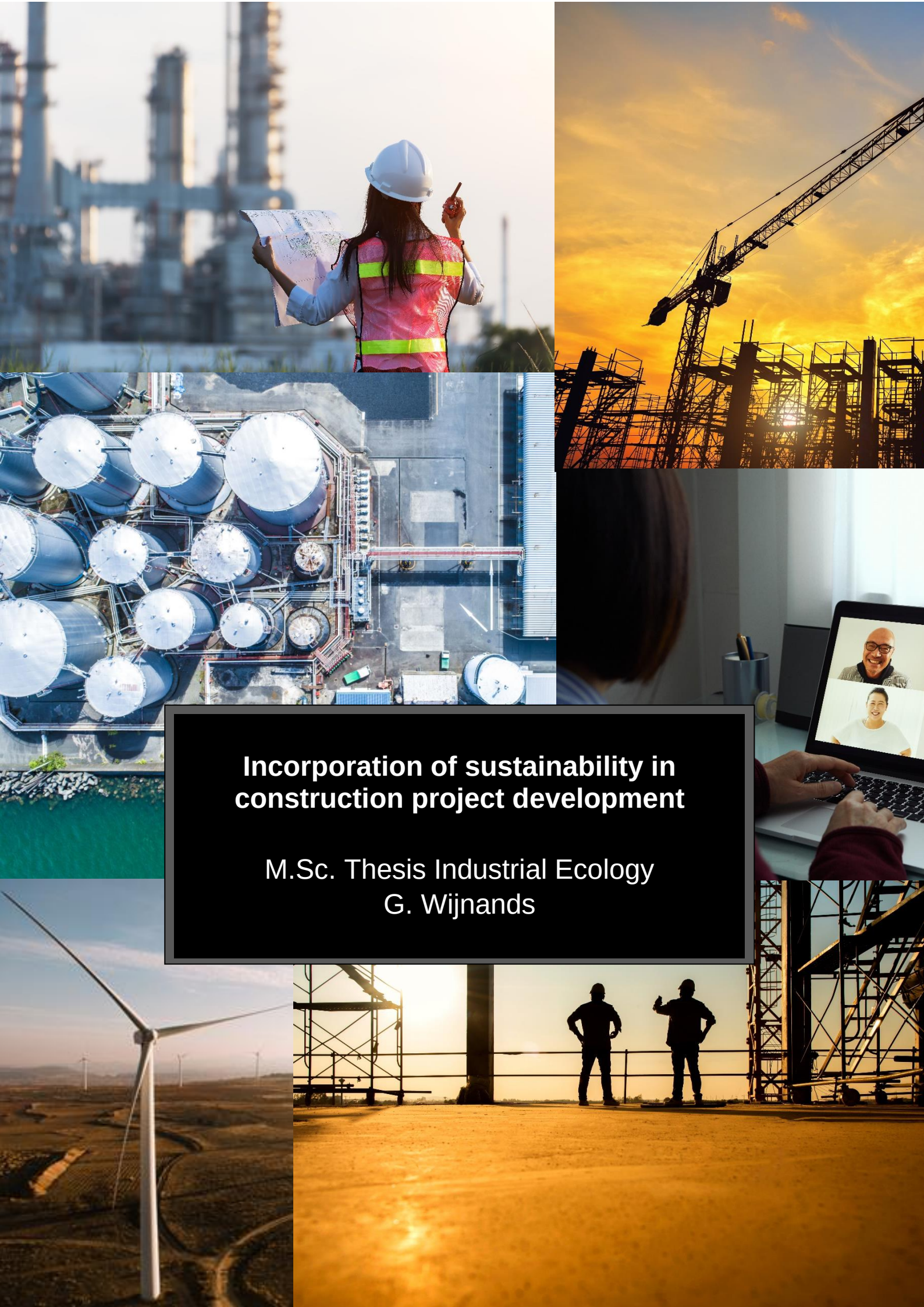

Incorporation of sustainability in construction project development

M.Sc. Thesis Industrial Ecology

G. Wijnands

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THESIS RESEARCH PROJECT

Incorporation of sustainability in construction project development - An analysis into the application of industrial ecology for the building environment

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Executive summary

Despite its importance for the functioning of society, the building environment is a major contributor the global GHG emissions. Although there is an increasing attention for the transition towards sustainability, this sector seems to struggle in realising this transition. As a result, environmental conditions are still exceeding (some of the) planetary boundaries. Moreover, for engineering organisations it is important to integrate sustainability into the project approach, in order to continue their business activities in the future.

In order to improve the sustainable performance and stimulate the transition towards a zero-emission economy, literature suggests to study the missing link between formulation of corporate sustainable ambitions and vision (sustainability strategy) and the implementation on project level. This research responds to this suggestion, as it identifies the main barriers that hamper the implementation of sustainability strategy in engineering and consultancy organisations, and derive factors and activities that stimulate the application. As industrial ecology is described as the 'toolbox' for sustainability issues, this research considers this discipline and evaluates its application for the implementation of sustainability strategy. Besides the insights in the barriers, this research includes the results into a framework: the VOC framework. This framework stimulates the incorporation of sustainability (understood as implementation of sustainability strategy in this research) within construction project development. The starting point of the research is a background study, including literature on businesses, corporate strategy and sustainability in the building environment. Next to these aspects, a specific chapter will review the relevance of industrial ecology for the incorporation of sustainability, by focusing on three industrial ecology tools: Life Cycle Assessment, Industrial Symbiosis and Supply Chain Positioning.

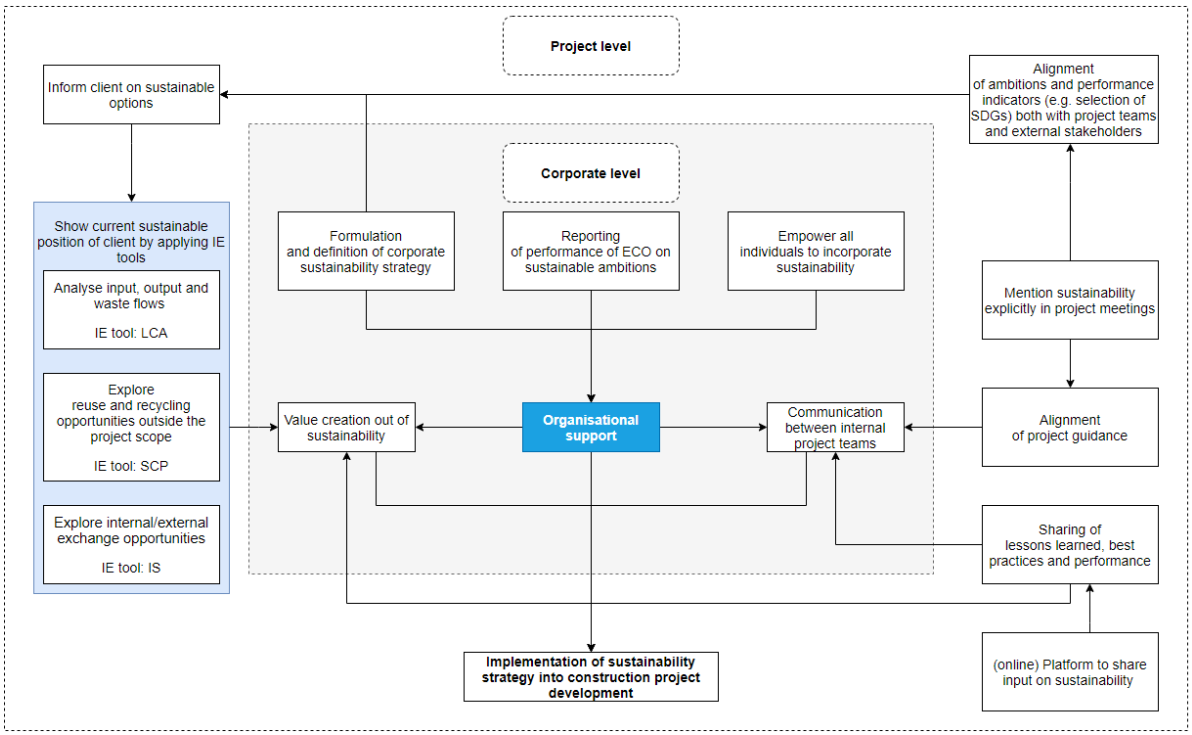

Figure 7.2 VOC Framework for the implementation of sustainability strategy into construction project development

Design Science Research Methodology is considered the leading research approach for the analysis. This methodology does describe a model that aligns six activities that should be followed to structure the development of a framework. For the structure of this research, the methodology was divided into three phases: exploration, design and evaluation. Before the implementation of sustainability strategy in practice is investigated, the sustainable elements in the corporate sustainability strategy should be clear. Therefore, external and internal documents are reviewed. Next, primary data is collected via case analysis. Within these cases, semi-structured interviews were conducted. In this way, both primary and secondary data is included in the analysis. The data analysis is part of the exploration phase. Within the design phase, barriers and stimulations together with perceptions of professionals were included in the VOC framework. As part of the evaluation phase, the conceptual framework was tested in a online focus group.

Overall, barriers for the implementation were identified on both the corporate and project level. The main barriers that are considered the starting point for implementation of sustainability are (1) communication with the internal project teams, (2) organisational support and (3) value creation out of sustainability. The results show how the three barriers on the corporate level are influencing all indirect limiting factors on the project level. On the project level, sustainability is in many cases considered a cost, without thinking about the value that is captured by sustainable interventions. To enhance this value creation, Life Cycle Assessment, Industrial Symbiosis and Supply Chain Positioning are integrated in the VOC framework as industrial ecology tools. The results from the focus group indicated a lack of attention for the external project owner in the framework. Therefore, VOC framework is not about applying the specific IE tools directly, but use the tools to inspire and convince the project owner on sustainable options in the project concept. In addition, sharing of experiences and best practices needed to be emphasised as crucial actions for the incorporation.

To sum up, this research applied industrial ecology in order to bridge the gap between formulation and implementation of sustainability strategy. Document review and case analysis are applied to derive how sustainability strategy can be implemented into engineering organisations and stimulated to apply in practice. The contribution for environmental impact has not been tested in real cases. Hence, future research should focus on applying VOC framework in practice and continue to analyse the behavioural aspects that are hampering the implementation of sustainability strategy.

Acknowledgement

During my graduation project I have received great support and assistance. In addition, without the input and help of all involved participants the insights that were retrieved from data would not have been that elaborate.

In the first place I would like to thank my supervisors from Delft University of Technology, Marian Bosch-Rekveldt and John Heintz. Their expertise on construction management, construction projects and industrial ecology inspired me to look for new aspects and valuable elements in the data and results. Moreover, their critical remarks on my progress supported the study, and in my opinion this increased quality of the conclusions and final deliverable. I could not have completed this thesis project without an academic research proposal. Therefore, I would like to thank Linda Kamp, who critically evaluated my proposal and directed the process of defining a research scope and research question.

A special thank to my external supervisor, Wouter van Gerwen, for providing me the opportunity to write my graduation thesis at an engineering and consultancy firm. During the internship Wouter facilitated all the required devices and permits that were needed to communicate and work on the thesis online. As he had the perspective of ECO, my research included feedback from both a scientific and a practical perspective. As external supervisor, Wouter used his years of experience to gave additional direction to my research. The combination of both academic and external supervisors lead to interesting discussions with the thesis committee, which resulted in the incorporation of both academic and practical aspects in the research.

Besides my supervisors, I thank all my colleagues of ECO that supported me during my graduation project. I received much support of colleagues, as they were always willing to discuss content of my research and explain practical issues to me. I am grateful for the participation of that many colleagues in both the interviews and the focus group. This research could not have taken place without the effort of these participants.

At last, I would like to emphasise the support of my fellow interns. I enjoyed our weekly to daily meetings. In addition, the ‘coffee breaks’ helped me to gain motivation. By sharing our findings, research issues and thoughts on each others work, I have been able to overcome hurdles and apply new ideas towards my thesis research project.

Almkerk, 2021

Gerrit Wijnands

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1 Introduction

1.1 Reason for this research

The development of construction projects is an important practice for all societies, as it supports the functioning of global societies by providing the required needs and assets (e.g. infrastructure, energy supply and buildings). Despite its benefits for society, the global construction sector is considered a significant contributor to the global emissions, being responsible for almost a quarter of the total greenhouse gas (GHG) emissions back in 2009 (Huang et al., 2018). With an expected annual growth of approximately five percent, the current construction sector would be responsible for more than half of the global GHG emissions (Global Construction, 2010). Emission rates are affecting environmental conditions, and will drastically damage the global environment if the trend continues in this pattern, resulting in unsafe or unliveable planetary conditions (Rockström, 2009; Waters et al., 2018). Societies are well aware of this situation, hence an on-going societal debate on the incorporation of sustainable elements and social responsibility into both the practise and academic environment of construction project development (Becerik-Gerber & Kensek, 2010; Silvius, Schipper & Planko, 2012). One of the results of growing societal attention for environmental conditions is the emergence of Sustainable Development Goals (SDGs), a template for global enhancement of sustainability, designed and presented by the United Nations at the beginning of 2016 (Open Working Group of the General Assembly on Sustainable Development Goals, 2015). The SDGs provide guidance for both public and private organisations, in an attempt to get on track for the sustainable agenda of 2030 (United Nations, 2015; United Nations, 2017). While in the building environment a traditional business perspective that prioritises financial and operational interests over sustainability is leading, an increasing amount of organisations considers (a selection of) SDGs as core part of corporate strategy (Porter & Kramer, 2011; Vencato et al., 2014; Westley et al., 2011). Stead and Stead (2013) would describe this as sustainable strategic management; a process that includes the incorporation of environmental expectations into the corporate strategy and business activities.

However, it is stated that the incorporation of sustainability into corporate strategy of organisations is still underdeveloped, especially amongst organisations in the engineering field (Braham & Casillas, 2020; Dentchev et al., 2016). Even when corporate strategy does include sustainable goals, issues can arise while implementing this strategy throughout an organisation (Engert & Baumgartner, 2016). Taking into account the status of planetary boundaries, there is need for a radical shift in the main aspects of corporate strategy of engineering and consultancy firms. Moreover, current trends on the market point out an increasing demand for sustainable forms of engineering, making the implementation of sustainability into the core activities of engineering and consultancy firms relevant for the continuation of business models on the long term as well (Hoffman, 2018).

Industrial ecology (IE) contains principles that enhance the connection between sustainability and corporate business models, and supports the process of incorporation of sustainability into practice. This emerging discipline includes three pillars – (1) design and engineering; (2) natural science and environmental analysis; (3) social sciences – that are combined to approach complex, societal problems. Within an IE perspective, industrial systems are not isolated from surrounding systems, but are considered as part of a network of industrial systems (Jelinski, 1992). This unique systematic approach, in combination with the principles of IE (discussed in chapter 3), make IE an appropriate perspective to address the gap between sustainable strategic management of engineering and consultancy firms and the incorporation of sustainability into construction project development. The incorporation of sustainability into the strategic approach is crucial for organisations, as the corporate sustainability strategy can be the starting point for realising both competitive advantage over competitors and a reduction in environmental emissions (Short, Bocken, Barlow & Chertow, 2014). Moreover, Engert and Baumgartner (2016) also highlight the importance of the implementation process of corporate sustainability as a form of incorporation of sustainability. Therefore, this study focuses on the implementation of sustainability strategy into the activities of engineering organisations.

To summarise, as IE is the 'toolbox' for complex problems with a sustainable aspect, this research considers this discipline and evaluates its application for the incorporation of sustainability into construction project development. A requirement for a successful incorporation of sustainability in an organisation is designing an aligned corporate sustainability strategy (Haugh & Talwar, 2010). So, in order to evaluate the application of IE for project development, the corporate strategy should be taken into account. Like Engert and Baumgartner (2016), Haugh and Talwar (2010) are also highlighting the importance of the implementation process. Hence, this research has its focus on the incorporation of sustainability by analysing how the implementation of sustainability strategy into construction project development is managed. In this research a notable distinction is made between incorporation on the one hand and implementation on the other. While implementation has the goal to bring a formulated strategy into reality, incorporation is about integration or transformation of sustainability objectives in the corporate strategy of an organisation. To study how sustainability becomes part of the organisational culture (= incorporation), the process of translating and managing sustainability strategy to practice (= formultaion and implementation) is analysed. By analysing the process of sustainability implementation, the results of this thesis research project will provide insights on how to stimulate the incorporation sustainability in construction project development.

Studying the implementation of sustainability strategy touches upon all IE pillars; a study that aims to complement to the incorporation of sustainability within construction project development (1) in order to reduce environmental impact of this sector (2), by taking into account socio-economic aspects (3).

1.2 Problem exploration and knowledge gap

Scientific literature indicates a notable lag effect; while the attention for sustainability in academic and commercial environment increases, the global GHG emissions are not yet decreasing. Sustainability strategies are widely developed and there seems to be a collective agreement amongst actors in the construction sector on transition towards sustainable manners of construction project development (Loosemore & Lim, 2018; Olanipekun, Oshodi, Darko & Omotayo, 2019). Taking into account that 65 percent of construction projects fail to meet the business objectives (over 85 percent taking into account time and budget) (Merrow, 2011; Shenhar & Dvir, 2007) and the magnitude of impact by this sector on the planet, it is advisable to look into the sustainable aspects of engineering practices (Fernández-Sánchez & Rodríguez-López, 2010; Levit, 2007). Currently, there is a missing link between design and implementation of corporate sustainability strategy, which hampers the incorporation of sustainability into engineering firms. According to Engert en Baumgartner (2016), the design process typically takes place on the organisational level and the implementation process on project level. Following this theory, this thesis aims to close the gap between the organisational system that formulates the corporate sustainability strategy and the project level that translates the corporate sustainability strategy into actions. Hence, this research is motivated by the following problem statement:

Implementation of sustainability strategy into construction project development is limited by a gap between corporate level and project level

In general, literature provides multiple insights in bridging the gap between formulation and implementation, mostly approached by a strategic management discipline (Engert & Baumgartner, 2016; Engert, Rauter & Baumgartner, 2016). Even though strategic management insights on implementation are valuable for all disciplines, these studies are limited by focusing on a single firm. Therefore, future research into incorporation of sustainability in organisations has been encouraged (Arbolino et al., 2018; Short, Bocken, Barlow & Chertow, 2014). In addition, Sullivan, Thomas & Rosano (2018) recommend future research to continue on their research of designing a framework to bridge the gap between IE and strategic management.

This study can be considered as response to the suggestion of developing a framework that can be used for linking the formulation and implementation of sustainability strategy throughout all the levels of engineering organisations. Instead of applying a business perspective, this research selects an IE perspective. As an additional aspect, this thesis evaluates the application of IE tools as a stimulation and complementation of corporate sustainability strategy.

1.3 Research question, research objectives and deliverable

This thesis research project aims at designing an effective framework for the implementation of sustainability strategy into construction project development. The framework will serve as a procedure for thinking about the implementation process of corporate sustainability strategy. A qualitative analysis of both documents and cases is executed in other to gather data. The main goal is to receive valuable and new insights in the barriers hampering the implementation

process, and derive objective actions to overcome these barriers. Implementation in this research should be understand as the process of translating the corporate strategy into a project approach, without suggesting any specific interventions for professionals in the building environment. The framework aims to provide an overview of the mechanisms that cause limitations for the implementation of sustainability, and suggests actions based on these barriers. By studying the implementation of organisational sustainability strategy, this study aims to complement to the incorporation of sustainability into engineering firms as well. The unit of analysis for this research are construction projects that are still in the development phase (chapter 3 will elaborate on this). Based on these research objectives, the following main research question is formulated:

RQ. How can sustainability strategy in construction project development be implemented and stimulated?

To get an answer for this research question, five sub question have been designed. These sub questions are formulated based on Design Science Research Process model, explained by Peffers, Tuunanen. Rothenberger and Chatterjee (2008) as a model for the creation of frameworks. The sub questions are covering three different research phases. The research phases and developed sub question are visualised in figure 1.1.

Exploration phase	SQ1. What is the organisational sustainability strategy of ECO? SQ2. Which factors affect the implementation process of sustainability? SQ3. How are factors affecting the implementation process of sustainability?
Design phase	SQ4. How can a framework, aimed to implement and stimulate sustainability strategy within construction project development, be structured?
Evaluation phase	SQ5. How can a framework to grasp the implementation and stimulation of sustainability strategy, contribute to incorporation of sustainability in engineering and consultancy firms?

Figure 1.1 Sub question, research phases and research objectives
Note. ECO is an abbreviation of Engineering and Consultancy organisation

In order to create this framework, data on the sustainability strategy and the factors affecting or stimulating sustainability within construction project development have been collected by document review and cases analysis. A total of 15 semi-structured interviews have been conducted over six different cases. The evaluation phase made use of a focus group as research tool, which involved 11 professionals from the field of building environment. Within this group the perception on the developed framework amongst professionals was discussed. In addition, the applicants had the opportunity to make suggestions for improvements or to emphasise important requirements.

1.4 Scope

As an involved party, this research has been conducted at an engineering and consultancy organisation (ECO), located in the Netherlands. ECO provides industrial engineering and consultancy services to a range of global customers. In order to collect data from the field, ongoing projects of this organisation have been analysed. The interviews were mainly conducted amongst project managers, engineers and consultants. Besides interviews, external and internal documents have been reviewed. The timeframe allowed for this research was seven months. During these seven months all data collecting activities were organised in online settings, due to the governmental regulation, as a result of the COVID-19 virus, that were active during this research.

This study is performed as part of a graduation project for the Master Program in Industrial Ecology. The research method will have its specific focus on the socio-economic pillar, as the experiences and perceptions of people within construction project development are assumed to be crucial for the implementation of sustainability strategy.

1.5 Report outline

Three parts can be assigned towards the outline of this research: background, core research and closing. At first, this research starts with reviewing the relevant academic literature in chapter 2 and 3. These chapters will review literature related to sustainability in organisations and the application of IE respectively. Chapter 3 concludes the first part of this research.

Next, chapter 4 describes the research methodology that is used to answer the main research question. Chapter 5, where the sustainability strategy of ECO is discussed, is the start of the data analysis. This chapter will provide an answer to sub question 1. This part of the thesis does also contain the case analysis, framework development and framework testing in chapter 6 and 7. Sub question 2 to 5 are discussed within these chapters.

