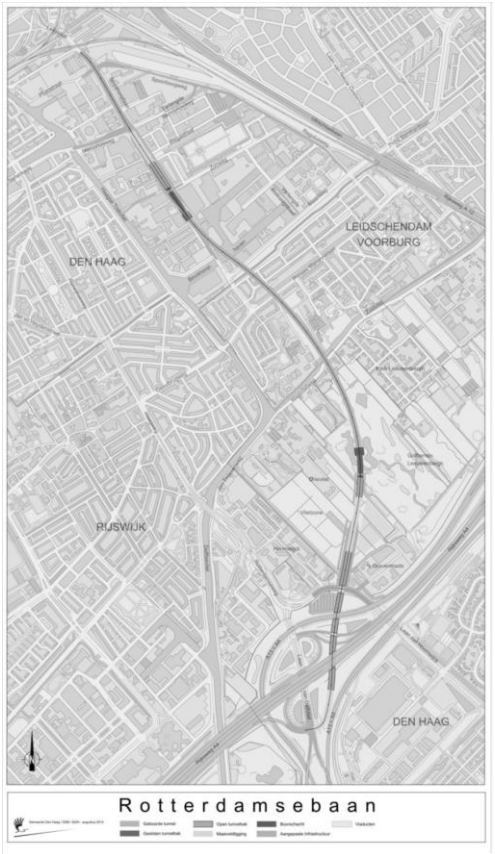

Figure 32. Trajectory Rotterdamsebaan

Phase 1: general project information

Rotterdamsebaan is a new national motorway which connects the node Ypenburg (A4/A13) and the centre ring of The Hague. The accessibility of The Hague has been in danger over the recent years and long traffic jams occur from and into the city. The most important traffic vein in the city is the Utrechtsebaan (A12), and accounts for almost 40% of transportation from and into the city. The main goals of the construction of Rotterdamsebaan are to unburden the Utrechtsebaan and to ensure the accessibility of The Hague and its neighbouring municipalities.

The contract used to tender the Rotterdamsebaan is Design-Build-Maintain (DBM) and the tender process includes a competitive dialogue. The Rotterdamsebaan will be constructed between 2014 and 2020, and the total investment is estimated at 610 million euros and is financed mainly by the central government and the municipality of The Hague. The Rotterdamsebaan will include a road of 3800 meters long and 1860 meters will constructed underground by the use of a drilled tunnel. Additionally, the project includes the connection of the Rotterdamsebaan with the centre ring and the node Ypenburg (A4/A13). The project area is relatively densely populated and the city has struggled recent years with harmful vehicle emissions.

Phase 2: sustainability assessment method

The contract has been awarded based on the economic most beneficial bid (Dutch= EMVI). This means that the contract is not only awarded based on the lowest-price, but other sub award criteria have been included such as: risk management, nuisance reduction, integral construction and sustainability. When a bid scores good on a specific sub award criteria, a fictional discount can be achieved which may reduce the bid- price, and lead to the winning of a tender. During the tender of the Rotterdamsebaan the maximum fictional discounts which could be awarded are visualized in Table 28.

Table 28. Maximum fictional discount Rotterdamsebaan

Theme	Maximum fictional discount (€)
Price	250.000.000
Sustainability	17.500.000
Risk management	22.500.000
Nuisance reduction	20.000.000
Integral construction	15.000.000
Total maximum fictional discount	**75.000.000**

As visualized in Table 28 sustainability during the construction of the Rotterdamsebaan can lead to a maximum fictional discount of the bid-price by 7%. This is a relatively high amount considering the relatively low-margins in the building sector.

The level of sustainability of an offer is assessed by using two separate methods: the CO_2 performance ladder and a sustainability plan. The distribution of the fictional discount between these two sustainability assessment methods is visualized in Table 29.

Table 29. Distribution sustainability discount

Theme	Maximum fictional discount (€)
CO_2 performance ladder	5.000.000
Sustainability plan	12.500.000
Total maximum fictional discount	**17.500.000**

Both assessment methods are divided in five levels. The audited level of a bidder on the CO_2 performance ladder determines the height of the fictional discount. The appreciation of the sustainability plan determines the other fictional discount, where level five stands for exceptional quality and level one for almost no quality.

Table 30. Fictional discount for each level

Level	Sustainability plan (€)	CO_2 performance ladder (€)
0	0	0
1	2.500.000	1.000.000
2	5.000.000	2.000.000
3	7.500.000	3.000.000
4	10.000.000	4.000.000
5	12.500.000	5.000.000

Phase 3: sustainability priorities, objectives and requirements

A major goal of the construction of the Rotterdamsebaan is to reduce CO_2 emissions, which will be assessed by the CO_2 performance ladder. Additionally the following themes have been prioritized by the client as sustainability themes, which are required to be incorporated in the construction of the Rotterdamsebaan: future value, sound, air quality, material use, energy use. The contractor is required to make a sustainability plan were it makes clear which sustainability measures it plans to incorporate, the demonstrable effect of the measures, and the way the contractor aims to verify these effects on all the sustainability themes. All the sustainability themes are shortly discussed in Table 31.

Table 31. Sustainability themes Rotterdamsebaan

Theme	Description
Future value	The future value theme of the project aims to incorporate measures which have a positive effect on the ruggedness and perception value of the work during its entire life cycle.
Noise	The sound theme of the project focuses on creating an acceptable sound level in the direct environment of the project during its operational phase. This theme focuses on creating a sound reduction which is significantly lower than the legal level.
Air quality	The aim of the air quality theme is to realize a healthy air quality level at both entrances of the tunnel, and to minimize the emission of fine dust and NO_x.
Material use	The aim of the material use theme is to minimize the use of harmful and scarce materials during the construction and operational phase, and minimizing the production of waste during the entire life cycle of the work.
Energy use	The aim of the energy use theme is to minimize the use of energy and fossil fuels during the construction and operational phase.

The sustainability ambitions of this project are visualized in Figure 33 and explained in Table 32.