Once results have been collected and reported, the closing part of this thesis starts with the evaluation of the applied research approach (chapter 8). The discussion is continued by stating an answer to the research question and deriving recommendations for ECO (presented as chapter 9 and 10). Recommendations will include both in depth advices for ECO on how to improve the implementation process and suggestions for future research. The outline of this research is visualised in figure 1.2.

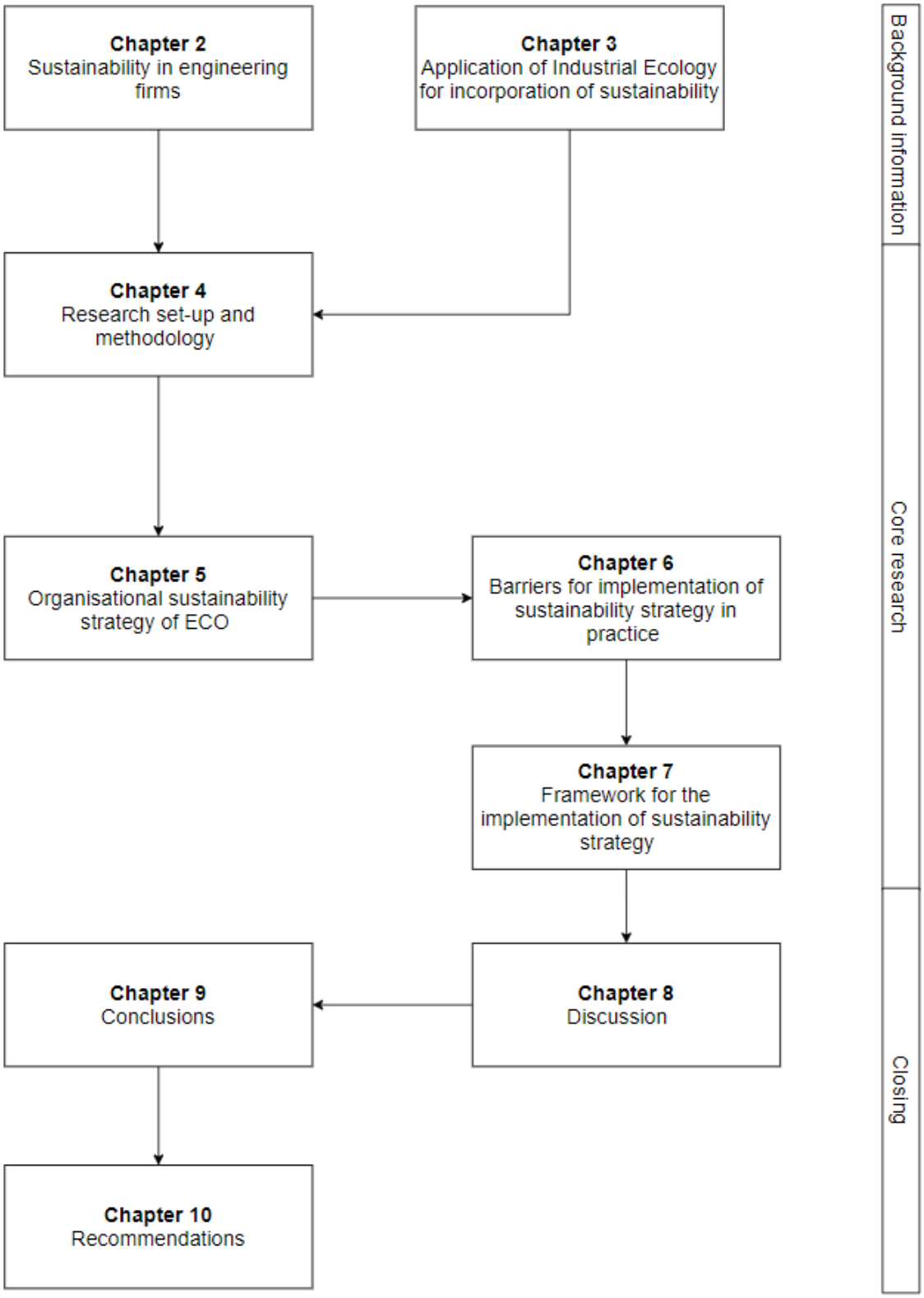
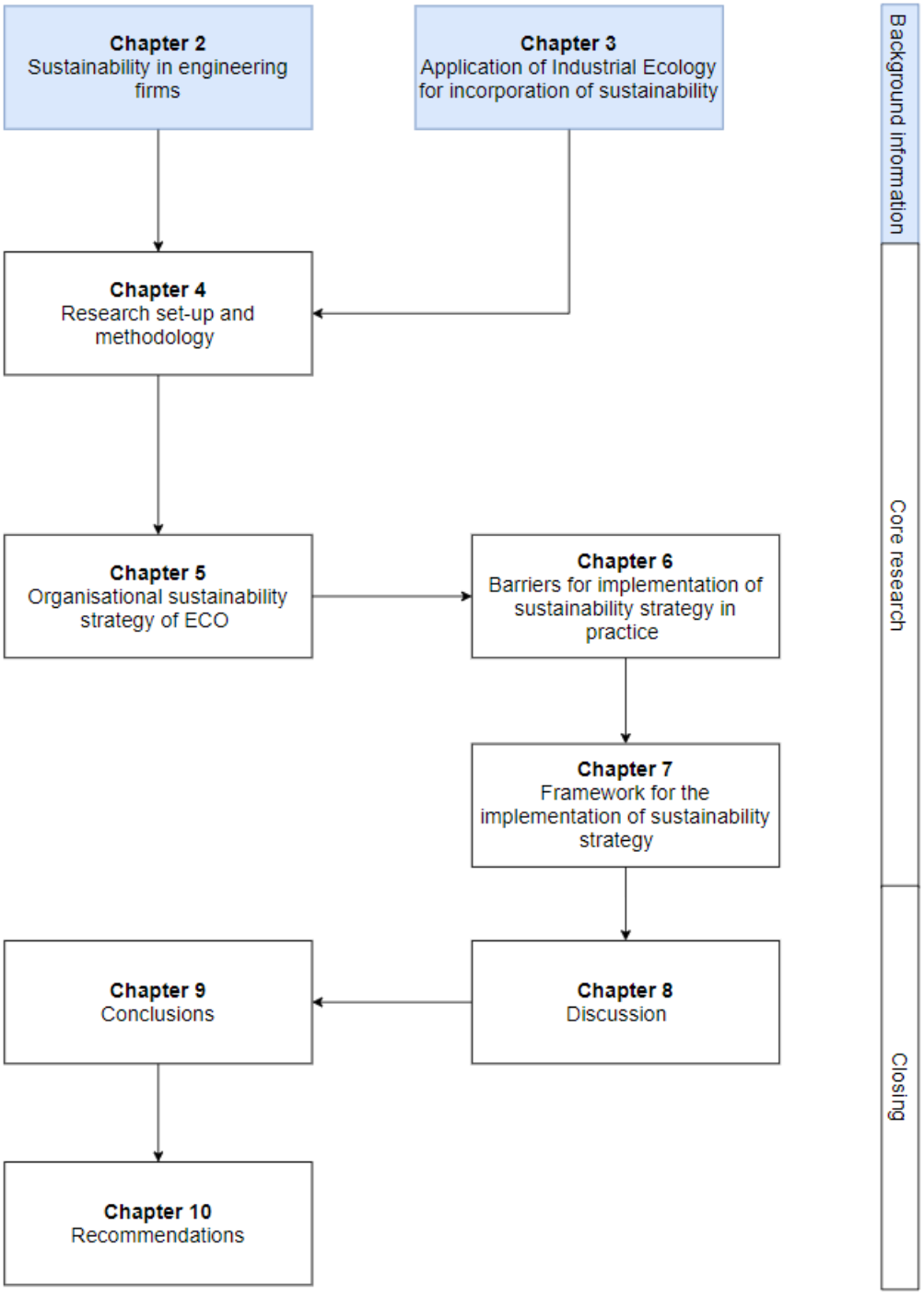


Figure 1.2 Thesis outline

Part 1: background information



2 Sustainability in engineering firms

The starting point of this thesis is background research. In the first chapter of the background research, literature on the role of sustainability in businesses is reviewed. In order to retrieve readings, Google Scholar and the repository of Delft University of Technology have been used as databases. For the purpose of this part of the background study, combinations of the following keywords were entered during the review: *sustainability strategy, incorporation, implementation, building environment, engineering projects, management, organisations.* While searching for literature, the aim was to only include academic readings that are published since 2010. However, some of these articles contain valuable information originating from older articles.

2.1 Corporate strategy and sustainability

To get a better understanding of how sustainable aspects are applied within corporate strategy and construction project development, literature on corporate sustainability strategies, the design and implementation process of corporate strategy and the role of sustainability in the building environment is reviewed.

Both private and public organisations need to develop a business cycle that supports the day-to-day business in order to sustain their business. The way an organisation develops this cycle includes an organisational or a corporate strategy; the goal of this strategy is to analyse the competitors in the market environment, determine their place in the environment, develop advantages over competitors, and understand potential factors threatening their competitive advantages (Casadesus-Masanell & Ricart, 2010). The competitive corporate strategy is integrated into a business model, which provides an overview how the organisation or business creates, delivers and captures value (Osterwalder & Pigneur, 2010; Osterwalder, Pigneur & Tucci, 2005). The value and purpose of an organisation, and the ground rules to achieve these ambitions are defined as the vision of an organisation (Sivakumar & Rao, 2020). The corporations of interest has a design and advisory role in construction projects as core activities of their business model.

Whereas the original intention of corporate strategy was focused on the improvement of competitive advantage and lowering costs (Porter, 1989), over the last few decades there has been a growing attention for environment within corporate strategies (Graedel & Allenby, 2010). For instance, the development of the triple bottom line model described by Elkington (1999). This model is an accounting framework that includes three dimensions of performance: social, environmental and financial (Slaper & Hall, 2011). While the model of Elkington (1999) has its particular focus on accounting, much research has been done into the integration of sustainable elements into the organisation from a more practical point of view (Baumgartner & Ebner, 2010; Rohm, & Montgomery, 2011; Wijethilake, 2017). In general, corporate

sustainability strategies include activities such as efficient use of resources, efficient waste and discharge management, company image marketing, sustainable preferences by customers, and designing innovative capabilities (Banerjee, 2001; Bhupendra and Sangle, 2015; Christmann, 2000; Judge and Douglas, 1998; Sharma and Vredenburg, 1998). Amini and Bienstock (2014) designed a framework to integrate these activities into the organisational vision, by linking business strategy, compliance and sustainability. The key features of this framework are integration of corporate communication, emphasising relevance of external communication and balancing the social, ecological and economic aspects. By balancing the people, planet and profit aspects, the framework of Amini and Bienstock (2014) touches upon the triple bottom line.

While organisations and businesses consider sustainability as an important aspect in their strategy, environmental conditions have not improved over the last decade (Whiteman, Walker & Perego, 2013). In some cases, planetary boundaries have even become worse, leading to dramatic environmental conditions (Gerten et al., 2020; Li, Wiedmann, & Hadjikakou, 2019). Hence, one can state that the incorporation of sustainability into corporate strategy has not yet succeed. Engert, Rauter & Baumgartner (2016) noticed the discussion between theory and practice, and reviewed 114 articles related to the integration of sustainability into strategic management. A literature review by Engert & colleagues (2016) lead to the conclusion that the number of publications on this topic is increasing, that most of the studies consider a traditional business perspective and that there is still need for more empirical evidence in this field. In an additional study Engert and Baumgartner (2016) showed that the implementation process receives little attention in comparison to its strategic formulation. Engert and Baumgartner (2016) studied the gap between formulation of sustainability strategy and implementation and reported both internal (organisational structure; organisational culture; leadership; management control; employee motivation and qualifications; and communication) and external (coherency of formulated strategy) features of an organisation as factors influencing the incorporation process.

Focusing on the internal features of an organisation, the traditional business perspectives hamper the transition towards sustainable organisations, by favouring economic benefits over environmental and societal interests (Sullivan, Thomas & Rosano, 2018). The organisational culture (OC) as discussed by Engert and Baumgartner (2016) is pointed out as an important factor for the incorporation of sustainability. Ramachandran, Chong and Ismail (2011) analyse definitions of OC in literature. At first the definition of OC as described by Martin and Siehl (1983) is evaluated. Martin and Siehl (1983) assign values, beliefs and attitudes of individual members of an organisation to the OC. Moreover, the OC provides understanding to the functioning and key values of an organisation (Deshpande, Farley and Webster, 1993). The elements of OC are critical factors that influence the individual drivers for sustainability. Haugh and Talwar (2010) state that if one aims for an organisational transition towards sustainability, alignment throughout the entire organisation is required. Simultaneously, they describe organisational transition as a gradual process. Two levels of an organisation are divided in this reading: the corporate level and project level. Corporate level refers to the decisions in the direction of an organisation, for instance the vision, goals and values. Project level includes the conversion of goals, mission and values into project development. Changes on the corporate level should be connected towards the project level, in order to translate the ambitions into practice. So, one can make a distinction between the two levels and consider the levels as separate systems, without neglecting the connection between the systems. All

the elements of the OC should contain the fundamental values of the vision of an organisation, in a practical way for employees. Haugh and Talwar (2010) developed a model for the transition towards sustainability, by applying the following techniques: (1) include ambitions into the code of conduct; (2) measure the impact; (3) include the ambitions into the company structure and policies; (4) research sustainability within product supply chain; (5) communication and dialogue; (6) employee training and workshops; (7) company visits; (8) employee volunteering opportunities. In terms of external features that influence the implementation of corporate strategy, aligning all the elements of OC requires a coherent, formulated sustainability strategy.

2.2 Sustainability in the building environment

This thesis defines construction projects as national or global infrastructural and industrial developments that help societies functioning (Tabish & Jha, 2012). Moreover, this definition is complemented with the definition of projects in academic literature. Based on that, projects are described as temporary work systems, in which certain tasks are done under specific conditions for a particular reason (Turner, 1999; Turner, 2008; OGC, 2009). A construction project includes different phases over its life cycle. A general known division of phases starts with the front-end phase, followed by the execution phase, monitoring and control phase and finishes with the project closure phase (PMI, 2013). The front-end phase – referred to as early phase in this research – is considered as critical in terms of design of the concept project, as within this phase goals are defined, project teams are composed, risks and costs are assessed and stakeholders are aligned (Bosch-Rekveldt, 2011; Enshassi, Kochendoerfer & Al Ghoul, 2016). As for most sectors, sustainable aspects have become unavoidable for the construction sector as well. However, as this sector is continuously growing, there is a wide range of opportunities for the incorporation of sustainable aspects into practice (Papargyropoulou, Preece, Padfield & Abdullah, 2011). Within construction sector studies, this wide range of opportunities is acknowledged. However, instead of viewing sustainable practices as a single aspect of construction engineering, many studies include sustainability as an element of corporate social responsibility (CSR) (Loosemore & Lim, 2018; Olanipekun, Oshodi, Darko & Omotayo, 2019). The European Commission (2019) defines CSR as the responsibility of organisations for impact on society. The ‘impact on society’ encompasses many aspects complementary to sustainability, amongst others labour conditions and safety measures (Ibragimbekova, 2020). Despite the range of aspects related to CSR, the process of creating, delivering and capturing value with sustainability strategy is core matter in CSR (Maas & Boons, 2010).

CSR, sustainability strategy and construction project development are connected via ‘good governance’. This form of governance refers to policy that strives for maximising public interest (Keping, 2018). Although the political characteristic of good governance, the application of good governance is crucial for the formulation and implementation of sustainable practices and strategies (Atienza, 2011). One important aspect of good governance is accountability, which implies that every actor in society is responsible for its own behaviour (Keping, 2018). Although good governance does not guarantee sustainability, it can be applied to derive long-term strategic objectives, coordination amongst societal actors, transparency and participation that support sustainability (Kardos, 2012). Silvius, Schipper & Planko (2012) describe the integration of sustainability as the ethical responsibility for project managers. A weakness of

good governance is the level of application for businesses. It does not explicitly provide an opportunity to link the corporate sustainable ambitions with the activities on the project level. Moreover, it is mainly assigned to organisational policy and structure, whilst project managers and lead engineers are the crucial nodes in the network that connect corporate strategy with project strategy.

The interaction between governance and management has been visualised by Too and Weaver (2014); based on the principle of good governance, the authors developed a framework to create optimal value from projects. In their research they emphasise the connection and alignment between project output and organisational business strategy. Figure 2.1 shows how the hierarchical systems of an organisation need to conform to the objectives and requirement of higher levels.

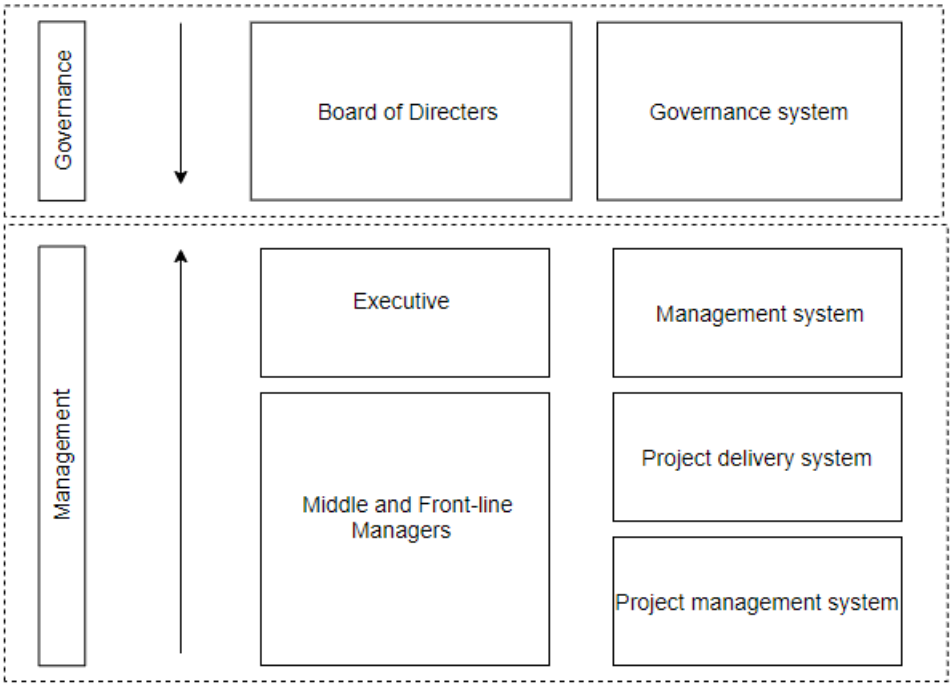


Figure 2.1 Nested governance and management systems
Source. Too & Weaver, 2014

The arrows indicate the hierarchal policy-making process. In terms of organisational levels, both the corporate and project level can be found within the framework. The governance and management system can be considered as corporate level. Within figure 2.1 it should be noticed that the board of directors might be forced to conform to regulatory, governmental regulations. Moreover, this framework indicates that strategy will be integrated in an organisation via a top-down method, starting from the board of directors (indicated as corporate level), via the project management team to the middle and front-line managers (indicated as project level). Too and Weaver (2014) conclude four key elements that are crucial for the integration of organisational strategy into projects: (1) select projects and programs that are in line with the organisational strategy (portfolio management); (2) provide a direct link between the executive and program managers (project sponsorship); (3) provide oversight and strategic reporting capabilities (project management office); (4) emphasise that effective management of projects is the measure of effective governance system (project and programmes). It has to be admitted that some of these steps can be difficult for engineering

and consultancy firms, as these firms are dependent on the behaviour and opinions of the client. In addition, Giesekam, Barrett and Taylor (2016) do also bring up the problem of unskilled employees. Employees that cannot fulfil the desirable tasks might hamper the process of implementing strategy.

Within engineering practices, there is a notable division between old-fashioned and modern engineering. While the traditional perspective focuses on costs, quality and time, the modern sustainable perspective attempt to integrate sustainable criteria, such as minimising resource depletion and environmental degradation (Hussin, Rahman & Memon, 2013). These additional factors should help the engineering practices to shift to a new paradigm. However, in order to integrate sustainable criteria into engineering, many studies suggest incorporating sustainable interests into the current teaching curriculum (Davidson et al., 2010; Shields, Verga & Blengini, 2014). To overcome future challenges and shift to a sustainable way of engineering, education is considered an important aspect. The transition towards sustainable engineering practices is designate by the upcoming certificates and licenses in the building environment. In the building environment, the global applied certificates are Leadership in Energy and Environmental Design (LEED, United States and Canada), Building Research Establishment Environmental Assessment Method (BREEAM, United Kingdom) and German Sustainable Building Council (DGNB, Germany). These kinds of systematic assessments evaluate the sustainability of a construction project by analysing several indicators related to energy and water utilization, material and resource depletion and pollution (Orova & Reith, 2019). According to Hamedani and Huber (2012), these certificates stimulate sustainable practices and, in this way support the transition towards an environmental friendly way of engineering. Although the organisational motivation to apply for a certificate or licence might be marketing originated (Gou & Xie, 2017), it is a common example of how sustainability is integrated into construction project development.

2.3 Transition towards sustainability in the building environment

Organisations out of all sectors, both public and private, make use of a set of ideas and ambitions to sustain the market position and continue the production process or provision of services, understand as the corporate strategy. In literature, multiple frameworks have been designed in order to formulate and implement corporate strategy, including frameworks that have its specific focus on sustainability aspects. Here it is stressed that both alignment and OC are crucial for the transformation of organisations.

The literature on design and implementation of corporate sustainability strategy emphasises a mismatch between design and implementation of sustainability strategy. When combining this literature with the management framework of Too and Weaver (2014), one could identify a gap between the different levels of an organisation as well (hence the problem statement is focusing on the corporate and project level). Although scientists start publishing readings on sustainability transformations since decades ago, the transition still seems to operate on a low speed. This first part of the background research gives a clear overview on the current status of sustainability in engineering firms and mentions few critical conditions that hamper the implementation. Nevertheless, to further investigate the ‘stimulation of sustainability strategy’ part of the central research question, it is important to search for appropriate methods and tools that can be applied by engineering firms.