Table 32. ambition web level explanation case 1

Sustainability theme	Ambition level	Explanation
Energy	3	Energy has been an important topic for this project and was included in the tender as a topic for competition. Significant effort is put into energy neutrality. The project will generate its own energy by PV-panels placed on the southern entrance of the tunnel, and the control building has been equipped with PV-panels and will be fully energy neutral. New innovative "transition fuels" and low-energy asphalt has been used to limited the CO_2 emissions
Materials	3	Materials has been an important topic for this project and was included in the tender as a topic for competition. The project has contributed to a circular economy by reusing the tunnel drill, asphalt and by using modular installations, which can be easily replaced and reused. Concluding, the waste streams of the project will be effectively managed which will result in 98% recycling. Therefore, added value is created and waste streams will be almost fully circular.
Water	2	The water theme is not included in the tender as a topic for competition, but several requirements have been set to ensure water quality, and the height of the groundwater. Because the projects includes the construction of a tunnel a lot of construction activities are concerned with redirecting groundwater. Only a few improvement requirements have been set for the water theme and therefore the ambition level is 2.
Ground	3	The ground theme is not included in the tender as a topic for competition, but several requirements have been set to ensure ground quality, and the preservation of the ground system. Excavated ground will be stored on –site, and reused in a later construction phase. The fact that the excavated ground will be fully reused indicates an ambition level of 3.
Ecology	2	The ecology theme is not included in the tender as a topic for competition, but several requirements have been set to ensure the biodiversity and ecological structures. The tunnel will become a landmark of sustainability and the entrance will be fully planted with plants that enhance the biodiversity, and require low amount of maintenance. The fact that additional effort is put in the biodiversity and ecology indicates an ambition level of 2
Space use	2	The space use theme is not included in the tender as a topic for competition, but several requirements have been set to ensure the multi functionality of the space and future value. The tunnel is constructed slightly larger than the minimal requirements, so that the tunnel can be expanded in the future.
Spatial quality	2	The spatial quality can be considered as relatively good because the road was been constructed as a tunnel so that the spatial quality stays intact. The demand for this road was relatively large because the only road towards the centre of the Hague was suffering from severe congestions. Additional effort was put in ensuring future value of the project and therefore an ambition level of 2 has been assigned
Well-being	2	The well-being theme has been partially included in the tender as a topic for competition. The nuisance of air pollution and sound pollution have been a platform for additional sustainability focus. Several measures have been taken to minimise the nuisance of the project. Therefore ambition level 2 has been assigned
Social relevance	2	The project has focused on creating social relevance for the project. Schools and universities have been included to help create new innovative and sustainable ideas. The local community will be involved in the project by reporting of the progress and sustainability developments by several media such as Facebook, newspapers, websites and billboards. Additional effort has been put in social relevance and therefore an ambition level of 2 has been assigned
Investments	2	The investment theme is not included in the tender as a topic for competition, but is partially discussed in the sustainability plan. The LCC and TCO have been partially discussed, and effort was put in the optimisation of these topics, therefore an ambition level of 2 has been assigned
Business climate	2	The business climate theme is not included in the tender as a topic for competition, but is indirectly part of this project. The construction of the new entrance road for the city of Rotterdam is partially done because of the development of the inner city business climate. Therefore, an ambition level of 2 has been assigned
Accessibility	3	The whole reason to construct the Rotterdamsebaan is to improve the accessibility of The Hague. Therefore, an ambition level of 3 has been assigned

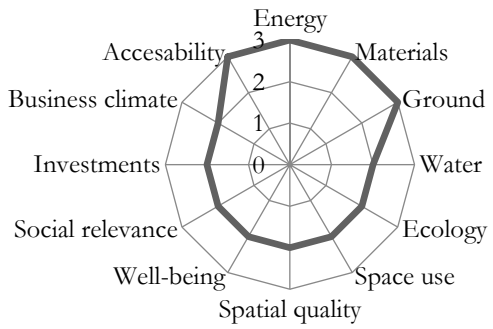

Figure 33. Project ambition web Rotterdamsebaan

Phase 4: offer of BAM

BAM has created a specific sustainability strategy for the Rotterdamsebaan called: "Trias Ecologica Rotterdamsebaan". This strategy is based on the principles of the Trias Energetica and the principles of Cradle-to-Cradle (C2C).

The aim of this sustainability strategy is to reduce its environmental impact by using three simple steps:

- **Step 1:** Tackle the problem at the source, so focus on minimizing waste (material and energy) and pollution (sound and fine dust emissions). This means doing more with less.
- **Step 2:** If the decision is made to use specific materials or energy sources, the sustainability impact has to be maximized and the harmful consequences need to be minimized. The main aim of this step is to use sustainable alternatives and closing material cycles.
- **Step 3**: Is it possible to even reduce the impact of the work, by being more efficient

The sustainability plan is focused on what BAM can provide extra on top of the requirements set by the client in Table 33 the extra measures taken by BAM will be discussed.

Table 33. BAM its extra sustainability measures for Rotterdamsebaan

Theme	Extra measures
Future value	**Increase perception value (step 1)** Energy neutral service building and roof with PV panels Green slopes to enhance biodiversity PV panels for light screens entrance tunnel Led lighting Information screen about sustainable measures Involving schools in designing sustain sustainability measures **Increase flexibility and adoptability (step 2)** Sustainable concrete C2C lighting **Enable adjustments (step 3)** Reusable Tunnel Drilling Machine Larger diameter of tunnel Modular installations
Noise	**Limit sound production (step 1)** Implementing sound reducing asphalt Implementing a continuous top layer of asphalt Dynamic traffic guidance system (green wave) **Absorbing or redirecting sound (step 2)** Implementing diffraction measures **Stopping or redirecting sound (step 3)**

Air quality	**Improve air quality (step 1)** Reduce traffic movements Using cleaner combustion technologies and fuels Dynamic traffic guidance system (green wave) **Intercept fine dust (step 2)** Implementing Fine Dust Reduction System(FDRS) **Dilute concentration(step 3)**
Material use	**Prevent unnecessary use (step 1)** Reusable pile walls by smart planning **Use renewable sources (step 2)** Use of reused asphalt with "PA stone" Reusable Tunnel Drilling Machine Recycled composites Waste management Reuse of ground material from drilling **Use finite sources as efficient as possible (step 3)** Optimization of concrete mix and dimensions
Energy use	**Prevent unnecessary use (step 1)** Implementing busbar energy system Optimization cooling technical spaces **Use renewable sources (step 2)** Implementation of pv panels Procuring clean energy from suppliers **Use finite sources as efficient as possible (step 3)** Using clean energy asphalt concrete LED lighting Logistic hub Transportation of tunnel segments by train Dynamic traffic guidance system (green wave)

Phase 5: project related barriers, drivers and enablers

During this project there were some factors which influenced the ability of BAM to distinguish itself from its competition by implementing sustainability measures.

The location of this project can be seen as both a major barrier and driver for implementing sustainability measures. Because the Rotterdamsebaan is located in a highly populated urban area there is not much room for storing materials. Moreover, the probability of nuisance from the construction activities in this urban area is relatively high. However, this high probability of nuisance provides an opportunity for contractors to implement sustainable solutions to minimize this nuisance in the form sound and air quality. The urban area provided an opportunity to incorporate innovative sustainability solutions.

The project was tendered functionally, which means that a lot of design and construction decisions were deliberately not taken by the client, to provide the contractor space to use its expertise to incorporate the project ambitions, and increase the durability and quality of the project. Moreover, a competitive dialogue was used to include contractors in the decision making process. The use of a competitive dialogue was perceived by the client and BAM as a useful method to use the expertise of the contractor to implement sustainability requirements in the project.

The Rotterdamsebaan has a lifetime of 100 years which provide opportunities to not merely focus on the short term investment, but to focus on operational cost, reusability, maintenance, adaptability and its future value. However, a lifetime of 100 year results in many risks and uncertainties. The handling of these risks and uncertainty over time proved to be a creative platform for contractors to distinguish itself in terms of sustainability.

The municipality of The Hague has set itself ambitious sustainability targets, and aims to incorporate these targets in the project Rotterdamsebaan. Rotterdamsebaan is a prestige project

and has to become a new sustainable entrance of the city of The Hague. The appearance of this project provided a possibility to incorporate sustainability.

The project Rotterdamsebaan has some challenging opportunities to incorporate sustainability. The client was willing to incorporate sustainability, which is a major driver for sustainability. Additionally, the client has used a tender process which enabled client and contractors to focus on the most important sustainability issues and incorporate these in the project. The location of this project proved to be a barrier for sustainability. However, the location provided a good basis for sustainability related competition.

Appendix B: Case study 2 Railway station Driebergen-Zeist

The second case study is focused on an infrastructural project in the city of Driebergen-Zeist. The case study will be described according to the five steps of the "project sustainability assessment method".

Phase 1: general project information

The second case study is focused on the renovation of the railway station Driebergen-Zeist. Recent years the railway station has become very crowded. Traffic jams have occurred near the railway crossings, and there has been a shortage for bicycle and motorcycle parking spaces. The existing railway station has been slightly outdated and all these problems have created an urge to renovate the existing railway station. Prorail has used a Design and Construct contract (DC) which means that Prorail is responsible for the design, and the contractor is only responsible for the construction activities of the railway station. Prorail has created a design in collaboration with Arcadis, which solves the existing traffic jams near the railway crossings by passing the rail through a widened tunnel construction. Additionally, a new train and bus station will be constructed and 600 car and 3000 bicycle parking spaces will be realized. The new station square will be located underneath the railways to ensure a safe entrance to the platforms. Lastly the railways will be expanded from three to four railways, in order to let fast intercity trains pass slow sprinter trains. Lastly, Prorail aims to realize the renovation of the railway station as sustainable as possible by making it energy neutral. The construction of this project has started in 2017 and is expected to be ready in 2021 and has an expected lifetime of 50 years. The total investment of Prorail is estimated to be around €173 million. However, the construction activities roughly cost only €90 million.

Figure 34. Impression design station Driebregn-Zeist

Phase 2: sustainability assessment method

The contract has been awarded based on the economic most beneficial bid (Dutch= EMVI). This means that the contract is not only awarded based on the lowest-price, but other sub award criteria have been included such as: nuisance and sustainability. During the tender of station Driebergen-Zeist, the maximum fictional discounts which could be awarded are visualized in Table 34.

Table 34. Maximum fictional discount station Driebergen-Zeist

Theme	Maximum fictional discount (€)
Price	70.000.000
Sustainability (CO_2)	10.000.000
Sustainability (ECI)	10.000.000
Nuisance reduction (road)	5.000.000
Nuisance reduction (surroundings)	5.000.000
Total maximum fictional discount	**100.000.000**

Sustainability has played a significant role during the tender, and the maximum fictional discount can become 20% of the total bid-price. The level of sustainability of an offer is assessed by using two separate methods: the CO_2 performance ladder and the ECI.

The audited level of a bidder on the CO_2 performance ladder determines the height of the fictional discount. The height of the fictional discount based on the CO_2 performance ladder is visualized in Table 35.

Table 35. Fictional discount for each level CO_2 performance ladder

Level	CO_2 performance ladder (€)
0	0
1	1.000.000
2	2.000.000
3	4.000.000
4	7.000.000
5	10.000.000

The second assessment method is by calculating the ECI of sustainability enhancing design alterations. The ECI is focused on determining the environmental impact of materials on a specific design. Arcadis and Prorail have made a reference design and the total ECI of the reference design is €2.597.710. Prorail aims to reduce the environmental impact of its bidders designs and has set a target ECI of €1.958.283. In other words, if a design its ECI has reduced the ECI of the reference design less than 40%, the bidder is awarded with no fictional discount. However, if a design its ECI is lower than the target value a bidder is awarded with the maximum fictional discount of €10.000.000, as visualized in Table 36.

Table 36. Fictional discount for each level ECI

ECI percentage	ECI Value (€)
<40%	0
40%-55%	1.000.000
56%-70%	2.000.000
71%-85%	4.000.000
86%-100%	7.000.000
>100%	10.000.000

Phase 3: sustainability priorities, objectives and requirements

One of the most important goals during the project of station Driebergen-Zeist is to make it near energy neutral. Additionally, all the energy and materials used during the construction of the station need to be minimized, and the project has to be as transparent as possible. Therefore, Prorail has included requirements to only use sustainable timber and to work according to BREEAM-NL-MAN2 standards. Additionally, Prorail finds it of great importance to communicate its sustainable practices to its surroundings. Therefore Prorail demands its contractor to communicate the sustainable measures included in the project Driebergen-Zeist to be reported upon.

Because station Driebergen-Zeist is such a multidisciplinary project it may be difficult to focus the themes on which sustainable improvements are feasible. Therefore Prorail and Arcadis have identified the elements of the project which use most materials or are the most harmful to the environment. The most important elements according to the client are: ground works, concrete works, water closing layer, steel works and final hardening. Therefore these elements have been included in the ECI and other less important elements have been neglected because of time constraints. The scope of the ECI calculations includes all materials which will be permanently placed or taken out the existing project situation. Furthermore, the ECI calculations only focus on the construction, maintenance and end-of-life phase. So, the operational phase will not be included in the ECI calculations because it is presumed that all the bidders will have the same operational phase. This means that nobody can distinguish itself during this phase, and calculating the ECI of this phase will only result in extra work. The sustainability ambitions of this project are visualized in Figure 35 and explained in Table 37.