3 Application of industrial ecology for incorporation of sustainability

The second part of the background research introduces industrial ecology (IE) as a discipline to enhance the incorporation of sustainability into engineering and consultancy firms. Scientific literature from IE journals has been reviewed in order to identify, evaluate and suggest IE principles and tools valuable for the building environment. As for this review, Google Scholar has been adopted as database. Key words that were leading for this review are: *Industrial ecology*, *sustainability strategy*, *strategic management*, *industrial ecological principles*, Industrial Ecology tools *engineering practices*.

3.1 Industrial ecology as a mediator

Although much research into the linkage between corporate strategies and sustainability has been done the last decade, it is notable that most publications have been published in management or business related journals, such as Journal of Management Studies, Journal of Business Studies or Journal of Environmental Management. A transdisciplinary research approach has been suggested to study sustainability (Williams, Kennedy, Philipp, Whiteman, 2017). At this point IE can operate as a mediator, as this discipline applies a system perspective towards complex sustainable problems (Graedel & Allenby, 2010). Whilst business management disciplines consider sustainability and finance as distinctive aspects, IE couples the environmental and economic interests (Lifset & Boons, 2011). IE principles that encourage the improvement of environmental conditions, while taking into account economic demands of industry, are accenting the importance of partnerships and exchange of material and energy flows, creating value by reuse and recover waste and energy flows, providing space for cleaner production and demonstrating commitment to the benefit of sustainable industries (Roberts, 2004). For the incorporation of CSR into construction projects, IE system thinking and principles are commonly applied (Hoffman, Corbett, Joglekar & Wells, 2014; Belaud et al., 2019; Short, Bocken, Barlow & Chertow, 2014). Current developments show rapid evolution of innovation that influences the environmental conditions of society, therefore it is recommended for engineers to adopt ethical and social values while designing projects (Bryce, Johnston & Yasukawa, 2004; Mulder, 2004).

Overall, IE principles are involved in researching opportunities for sustainable manufacturing (Magnusson, Andersson & Ottosson, 2019; Yune et al., 2016; Lèbre & Corder, 2015). Very little research attempts to connect IE principles with corporate sustainability strategy. It needs to be emphasised that there is a distinction between these types of research; sustainable corporate strategies imply a changing ‘way of doing business’ that goes beyond processes and products (Amit & Zott, 2012). Besides the manufacturing process, literature provides insights on how IE can be applied to improve sustainable business models and strategies. Hoffman, Corbett, Joglekar and Wells (2014) analyse how businesses are able to adopt IE

principles and gain competitive advantage over their competitors in the market. This research explains IE as the provider for collaboration between engineering, environment and management. Bocken, Short, Rana and Evans (2014) designed eight different business model archetypes that support the integration of IE philosophy into corporate sustainability strategy. The models, that are highly aligned with the IE principles of Robets (2004), are considered as starting point for the research into sustainable business models (Bocken, Short, Rana & Evans, 2014). Other studies that apply IE to improve the development of corporate sustainability strategy have a particular focus on the implementation process and link IE principles to sustainable development (Sullivan, Thomas & Rosano, 2018; Korhonen, 2004). However, an interdisciplinary approach that links the fields of ecology, economics, engineering and business management is given as a stimulation for sustainable development (Roberts, 2004). The importance of OC is noticed in IE studies as well, as studies identify OC as a potential barrier for incorporation of sustainability in the organisation and business activities (Gibbs & Deutz, 2007; Lombardi & Laybourn, 2012).

As noticed in the introduction, Engert and Baumgartner (2016) report a mismatch between corporate strategy and incorporation of sustainability within project development. The gap between design and incorporation of sustainability has been indicated as a 'wicked' problem. These kinds of problems – also referred to as wicked sustainability issues – involve divergent societal stakes and (academic) uncertainties, resulting in multiple understandings of the concept 'sustainability' amongst a wide range of people (Cuppen, 2012). Because of high level complexity, wicked problems are difficult to approach. Literature suggests a multi-dimensional system perspective to approach wicked sustainable issues (Bettencourt & Brelsford, 2015). Hence, IE is an appropriate perspective to adopt in this research. Moreover, IE studies have been investigating the gap between corporate strategies, IE and implementation for over 30 years. In general, these studies suggest that the system perspective is useful for companies, although a traditional perspective does delineate a situation in which benefits do not outweigh costs (Esty & Porter, 1998; Graedel, 1994; Lowe & Evans, 1995). Nevertheless, recent work by Sullivan, Thomas & Rosano (2018) researched the potential benefits, by analysing how the application of IE principles complement towards the realisation of the Sustainable Development Goals (SDGs). In their research, IE is used as a stimulation by considering firms as part of a socio-ecological system, in which firms are dependent on the system. By considering organisations as node of a socio-economic network, IE principles provide potential new markets, products and business models, resulting in competitive advantage. This view on the position of organisations is in line with the principles given by Roberts (2004), who emphasised the importance of partnering opportunities between companies for both economic and sustainable interests.

3.2 Relevant industrial ecology principles and tools

In the previous section the role of mediator has been assigned to IE. However, the studies did not explain what type of IE tools can be applied to improve the incorporation of sustainability. Adopted IE principles for this study are based on the work of Roberts (2004), who derived four general IE principles relevant for industrial actors: (1) industrial partnerships; (2) reuse and recovery of waste and energy flows; (3) cleaner production; (4) sharing of best practices and performances. These principles are typically aspects to focus on in order to increase the value

of sustainability. When having a closer look at these four recommendations, specific and more concrete IE tools can be integrated into the principles.

3.2.1 Industrial Partnerships

This is a principle that is related towards Industrial Symbiosis (IS). IE views companies as agents for environmental improvements of society, which develop and possess the technological expertise that is required to improve the sustainable performance of a society (Lifset & Graedel, 2002). The focus within IE is on the interaction between the human technological activities and the providing system (that is the ecosystem which delivers goods and needs) and how activities can improve or affect the providing system. IS is a well discussed and applied IE tool that refers to a situation in which two or more firms exchange materials and/or energy in order to obtain both competitive advantage over competitors in the market and reduce environmental impacts (Chertow, 2007; Graham et al., 2015). Amongst many successful situations in industrial context, the area of Kalundborg (Sweden). Within this area, each firm evaluated its incoming and outgoing streams, and discovered partnering opportunities. This resulted in an industrial area where over ten industrial companies were exchanging input, output and waste flows and reduce environmental impact (Jacobsen, 2006). A critical note to IS is the fact that contractual requirements, site conditions and market demand can become limitation for industrial partnering. Nevertheless, companies were willing to discuss partnering with other firms, which eventually lead to both environmental and economic benefits (Jacobsen, 2006). Evaluating the options for industrial partnering is a common applied tool to reduce environmental impact of industrial plants (Biswas, 2012). On project level, this would mean to broaden the project scope and scan actors on the industrial site.

3.2.2 Reuse and recovery of waste and energy flows

The analysis within IS does contain some technical knowledge, such as which streams can be integrated in the project, or what type of output of the project can be used elsewhere. To evaluate reuse and recovery options of waste and energy flows, IE suggests Life cycle Assessment (LCA) as a tool to analyse the input, output and waste streams. In the first place, this assessment tool is applied to evaluate the environmental impact of products and service systems (Guinée & Lindeijer, 2002). Nevertheless, one of the main action objectives within this assessment tool is the inventory analysis, where the incoming and outcoming flows are reported. Moreover, LCA would also be a useful tool to identify hotspots in the project design or specific interventions . For instance, in the engineering field, LCA could help project managers to conclude that a certain heat pump would be more environmental friendly when the time range exceeds five years. However, to make decisions on interventions, all information in terms of goal and life span should be known. A successful example of the application of LCA in the construction sector is found in the work of Li, Zhu and & Zhang (2010). Within their study, LCA is used to develop an assessment model that can be used by engineers to select the most environmentally friendly construction plans. So, LCA does not only provide insights in potential partnering opportunities, but also supports professional in merging sustainability in the construction project design.

3.2.3 Cleaner production

IS and LCA explain how the value of sustainability can be increased, by exploring the options for material and energy exchange outside the scope of a single firm. This is in line with supply

chain positioning of individual actors within the societal system, as described by the evaluative paper of Lifset and Graedel (2002). Translating the perspective of IE into a tool, this paper is used as an inspiration for a third tool that can stimulate the incorporation of sustainability: supply chain positioning (SCP). This tool refers to the positioning of firms in the supply chain, as in many cases the sustainable advantage is limited by considering the firm as central node of a system. This is for instance done in the strategic management tool resource-based view, a tool that is designed to strategically select resources and gain advantage over competitors in the market. However, the scope the system boundaries are set to the firm system (Kraaijenbrink, Spender & Groen, 2010). This is contradictory to the SCP as described in IE, where the system contains many actors and society has the role of central node. Within this research, SCP as a tool focuses on analysing upstream and downstream options in the supply chain, discussing external processes with contractors and reducing environmental impact by considering (a selection of) actors and streams in the supply chain. In this way, firms are not trying to increase clean production independently of each other. Recent publications also combine SCP with LCA, in order to get an overview of the different streams in the supply chain of interest and analyse how to improve environmental performance of a supply chain (Baynes, 2018; Zhu, Sarkis, & Lai, 2019).

3.2.4 Sharing of best practices and performances

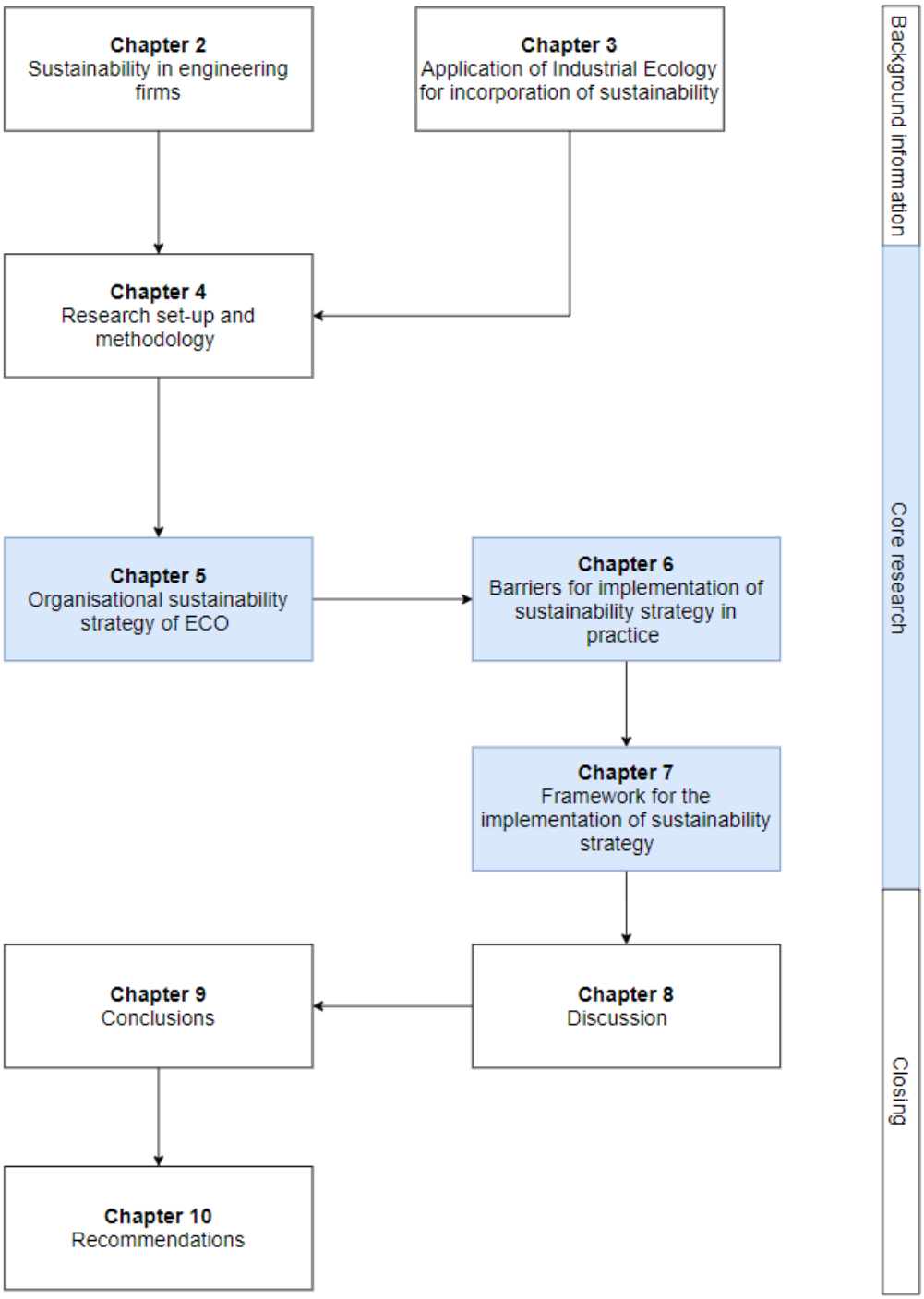
For the fourth principle no specific IE tool is applicable. However, this principle complements to the OC as discussed in the first paragraph. Roberts (2004) emphasises the importance of a network of transparency, where information sharing is explained as a key activity. Information on best practices and successful projects is valuable to share. Taking into account the literature on corporate strategy and alignment of chapter 2, it can be stated that this principle should not only be applied to the external environment, but also within an organisation.

3.3 Relevance for construction project development

The degree to which one of the discussed tools is applicable for the analysis of a project, depends on the characteristics of the project. This research defines two different types of construction projects; (1) construction of the industrial plant; (2) constructing the production processes of the industrial plant. Engineering firms are involved in both types of projects, however, a type 1 project would lend itself for a LCA on building materials or industrial pumps, while in a type 2 project the emissions of the production process are the focus point. The same comparison applies to IS (degree of path dependency is different for the types of projects, as within type 2 more contractual issues can limit the options) and SCP (projects of type 1 does not have a place in the supply chain yet).

By adopting IE perspective, and apply LCA, IS or SCP within the development of construction projects, both economic and sustainable value can be captured. The IE tools discussed within this chapter support the process of brainstorming for sustainable interventions and attempt to stimulate value creation out of the sustainable interventions. This increase value creation would be useful for the implementation process of sustainability strategy.

Part 2. Core research



4 Research set-up and methodology

In this chapter the research set-up is described. Sub section 4.1 provides an introduction on the type of research and the leading design model of this study. The research plan exists of three phases: exploration phase, design phase and evaluation phase. Sub section 4.2 discusses how the three phases are divided and what are key activities. Moreover, 4.2 would also discuss the selected instruments to collect and analyse data. As a closing part of this chapter, an overview is given of the research plan.

4.1 Design Science Research Methodology

To structure the research plan, activities of Design Science Research Methodology function as a basis. The activities of this methodology (figure 4.1), described by Peffers, Tuunanen. Rothenberger and Chatterjee (2008), support the creation of frameworks that contribute to the information system within organisations, and do not need to be based on a formal theory in advance. Peffers and colleagues designed this methodology with particular focus on physical information systems; however, as the focus is on framework development, design science research methodology is successfully applied in other disciplines as well (Peffers, Tuunanen & Niehaves, 2018). Moreover, Peffers et al. (2008) developed the design science research process (DSRP) model, a model that contributes to design science by taking into account six aligned activities that provide guidance and structure during the analysis and development of frameworks. The six sequential activities that guidance this research are indicated in figure 4.1. The different activities are assigned to the developed research phases.

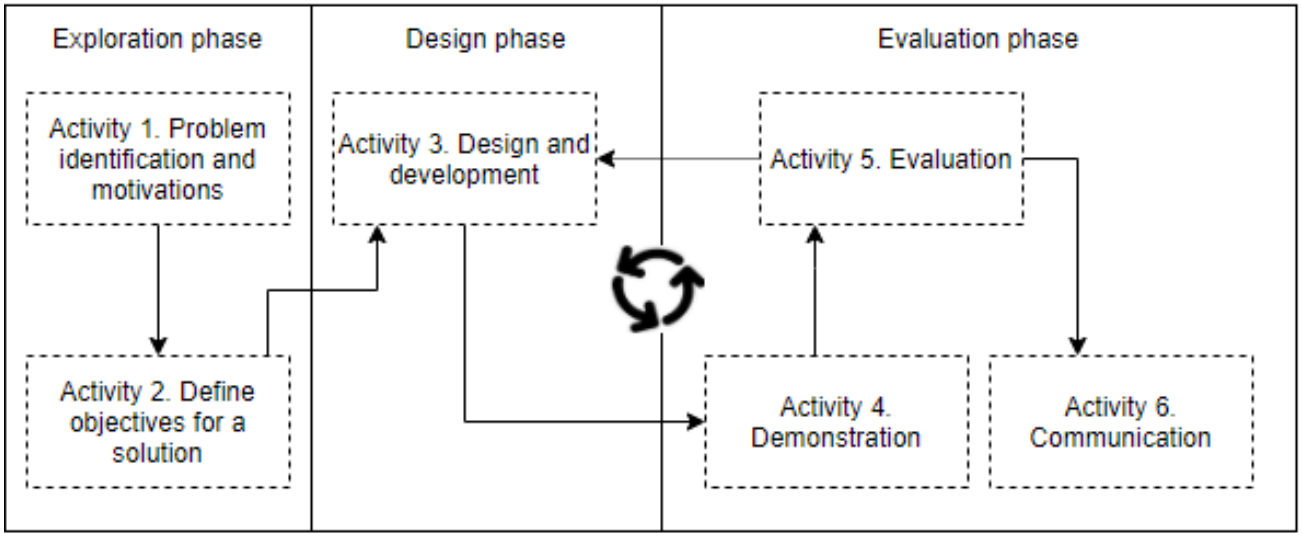


Figure 4.1 Activities and phases of DSRP model

Currently, little research applies IE perspective to the implementation of corporate sustainability strategies within engineering firms; hence, an exploratory character can be assigned to this study (Brown, 2006; Dudovskiy, 2016). By adopting the DSRP model, this

study covers all the essential parts of explorative research, making it a suitable model to answer the main research question.

4.2 Research phases

Based on the activities of DSRP model, the research set-up can be divided into three phases: exploration, design and evaluation. As the problem statement turns out to be a wicked problem, the first step is to explore the field in order to get insights on the complexity of the problem and what type of barriers are indicated in the field. Therefore, the exploration phase contains identification of the problem and formulation of solution objectives. This phase also includes the data collection activities. After the data collection and analysing activities, there are much data regarding factors that influence the implementation of sustainability strategy. Within the design phase, the knowledge and theory on the objectives are integrated into a framework. The goal of this framework is to support construction organisations in successfully implement corporate sustainability strategy within construction project development. In the last research phase of this set-up, the created framework will be evaluated. In this evaluation process the most important question is: how well does the created framework support engineering organisations in implementing and stimulating sustainability strategy? Demonstration and evaluation will be done by discussing the framework with a group of professionals in the building environment, via an organised focus group. Based on the input of professionals, the design of the framework can be reviewed in order to increase its effectiveness. This iterative process can also be found in the figure 4.1. The description and sharing of all research steps and results do represent activity 6 of DSRP model. The sub questions that are developed to answer the main research question cover the activities of the divided phases, as shown by figure 4.2.

Exploration phase	SQ1. What is the organisational sustainability strategy of ECO? SQ2. Which factors affect the implementation process of sustainability? SQ3. How are factors affecting the implementation process of sustainability?	Data collection
Design phase	SQ4. How can a framework, aimed to implement and stimulate sustainability strategy within construction project development, be structured?	Framework development
Evaluation phase	SQ5. How can a framework to grasp the implementation and stimulation of sustainability strategy, contribute to incorporation of sustainability in engineering and consultancy firms?	Testing framework

Figure 4.2 Overview of research phases, sub questions and key activities

4.2.1 Exploration phase

The starting point of problem exploration is to get an overview of issues and how problems appear in practical context. DSRP model provides two starting activities in order to explore the research problem: (1) problem identification and motivation; (2) define the objectives for a solution. The function of these activities is to define a specific problem statement and relevance for this study, and to collect the required input in order to develop solutions to overcome the research problem. To gather the appropriate input for these tasks, a document review is conducted, complemented with case analysis.

Document review

The problem statement and relevance is already discussed in the introduction and further explained in the literature background. However, to get a better understanding of the problem, there is need to analyse the sustainability strategy of the involved construction organisation. An overview of the current implementation of sustainability strategy in the project approach is required to analyse sustainability incorporation within the organisation. In terms of corporate documents, many open-source documents that provide descriptions of the developed vision, mission and corporate strategy for the coming years have been published on the World Wide Web. The expectation is that these documents do focus on the organisational ambitions, while not covering the description of project guidance during construction project development. Therefore, internal documents on project strategy will be reviewed, provided by ECO. Once both the corporate and project level sustainability strategy is identified, it will be able to derive the (missing) connections between the two levels. By using documents as 'sources for perceptions', it is possible to derive the ideas and beliefs of an organisation (Karppinen & Moe, 2012). These ideas and beliefs are interpret in order to derive the organisational sustainability strategy. Additional data on the sustainability strategy will be derived in the case analysis, as some of the respondents were involved in the development of the reviewed documents. The insights given by those respondents give opportunity to verify the findings of the document review.

Case analysis

Once the sustainable elements in the corporate strategy of ECO are evaluated, its implementation in practice can be reviewed. This will be done by analysing multiple cases that include a form of sustainability. In order to study the cases, interviews with involved professionals were conducted. Note that the analysis of cases is not considered the leading research method – as described by Yin (2014) – in this thesis research project, but that the tool is applied for data collection. Flyvbjerg (2011) describes this tool as a strategy for methodological exploration, which makes it applicable for exploratory studies. Even though the results of case studies cannot be generalized towards a population, if findings are replicated over multiple cases, theory might be applicable to situations with the same conditions (Yin, 2012). Due to application of multiple tools – document review and case analysis – it is less likely fundamental biases appear (Noble and Heale, 2019). Using multiple instruments for data analysis will lead to an increase in quality, looking at credibility and validity of the results (Cohen, Manion and Morrison, 2000). Case analysis will not only contribute to identification of the problem, it will also provide insights on the objectives for solutions. These objectives will be core part of the designed framework.