Table 37. ambition web level explanation case 2

Sustainability theme	Ambition level	Explanation
Energy	3	Energy has been an important topic for this project and was included in the tender as a topic for competition. Significant effort is put into energy neutrality. The project will generate its own energy by PV-panels placed on the station roof. Additionally, significant effort was put in the minimisation of CO_2 emissions by optimising the design using DuBoCalc.
Materials	3	Materials has been an important topic for this project and was included in the tender as a topic for competition. Especially the optimisation of building materials using DuBoCalc has been a method to reduce the harmful environmental effects. Materials have been one of the most important sustainability themes during this project.
Water	2	The water theme is not fully included in the tender as a topic for competition, but several requirements have been set to ensure water quality, and the height of the groundwater. Because the projects includes the construction of a tunnel underneath the railway, a lot of construction activities are concerned with redirecting groundwater, such as the water closing layer. Several improvement requirements have been set for the water theme and therefore the ambition level is only 2.
Ground	3	The ground theme has been included in the tender, and was one of the most significant components of the DuBoCalc calculations, due to the high quantities of excavated materials. Several requirements have been set to ensure ground quality, and the preservation of the ground system. Excavated ground will be stored on –site, and reused in a later construction phase. The fact that the excavated ground will be fully reused indicates an ambition level of 3.
Ecology	2	The ecology theme is not included in the tender as a topic for competition, but several requirements have been set to ensure the biodiversity and ecological structures. The rural impression of the area needed to be preserved and several requirements have been set during the design phase to ensure the preservation of biodiversity and ecology.
Space use	2	Space use is a very important theme when constructing a railway station because it connects several transportation modes, and includes several functionalities. Combining functionalities has been an important topic during the design phase but during the tender phase a limited number of additional requirements have been set on this topic and therefore an ambition level of 2 has been assigned
Spatial quality	3	The spatial quality has been an important sustainability topic during this project. Significant effort has been put in the optimising the user, future and perception value of the railway station. The user has been the most important inspiration for the design of the project. Especially the flows of users from one transportation mode to another has been an topic of extensive research. Because of the significant additional effort put in the optimisation of spatial quality the ambition level of 3 has been assigned.
Well-being	3	The well-being theme has been extensively included in the project. The nuisance of construction activities has been minimised by optimising and simultaneously conducting construction activities. Moreover, the nuisance has been minimised for train users by planning all construction activities in only 4 weekends. Significant effort has been put in the well-being of the users and therefore the ambition level of 3 has been assigned.
Social relevance	2	The project has focused on creating social relevance for the project. The local community will be involved in the project by reporting of the progress and sustainability developments by several media such as Facebook, newspapers, websites and billboards. Additional effort has been put in social relevance and therefore an ambition level of 2 has been assigned
Investments	2	The investment theme is not included in the tender as a topic for competition, but is partially discussed in the sustainability plan. The LCC and TCO have been partially discussed, and effort was put in the optimisation of these topics, therefore an ambition level of 2 has been assigned
Business climate	2	The business climate theme is not included in the tender as a topic for competition, but is indirectly part of this project. The construction of a new railway staion with additional railways is partially done because of the development of the business climate. Therefore, an ambition level of 2 has been assigned
Accessibility	3	One of the most important reasons to construct the new railroad station is to improve the accessibility Driebergen-Zeist, and other cities connected to this railway. Therefore, an ambition level of 3 has been assigned

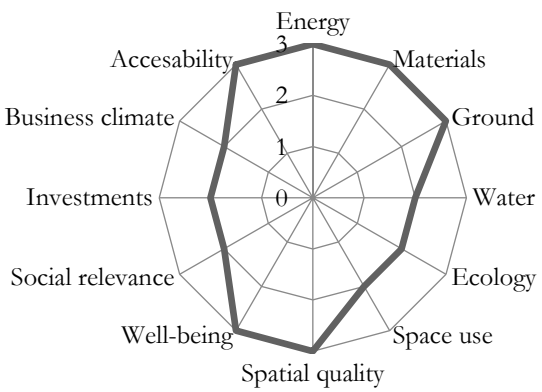

Figure 35. Project ambition web Driebergen-Zeist

Phase 4: offer of BAM

BAM has conducted the ECI calculations by using the tool DuBoCalc and has scored an ECI of €1.955.213, this value is lower than the target ECI which means that BAM was awarded with the maximum fictional discount. In Table 38 the reference design and BAM its design can be compared per element.

Table 38. ECI values of BAM and reference design

Element	Reference(€)	BAM(€)
Ground work	690.481	153.000
Concrete work	732.550	608.459
Water closing layer	232.879	311.024
Steel work	565.100	598.647
Final hardening	376.700	283.312
Total	**2.597.710**	**1.955.213**

As can be seen in Table 38 the main environmental cost reduction has been made on the groundwork. In the reference design the excavated material was transported to an off-site location, while BAM has used additional space on the building site to store excavated materials. By using an improved site and building planning BAM was able to store excavated materials on location while Arcadis calculated that most materials need to be transported to an off-site location 25 kilometres from the building site. Due to the high quantity of excavated materials this has realized a huge environmental cost saving.

The concrete work design of BAM has also a lower ECI than the reference design. The main reason for this reduction is that BAM has performed a LCA which proved that their concrete mix is more sustainable than that of the reference design.

The water closing layer of BAM its design has a higher ECI than the reference design. Bidders were required to perform a LCA on the water closing layer and the LCA of BAM was significantly higher than that of the reference design. The higher ECI can be explained by an error in the calculations used by Prorail in the reference design. The reference design has used the wrong quantity of water closing material. Because this material can only be storaged in the hollow spaces of the ground which is roughly 35%, the ECI of Prorail its reference design is slightly lower than BAM its design.

The steelwork design of BAM has a little higher ECI than the reference design. BAM has conducted a LCA on the steel used for sheet walls and the reinforcement of concrete. The LCA proved that the Environmental cost of the steel used in the design is significantly lower than the steel of the reference design. However, the ECI of BAM is still higher than that of the reference design. The

only way this can be explained is because the quantity of steel used in the reference design is significantly lower than that of BAM its design. BAM has optimised its steel design and believes that the reference design has not included all components of the steelworks.

The last component is the final hardening. The final hardening of BAM its design is significantly cheaper than the reference design. This difference cannot be impacted by optimizing quantities because the surface which requires final hardening is predetermined. So, this difference can be explained by the use of materials. A significant difference can be explained by the use recycled ground.

BAM was able to earn the maximum fictional discount by optimizing its sustainability on the key elements of the design. However, some elements scored a little higher that of the reference design. Because the ECI calculations of Prorail and Arcadis have never been made public it is difficult to explain some of these differences.

Phase 5: project related barriers, drivers and enablers

During this project there were some factors which influenced the ability of BAM to distinguish itself from its competition by implementing sustainability measures.

The station area combines many functions such as railway station, bus station, parking place for cars and bikes and a couple of roads. The combination of all these functions has proven to be a good basis for implementing sustainability measures. Because there exist so many functions, in a relatively small area, many synergy advantages have been made.

The station is located in a rural area and is surrounded by forests and estates. This typical "green" environment could be a good basis for incorporating flora and fauna within the project. However, hardly any requirements have been set by the client to incorporate the sustaining of the rural appearance. The rural location of the project provided opportunities for the storage of building materials, which stimulated the flexibility and reduced the transport distance of materials to off-site locations.

The main sustainability focus during the tender was on CO_2 reduction and on the environmental impact of materials. These two topics have the largest impact on the environment for this specific project, and therefore are most relevant to reduce.

The willingness of the client to implement GPP in this project was a major driver for the level of sustainability in this project. Prorail has set ambitious organisational targets regarding sustainability, but was not successful in incorporating these in the project. Prorail used a traditional contract were the design was procured separated from the construction, what can be classified as a barrier for the implementation of sustainability measures. Another barrier for sustainability is the fact that sustainability was incorporated in the project, after the design was finished and many decisions have been taken. The product was almost entirely designed and therefore contractors could merely distinguish itself on the process. Moreover, the client was not able to specify its sustainability ambitions and used an ECI to test the sustainability designs of the bidders. The calculations of the reference design have never been made public so contractors did not know which decisions have been made in the reference design related with sustainability. This did not provide a good basis for sustainability related competition. Furthermore, all contractors received the highest fictional discount for this project and therefore sustainability proved to be not distinctive.