Selection of cases

For the data collection, it is desirable to study multiple cases in order to guarantee diversity in terms of ideas, perceptions and opinions in the data. All selected cases need to have a common focus, as this would improve the external validity and option for comparison (Goodrick, 2014; Yin, 2012). Therefore the following selection criteria have been developed:

- Project does include a discussion related to sustainable development
- Project is executed in building environment (either a type 1 or a type 2, see chapter 3)
- Project developed after the year 2016
- Reserved budget between 1 to 500 million Euro
- The involved construction organisation is involved in the design process

The focus on sustainable aspects within the projects forces the analysis to study how the organisational sustainability strategy has been applied within the projects. In addition, the timeframe of the projects has been set based on the introduction of the Sustainable Development Goals at the beginning of 2016. The selected budget range makes sure the project will contain a significant amount of content, without being considered overly unique (Bosch-Rekveldt, 2011). For the data collection of this research, a total of six cases have been selected. A description on the project cases, together with the goals and missions are described below. Although the similarities, the cases differ in type, sector and geographical scope.

Case 1. Expansion of a pharmaceutical company

The goal of this project is to design an expansion for a pharmaceutical company. This company has asked ECO to develop a plan for a new building that will contain two additional production lines. In the time of the analysis, the first concept has been communicated towards the client. So, this project was still in its early phase. As ECO is responsible for the new building, this case is considered a type 1 project.

Case 2. Design of Quality and Control laboratory

Quality and Control (QC) laboratories are important for the food industry. Due to regulation producers have to check their products on a selection of safe and health criteria. Therefore, the client needed an additional lab. ECO was involved in the design of this lab (type 1). Within this project the client had a lot of explicit sustainable ambitions that needed to be included in the design (client also applied for a LEED-certificate). Due to this ambitions, it is expected that sustainability of the project has been a recurring topic of discussion.

Case 3. Expansion of a plant in the food industry

Due to a lack of space for production equipment, the client of this product was aiming for a new department of the food plant. While the client was arranging the mechanical processes itself, the design of the building needed to be done by ECO (type 1). Within this project the client discussed the option of applying for a LEED-certificate, as it is expected that this case does include a discussion on sustainability.

Case 4. Biodiesel from waste streams on plant site

The task of ECO within this project was linking the converting processes on the site (type 2). Within this project most of the engineering solutions were proposed by the client. However, ECO served as calculator for the integration of the processes. By linking industrial processes, this case does contain a form of IS, making it relevant to study this case.

Case 5. Design of chemical company

The client of this project contacted ECO, as they needed an engineering organisation for both the design and governmental approval of a chemical company. ECO was involved in both the design of the factory – both the building and equipment (type 1 and 2) – and all issues regarding permits. As this project covers a wide range of topics that are relevant for sustainability (material, material streams, emissions), it is a valuable case to analyse.

Case 6. Design of biomass pellets production company

This project fundamentally contributes to the environment, by creating biomass pellets that can be used for the production of energy. The project owner needed support for the design of their new company, although it was already clear what type of design was required in this case. However, to make sure all the engineering issues were solved, ECO was involved. In addition, ECO analysed the design concept on improvement opportunities (type 1 and 2). Modularity of industrial plants (and how this influence sustainability) was an aspect of this project, making it relevant to include in the research.

Data collection from cases: socio-technical analysis

To collect data from cases, semi-structured interviews are conducted. Within this form of interviewing, the dialogue is not completely standardised, such that the participant can elaborate on all ideas and perspectives (Newcomer, Hatry, & Wholey, 2015). To organise the grouping of data and ensure that all the participants discuss the same topics, a pre-defined topic list was developed as guidance during the semi-structured interviews (see appendix). Central topics for the interviews were the sustainability strategy of ECO, how this strategy was applied in the case, what factors influenced the implementation of sustainability and what can be done to stimulate this implementation. During the interviews participants were able to elaborate on their expertise, but simultaneously provide insights on other aspects that are important in their opinion as well. Due to privacy and contractual regulations, only respondents from ECO were involved in the semi-structured interviews. In this way the data does not provide the opportunity to compare the perception of ECO with other stakeholders. In the case analysis, a total of 15 semi-structured interviews have been conducted amongst project managers, (lead) engineers, architects, process engineers and sustainability consultants. Table 4.1 gives an overview of the conducted interviews.

Table 4.1 Project case and participants

Case number	Numbers of participants	Role of interviewees in project case
1	2	1a. Architect
		1b. Lead engineer
2	3	2a. Architect
		2b. HVAC engineer
		2c. Project manager
3	3	3a. Lead engineer CSA
		3b. Lead engineer HVAC
		3c. Project manager
4	2	4a. Process engineer
		4b. Project manager / sustainability consultant
5	2	5a. Energy engineer
		5b. Project manager
6	3	6a. 3D mechanical engineer
		6b. Process engineer
		6c. Project manager

The semi-structured interviews lead to qualitative data. More specifically, textual data that exist out of words, quotes and narratives. This is systematically organised and labelled by making use of the qualitative data-analysis software program ATLAS.ti. The semi-structured interviews were uploaded into this program, and notable patterns are structured by making use of coding labels. By organising the data in this way, the labelled words and narratives were able to be aggregated into groups. These groups of codes can be considered as central themes. The screenshots (figure 4.3, 4.4 and 4.5) show how the socio-technical analysis has been done. Respectively showing how text was labelled, how the codes of the labelled quotes were assigned to groups and an overview of the final themes of the socio-technical analysis.

When the semi-structured interview has been conducted, summarised and verified by the respondents, remarkable and valuable quotations were labelled by a certain code. Within figure 4.3, for instance, a quotation of respondent on the increasing attention for sustainability amongst clients have been labelled as ‘clients are looking for sustainable options’. All recurring quotes that are related to this code can be labelled with this code as well, which provides the first method of structure to the analysis. Interviews could easily contain up to 20 coding labels. 15 interviews that are all containing between 10-30 coding labels lead to a total of 84 codes in the analysis. Those 84 codes were assigned towards code groups. So, the second step in structuring the data analysis is to merge the codes into groups (as shown by figure 4.4). This lead to a collection of code groups (figure 4.5), which was helpful for the analysis. After executing these steps, it is able to search for patterns and solution objectives in the data, that will help this research to answer the main research question.

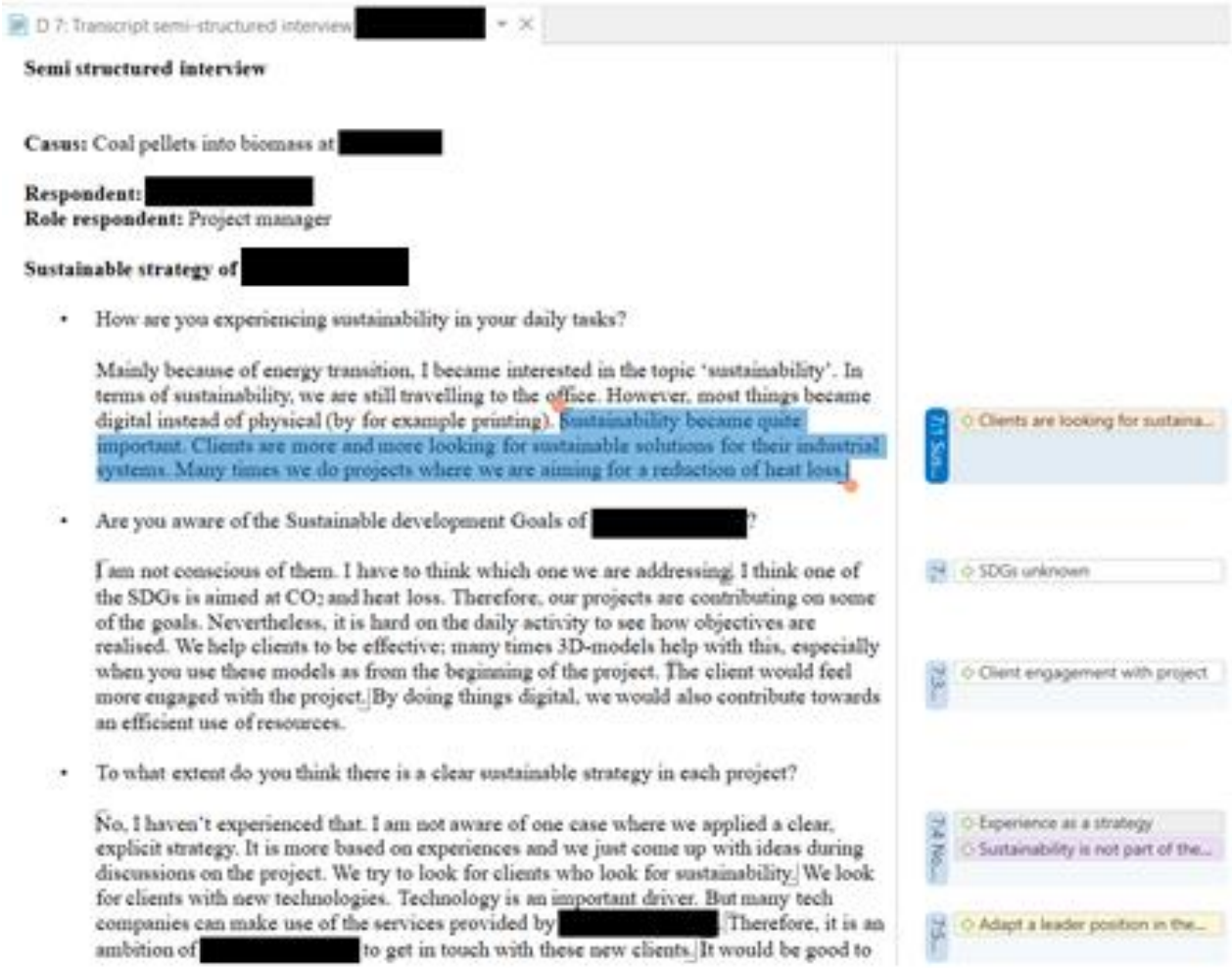


Figure 4.3 Illustration of labelling quotes

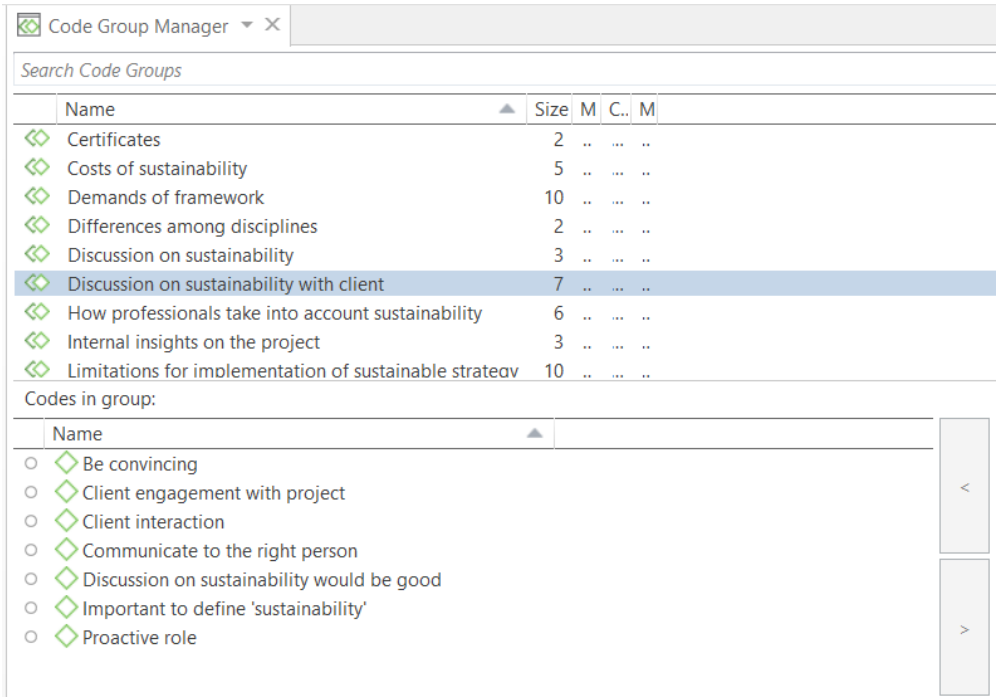


Figure 4.4 Illustration of how codes are aggregated into code groups

Figure 4.5 Overview of code groups

Based on pattern-logic, the cases can be compared and patterns or relationships between the cases can be analysed (Yin, 2012). As this research aims to integrate the results into a framework, it is important to compare patterns over cases and look for replicated relationships. Here it should be taken into account that collected data may change the plan, but Yin (2012) emphasises that it is better to have an initial plan instead of having no plan at all. As incorporation of sustainability is defined as a highly complex process in literature, further research into the factors influencing this process is relevant to answer the research question. Moreover, specific insights on the implementation process are also valuable elements in order to define the objectives for a solution.

As addressed in the literature background, employee motivation and organisational structure are considered as crucial factors for the implementation of corporate strategies. To cover all aspects of the problem statement and objectives for solutions (and complete the input for the framework), the semi-structured interviews are focusing on the perceptions and actions of professionals within the field of construction project development.

4.2.2 Design phase

According to Peffers, Tuunanen. Rothenberger and Chatterjee (2008) the starting point of the design of a framework would be to determine its function. Within this research, the desirable function of the framework would be to support professionals and organisations in the construction-engineering field with the implementation of sustainability interventions into projects. At this point, the input on sustainability strategy of ECO and the implementation in practice from the case analysis provide insights to develop an applicable framework. During

the development it is important to divide the corporate level and project level, and identify activities that would enhance the connection between these levels.

This phase covers the design and development activity of the DRSP model. This activity faces some disadvantages, as creating a framework can be time consuming and limited by the amount of data collected (Ball, 2001). In order to create both a structured and functional framework, the design process contains an iterative character, as it can be redesigned based on the outcome of the evaluation phase. The identified factors of the qualitative analysis were interpret as hurdles to overcome. In this way, the framework addresses the main barriers for the implementation of sustainability strategy, by developing action objectives to approach the project hurdles on both corporate and project level.

4.2.3 Evaluation phase

Once the framework has been created, its function and validity should be tested by a certain way of evaluation. A commonly used tool to evaluate the quality and validity of a framework is a focus group. Within this evaluative tool a group of individuals – in this case professionals from the field of building environment – discusses a particular topic. The discussion provides the researcher perspectives, beliefs, perception and attitudes of the participants towards the functionality of the framework (Cornwall & Jewkes, 1995; Hayward, Simpson & Wood, 2004; Israel, Schulz, Parker, & Becker, 1998; Kitzinger, 1994; Morgan, 1996). This would be a cost and time efficient option to demonstrate the framework and evaluate its value and applicability. Within focus groups an independent moderator should be leading the group, in order to avoid the steering of the discussion (Gibson & Arnott, 2007).

The focus group was organised in an online setting, facilitated by the online workspace GroupMap. As table 4.2 describes, both consultant and engineers of different departments of ECO were involved in the evaluation of the conceptual framework. It was decided to organise the session online, as the COVID-19 restrictions during this thesis research project were strongly advising to avoid physical contact as much as possible. The focus group was structured by three steps:

1. The focus group started with a brainstorm session, in which applicants were able to provide two to five ideas on framework requirements. This first step generated some evaluation criteria for the application of a framework. Before the session goes on to the next step, the ideas were grouped together if possible. This first step mainly had the function to activate the respondents of the focus group.

2. As a second step the respondents were able to assign five votes towards the ideas or requirements that are most important from their point of view. This voting step was used as an inspiration for the discussion on framework requirements. These introducing steps also provide the opportunity for respondents to share and discuss their ideas and opinions on what are important factors for a framework amongst each other.

3. After discussing the voting, the conceptual framework was shown to the group of professionals. Within this step the respondents could share their thoughts on the framework, suggest improvements and evaluate the presence of important requirements that are

discussed in the previous steps. The input of the focus group is used to improve the framework.

Table 4.2 Role of participants within focus group

Role	Number of participants
Process engineer	4
Business and Account Developer	1
Lead engineer electricity	1
Lead engineer HVAC	1
Manager consultancy	1
Manager QOHSE	1
Sustainable consultant	1
Regional director	1

Based on the discussion on the voting step, the application ideas and requirements within the framework were evaluated. This input has led to some additional requirements that were integrated into the framework. The output of this phase will provide information on the final sub question. The framework, together with the retrieved insights and reflections will be communicated towards the involved party and universities.

4.3 Overview research activities

This chapter described the general research approach, adopted methodology and applied instruments for data collection. All research activities are visualised in figure 4.6. Within this figure the arrows are indicating the sequential activities in the research set-up. In addition, the steps are linked towards the activities of the DSRP model. So, to analyse the incorporation of sustainability, this study has its focus on implementation of sustainability strategy. By following the steps of the visualised research flow diagram, main barriers that influence the implementation of sustainability strategy in construction project development can be derived and understand. Next, data will also provide stimulating factors and activities that will be structured in a framework. This framework will be tested by the focus group in the evaluation phase. In this way, a combination of the results on the sub question will be used to state conclusions on the main research question of this thesis research project and derive recommendations for ECO. As activity 6 (communication) is in this research done by describing the research within this thesis research project, it is not explicitly visualised in figure 4.6. This research approach provides data to an answer all sub questions and the main research question.

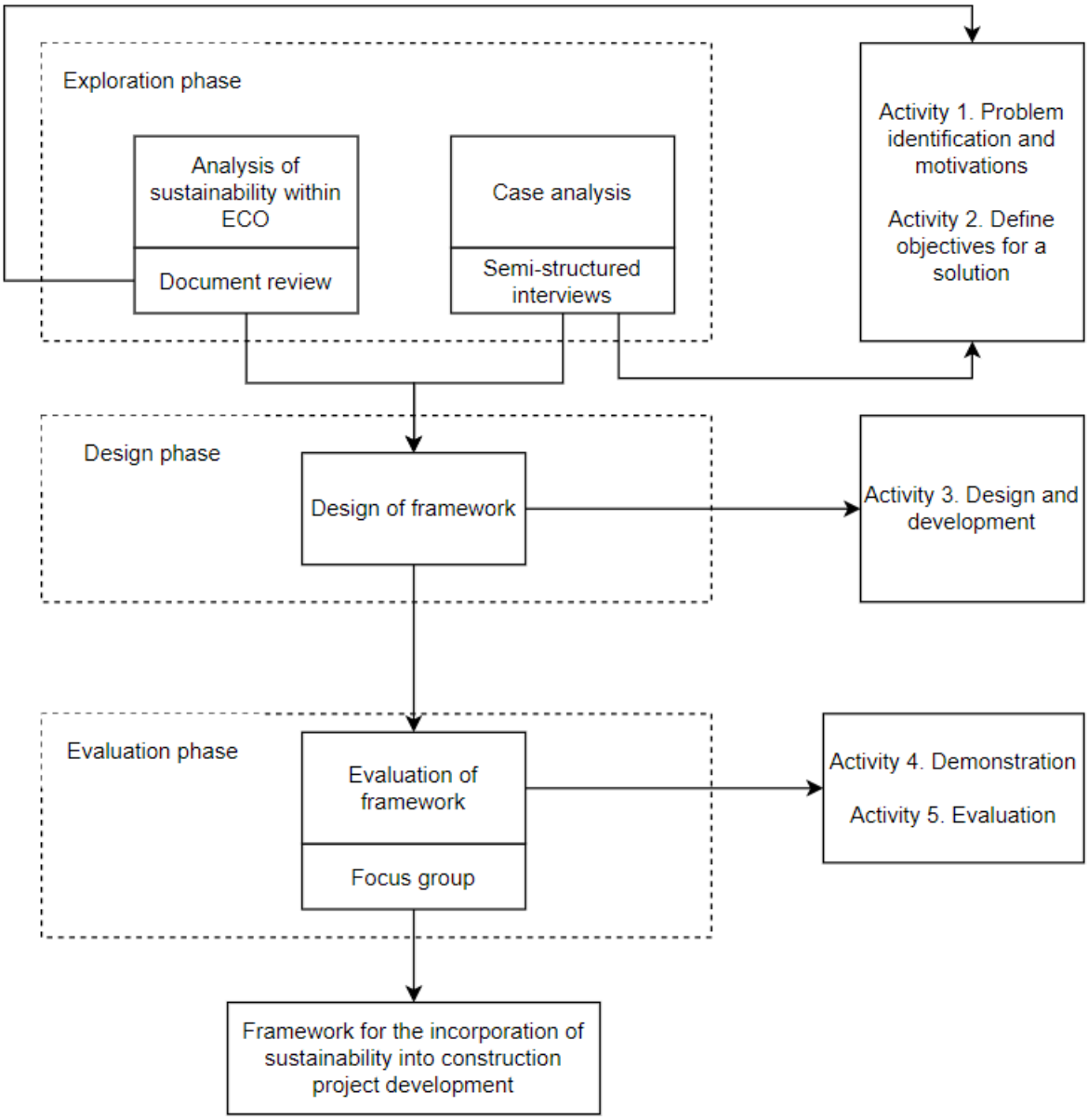


Figure 4.6 Research flow diagram
Note. Activity 6 of DSRP model not explicitly visualised

5 Organisational sustainability strategy of ECO

This chapter will elaborate on the sustainability strategy of ECO, by analysing external and internal corporate documents. The aim of this document review is to derive how sustainability has been formulated within the corporate strategy and how the strategy on the corporate level is converted into practical objectives on the project level. Section 5.1 elaborates on the reviewed documents. Within section 5.2 to 5.4, the organisational strategy on both the corporate and project level is derived, and its relationship towards sustainability is compared. After this step, section 5.5 evaluates the corporate strategy based on Industrial Ecological elements. Section 5.6 concludes the outcome of this chapter.

5.1 Document analysis: selected documents

As stated before, ECO is a Dutch subsidiary of a global corporation. Therefore, annual reports make no clear distinction between strategy of the global corporation and its individual national companies. This is notable, as in practice the project strategy might be varying amongst

Table 5.1 Documents included in review

	External Name of document	Category
1	Annual report 2019	Annual report
2	CSR report 2011	Annual report
3	CSR report 2012	Annual report
4	Sustainability report 2018	Sustainability report
5	Website article on circular economy scan	Online website article
6	Website article on environmental services	Online website article
7	Website article on corporate strategy	Online website article
8	Website article on sustainability ambitions	Online website article
9	Website article on increasing attention for sustainability	Online website article
10	Website overview on specific services	Online website article
	Internal Name of document	Category
11	Business Process Activity	Overview of possible business activities
12	Execute plant design reviews	Project guidance
13	Project Basis of Design	Project guidance
14	Project Execution Plan	Project guidance
15	Project HSE Management	Project guidance
16	SDG scan	Project guidance
17	Quick reference card tenders	Roadmap for tenders

different countries or regions. In addition, the corporate strategy is described in a general way. However, the annual reports are a valid starting point for this document analysis. These documents are free accessible and can be read and downloaded without any restrictions. In addition to annual reports, published articles about or by the organisation have been included in the review as well. Both the published articles and annual reports are mainly used to derive the organisational strategy and sustainable fundamentals within this strategy.

To analyse the project strategy, internal documents on the project level have been provided by ECO, for the purpose of this research. The internal documents can be found within the restricted forum of the organisation and are therefore not accessible. An overview of included documents can be found in table 5.1.

5.2 Organisational systems: corporate level and project level

The aim of this chapter is to derive a complete understanding of the organisational sustainability strategy and how this is applied on the project level. IE will be applied to indicate the connections between corporate and project level, and how this connection is aligned with IE principles for implementation of sustainability strategy. Note that within this research there is a clear distinction between the different systems within an organisation. First, there is the corporate level, that includes the general ambitions and management tasks. Second, the project level has been identified. This level represents the system where sustainable ambitions of the corporate level are converted into practice. Although the systems are connected via the different management layers (as explained in chapter 2), the incorporation of sustainability is evaluated for both systems separately. Later on in this chapter, the connection between the different systems is discussed.

5.3 Corporate level

The main business of ECO exists of provision of industrial services or facilities to a global range of customers. The type of industrial services can be divided by focusing on consulting and engineering on the one hand, and maintenance on the other. In addition, the services increase the efficiency of assets in the process industry, ensure the availability of assets and decrease maintenance costs for industrial actors. By applying these services, the organisation aims for the highest safety and quality standards, as described in the annual reports.

In terms of corporate strategy, within the 2019 annual report an approach for the coming years is formulated. This approach considers three aspects as crucial for the construction project design services: predictability, reliability and sustainability. To continue this approach and stimulate organic growth in terms of financial capital, ECO mention that motivated and skilled employees are required. A part of the expected financial growth is invested in the related markets, by exploring solutions for climate change related problems. This exploration of opportunities is indicated by the investments in innovations, which grew in 2019 with approximately two million Euros, compared to earlier years. In general, the corporate strategy as described in the external documents can be converted towards the project activities, as the corporate strategy suggests to continue key activities within the engineering and maintenance market. Figure 5.1 provides an overview of the key activities of ECO. Note that this figure covers the key activities of the individual engineering organisation of this research. The

creation, capture and delivery of value is mainly done by engineering services, as shown below. Based on the adopted unit of analysis, design and engineering services are the main focus of this study.

Figure 5.1 key activities ECO

5.3.1 Sustainability in organisational activities

In the annual reports of 2011 and 2012 the organisational ambitions regarding sustainability were reported. Within the early annual reports, they included sustainable into the CSR part. The CSR encompasses multiple elements, with most of these elements relating towards industrial services. In general, the goals for 2012 were to increase the amount of meetings with customers on sustainability, create a database with sustainable innovations and present/exchange the sustainable solutions. A different focus point was about a training program for employees. At the end of 2012 several meetings on sustainability were held with clients, sustainable innovations were shared on the internal server and the organisation initiated a training program for professionals.

When analysing the recent annual reports, a combination of predictability, reliability and sustainability is the fundamental baseline for the strategic approach of the coming years. To incorporate sustainability, the organisation adopted six Sustainable Development Goals (SDGs) on which they aim to contribute. Although this approach looks quite similar to the selection of sustainable elements of the CSR reports of 2011/2012, the SDGs are described broad and general, without linking it to specific measurement indicators. The selected SDGs can be split up into two groups. The first group of SDGs is related towards the social structure of the organisation, whereas the second selection is more applicable towards construction project development. In terms of focus areas, the second group is applicable to the industrial services and development of projects, whereas the first group has more influence on the organisational code of conduct.

Social structure and organisation

Quality education, gender equality and decent work and economic growth do represent the internal ambitions. In terms of strategy, the internal goals are more related towards the behavioural guidelines of the organisation. However, as these SDGs are considered as fundamental aspects they are included into this review. Within this paragraph the adopted SDGs, related to the internal structure, are discussed.

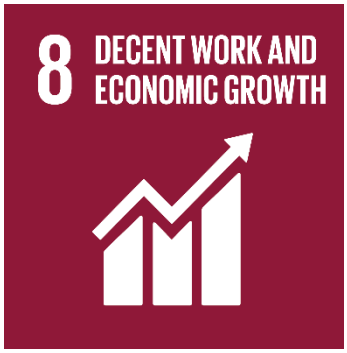
SDG 4: Quality education

Quality education promotes the learning activities for employees (United Nations, 2016), by providing learning opportunities in order to keep employees up-to-date of the latest innovations. This goal is related to the skills of employees and training programs, as discussed in the CSR report of 2011. ECO converts this goal to practise by stimulating the participation of employees in exercises and enhance the exchange of knowledge.

SDG 5: Gender equality

Woman's empowerment is a prominent aspect of this goal. ECO included gender equality as a core value in their Code of Conduct, as described within the article on strategy on the website. The principles of goal are applied by treating employees equally when it comes to hiring, promotion, remuneration and employee development.

SDG 8: Decent work and economic growth



While executing the tasks, safe and fair working conditions are guaranteed, according to the annual report of 2019. Not only did ECO included this as an explicit guideline in the code of conduct, the suppliers activities are also evaluated on the aspects of this goal.

Construction project development
Within the engineering and maintenance activities, there are always monetary budgets that might hamper certain sustainable interventions. While taking into account the budget and customer demands, the organisation aims to contribute in a positive way to the environment. Within the key activities they take into account clean water and energy conditions, as well as sustainable industries.

SDG 6: Clean water and sanitation

Potable water is not a guarantee for a big part of the global population. Within the sustainable report of 2018 it is stated that the organisation has an expertise in the development of seawater desalination plants. With the provision of this service, seawater is converted into potable water, and the availability of potable water increases. This service is particularly applied in Middle East regions.

SDG 7: Affordable and clean energy

During the execution of projects, the life cycle of energy plants is evaluated on opportunities to reduce emissions and improve efficiency. Within the information provided on affordable and clean energy, the organisation did not provide details on specific innovations (wind or solar power). However, in their latest annual report, hydrogen energy is indicated as a potential new market. The affordability of energy is not explicitly discussed in the annual reports.

SDG 9: Industry, innovation and infrastructure

This SDG is important for ECO. As a market leader in construction project development services, the annual reports state that the promotion of modernization and innovation is included as part of the corporate strategy. Moreover, both clean water and sanitation as well as affordable and clean energy are related to SDG 9. ECO aims for sustainable industries, but also emphasises investment in infrastructure and innovation. Within the key activities, there is a particular focus on improving efficiency of assets and plants, while reducing maintenance costs. In this way, the organisation attempts to contribute to sustainable industries.

5.3.2 Sustainability as part of the corporate sustainability strategy

Although the selection of SDGs determines the sustainable ambitions to a certain extent, both the sustainable reports and the annual reports do not provide information on how the SDGs are taken into account in practice. Based on the documents, a part of the sustainability strategy is the inclusion of SDGs as a basic guideline within every construction project. When reviewing the website articles on circular economy and environmental reporting, it is able to derive practical examples of the application of SDGs. For instance, calculation models, scenario mapping and chain analyses are applied tools to study sustainable improvements. Moreover, the organisation is able to execute circular production scan for products and processes, a tool that can be used to estimate the impact of new investments. The goal of the scan is to analyse projects on improvements on water, energy and material efficiency. The selected SDGs are adopt as impact categories within this scan. The environmental reporting service gives an overview of environmental impact of industrial actors, by making use of a range of standardised and approved calculation tools.

For the last decade, ECO strives to work with clients who aim for sustainable project development. As noticed before, problems can arise here as a result of the dependent role of ECO within the design of construction projects. Moreover, multiple methods and tools are applied in practice to support clients with indicating hotspots for sustainable improvements. At this point a first connection can be made between the corporate sustainability strategy and IE tools, as LCA is applied in order to analyse potential environmental improvements. To continue, reporting and communicating the hotspots in design, a reduction in environmental impact can be realised. Moreover, SDG 8 and 9 connects IE elements with the corporate strategy as well. IS has been used to explore industrial innovation and improve sustainability by partnering, which is in line with the idea of SDG 9. A form of SCP is applied within SDG 8, as the behaviour of upstream and downstream industrial actors are evaluated and discussed by ECO, driven by sustainability ambitions.

When it comes to a formulated sustainability strategy, the documents do only include ambitions on contribution to global sustainability. The specific applied philosophy and guidelines in terms of sustainability strategy within construction project development have not been described on the corporate level. The document review combined several annual reports and web articles, resulting in a set of goals and ambitions, applied method and tools.

5.4 Project level

To analyse how the developed goals, methods and tools of the corporate strategy are applied in practice, a closer look at the project approach is required. To gain understanding of the sustainability strategy on the project level, internal documents that contain specific steps in the project cycles have been reviewed. These documents are not open source and were provided by ECO. In addition to the internal documents, the sustainability strategy on the project level is discussed with sustainable consultants and a regional director. This research will now continue with elaborating on the general project approach of ECO within construction project development.

5.4.1 Project approach of ECO

Internal documents give a detailed overview of the tasks that need to be fulfilled in certain steps: (1) Business development; (2) Tender; (3) Initiate and plan; (4) Execution; (5) Closeout. The early phase of the project cycle of ECO exists out of three steps. Especially the first two steps are important for the integration of sustainability. During the execution step sustainability is not discussed. The last step does have a connection with sustainability, by evaluating the lessons learned of the project. But it has to be said that improvements on the project cannot be implemented by then. The typical cycle for the delivery of projects exists of the following sequential steps:

1. *Business development.* The first step is to inform the services to a client. Within this step, the selection of cases is discussed. Therefore, a roadmap for tenders has been developed. This map entails all kind of criteria that have to be evaluated, before the organisation registers for a certain construction project. When assessing the risks of the project, the corporate strategy of the client is compared towards the strategy of the engineering organisation. However, sustainability is not explicitly included as a criteria within this phase.

2. *Tender.* Once the director or project manager has approved a project registration, a concept plan will be developed. In terms of sustainability, an explicit task of this step is to discuss the circular production scan with the project owner. By executing this scan, it is analysed how ECO can contribute to (a selection of) SDGs within the project. As from a certain financial budget (> €100.000), the organisation includes the opportunity for a sustainable workshop (assisted by the consultancy department). Next to this workshop, ECO obligates the project team to execute the circular production scan once this financial burden has been exceed. The tools discussed in the previous part can be used to identify sustainable opportunities in the project. The circular production (or SDG) scan is explicitly recommended to include as an option for the client.

3. *Initiate and plan.* This is the final step of the early phase of construction project development. By this time, the design of the project has been finalised. All tasks in order to prepare the realisation of the project are part of this step.

4. *Execution.* Project information in terms of scope, time schedule and costs is shared amongst all the shareholders within this step. Sustainability is not a topic of discussion in this step, as it is not covered within the project execution plan document. The primary tasks are to monitor the construction of the project and communicate all activities to shareholders.

5. *Closeout.* The main goal of this step is achieve continuous improvement within the activities of the engineering organisation. This is done by evaluating the execution process: did it followed the initiated plan? The internal share of knowledge is mentioned in the corporate strategy as an important activity for sustainable development. It would for example be easier to explore sustainable hotspots in similar projects, once colleagues are informed on these experiences.

5.4.2 Project sustainability strategy

As all the steps of the project cycle are describing, sustainability is covered within the early phase by the circular production scan tool. Moreover, the integration of sustainability is initiated by the execution of such an analysis. Once sustainable improvements were found, the project manager will discuss the potential changes in the design with the client. This discussion lead to a final decision on the integration of sustainability into the design. This process is visualised by figure 5.2. However, as discussed in the previous section the SDG scan is an obligatory tool when project budget exceeds 100.000 Euros. In addition, the strategic cycle does guarantee identification of sustainable hotspots or implementation of sustainable intervention. As shown in the figure 5.2, the project scope and decision of the client determines the outcome significantly. The SDG scan is not included in the standard project approach, according to the criteria given in the internal documents (only to provide it as an option). This is contradictory to the website article on sustainability, as those documents are emphasising that: in order to optimise sustainability within the project cycle and prepare ECO for future demands of clients, there is need for an implemented sustainability strategy throughout the complete early stage of projects.

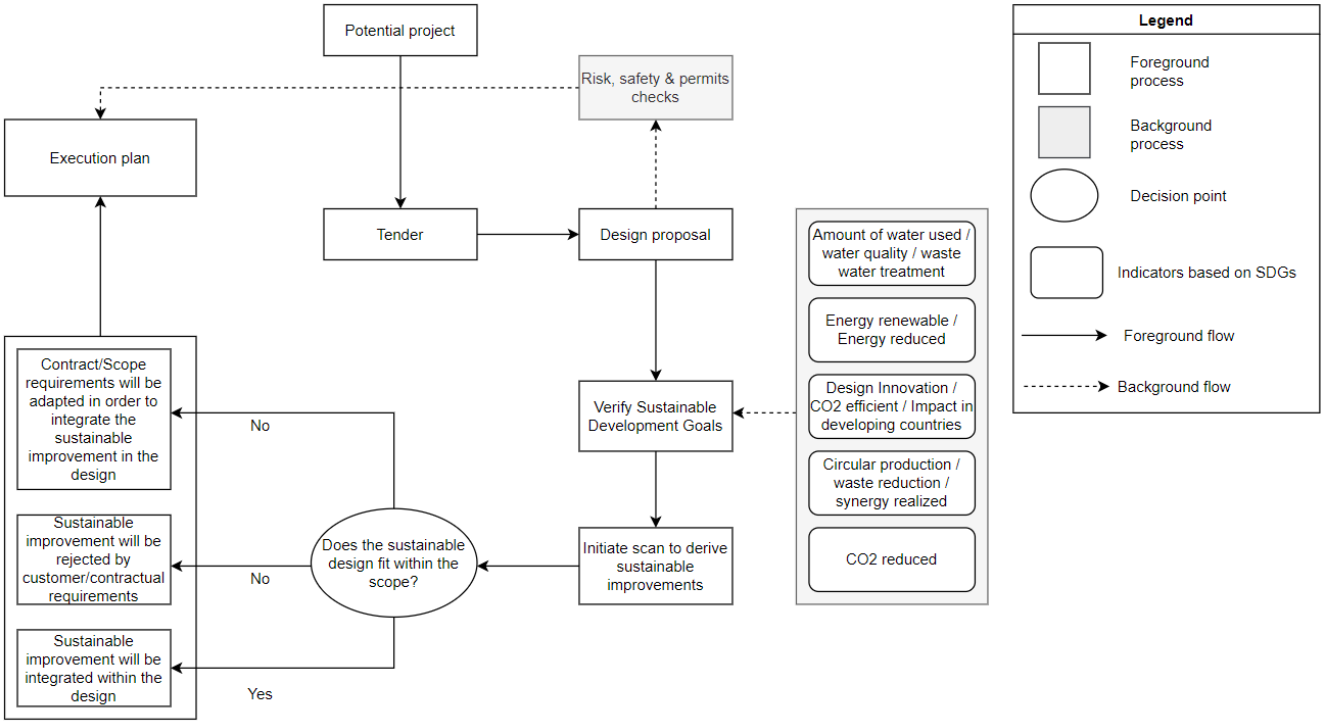


Figure 5.2 Sustainability strategy on the project level

As shown in the process cycle, the design of a proposal also contains the check of permits safety and potential risks. When projects are initiated, they need to pass governmental regulations to get municipal approval. Within the guidance for the permission checks, sustainability is discussed several times. Nevertheless, it is not considered as part of a sustainability strategy, as it is not linking the corporate ambitions, vision and goals to the project level. The main tasks in terms of permission is to serve the client in its demands, and achieve an approval for a specific project. In terms of selected SDGs, the verification of SDGs on project level does convert some of the selected SDGs on the corporate level into applicable values.

5.5 Industrial ecology principles for linking corporate and project strategy

As from this point sustainability strategy on both levels have been identified, however the next step is to analyse the connection between the systems. IE system thinking give the opportunity to link the different system levels (corporate and project) of ECO. The connection between organisational levels is structured by looking at five hierarchic levels, inspired by the sustainable development model of Robèrt et al. (2002). As an additional study, Korhonen (2004) assigned IE principles towards the systematic approach to achieve sustainable development. In this research, IE principles that are relevant for sustainability are assigned towards specific levels for sustainable development. The general idea behind this model is a stepwise plan, where incorporation of IE increases via the sequential levels. Levels are assigned to either corporate level or project level. However, the levels are interconnected in a hierarchical way, which requires an aligned structure throughout the organisation. Hence, it is analysed how the elements of the levels are present within ECO. The five levels of the sustainable development model, designed by Robèrt et al. (2002) and complemented with IE principles by Korhonen (2004), are:

Level 1.	Constitution of the system
Level 2.	Principles for sustainability as the desired outcome
Level 3.	Process to reach the above outcome of sustainability
Level 4.	Actions and concrete measures
Level 5.	Tools and metrics to monitor and audit

5.5.1 Constitution of the system

A key characteristic of this is pointing out the economic system as a subsystem of society, which is connected with a sustainability system (Korhonen, 2004). When deriving the corporate sustainability strategy, ECO aims on reducing environmental impacts and maximise the resource efficiency of projects. However, within their approach sustainability is not linked with the economic system. Sustainability is covered by a specific chapter within the annual reports or website articles, as only broad descriptions of the ambitions of ECO are given in these documents. This is not in line with the IE principle of interdependency between economic and social subsystems (part of the constitution of the system). Nevertheless, the sustainable ambitions are providing insights on material and energy flow principles, in such a way that the societal values are covered. So, the corporate sustainability strategy includes elements of IE, but does not make an explicit connection between sustainable and economic interests.

5.5.2 Principles for sustainability as the desired outcome

Within the reviewed CSR reports and the annual report of 2019, the current status of environment is described as problematic, and ECO states that it is willing to take its responsibility in construction project development. As mentioned in both the corporate and project strategy, ECO is aware of multiple IE tools that identify hotspots in the project design. However, as for some tools (for example the SDG scan) a minimum budget is required, the favourable outcome of applying IE principles for sustainable development is questionable.

5.5.3 Process to reach the above outcome of sustainability

This level contains a description of the tasks that have to be executed in order to achieve the desirable outcome. In other words, within this level corporate strategy is translated into project strategy. Here it is mentioned that locality, diversity and cooperation or community are important when one faces a competitive market environment. The desirable outcome – that is described in the corporate annual report and website publications – is achieved by including sustainability explicitly in the business development and tender phase of the project approach. ECO does this via the application of calculation tools such as the circular production scan. Even though the SDG scan might be an optional tool, the tender managers are forced to think about the SDGs that are relevant for the project and to discuss this with the owner(s) of the project. In addition, the roadmap for project selection does force managers to compare the clients strategy, and to discuss how the organisational strategy of ECO is aligned with the strategy of the project owner.

5.5.4 Actions and concrete measures

As discussed in the background, IE principles cover a wide range of tools and approaches that stimulate sustainable industries (for instance creating value out of waste or exchange of materials between industrial actors). Some measures are explicitly mentioned by the adopted SDGs of the company, but not all are directly linked towards the project approach. A possible explanation for the degree of abstraction associated with the project guidance, would be the basic engineering principles. It sounds plausible that professionals will apply basic engineering principles that include sustainable interests (such as energy and material efficiency). Within this level, value creation via the application of IE tools is mainly done via the Life Cycle Inventory Analysis step, which is part of LCA. But concrete measures in terms of IS or SCP are not described in both internal and external documents. This is notable, as the main focus ECO is on the reduction of environmental impact.

5.5.5 Tools and metrics to monitor and audit

As a final principle of IE, Roberts (2004) mention the demonstration of commitment to the benefits of industries. Korhonen (2004) apply this principle to the fifth level of sustainable development of Robèrt et al. (2002). By monitoring results, the actual impacts within the earlier levels can be measured, and the benefits for society and industry are able to be demonstrated. The project strategy does slightly touch upon this principle, by forcing the project teams of ECO to think about the lessons learned in the closeout phase. Not only should the lessons learned be documented, the project manager should also share these lessons internal. Nevertheless, no indication is found that ECO measures and shares the actual positive impact made because of the application of IE tools, in terms of CO_2, energy or materials saved.

5.6 Concluding

The goal of this chapter was to describe the organisational sustainability strategy of ECO and apply IE principles to compare how the corporate strategy is integrated into the project guidance. For this analysis, a clear distinction was made between the corporate level and the project level.

Internal documents contain some of elements of the corporate sustainability strategy, but most of the ambitions and goals on the corporate level are broad and in an abstract manner defined. A successful translation of corporate sustainability strategy into project guidance is the application of the circular production scan. However, besides LCA no IE tools are explicitly found in the selected documents. Furthermore, sustainability was mainly considered as a separate topic, which can be categorised next to permits, risks and safety. Sustainability seems not included in the core values of ECO, while it claims to strive to engineer as sustainable as possible.

When comparing the different levels of sustainable development (identified in academic research), it seems that ECO integrated the corporate goals into the project strategy in a too broad and abstract manner. As the sustainability strategy on the project level is not clearly described, problems in practice can be expected. To get further insights in how the implementation of sustainability strategy is realised in practice, the next chapter will analyse six construction project development cases.

6 Barriers for implementation of sustainability strategy in practice

Case studies were performed to identify aspects that stimulate or affect the design and implementation of sustainability strategy within construction project development. The semi-structured interviews focused on both relevant factors and the perception on sustainability strategy amongst involved professionals. In terms of DSRP model activities, this chapter continues on the problem identification and motivation and appropriate solution objectives.