Appendix C: Case study 3 ABN AMRO pavillion

The third case study is focused on a building project in the city of Amsterdam. The case study will be described according to the five steps of the "project sustainability assessment method".

Phase 1: general project information

Figure 36. Design impression ABN AMRO pavilion

The third case study is a building project in the utility sector and focuses on the construction of a newly build office building. The office building has been constructed between July 2015 and December 2016. The construction of the office building has been combined with the renovation of the neighbouring Gustav Mahlerplein and the construction of new underground bicycle garage. The construction of these separated projects is integrated to reduce the construction time and nuisance. The new office building will consist of roughly 3400 m^2 gross floor surface and has roughly costs €10 million. The office building will consist of a roof terrace flex working-spaces on the ground floor and meeting rooms in the basement. This project can be called sustainable because all materials are designed to be nearly 100% demountable and circular. This means that almost all materials can be reused in new building projects. All materials can be demounted except the concrete basement container. BAM has been engaged during the early design phase of the building and has collaborated closely with ABN AMRO to create a circular office building. BAM has created an extensive BIM model to design the office building and has incorporated extensive "material passports", which hold all the material specifications to ensure the future reusability of materials.

Phase 2: sustainability assessment method

The client ABN AMRO did not use a specific sustainability assessment method to assess the sustainability performance of BAM. BAM was included early during the design process to help realize a circular office building. So, the design of the new office building was tested against the definition of circularity. Circularity can be defined as: (1) raw materials in existing supply chains are utilised in an efficient and high-quality manner, (2) in cases in which new raw materials are needed, fossil-based, critical and non-sustainably produced raw materials are replaced by sustainably produced, renewable and generally available raw materials when possible, (3) new production methods and products will be designed for a circular economy , areas will be reorganised and new ways of consumption will be promoted in order to give an extra boost to the desired reduction, replacements and utilisation of raw material for strengthening of the economy. Additionally, the project team aimed to audit the sustainability performance of the design by using a BREEAM certificate.

Phase 3: sustainability priorities, objectives and requirements

Table 39. ambition web level explanation case 3

Sustainability theme	Ambition level	Explanation
Energy	2	Effort has been made to reduce energy use during the operational phase by implementing new innovative installations which run on DC. The office building does not generates its own electricity and therefore only an ambition level of 2 can be assigned.
Materials	3	The whole project was focused on constructing a circular office building. Because every design and construction decision was tested against the principle of a circular economy and material passports have been included for the building materials this theme can be assigned with an ambition level of 3.
Water	1	Surface water is not part of the site location and the only relationship with water is with the groundwater. Minimal requirements have been met to ensure the quality and height of the groundwater. No additional effort has been made on this theme and therefore an ambition level of 1 has been assigned.
Ground	1	The ground theme has not been an important topic during this project due to the limited excavation activities. Minimum additional effort has been put in the improving of the quality of the ground and therefore an ambition level of 1 has been assigned.
Ecology	2	The location of the project is in a very densely populated area with lots of office buildings. Additional effort has been put in the improvement of the existing biodiversity and ecology by constructing a roof terrace with lots of plants in order to enhance the ecology. Therefore an ambition level of 2 has been assigned.
Space use	3	The office building is constructed according to the circular economy principle. Almost every building components is easily demountable which enables the building to be adapted in the future. Additionally, the building is multi-functional and can be used by many different users. The significant extra effort on space use and the circular building indicates an ambition level of 3.
Spatial quality	3	This project can be seen as a prestige project of the client to show its commitment with a circular economy. Therefore significant extra effort has been put into the perception, user and future value of the project. The building if designed with large windows which increases the perception value. Moreover, because the building is designed according to the circular principle, the building can be easily adapted which ensures its future value. The significant extra effort indicates an ambition level of 3.
Well-being	3	This project is constructed simultaneous with a neighbouring bike basement in order to reduce the nuisance. Additionally significant effort has been put into the indoor quality of the building to maximise productivity and the effect on health and well-being. The significant extra effort indicates an ambition level of 3.
Social relevance	3	The building can be used for various purposes and groups of people which increase the social relevance of the project. The project has included a café on the roof where people from neighbouring office building can spend their lunch time in a "green" environment which is scarce in the neighbourhood of the project location. The significant extra effort indicates an ambition level of 3.
Investments	2	The building project was funded by the client in order to show their commitment to a circular economy. The project can be regarded as a pilot project on how to construct a circular building. TCO and LCC have been partially mapped in order to understand the working of a circular building. Therefore an ambition level of 2 has been assigned.
Business climate	3	The project has put significant effort into the stimulation of the local business climate. The building includes conference rooms and flexible working spaces to stimulate the local business climate. Additionally, the project includes a café on the roof for people to meet and enhance the business climate. The significant extra effort indicates an ambition level of 3.
Accessibility	2	The location of the project is on one of the most densely populated areas of Amsterdam. The accessibility of the building is therefore very important. The construction of a bike garage has contributed to the accessibility of the area by a sustainable mode of traffic. Therefore an ambition level of 2 has been assigned.

The most important sustainability priority during this project was that the office building needed to be circular. During the entire design and construction phase each decision needed to be tested against the definition of circularity. Additionally the project team aimed to audit circular and sustainable design of the office building by using the BREEAM-NL assessment method which means that the design was assessed on the following sustainability themes: management, health & well-being, energy, transportation, water, materials, waste, land use & ecology and pollution. In order to score good on this assessment, all these themes needed to be incorporated in the design. The sustainability ambitions of this project are visualized in Figure 37 and explained in Table 39.

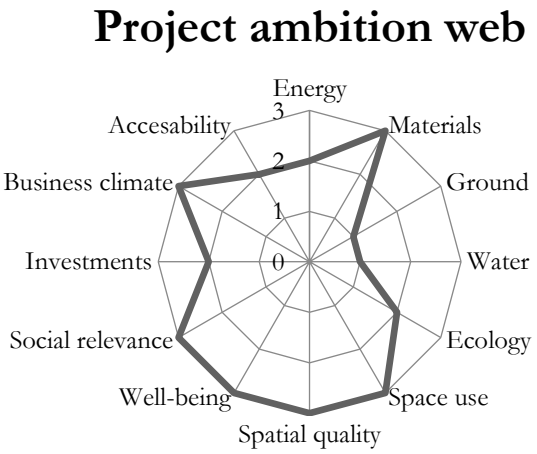

Figure 37. Project ambition web ABN AMRO pavilion

Phase 4: offer of BAM

The sustainability of the design was audited by the BREEAM-NL method and received a score of 75.75% which means that the project received a 4 out of 5 star rating. The sustainability scores for each project are visualized in Table 40.