6.1 Case overview

A total of six cases have been analysed in this phase, see also section 4.2.1. The set cases represents ongoing projects, all started in a recent time period (> 2016). So, not all cases have encompass the complete project cycle (early phase to aftercare), but the activities in the early phase (design and discussion of the concept plan) were present in all six cases. In terms of project types, cases cover both projects that were focusing on the design of industrial plants and projects that were focusing on industrial processes. The cases were executed within different sectors, for instance the pharmaceutical sector, food industry, chemical industry and energy industry. ECO was involved in the early phase, and was able to influence the concept of the project. A minimum of two persons were interviewed from each case. Following this protocol, 15 semi-structured interviews have been conducted with involved engineers, project managers and a sustainability consultant. All semi-structured interviews were recorded and summarised. The transcriptions were shared and approved by the participants before the start of the data analysis. Apart from one interview, the main language spoken in the interviews is Dutch. The transcripts were analysed on narratives of the respondents that relate towards the application of sustainability into projects, subsequently drivers that cause a successful implementation or neglection of sustainability into the projects were identified. In this way, behavioural and contextual aspects that represents a barrier for applying sustainability strategy on project level were identified. Besides identifying those factors, explanations of respondents on how sustainability was implemented during the cases were reviewed, in order to derive stimulating factors. Cases were mainly providing data on the project level. Because of the exploratory character of this study, the interviewees had not been informed on the background information.

During the interviews candidates were able to provide a comprehensive story as response to the questions. To make the analysis efficient, the notable parts within the quotations were labelled as a code. Examples of these codes are ‘Client should take into account sustainability’ or ‘Hard to develop best practise strategy’. Eventually 84 codes were assigned to the 15 transcriptions. These 84 codes were merged into code groups, in this way related codes were merged and represent a central theme, as visualised in figure 6.1. Each group represents a central theme of the analysis, which would be ‘Internal communication on the project’ in figure 6.1. By aggregating codes into groups, the general themes of the data are identified. It supports the analysis in terms of data structuring to derive the relevant aspects to answer the

research questions. Eventually six central themes were derived from the transcripts which will be discussed in the next section. Note that not all 84 codes were assigned to a code group, as not all codes were related to factors influencing implementation.

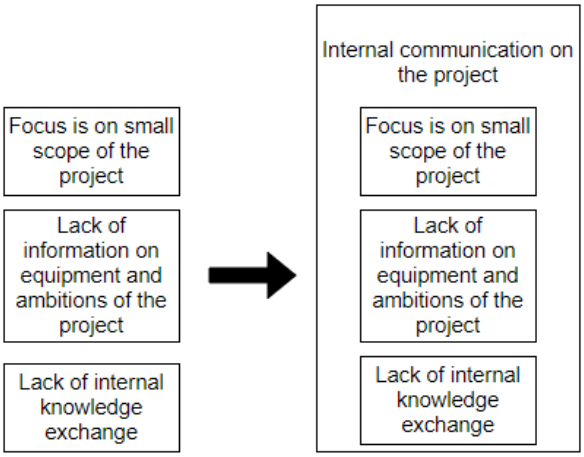


Figure 6.1 Codes merge into a group

While looking for factors that stimulate or affect the implementation of sustainability, an attempt has been made to assign factors relevant for either formulation or implementation. However, in reality the factors influence both the formulation and implementation, as both processes are related to sustainability strategy of ECO. Within the analysis we will look into the different factors, and compare their influence to both formulation and implementation of sustainability strategy.

The discussion on sustainability differs over the cases, ranging from fundamentally integrated to excluded from the project. Before discussing the factors found in the data, some more information on the context of the cases is shown in table 6.1. Based on the perceptions and experiences of the respondents, the cases are rated on four indicators: (1) fundamental sustainability; (2) step in project cycle; (3) sustainability demand of client; (4) governmental regulations. The first category rates sustainability as recurring topic of discussion. For example, within case 2 the client applied for a LEED-certificate, which increases the discussion and attention for sustainability in this case. But within case 5 sustainability is not considered a central issue, resulting in a lower fundamental sustainability. Within the second category, the step in the project cycle is given. This is important, as the step in the project cycle determines the implementation of sustainability to a certain extent.

Table 6.1 Characteristics of cases

	Fundamental sustainability	Step in project cycle	Sustainability demands of client	Governmental regulations
Case 1	1	Tender	0	1
Case 2	2	Initiate and plan	2	1
Case 3	1	Execution	0	1
Case 4	2	Execution	1	1
Case 5	1	Tender	1	2
Case 6	2	Initiate and plan	2	2

Note. 0 = low, 1 = middle, 2 = high

The third and fourth category represent the sustainability ambitions of the client and governmental regulation respectively. To what degree is sustainability integrated into the ambition and demand of clients is an important aspect for ECO. Moreover, governmental regulation can be a significant driver for sustainability implementation as well, hence the influence of (inter)national policies within the case is indicated. An elaborate description of the cases is given in chapter 4. Data has been collected by studying the following six cases:

Case 1. Expansion of a pharmaceutical company
Case 2. Design of Quality and Control laboratory
Case 3. Expansion of a plant in the food industry
Case 4. Biodiesel from waste streams on plant site
Case 5. Design of chemical company
Case 6. Design of biomass pellets production company

6.3 Factors influencing implementation of sustainability strategy

An overview of the identified factors is given in table 6.2. The right column shows which individual codes are included into the central groups. The first group of this overview entails all codes that are related to the information and data on the project. Not only does this category cover factors that are related to information provided by the client to ECO, but also the information exchange within ECO. When the focus is only on specific part of the project scope, required data that would be needed to explore sustainable improvements (such as energy use or functionality of the project) is not present. So, missing information on technical or functional aspects hampers the implementation of sustainability strategy. However, once data for sustainable interventions is available (for example for the SDG scan), this is not always communicated throughout the project team (case 3). Therefore, lack of internal communication on the project affects the strategic approach.

The service-oriented perspective addresses all codes that suggests a reactive role of ECO, instead of a proactive. As most of the codes suggests, the primary goal of ECO is to serve the client in its demand(s). This perception is not in line with the sustainability strategy as described in section 5, as proactive behaviour is desirable when discussing sustainability. A service-oriented perspective is a factor that limits the formulation and implementation of sustainability strategy, as professionals that adopt this perceptions will be less motivated to bring the sustainable project approach into practice. In addition, respondents also mentioned geographical location as a practical limitation (case 1), leading to a reactive role. Some respondents indicated that, because of the service-oriented role, options for sustainable interventions (such as the sustainability workshop) are not communicated to the client (case 5).

Standardisation encompasses codes that point out prior decisions on project design. Even before ECO is involved in the project, certain choices on methods or materials are already determined. This standardisation can be caused by governmental regulations (for example strict hygiene conditions in the food and pharmaceutical industry, case 1), or because of reliability in the normally applied methods (case 5). As standardisation hampers the integration of the project sustainability strategy (no space to integrate any sustainable improvements),

the corporate ambitions cannot be realised in projects. Therefore, this category is considered as affecting factor for the implementation process.

From the literature review the early phase of a project (business development, tender and initiate and project plan) is described as the crucial period for the integration of sustainability into the project approach. Late involvement of ECO was mentioned several times throughout the transcripts. Besides the late involvement, the change in sustainable demands was indicated as a factor as well. When the project has entered execution, there is no space to change the designed project concept (by for example execute a SDG scan). In this way, entering the execution phase is derived as a limiting factor for the implementation of sustainability strategy.

A different theme that affects the opportunity and space for applying the sustainability strategy on the project level is lack of reserved time for sustainability. While sustainable integration is mentioned as an iterative process, in many cases there is not enough time and space provided to discover and develop these interventions. Hence, it is indicated as a barrier in this analysis.

The financial aspects of sustainability represents the final limiting factor. This theme is interesting for two reasons. First, while IE is emphasising to couple economic and sustainable systems, in many cases sustainability was considered as a single subsystem. Second, the specific codes assigned to this group are determining the presence of other limitation factors as well. For instance, within case 3 due to budgetary reasons no time was reserved for sustainability. Budgetary drivers are mentioned in a lot of cases.

Table 6.2 Code groups of the analysis (based on 6 cases, 15 interviews, 6 groups)

Name of code group	Individual codes included in the group
Internal communication on the project	
1	Focus is on small scope of the project
2	Lack of information on equipment and ambitions of the project
3	Lack of internal knowledge exchange
Service-oriented perspective	
1	Considering demands of clients as leading
2	Operational tasks of a plant are most important
3	Practicality of sustainable interventions
4	Request a permit is primary task
5	Traditional engineering approach
Standardisation	
1	Reliability in common applied methods
2	Standardised materials
3	Standardised methods of client
Project already entered execution phase	
1	Change in (sustainable) demands after concept phase
2	Involved after concept phase
Time reserved for sustainability	
1	Iteration for sustainable improvements is time intensive
2	No additional time reserved for discovering sustainable options
3	No time to check project guidance documents
Costs of sustainability	
1	Affordability of sustainable investment
2	Reserved budget
3	Short payback periods are desired
4	Sustainability considered as a cost

Table 6.3 shows the role of the factors in terms of frequencies. Based on the frequencies, the main factor limiting the implementation of sustainability strategy is related to the positioning of ECO in comparison to the client. As table 6.3 visualises, the demands of clients are in many cases considered as the main goal, without having any discussion on sustainability. Not only is it the most frequently mentioned factor (seven times), but it also affected the project approach in five cases. Also, costs and standardisation are often mentioned in the interviews over several cases. Especially the appearance of factors within different cases is interesting, as the frequency of cases indicates a pattern of recurring factors.

Table 6.3 Contribution of factors to implementation of sustainability strategy on project level (based on 6 cases, 15 interviews, 20 factors)

Factor	Mentioned in number of interviews	Mentioned in number of cases
Considering demands of clients as leading	7	5
Reserved budget	7	4
Short payback periods are desired	5	4
Standardised methods of client	5	4
Change in (sustainable) demands after concept phase	4	4
Affordability	4	4
No additional time reserved for discovering sustainable options	4	3
Lack of information on equipment and ambitions of the project	4	3
Traditional engineering approach	4	2
Reliability in common applied methods	4	2
Standardised materials	4	2
Focus is on small scope of the project	3	2
Sustainability considered as a cost	3	2
Lack of internal knowledge exchange	2	2
Operational tasks of a plant are most important	2	2
Practicality of sustainable interventions	2	2
No time to check project guidance documents	2	2
Request a permission is primary task	1	1
Involved after concept phase	1	1
Iteration is time intensive	1	1

6.4 How are the factors affecting implementation of sustainability strategy?

The previous section gave insights in which factors are prominently affecting the implementation of sustainability strategy. Although the quantities of factors do gave insights on the likelihood of appearance, it does not explain how the factors are limiting implementation of the sustainability strategy.

As conclude in chapter 5, ECO intends to couple the corporate strategy to the project strategy via the application of calculation tools and sustainability workshops. Within the project guidance, it is explicitly mentioned to communicate this options the opportunity to project owners. Based on the transcriptions and identified factors, the likelihood of applying these tools in practice is considered low.

The primary business activities of ECO exist of the provision of industrial services (without including sustainability as a key element). By looking at the individual codes of the service-oriented perspective group, it can be stated that the functionality of the project is determining the sustainable options. For clients the functionality (in terms of primary industrial process for which the facility is being constructed) is important, and following this perspective the primary task of ECO should be focusing on the regulatory aspects of a project (for instance the request for emission permits). Sustainable interventions seem to be considered as secondary goals, and would be removed from the concept once budgetary problems arise. Such a situation occurred in case 3, where the client removed the sustainable workshop form the agenda, as it was not required for the functionality.

Moreover, the lack of internal knowledge exchange points out the situation in which the concept plan for the tender registration has already been submitted, without a discussion on the final concept with the project team. Internal communication hampers the implementation of sustainability strategy in this way, as administrative and communicative tasks are not executed conform the project guidance. A possible explanation for this factor would be the lack of time provided for addressing sustainability issues. Planning can produce a lot of pressure on the involved members of the project, hence there would be no time to check the internal project guidance on updates or changes. This situation appeared in case 4, as the project owner did not reserved time to evaluate the project on sustainable improvements. Again, this is related to the opportunities for ECO to study sustainable interventions and how sustainability is integrated in projects. Because of the pressure and the lack of time that is reserved for research into sustainable options, professionals cannot research all the options. So, in this way the implementation is hampered as a result of strict planning.

As mentioned in four cases (case 1, 2, 3 and 5), once the early phase has been completed (without sufficient attention for sustainability), it is difficult to implement (part of) sustainability strategy. By then, the project concept has already been designed and accepted by all involved stakeholders. To follow up, involved members of the project team would already be position to execute their tasks. Interviewees have indicated that there is not much space left to suggest new options for the design, once every member is executing the project tasks. Changes in the concept would also be hard integrate because of technical choices in the design that cannot be undone after the early phase.

Figure 6.2 visualises the relationships between the derived central factors. Although the qualitative analysis cannot indicate causality, based on the derived factors a loop diagram has been created. Based on quotes of respondents on how factors are influencing the implementation of sustainability strategy, relationships between different factors are determined.

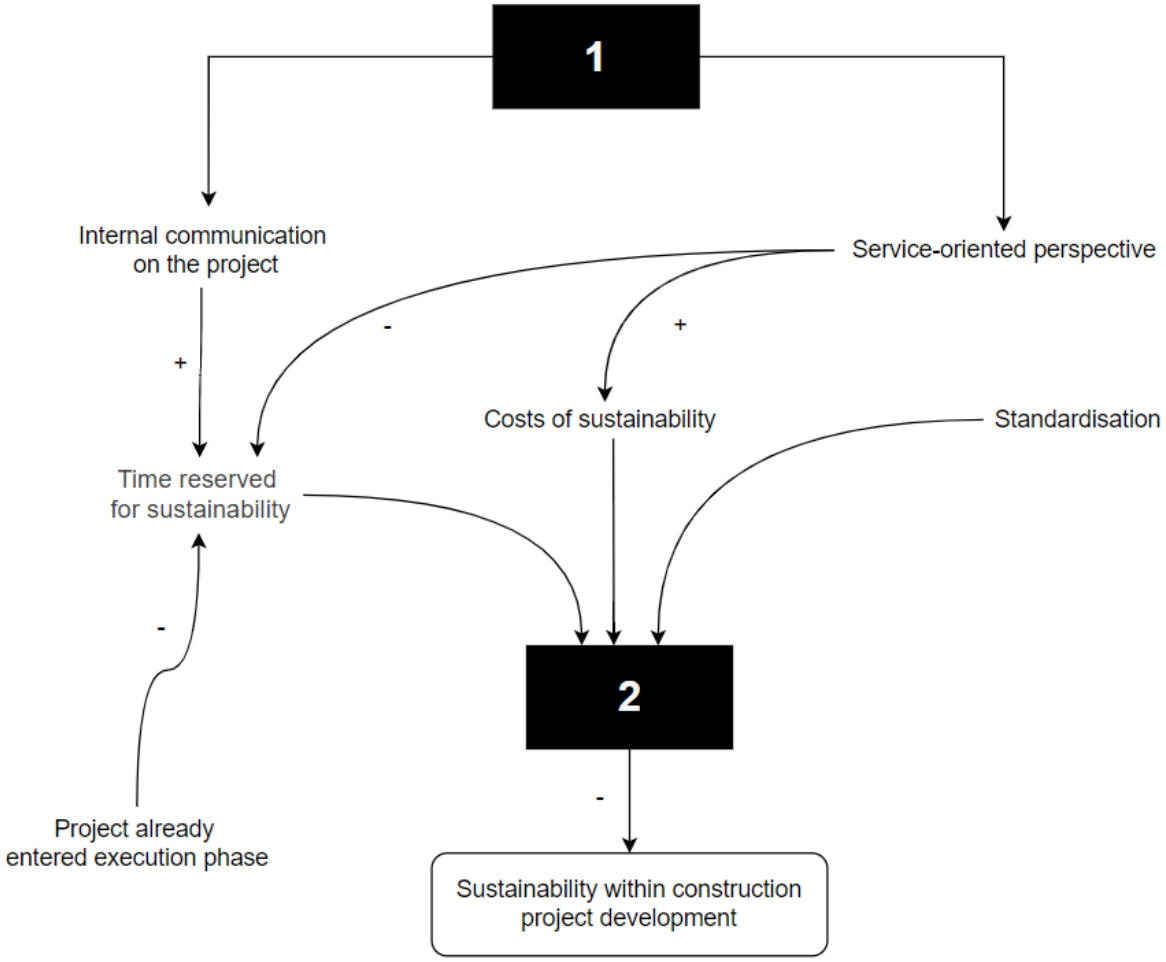


Figure 6.2 Loop diagram including the factors influencing the sustainability strategy (project level)
Note. The '-' symbol represents a negative relationship, the '+' symbol represents a positive relationship

Moreover, figure 6.2 shows how the factors are interconnected, and via which factors the sustainability strategy is limited. In general, lack of reserved time for sustainability, costs of sustainability and standardisation are affecting the sustainability strategy directly, whilst the other factors are indirectly connected to the sustainability strategy.

It is notable that within figure 6.2 there are two black boxes. Black box 1 is related to mechanism that is causing the factors on the project level. It is not clear via what type of mechanisms the implementation of sustainability strategy is affected. Therefore, it is relevant to search for the factors outside the project level. Black box 2 is located between the factors and the eventual implementation of strategy within construction project development. To analyse if factors of figure 6.2. influence the implementation process directly, the perceptions

of respondents on sustainability strategy of ECO need to be reviewed. Within these perceptions it is relevant to explore the given reasons for why sustainability is not implemented, apart from the identified factors of this section.

6.5 Perception on sustainability strategy amongst project members

Factors that influence the sustainable integration on the project level are interrelated, especially the service-oriented perspective of ECO is identified as barrier. Linking this back to the sustainability guidance on the project level of chapter 5, it is remarkable that the application of sustainable tools or explicit guidance to implement sustainability are hardly mentioned within the data. Only one respondent (the project manager of case 4) suggested the SDG scan as an explicit example of sustainability strategy. However, interviewees did mention other types of sustainability strategy, as shown in table 6.4.

Table 6.4 Types of sustainability strategy mentioned in interviews

Type of sustainability strategy	Mentioned in number of interviews	Mentioned in number of cases
Implicit sustainable engineering	7	5
Propose sustainable options to client	6	4
Experience as a strategy (ad hoc)	2	2
SDG-scan	1	1

Many respondents indicate that the project guidance is done ad hoc or based on experience. For instance, the process engineer of case 4 mentioned that this approach might result in a better implementation of sustainable improvements in comparison with an approach where every interventions will be studied before suggesting it. Nevertheless, experiences on sustainability strategy are different amongst the disciplines. Based on experience and technical/engineering expertise, many sustainable improvements were integrated into the projects. This pattern is defined as ‘implicit sustainable engineering’. For example, the energy engineer of case 5 explains the (sustainability) project strategy that is applied for the design of projects. The strategy is not explicitly formulated, but based on experience and engineering principles, such as optimisation of energy efficiency or carbon capture when possible (based on Trias Energetica). Sustainability is implicitly included, as engineers follow certain key principles in terms of energy or material use. Those key principles mainly cover technical issues, such as the application of solar panels or energy efficient design when possible (and economical feasible) (as was the situation in case 2). However, it is stated that the suggestion of sustainable options is important for the implementation of sustainability. One could consider the proposition of sustainable interventions as part of strategy as well, despite the fact that it is not explicitly formulated within the project guidance. If sustainable options are proposed, the client has the chance to take these improvements into account. Here it is questionable if employees of ECO are well aware of what options they can provide to implement sustainability, as only a single applicant.

Perceptions of respondents indicate that, although sustainability strategy has been formulated on the corporate level, it is hardly followed on project level. The general pattern indicates that professionals are hardly communicating sustainability explicitly while designing a project. Sustainability will not become a central theme of discussion if it is not communicated from

ECO to the client and the other way around. A potential mechanism for the lack of discussion might be the organisational relationship between layers, as some respondents mention that they do not feel supported by either both board of directors or project managers to incorporate sustainability in their daily activities. Project managers are in the position to translate the corporate ambitions into the individual projects, making this position essential for the implementation of sustainability strategy. The transcriptions suggests that engineers and consultants assign responsibility to their tasks and that they are willing to propagate this responsibility. Moreover, many respondents indicate that ECO should adopt a convincing role when it comes to discussion on sustainability. While professionals support a discussion on sustainability, and consider sustainability as an added value of a project, only few practical examples were identified within this research.

The data suggests that discussion on sustainability (both internal and external) is easily passed over; there are cases in which project managers assume an intervention would not be implemented by the client, because of its additional costs (or long payback periods). In addition, the discussion on sustainability is also avoided because of the position of the contact person within the serving organisation. As indicated by the process engineer of case 4, not all contact persons have the ability and position to convert corporate ambitions into practice. In such a situation, implementation is hampered by the contact person. Most of the times stakeholders within the clients organisation are limited to technical decisions. It could also be the case that contact persons are not aware of all the data, sustainable goals or strategy, which is given as a reason for professionals to avoid discussion on sustainability in case 4.

Although ECO discusses sustainability as a valuable element, only little evidence on successful application of sustainability strategy has been found within this data. In addition to the factors derived in section 6.4, the communication between the board of directors and project managers, organisational support and difficulty of creating value out of sustainability are added towards the loop diagram (see figure 6.3). These factors are positioned at the corporate level, as these factors do influence the performance of professionals within the project level. The three mentioned factors are in this way representing black box 1. When analysing the perceptions of professionals, mechanisms that would directly hamper the implementation of sustainability strategy were derived as well. Experiences of respondents indicate a lack of discussion and reactive role of ECO as mechanisms that affect implementation of sustainability. As expressed in table 6.2, sustainability strategy is mainly applied in an implicit, ad hoc manner, without explicit discussion on sustainable interventions.

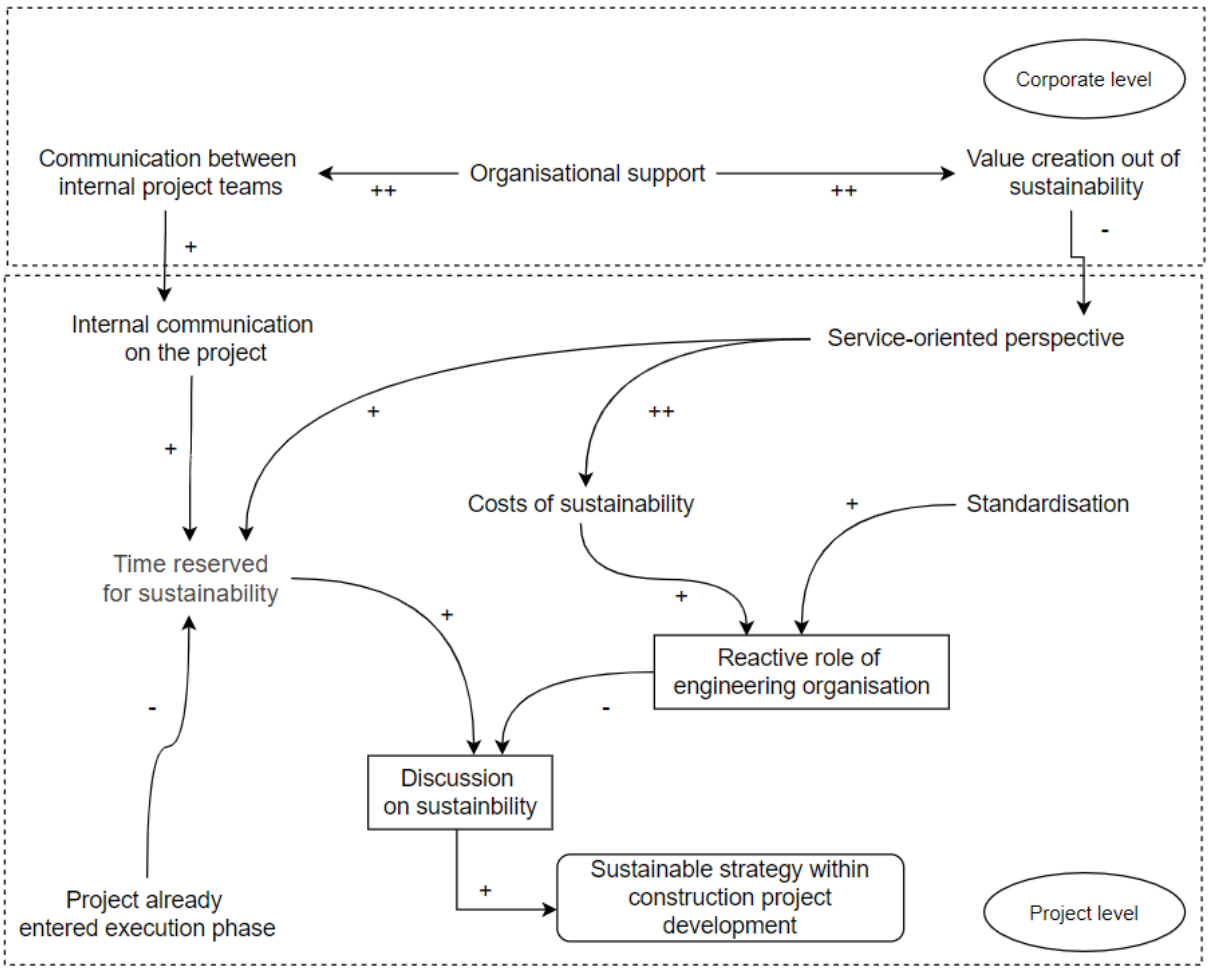


Figure 6.3 Loop diagram including the factors influencing the sustainability strategy (corporate and project level)
Note. The '-' symbol represents a negative relationship, the '+' symbol represents a positive relationship. The amount of symbols represent the influence of the factor.

Even when proposed, ECO will let go the sustainable interventions in the concept easily. ECO seems to adopt a reactive role, which can be understand as following the client in its demands, without suggesting new aspects. This reactive role, together with the other factors, create a project situation where sustainability is not discussed in the project concept. Even if it is discussed, professionals seem to struggle to convince clients on the value of sustainability. As engineers are not informed on solutions to create value out of sustainability, the costs of sustainability will increase a reactive role. In addition, from the transcript it can be derived that many engineers are considering sustainability as a cost as well, making it difficult to integrate this in the project concept. There is a certain drive amongst professionals of ECO to discuss sustainability, as convincing client is several times mentioned as an important process in the interviews.

6.6 Linking barriers to industrial ecology principles

When managing the implementation of corporate sustainability strategy of an engineering organisation, one should consider both the corporate and the project level. Too and Weaver (2014) reported that, in order to connect these levels, the (sustainability) strategy should contain aligned elements on all the levels. While it is able to link the corporate ambitions

towards the project execution plan, the results of this study suggests different. The organisational culture of ECO is still focused on a service-oriented perspective, instead of being proactive. One of the main drivers for this perception seems to be the budgetary scope of projects. In addition, project members do not feel empowered by managing layer to discuss sustainability in concept projects, whilst the project members indicate they are willing to do this. The latter touches upon the connection between the two systems in the organisation; if one aims for sustainability in the project approach, barriers on the corporate level needs to be addressed to find the causing mechanisms.

Moreover, the results show a clear distinction between costs and sustainability, while in the systematic approach of Korhonen (2004) the first principle is to consider costs and sustainability as interrelated subsystems. For professionals, it seems not possible to create value out of sustainability, and make use of this value in the discussion on sustainability. At this point IE provides valuable tools for professionals, which links the economic and sustainability system, and supports the discovery of sustainable interventions. However, as IE tools are hardly integrated in the project approach, the desirable contribution of ECO to the selected sustainable goals is limited. When looking at the applied IE principles on the third level of Robért et al. (2002), the process to reach the desirable outcome does not follow the systematic IE approach. Cooperation and community are identified as important drivers within this level, but project members miss the community aspect in terms of support from project managers and other levels of the organisation.

6.7 Summary of main barriers

Overall, main barriers have been identified on both the corporate and project level of ECO (table 6.5). As indicated by figure 6.3, the magnitude of influence of these four barriers does have consequences for the implementation of sustainability strategy via the adoptation of a reactive role and a lack of discussion on sustainability. In addition, from the data it is also derived that professionals are experiencing struggles when creating value out of sustainability.

Table 6.5 Overview main barriers

Barrier	Corporate level	Project level
Communication with the internal project teams	X	
Organisational support	X	
Service-oriented perspective		X
Value creation out of sustainability	X	

To improve the incorporation of sustainability on the project level, one should consider both organisational systems. Within this chapter the factors that influence the implementation are mainly framed as barriers, while some of the factors within loop diagram figures can also be interpret as stimulations for implementation of sustainability strategy (for example value creation out of sustainability). The next chapter will elaborate on how professionals can overcome the identified barriers, and develop manners to stimulate the implementation of sustainability strategy.

7 Framework for the implementation of sustainability strategy

The results of chapter 6 gave a comprehensive overview of the barriers and perceptions on corporate sustainability strategy in ECO and its activities on project level. This chapter will elaborate on sub question 4 and 5, aiming on designing a framework for the implementation of sustainability strategy and evaluating its contribution respectively.

7.1 Requirements for implementation of sustainability strategy

Whereas the previous chapter identifies affecting factors and the related mechanisms, within the semi-structured interviews participants were questioned on the requirements for the implementation of sustainability strategy as well. These requirements (that can be considered as 'stimulations for sustainability') are important, as they are needed to change the direction of the loop diagram (figure 6.3). Table 7.1 provides an overview of the range of requirements that were recorded in the transcripts. In terms of guidance, professionals indicate that action objectives (in terms of listing project steps) and clarification on the definition of sustainability is required to successfully implement and apply sustainability strategy on the project level. Next, knowledge exchange and effective communication are mentioned throughout the transcript as well. Notable in table 7.1 is the relative low consensus among the respondents, as for example six is not even half of the respondents. Looking at the spread of mentioned requirements over the cases, it can be stated that the list for project objectives and definition of sustainability are aspects that need to be emphasised when developing a framework.

Table 7.1 Suggested requirements for implementation of sustainability strategy

Requirements for incorporation of sustainability	Mentioned in number of interviews	Mentioned in number of cases
List for project objectives	6	4
Definition of sustainability	5	5
Communication to right person	2	2
Knowledge exchange on project	2	2

Further, the requirements of table 7.1 remain still broad and are therefore hardly applicable for professionals in practice. One could argue that the requirements, despite the definitions remain broad, are applicable for engineering organisations. However, to develop applicable stimulations, the requirements will be translated into specific project activities. Moreover, considering the requirements out of the transcripts, the value creation out of sustainability remain a barrier for implementation.

Table 7.2 connects barriers, requirements and solution objectives. In order to cover the main barriers, additional input have been included, in the form of IE tools. At this point the explained IE tools from chapter 3 (Life Cycle Assessment, Industrial Symbiosis and Supply Chain

Positioning) come into the process, as these tools are appropriate for stimulating the value creation out of sustainability. As discussed in chapter 6, ECO has already a corporate sustainability strategy that includes a rough Life Cycle Assessment in order to identify sustainable hotspots. Besides LCA, IS and SCP can be applied in order to add value on the sustainable interventions as well. However, to apply these tools successfully, members of ECO should be well informed on the goals, ambitions and guidance that are developed on the corporate level. The goal of the requirements is to strengthen the organisational support, and indirectly stimulate implementation of sustainability strategy into the development of construction projects. An attempt has been made to develop key objectives for all of the three barriers on the corporate level. According to the loop diagram (figure 6.3) focusing on the barriers on the corporate level, incorporation of sustainability on project level will get stimulated via a selection of indirect factors and mechanisms. Moreover, following the effects of this scheme, an organisation that supports its members in communicating among the departments and provide additional options to think of sustainable value will increase the chance of having a discussion on sustainability during the design of construction projects. Professionals increase their discussion position, by including the additional leverage (lessons learned in other projects, identified value of sustainability and clear sustainable goals and ambitions) that has been develop based on the action objectives for stimulation.

Table 7.2 Limitation factors and developed action objectives

Factor of limitation	Action objective for stimulation
Organisational support	
	Formulation and definition of corporate sustainability strategy Reporting of performance of ECO on sustainable ambitions Empower all individuals to incorporate sustainability
Value creation out of sustainability	
	Scan and evaluate input, output and waste flows (material and energy) (Life Cycle Assessment) Explore reuse and recycling opportunities outside the project scope (Supply Chain) Explore internal/external exchange opportunities (Industrial symbiosis)
Internal communication	
	Alignment of ambitions and performance indicators (e.g. selection of SDGs) Alignment of project guidance Sharing of lessons learned and performance

7.2 Design of conceptual VOC framework

The designed framework (figure 7.1) combines objectives and actions on both the corporate and project level in order to incorporate sustainability strategy within engineer organisations. On the corporate level, it is emphasised to specify the ambitions and missions, in terms of environmental contribution. Next to this objective, it is important to measure the goals and share the performance in the annual report, in order to evaluate the determined sustainable ambitions. To enhance the performance, organisational support is located as a key objective that makes the connects the project level to the corporate level. This organisational support contains internal communication (which is connected towards corporate action) and creating value out of sustainability. The latter will enhance professionals in the project design to integrate sustainable interventions. Within this framework, IE tools and principles are suggested to create value out of sustainability for engineering organisations. By applying this perspective, in combination with a managing layer that supports the sustainable ambitions, professionals of engineering organisations feel supported in their sustainable actions.

Nine objective actions are applied in this framework. The corporate level is the starting point that contains the three main limitations. All limitations contain action objectives on the project level, that support the incorporation of sustainability into the project.

The organisational support is the central node within this framework, that influence both the value creation out of sustainability and communication between internal project teams.

Within VOC framework it is important to start with clear formulation and definition of corporate sustainability strategy. This mean that goals, ambitions and guidance need to be present on the corporate level. While this was the case in ECO, the results were not suggesting a successful day-to-day implementation of sustainability strategy. Therefore it is important to (1) report and share the performance and (2) empower all individuals. Empowering can be done by pointing out tools for value creation (that contain several IE tools on the project level to discover new opportunities) and align the sustainability strategy and project guidance, such that all members can take sustainability into account at each activity that has to be executed. Within the internal communication it is important to share the sustainable solutions and interventions, in order to apply the method in similar cases. VOC framework attempts to develop key objective actions that increase incorporation of sustainability, by converting the barriers for implementation of sustainability strategy into stimulations.

7.2.1 Application for professionals in the building environment

The VOC framework can be followed by both professionals positioned on management positions and engineering positions. As a member of the board of directors, it can derived from the VOC framework what are required conditions to successfully implement a sustainability strategy into the project level. In addition, the guidance in terms of activities on the project level is useful for managers and directors, to develop an aligned and structured corporate sustainability strategy. For professionals in the building environment, that are fulfilling tasks on the project level, this framework provides a list of activities that can be followed in order to apply the develop sustainability strategy in practice. For example, having an explicit discussion on sustainable options with all project members are applicable and realistic tasks to execute during the design of a project. In terms of value creation, VOC framework suggests three IE

related tools that can be applied in order to create and identify the value of sustainable interventions. This can be used as leverage for the discussion on sustainability.

7.2.2 Integration of industrial ecology tools in the VOC framework

Once the sustainability ambitions of the client are discussed, the VOC framework suggests three manners to stimulate value creation: (1) Analyse input, output and waste flows; (2) Explore reuse and recycling opportunities outside the project scope; (3) Explore internal/external exchange opportunities. Within this section, a stepwise description for the application of the three tools is given. VOC framework does not prescribe any specific interventions, but aims to stimulate the brainstorm process.

Analyse input, output and waste flows

Before sustainable improvements can be identified, it is important to get an overview of the current environmental impact of a project. Within this analysis it is important to determine whether you face a type 1 project or a type 2 project. As input, output and waste flows are mainly the result of production processes, this tool will be especially interesting when facing type 2 projects. However, by focusing on used materials, maintenance and construction emissions, it would be possible to apply this tool for type 1 projects as well. The idea of this tool is related towards the circular production scan that is already applied by ECO in some situations. By scanning the different flows (by making use of LCA or Life Cycle Inventory Analysis), check the impact on (a selection of) SDGs and compare these to the situation where sustainable improvements have been integrated into the project, the value of sustainability have become explicit for customers. As an additional step, it would be interesting to translate the saved emissions (if so) into monetary values (e.g. due to decrease in energy use or less permits needed for emissions).

Explore reuse and recycling opportunities outside the project scope

The unique system thinking of IE views firms as part of network of firms. The same philosophy (described in this research as Supply Chain Positioning) can be applied towards construction projects. Although ECO is in many cases consulting a single project owner, value can be captured by identifying your own position on the supply chain. When the position of the project of interests has been set, think about upstream or downstream actors that are related towards your project. Would any of these actors be valuable for the goal of your project, or is any outflow of the project relevant for one of the actors in the supply chain? For the different types of project (construction of plant or supporting the operational processes of a plant) it would even be possible to think about options in terms of building materials, while the primary task of ECO might be focused on process equipment.

Explore internal/external exchange opportunities

Industrial partnering is described as an IE principles within the background research. To explore internal and external exchange opportunities, the inventory analysis of incoming, outcoming and waste flows (as is done in the first tool) can be applied as well. However, instead of comparing the baseline scenario with the scenario where sustainable interventions are applied, this tool encourages to look for exchange opportunities in terms of materials or waste (IS). The emissions of the scenario in which flows amongst industrial actors are exchanged can be compared to the baseline scenario, in which firms are not exchanging flows,

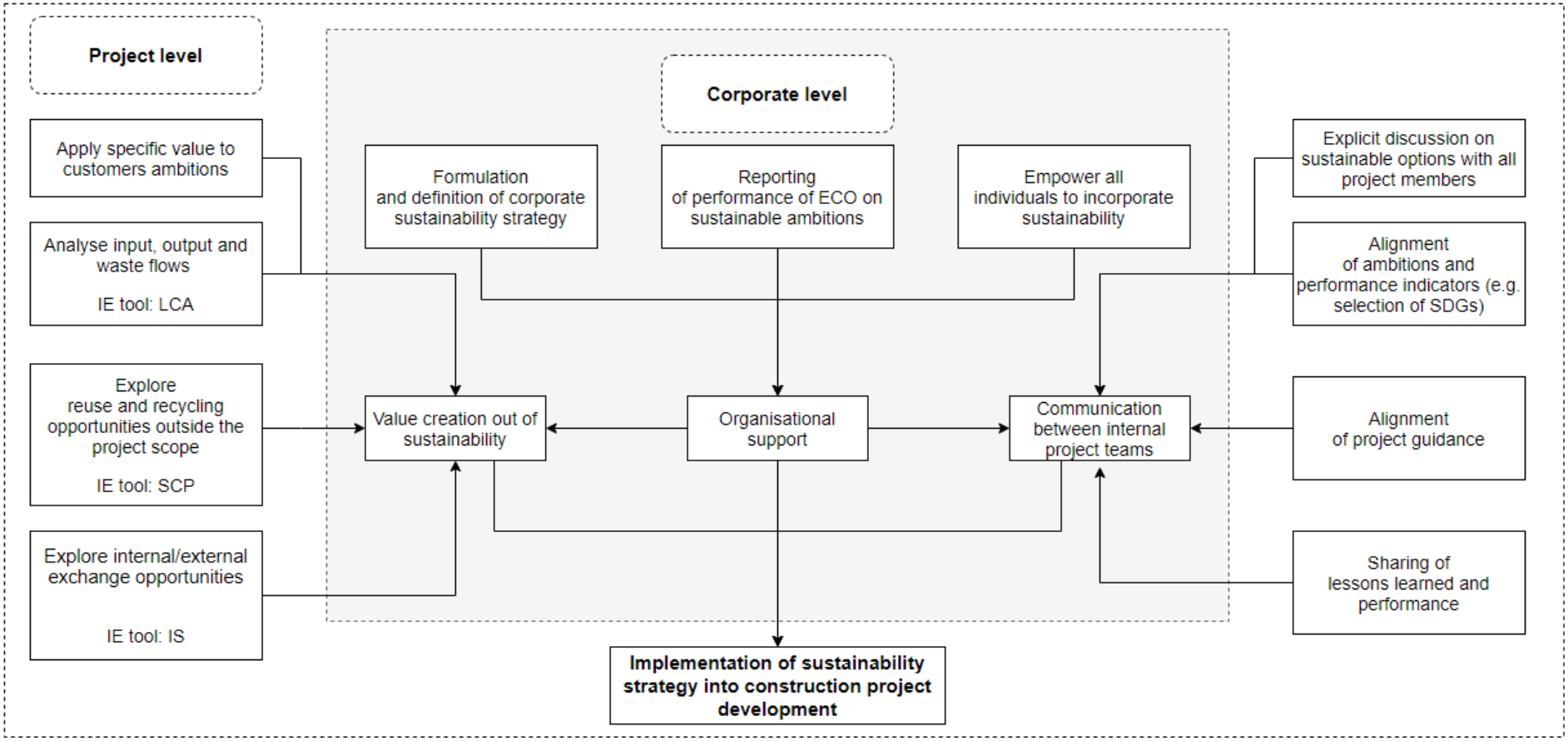


Figure 7.1 Conceptual VOC Framework

7.3 Framework testing

The VOC framework as visualised in figure 7.1 was tested within a focus group. In total 11 participants were present during the focus group. In the composition of participants, diversity in the years of experience, expertise and position within ECO was taken into account. Within the focus group ideas and perceptions on the effectiveness and applicability of the framework given. Eventually the group compared the provided input with the concept VOC framework.

For the start of the evaluation session, several categories were developed prior to the meeting, as inspiration for the respondents. Multiple categories were made up to structure the ideas, suggestions, values and requirements (referred to as input). The result of the semi-structured interviews and document review was used as inspiration and expectations for the headings of the categories. To clarify the meaning of categories, a description was added for the participants (table 7.3 does include this description). However, to make sure the categories were not understood as a force or limitation for the input, a category ‘other’ was included in the brainstorm overview. Input that did not fit in any of the given categories could be assigned to this category.

Next, a positioning step was created to assign the aspects of ‘other’ category towards a single one of the prior made categories. Collective discussion settled an agreement on the decision of the best fitting category for the input. A change of category was done for three values in the positioning step. The positioning step provides structure to the focus group input, but also stimulated discussion on the meaning of input. The brainstorm session resulted in 23 descriptions on requirements for implementation of sustainability. As participants were able to have visual sight on all the suggested ideas, similarity in input was avoided. However, one category held comparable values, hence these values were merged into a single group for this reason. The merged input appeared within the category ‘project approach’, and was emphasising the importance of early discussion on sustainability (and inclusion of sustainability in the tender phase). Based on this description, a new input value was created named ‘sustainability in tender’. The input of the focus group exists out of descriptions in one or more sentences, which has been converted into a phrase for structural reasons (table 7.4). A notable distinction should be made in the input, as some ideas refer to the question ‘What is needed to incorporate sustainability into ECO projects?’ and others are more an answer to ‘What is required in a framework that aims for the incorporation of sustainability in ECO projects?’. Within the focus group professionals were free to interpret the questions as they want. However, before this brainstorm session the goal of the focus group was explicitly communicated to the applicants. The input shows a variety of ideas and requirements, most of them located within the project approach category.

Analysis of the input shows some of the mentioned input (framework requirements) are included in the conceptual VOC framework. For instance, the individual drive for sustainability, the development of a corporate sustainable vision and measurable goals. In general, the input of the group is more related towards the communication of ECO. Not only internal, by the suggestion of sharing best practices and performance, but also external by aligning the external ambitions (ambitions of client) with the sustainable ambitions of ECO. Moreover, the individual drive of employees in the engineer activities was also mentioned as an requirement for the implementation of sustainability.

Table 7.3 Focus group categories and description

Category	Description
Definition of sustainability	Sustainable goals and mission of ECO
Information	Data on sustainability (e.g. sustainable ambitions client, governmental regulations or industrial area)
Value of sustainability	Creating benefits of sustainable interventions (for client)
Sustainable interventions	Sustainable engineering on project level
Specification	Application of framework for specific project or discipline/department
Project approach	The integration of framework within project scope, time and planning
Communication	Both internal (e.g. sharing of lessons learned or connection board and project teams) and external (e.g. discussion with client on sustainable interventions)

However, no concrete suggestions on how to create value out of sustainability and stimulate this drive for sustainability have been given in the focus group. This is in line with the results of the case analysis, where it is identified that engineers and consultants find it hard to evaluate or create additional value out of sustainable interventions in the design of a construction project.

Client interaction turned out to be an important requirement. ECO is primarily involved for the design of construction projects, but there are a lot of situations where multiple stakeholders are influencing the decision-making process of the design. According to the input of the focus group session, it is important to get insights in the external sustainable ambitions, and look for similarities in order to discover sustainable interventions.

The final step of the focus group was a voting activity. Although the meaning of input is discussed, it is important to analyse what types of requirements are preferred over others, in the perceptions of professionals. Each participant had the opportunity to emphasise their perception on the crucial requirements for a framework, as they got the option to divide five voting points over the input. Within this focus group participants could not assign more than one vote to an input value. The results of this voting round are noted down in table 7.5. Within this table the input values that have not received any votes are removed from the analysis.