Table 40. Sustainability score BREEAM-NL

Theme	Weighting (%)	BREEAM score (%)
Management	12	68.75
Health & well-being	15	43.04
Energy	19	100
Transportation	8	85.65
Water	6	75.00
Materials	12.5	41.11
Waste	7.5	85.71
Land use & ecology	10	72.73
Pollution	10	58.54
Total	**100%**	**Total score= 75.75**

From Table 40 can be concluded that the ABN AMRO pavilion has scored extremely well on the themes: energy, transportation and waste. However the design scores significantly worse on themes such as health & well-being, materials and pollution.

The main reason that the design scores poor on health and well-being is because the design consist of large open spaces without separation walls. The BREEAM-NL assessment method focuses on acoustics, protection from natural lighting, and thermal and light adjustments possibilities. Because the design has such an "open" character with large glass facades it may be difficult to control sound, temperature and light inside the building. Furthermore, the design scored poorly on the material theme. The building was designed to be able to demount materials and reuse these efficiently, therefore materials were selected with a relative high lifetime to ensure the reusability of the building materials. However the BREAAM-NL assessment methods focused mainly on selecting materials with a minimum environmental impact during construction and neglected the impact of the material during exploitation and reuse.

However, the design did received credits for several other sustainability techniques. For example, the design included the implementation of inorganic salt-based Phase Change Materials (PCMs) in the floor which can storage and release heat. For the main load bearing construction local wood

has been used which is more sustainable than wood which has been transported for a long distance. The design also included a new concept called: "urban mining". This concept focuses on reusing materials from other buildings. In the direct neighbourhood of the project, BAM was working on the demolition of another office building, and the window frames of this building were just replaced a couple of years ago and were in excellent condition. These window frames could easily be reused in the new office building without impact the quality of the total product. In order to be able to reuse more materials in future project BAM is actively including "big data" in BIM designs. Especially material specifications are included in the BIM model so that during future demolition of buildings specific materials can be easily reused because the material specification is known. This process is called using "material passports" and can be extremely helpful to reduce waste because: "Materials without information can be seen as waste". Moreover, the project team required its supply chain to help the design to become more circular. A good example of a circular supply chain is the elevator which is installed in the building. The supplier Mitsubishi installs the elevator in the building and is not paid for the product of the elevator, but for the service of transporting people between floors. After the life-time of the building, the elevator becomes property of the supplier again which can more easily reuse the materials because it knows which materials have been used to construct this elevator. Lastly, the building includes PV-panels and heat storage and recovery systems in the ground of the project.

Phase 5: project related barriers, drivers and enablers

During this project there were some factors which influenced the ability of BAM to distinguish itself from its competition by implementing sustainability measures. The client ABN AMRO has incorporated circular economy as one of its corporate goals, and this project was considered a possibility to show their commitment to contribute to a circular economy. This commitment of the client enabled BAM to specifically focus on designing a circular building and less on the investment cost of the building. Every design and construction decision was tested against the principles of a circular economy, which aims to maximize the high quality reusability of materials and building components.

The focus on creating a circular and sustainable office enabled BAM to incorporate some pilot projects within the office building. For example new installations are used which use direct current, and therefore use less energy during its operational phase. The electricity connections in normal office buildings use alternating current and many installations needed to be designed specifically for this project, which made them more expensive. Because some of the installations are relatively new the operational costs and reliability are somehow uncertain and therefore monitoring of these installations is required.

The fact that BAM was planning to build a new bicycle garage at the adjacent Gustav Mahlerplein enabled BAM to combine these projects and therefore reduce nuisance and the building time. This integral approach made many synergy advantages possible such as the optimization of material delivery, planning and reducing transport distance of machineries.

Furthermore, the early involvement of suppliers made it possible to make integrated contracts which may lead to a higher sustainability performance. Involving suppliers early in the project made it possible to create possibilities for suppliers to abjure its products after the buildings its lifetime. This increases the reusability because a supplier knows exactly which materials have been used in the product, and therefore can reuse materials or product more efficiently.

Especially, the use of material specifications was driving the sustainability performance of this office building. Material passports have proven to be a good platform for a circular economy because: "Building materials without information, are just waste".

Appendix D: Case study 4 Contact RHDHV

The fourth case study is also focused on a building project in the city of Amsterdam. The case study will be described according to the five steps of the "project sustainability assessment method".

Phase 1: general project information

Royal Haskoning DHV is looking for a new office building in Amsterdam. The office buildings have to provide working spaces for 130 employees, and have to stimulate collaboration. Therefore the client believes it needs roughly 1800 m^2 gross surface area, and at least 30 parking spaces. The client believes in "the urban challenge" which means that existing buildings need to be renovated and reused instead of building entire new office buildings. Therefore, the client is looking for an existing building which can be reused as office building. The client wants to rent the office building for a minimal period of five years and is looking for a contractor which can help to find a suitable building, and renovate this building to ensure it suits the corporate vision of Royal Haskoning DHV. Furthermore, the contractor is responsible for the maintenance and exploitation of the building which makes this project a very integrated contract with Design- Build- Finance-Maintenance and Operate (DBFMO) components.

Phase 2: sustainability assessment method

This project is tendered by using three main award criteria as visualized in Table 41. During the tender phase will be focused on the housing concept, the total process, and on how a building owner will be persuaded to participate in this project. After the contractor has been awarded with the project, a project team will be created, which will actively search for a suitable building. After a suitable building has been found, the building will be renovated to realize the housing concept, as submitted during the tender.

Table 41. Award criteria CoNtAcT RHDHV

Award criteria	Description
Housing concept	The incorporation of requirements and ambition(as discussed in phase 3)
Process	Plan to select a building Plan for design, construction and exploitation Description of project team Planning (for each phase) Distribution of responsibilities Contractor requirements for client
Participation	Innovative business model Commitment of building owner

Phase 3: sustainability priorities, objectives and requirements

The client has set some requirements and ambitions for its new office building, these are stated in Table 42 & Table 43 and visualized in Figure 38. Additionally, the ambition levels are explained in Table 44. The requirements are general conditions which need be incorporated in the plan, and the ambitions provide space for bidders to distinguish themselves from the competition.

Table 42. Requirements RHDHV

Requirements	Description
Planning	The office needs to be ready for use in week 48 2016.
Period of exploitation agreement	The period of the exploitation agreements is 5 years.
Location and accessibility	The location of the building is in Amsterdam and is located within 5 minutes of an intercity station.
Exploitation fee	The maximum exploitation fee available by the client is €500.000. on a yearly basis. This fee includes the costs for functioning and maintenance of the office building.

Table 43. Ambitions RHDHV

Ambitions	Description
Energy neutrality	Energy neutral office, use of renewable energy and monitoring of energy use
Health and well-being	Equilibrium between: comfort, influence ability, eligibility and meaningful design.
Resources and materials	Use of reusable and recycled materials, use of material contracts and creating separated waste flows
Multi functionality	Creating a flexible working environment, possibility for increasing/reducing the office surface

Table 44. ambition web level explanation case 4

Sustainability theme	Ambition level	Explanation
Energy	3	Effort has been made to reduce energy use during the operational phase. Adi6tionally the building is equipped with PV-panels in order to generate its own energy demand and therefore become energy neutral. Additionally, significant effort has been put in the reduction of CO_2 emissions and therefore an ambition level of 3 can be assigned.
Materials	3	Because the materials are not sold as a product(building) to the client, but rented for a certain period of time, the building materials remain property of the investment party and the contractor. The shift from building owning to new circular business cases where materials are merely used for a period of time before they are reused or recycled for other purposes is in line with the circular economy principle. The fact that building materials remain property of the contractor which can easily reuse these materials is a strong motivation for an ambition level of 3 on the material theme.
Water	1	Surface water is not part of the site location and the only relationship with water is with the groundwater. Minimal requirements have been met to ensure the quality and height of the groundwater. No additional effort has been made on this theme and therefore an ambition level of 1 has been assigned.
Ground	1	The ground theme has not been an important topic during this project due to the limited excavation activities. Minimum additional effort has been put in the improving of the quality of the ground and therefore an ambition level of 1 has been assigned.
Ecology	1	Minimum extra effort has been put in the enhancement of biodiversity and ecological structure. The building is in line with ecological legislation and therefore an ambition level of 1 has been assigned.
Space use	2	The selection of an office building included the requirement to include the possibility to expand and decrease the office space. The space will be arranged flexible and multifunctional so that the number of working spaces can be adapted. Because of the additional effort on space use an ambition level of 2 is assigned.
Spatial quality	2	This project has included extra effort on the spatial quality of the building. The building was required to be perceived as sustainable, which was in line with the corporate identity of RHDHV. Therefore significant extra effort has been put into the perception, user and future value of the project. The extra effort indicates an ambition level of 2.
Well-being	3	The project included several requirements to positively contribute to the direct surrounding of the office building. The main requirement was concerned with the urban challenge, and included the requirement to enhance the lives of the neighbouring population by providing services and work spaces for small companies. The significant extra effort indicates an ambition level of 3.
Social relevance	3	The building can be used for various purposes and groups of people which increase the social relevance of the project. The project has included a café in the building where people from neighbouring office building can spend their lunch time. The significant extra effort indicates an ambition level of 3.
Investments	3	The client required the contractor to design an investment plan where investment parties were included to participate in the project. Investing in sustainability measures is a hot topic for investment parties and creating new business and investing models may prove to be an excellent step towards more sustainable building. The significant effort in creating a innovative sustainable investment model indicates an ambition level of 3.
Business climate	3	The project included an requirement to enhance the business climate of the region, and providing opportunity for small business to work or rent parts of the office building. The significant effort to enhance the business climate of the area indicates an ambition level of 3.
Accessibility	2	The accessibility of the office building was also included as a requirement for the project. The location of the building needed to be within 15 minutes of an intercity station, and within 5 minutes of another public transportation station. However, the project has a limited impact on the accessibility for its users and therefore an ambition level of 2 has been assigned.

Figure 38. Project ambition web CoNtAcT RHDHV

Phase 4: offer of BAM

BAM was able to provide a plan which included the general conditions, and distinguished itself on the ambitions of RHDHV. Especially the investment and finance components were complicated and therefore these components will be shortly discussed and visualised in Figure 38. The client RHDHV has only one contractual relation with the building owner. RHDHV pays rent to the building owner, for the use of the building (including Gas Water & Electricity), for new equipment & installations and for exploitation and maintenance services (relation 1). The investing party, invest in upgrading and renovating the existing building (relation 2), and receives a periodically compensation. The building owner is the client for the renovation of the building, and owns the new equipment and installations, for which it compensates in the investing party. The contractor is responsible for the maintenance and service required for the new equipment and installations (relation 3). Lastly the contractor is responsible for maintenance services of the building during the contract (relation 4).

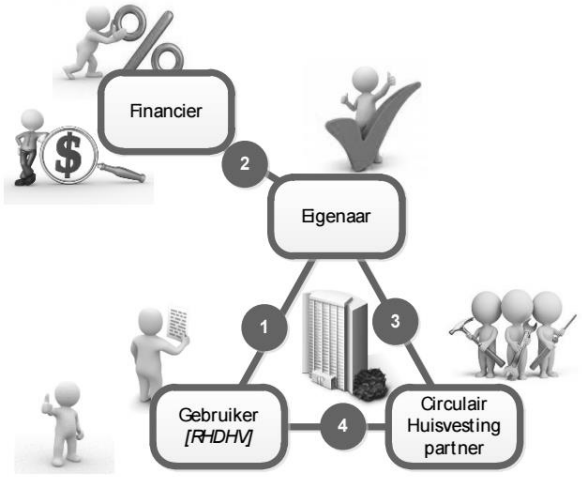

Figure 39. Stakeholder relations RHDHV office building

Phase 5: project related barriers, drivers and enablers

The new innovative business case can be seen as a major enabler for sustainability within this contract. The contract can be categorised as integrated, because it includes many different tasks such as: designing, building, maintenance and financing. But, also components such as searching for a location and collaboration have been included in the contract.

The fact that the project location was not predetermined was driving the sustainability possibilities and competition. The requirements for the location were very functionally specified, which provided contactors with lots of design freedom. Moreover, the fact that the office needed to be located in an existing building can be categorised as sustainable, because hardly any new materials need to be used, and the existing materials of the building can be mostly reused. Additionally, this project was located in a lower class area of Amsterdam and provides opportunity for business develo0ment in this area.

The fact that the client does not actually possess the building was driving the contractor to become more sustainable and think more circular. Normally, a contractor is focused on the construction of a certain product and after it is finished it becomes property of the client. In this project the contractor was responsible for the renovations and installation of the sustainability upgrades and maintenance. Furthermore, the contractor was responsible for the package after the period of exploitation. Therefore the contractor was forced to focus on the reuse of the installation after the period of exploitation.

The period of exploitation can also be seen as a major barrier for sustainability, because it causes high level of uncertainty about the return on investment. The period of exploitation is essentially 5 years. However, there is a possibility to extent this contract for a longer period of time. The depreciation, life-time of the package, and period of exploitation are relatively uncertain and will largely impact the profitability for the contractor in this project.

Finding investment parties is not always an easy task and can be quite uncertain. However, investments in sustainability and circular economy are popular. Including investment parties within new innovative projects can enable future sustainability investments. Close collaboration with investing parties may drive sustainable building and a circular economy.

New innovative business cases, such as this project, stimulate contractors to step out of their comfort zone and come up with new sustainable solutions. When clients their requirements are set more functionally, contractors can make maximum use of their expertise and relationships to develop a sustainable project with maximum value for their client.

Appendix E: Sustainability requirements in BAM Infra its projects 2015-2017

Sustainability has been an important topic during tenders of building projects. Between June 2015 and June 2017 a total of 40 projects have been tendered and won by BAM Infra, with some form of sustainability requirements. The tender price of 17 projects were lower than €10 million, 11 projects were lower than €100 million and 12 projects were tendered for more than €100 million.

The sustainability competition was based on different sustainability topics and can be divided in 5 categories: circular economy, ECI calculations, CO_2 equivalent calculations, Sustainability plan and the CO_2 performance ladder.

In 28% of the projects a circular economy has been an important topic for competition. These projects were often tendered by provinces and municipalities, and the tender price was often lower than €10 million. Moreover, in 23% of the projects some sort of CO_2 equivalent calculations were required. All the CO_2 equivalent calculations were required by provinces and municipalities. In 43 % of the projects sustainability competition was (partially) based on a sustainability plan. The sustainability plan was also most often required by provinces and municipalities.

The CO_2 performance ladder and ECI calculations were most often used by Rijkswaterstaat and Prorail. The CO_2 performance ladder was used in 63% of the projects, and ECI calculation were required in 65% of the tenders. Rijkswaterstaat and Prorail have incorporated the CO_2 performance ladder and ECI calculations in every tender won by BAM Infra between 2015 and 2017. The tender price of the projects of Prorail were mostly between €10-100 million, and an average of 15% of this price was reserved for a fictional discount on sustainability. The tender price for Rijkswaterstaat was most often above €100 million, and an average of 13% of this price was reserved for a fictional discount on sustainability. Provinces and municipalities used an average of 14% of the tender price for a fictional discount on sustainability. The average share of sustainability compared to the total tender price is visualised in Figure 40 for 2015-2017.

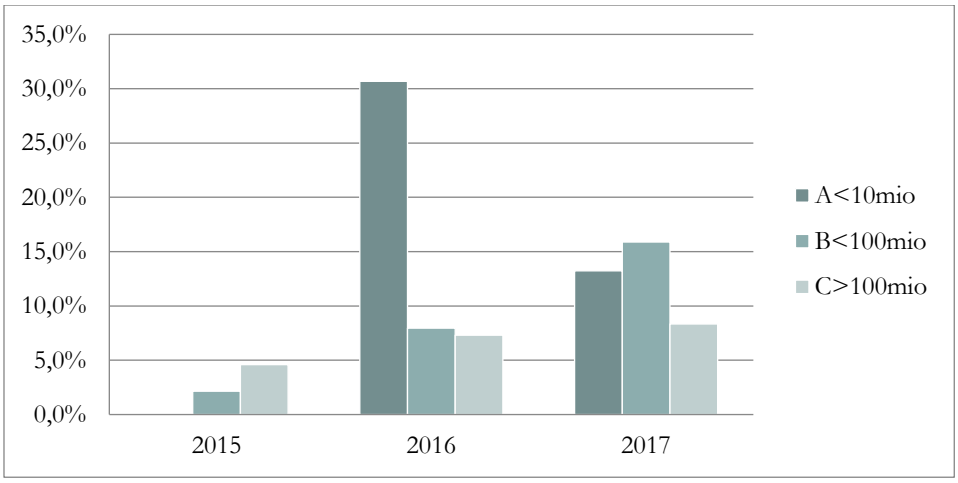

Figure 40. Average share of sustainability compared to the tender price(2015-2017)

Appendix F: Ambition-web level explanation

In this appendix the ambition-web will be more extensively discussed. The ambition-web consist of 12 sustainability themes. The project team is required to determine to what extent certain sustainability themes will be incorporated during projects. The ambition level is mainly influenced by the organisational goals of the client and the contractor, and by the specific project specifications. After the project team has determined the ambitions levels for all sustainability themes, the feasibility of these ambition levels need to be determined, and specific project sustainability goals need to be formulated.

During this research the sustainability ambition levels have been ex-post evaluated by using project related (tender) documents. The sustainability ambition levels have been ex-post evaluated in order to determine which sustainability themes are predominant in the utility and infrastructural sector. In order to ensure the validity of the determined ambition levels for the projects, all sustainability themes in the ambition-web will be discussed to scope what kind of sustainability measures align with which level of sustainability ambition for every assessed project. The sustainability ambition web is visualised in Figure 41.

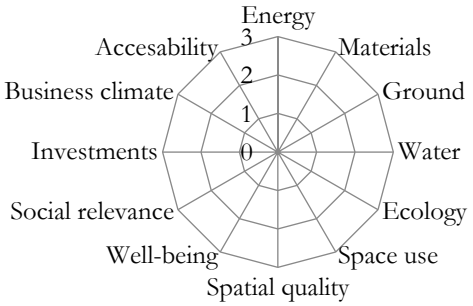

Figure 41. Ambition web

The ambition web includes 12 sustainability themes and assesses the sustainability ambition levels of a certain project on a scale from zero to three. The location of sustainability themes is randomly assigned over the web and therefore the centre of gravity of the figure does not possesses much meaning on its own, except visualising the distribution of ambition levels of a certain project. However, the ambition web provides opportunity to compare several ambition-webs with one another and identify the most common sustainability themes.

The ambition levels are distributed as follow:

1. Level one means that the largest sustainability load on a specific theme has to be determined, and that this load may not exceed the minimum requirements.
2. The second level means that certain reduction goals will be set for a specific theme.
3. The third level means that a new added value is created: rather than "less bad" the negative impact on a certain theme has become zero or even a positive sustainable contribution is made on a certain theme.

The sustainability themes are discussed in Table 45.

Table 45. Description sustainability themes

Sustainability theme	Description
Energy	The energy theme is concerned with the energy use and generation during all life-cycles of a project, and with all corresponding CO_2 emissions.
Materials	The material theme is concerned with minimising the negative environmental effect of material use. The harmful environmental impact is caused during production and assembly of the materials.
Water	The water theme is concerned with ensuring water quality and quantity. The water quantity is concerned with ensuring the availability of water and protecting the project from water nuisance
Ground	The ground theme is concerned with minimising ground pollution, and the impact on the ground system.
Ecology	The ecology theme is concerned with the coherence in space between Flora and Fauna, and by protecting ecological systems.
Space use	The space use theme is concerned with the efficient and multifunctional use of space.
Spatial quality	The spatial quality theme is concerned with the experience, use and future value of a project. In other words does the project result in a pleasant experience? Does the project fulfil a certain demand? And is the project flexible so it can easily anticipate on developments
Well-being	The well-being theme is concerned with the impact on the physical and mental well-being of all users and actors of a project. The well-being can be divided in health, nuisance and safety.
Social relevance	The social relevance theme is concerned with the well-being of all actors. In other words, is there social support for the project? Is there social involvement? Is local knowledge used to its fullest capacity? Does the project include social return?
Investments	The investment theme is concerned with the fair distribution of investment cost between actors and weighting of design choices on the basis of Total Cost of Ownership (TCO) and Life Cycle Costing (LCC)
Business climate	The business climate theme is concerned with the business activity of a location and the economic vitality of the local population.
Accessibility	The accessibility theme is concerned with the possibility of individuals to relocate within the boundaries of the project with the least possible resistance.