Based on the table 7.5, it is indicated that the communication of successful implementation in cases is crucial for the stimulation of sustainability into engineer activities. From the discussion in the focus group it appeared that, by sharing successful cases, professionals become more willing to incorporate sustainability. This is in line with theory on organisational culture (OC), as discussed by Haugh and Talwar (2010). Within their study they describe the inclusion of ambitions into the code of conduct and the measurement of impact as aspect that influence the OC. Within the results of the evaluation, the need for clear ambitions and vision, together with the exchange of successful cases and best practices show up as important features.

Table 7.4 Overview of brainstorm input

Concept phrase	Raw description in GroupMap
Cases performance communication	*Communicate cases and successes (intern and extern)*
Sustainability in tender	*Sustainability in tender*
Align internal and external sustainability strategy	*Link sustainability strategy of the client with potential for improvement in the project*
Identify best practices	*Realise best practices incorporate sustainable design: know how to identify them, flag in projects and communication*
Individual drive for sustainability	*We need our people to drive sustainability and we need to show our sustainable results to get clients and staff. Sustainability should be on everybody's short list of personal goals/indicators*
Opportunity for employees to contribute to corporate sustainability strategy	*Let the employee contribute ideas for improvements in sustainability aspects within ECO by yearly completing, for example, a 'sustainability form'.*
Personal mission and vision	*Embrace your mission and vision and don't use it as a greenwashing machine (show yourself)*
Discussion on sustainability with client	*Common sense discussion with client in a new project. Everybody is talking about sustainability but what's really important? Often it's a cost driven case. What if it takes more than 5 years to earn invests back?*
Sustainable vision	*Start a project with a sustainable vision (and embrace the values of our clients by looking at their management reports and websites*
Performance indicators	*Optimize ECO's impact (positive and negative) on the 5 selected SGD's to work towards a realistic route to 'zero harm'*
Sharing of performance	*A dashboard showing the effects on SDG's (based on the analysis of projects) would help. Even goals could be set like 'ommetje app'*
Project guidance	*Develop a vision (with employees) how ECO drives sustainability within its projects*
Integration of corporate ambitions in project approach	*Connect explicitly CSR ambitions and measurable goals in a project (APGS tool)*
Checklist	*Drawing up a (multidisciplinary) checklist where the sustainability objectives of a project can be demonstrated.*
Measurable goals	*Give measurable goals for various aspects*
Evaluate sustainability of client	*Position clients in current sustainability level with next levels (make this stairway with client)*
Costs effectiveness of sustainability	*Initial focus on improvement potential in monetary values*

Table 7.5 Weighting of requirements

Concept phrase	Votes
Cases performance communication	5
Sustainability in tender	4
Align internal and external sustainability strategy	3
Identify and share best practices	3
Individual drive for sustainability	2
Opportunity for employees to contribute to corporate sustainability strategy	2
Personal mission and vision	2
Discussion on sustainability with client	2
Sustainable vision	2
Performance indicators	2
Sharing of performance	2
Project guidance	1
Integration of corporate ambitions in project approach	1
Checklist	1
Measurable goals	1
Evaluate sustainability of client	1
Costs effectiveness of sustainability	1

Sustainability in tender obtained a significant amount of votes, which might be a result of grouping the similar ideas into this group. Sustainability is considered a complex issue, that many times is neglected in the tender phase (the phase when ECO makes the first concept for the client). Participants mention that this is a crucial phase for sustainability, and specify the following actions that should take place within this phase: (1) the sustainable ambitions should linked between ECO and the client; (2) all project members should be involved and completely informed on the discussion of sustainability. The influence of ECO is also dependent on the demands of clients, which was also derived from the data of semi-structured interview. In both cases, it was mentioned as a mechanism that led to reactive role and a lack of discussion on sustainability. Nevertheless, many ideas refer to communication with the client on sustainability. Only if there is time reserved for discussion, the value of sustainability can be communicated towards the client. Therefore, the conceptual VOC framework needs an additional step between the value creation of sustainability and IE tools on project level. Moreover, there is need for an additional activity that aims to reserve space for professionals to inform the client on sustainable value and show the added value that can be captured. Within this process it is recommended to develop an stepwise approach, in order to enhance the client in the sustainable story of the design. A final remark on this discussion was the

suggestion of evaluating the ‘sustainable position’ of clients, and inform them about the opportunities. Such opportunities could be revealed by using UE tools, such as LCA, IS and SCP.

7.4 Framework improvements

New insights were retrieved during the focus group that need to be integrated in the current framework. Overall, the VOC framework does cover the main issues and ideas that were mentioned during the focus group. When confronting professionals with the question of what is required for the implementation of sustainability strategy in ECO projects, the result can be summarised by the following three aspects: (1) align sustainable ambitions and strategy with client; (2) as from the beginning the project team and client should discuss sustainability; (3) communicate successes and best practices, such that these can be used in similar cases. When it comes to the delivery of sustainable value, an indirect step should be included that focuses on informing the client and reserve time to discover value. These elements are integrated in the VOC framework, as shown in figure 7.2.

The starting point of this framework has not changed; still the organisational support is the starting aspect that requires certain action objectives. However, the formulation and definition of corporate sustainability strategy is used to inform the client on sustainable options, in combination with the alignment of sustainable ambitions and performance of ECO. This is a different method, compared to the conceptual VOC framework. So, the information exchange to the client aims for an alignment of ambitions and sustainability strategy such that sustainability becomes part of an explicit discussion. In comparison with the conceptual VOC framework, the suggested IE tools are used to reserve time for the discovery of sustainable hotspots on the project. This is for instance done with the circular production scan that is part of the corporate sustainability strategy of ECO. In addition to this scan (which is quite similar to a rough LCA), SC and IS can be used to capture value in projects (the application of these tools have not changed in the final VOC framework). However, with an intermediate activity where the client is informed on potential sustainability improvements, professionals can make an attempt to reserve space to actually research sustainable improvements. According to the focus group, clients will be especially interested once their position in the market is compared to competitors. Therefore, the IE tools are primarily used to show the current position and to derive the actions that bring clients to an higher performance on its sustainability ambitions. Comparing a project or firm with other actors of the supply chain is in line with SCP. Moreover, LCA would be appropriate to determine a certain sustainability score of clients.

The alignment of ambitions and performance is an action item that is specifically linked to the communication between internal project teams. Nevertheless, for both the alignment of project guidance and ambitions and performance indicators it is required to make sustainability explicit, instead of considering sustainability as a separated system. When guidance and alignment is present within ECO, individuals feel empowered to contribute to sustainability. For example, because members who want to contribute to sustainability now have an option to check best practices and analyse the ambitions. Further, professionals indicated that they would be stimulated by some kind of reward. Besides the competitive characteristic, it would enhance the professionals in incorporating sustainability and sharing this within the internal environment. Hence, within the final VOC framework a new activity (setting up online sharing

platforms for successful implementation of sustainability) has been added. Sharing activities would stimulate the communication between internal project teams as well.

To sum up, sustainability needs to be part of discussion, in order to stimulate implementation of sustainability strategy. Although one would consider this relationship as straight forward, chapter 6 indicated a lack of discussion. Therefore, this framework can be followed to analyse potential hurdles and structure the thinking process. The goal of the framework is not to recommend specific engineer interventions, but to provide the space for experts in the environment of construction project development to capture value in sustainability, communicate this with clients and convince clients on reserving time for sustainability. By bringing up the market position of clients performance and show were value can be captured, sustainability has a chance of being successfully implemented. These successful situations should be shared both internal and external.

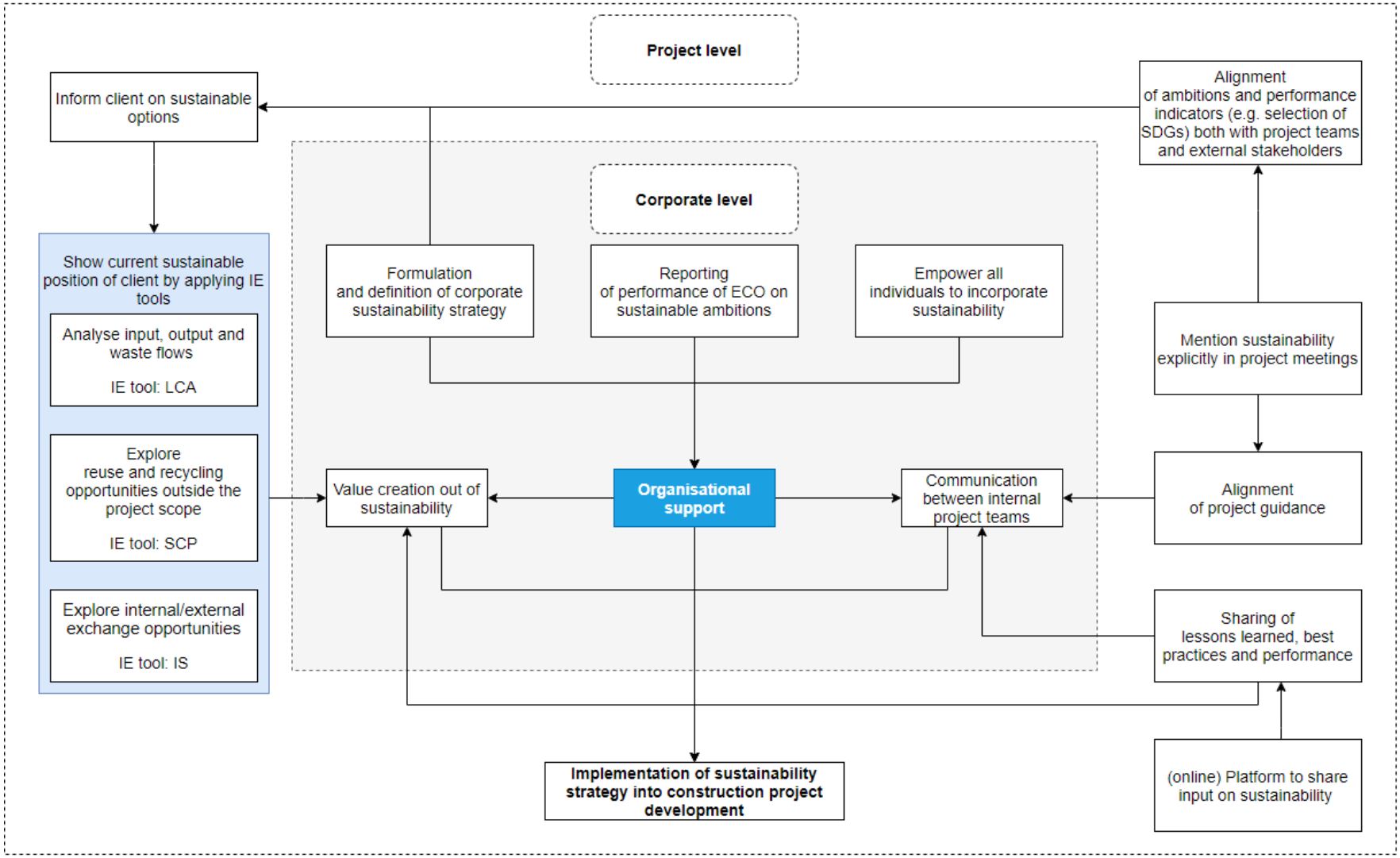
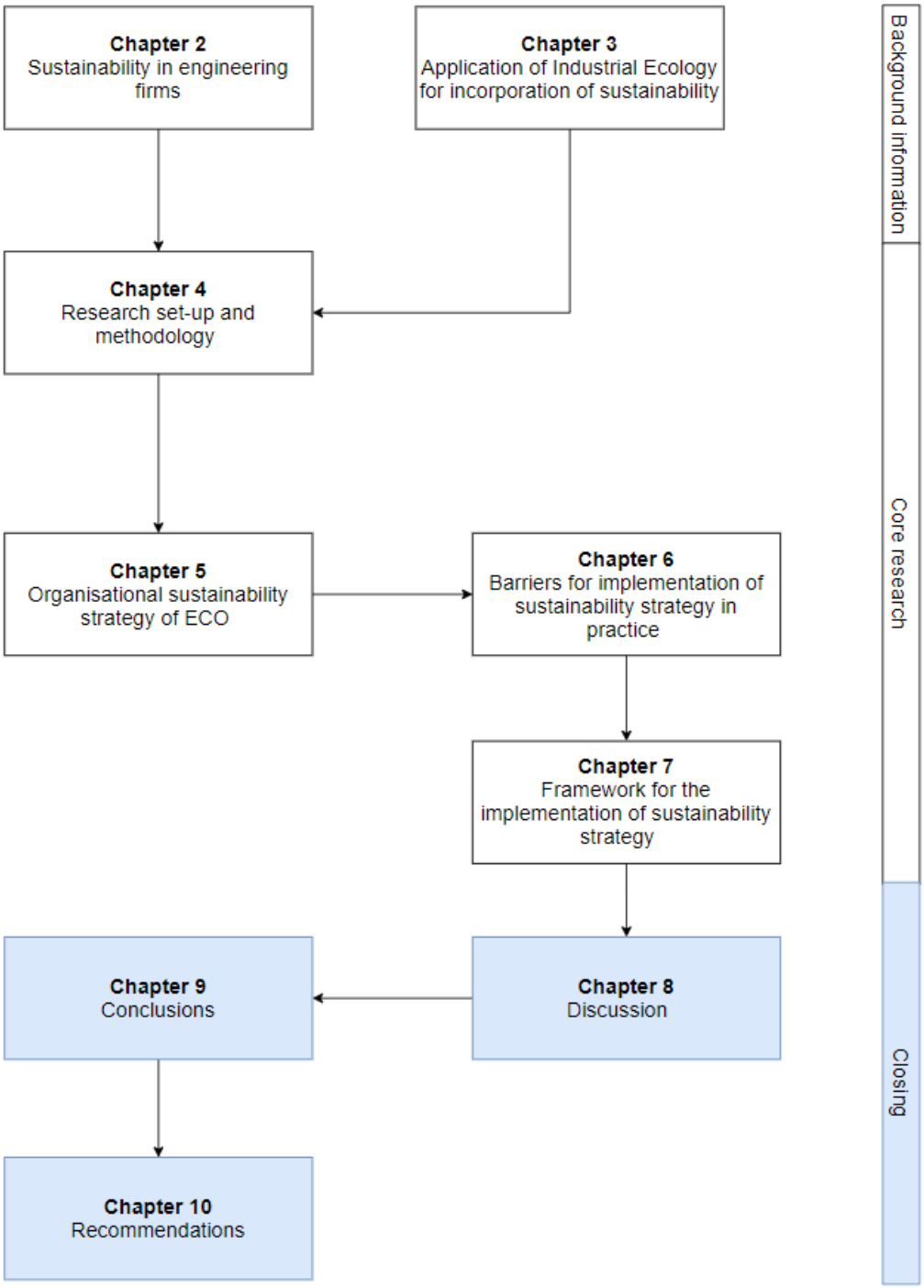


Figure 7.2 VOC Framework for the implementation of sustainability strategy into construction project development

Part 3. Closing



8 Discussion

Before drawing conclusions on the findings, methodological caveats are critically analysed. Next, the findings and developed stimulations are evaluated towards the reviewed literature. Subsection 8.1 puts the applied methodology into perspective, while 8.2 compares the findings of the data analysis with literature. The closing section, section 8.3, goes over relevance of this research for ECO.

8.1 Evaluation of methodology

All steps of DSRP model are executed in this research. However, within the data collection and analysis several trade-offs arose. The trade-offs are described next.

8.1.1 Research scope

The gap between formulation of corporate sustainability strategy and implementation is described as a complex problem (Engert and Baumgartner, 2016). Therefore, the research scope was focused on the factors that are having a role of barrier for the incorporation of sustainability. As this thesis is part of an IE graduation project, this discipline is evaluated towards the implementation of sustainability in construction project development. Hence, the tools to create value were all developed from IE point of view. In practice, capturing value out of sustainability is many times done by applying a business perspective that includes business tools such as resource-based view or dynamic capabilities (Bansal & DesJardine, 2014). As this thesis is especially interested in the applicability of IE principles for bridging the gap between formulation and implementation, business tools have not been taken into account in the developed framework.

Moreover, the geographical scope of this research was limited towards a single country. Therefore, results might not be applicable for engineering and consultancy companies that are located in different countries. Nevertheless, the selection of cases, that includes projects in different sectors, do increase the external validity of the results, as patterns were identified in both amongst different sectors. For example the main barriers as identified in chapter 6 appeared in multiple cases, spread over a range of sectors (food, pharmaceutical, energy and oil). But in terms of organisational culture and perceptions of professionals, the research scope is limited towards a single construction and consultancy organisation, focused on projects in the Netherlands.

8.1.2 Cases selection

Although the research has been done within a single engineering and consultancy organisation, the selection of cases contains a wide variety in terms of sector. However, the construction projects differed on many dimensions (as rated in chapter 6), such that results

would include a valid amount and range of limitation factors as well. Given the time limitations, some pragmatism was included in the selection of cases.

8.1.3 Data collection

Due to the governmental restrictions as a result of COVID-19 virus, it was not able to visit the office and speak to employees of ECO after the first month of this research. Hence, the analysis for this research was completely done via online instruments, such as Microsoft Teams or Zoom. These programs gave the opportunity to check the agendas of interviewees and set up a meetings. The same was done for the focus group, as the online platform GroupMap is created for online brainstorm sessions. Besides the 15 conducted semi-structured interviews, other input has been given via conversations within the office, over email or during other (online) conversations. The information that was gathered by these moments has not been recorded, but were implicitly used when considering the corporate documents. In terms of inspiration and stimulation of the analysis, the valuable insights obtained from these conversations was kept in mind during the analysis and design of VOC framework. Insights from document review and information from the transcript are considered as the main source for this study, as all these findings have been discussed and verified within semi-structured interviews.

8.1.4 Testing of VOC framework

As explained within the DSRP model the design of a framework is an iterative process. This means that the more testing activities are done, the higher the potential effectiveness of VOC framework. Nevertheless, the testing activities in this research were limited to one. As a result, the final framework might contain some errors that decrease its applicability. Iterative testing activities would also expand ideas and perceptions on the applicability of the included IE tools, as these were not part of an elaborate discussion.

The final VOC framework has not been applied to any case, nor has it been applied to any conceptual or fictional situation. Although the focus group provided the option for professionals to share perceptions on contribution of VOC framework in practice, it is difficult to draw conclusions on its within construction project development in reality.

8.2 Place findings in context of literature

Main factors that are related towards the implementation of sustainability strategy are in line with theory that has been reviewed in chapter 2. For example, one of the main of barriers is the service-oriented perspective. This perspective suggests ECO perceives the demands of clients as leading and sustainability as a cost. This factor is related to the traditional engineering perspective, which favours economic value over sustainability (Sullivan, Thomas & Rosano, 2018). As the traditional engineering perspective views sustainable interventions rather as a cost than a benefit, the connection with this factor and the reserved budget can be made. Nevertheless, transcript also showed that some elements of modern engineering – the form of engineering that focuses on minimising resource depletion and environmental degradation – were integrated on the project level. However, modern engineering elements (such as energy efficiency) are more related to basic engineering principles, than that they have been integrated based on an applied sustainability strategy on the project level.

While standardisation is mentioned as a barrier for implementation, this barrier have not been noticed in the literature review. On the other hand, the skills of employees that were discussed in the literature review, are not given as a limitation in the case analysis. Case analysis was mainly focused on engineering skills, while not studying skills on the creation of value out of sustainability and discussing these with the project owner. Many respondents indicate that ECO should adopt a convincing role when it comes to discussion on sustainability, but there seems to be difficult for professionals to adopt such a role. While professionals support a discussion on sustainability, and consider sustainability as an added value of a project, only few practical examples of successful implementation of sustainability (by executing a SDG scan or convincing a client to apply for a sustainability certificate) were identified within the cases. From the derived IE tools, only LCA have been included in the project strategy, as discussed in chapter 5. Both the mechanisms that cause the barriers and stimulations for sustainability are related to theory of organisational culture, as results show that current communication activities between different layers and the degree to which individual employees feel empowered are limiting the implementation of sustainability strategy, and in this way hampering the incorporation of sustainability. Hence, the starting point 'organisational support' in the VOC framework.

8.3 Relevance for ECO and similar organisations

As found in chapter 5, the firm that is analysed within this thesis already has several sustainable ambitions and converted these into activities on the project level. However, the results of chapter 6 do not support the implementation of corporate sustainability strategy in projects. ECO has its primarily focus on delivering design and consultancy services for the building environment, an environment in which sustainability does not have to be fundamentally included. When one adopt a perspective of an engineering and consultancy organisation, one could state that these organisations need to be prepared for the future market demands. Although governmental regulation is not explained as a crucial barrier in this research, it can be expected that (at least part of the) governments will introduce policies and laws to keep in track of the national sustainability agenda. Taking into account the transition of engineering companies in order to guarantee the continuation of their business model, sustainability will become a more central aspect in the day-to-day activities. VOC framework supports organisations in implementing the sustainability strategy, by visualising what type of activities are required to stimulate the application of such a strategy on the project level. Via the developed tools and activities, professionals in engineering organisations on both the corporate and project level get an overview of stimulating activities, which can be applied in order to overcome the gap between corporate level and project level.

Nevertheless, from the conversations and interviews a strong preference towards sustainable engineering of ECO is identified. This research provides new insight in the corporate sustainability strategy of ECO and made an attempt to stimulate the implementation of sustainability strategy within construction project development. In addition, principles of IE in combination with other action objectives are systematically suggested in the VOC framework in order to improve the implementation of sustainability. In a time where sustainability has become a central theme of debate in society, one can state that it is important for ECO to prepare for external regulations, societal opinions and market demands. Making this research and developed framework highly relevant for ECO and similar organisations.

9 Conclusions

This research was driven by the current environmental impact of the global building environment and the indicated lagging effect within the sector. Through all the steps of this thesis research project, it turned out that sustainability is in different ways connected towards construction project development. Within this thesis, incorporation of sustainability was studied by studying the implementation of sustainability strategy amongst engineering organisations. Within the analysis a distinction was made between corporate level (formulation of strategy) and project level (application of strategy). Via document review and case analysis barriers for the implementation of sustainability were derived, and solutions in terms of stimulating factors were developed and included in the VOC framework.

When it comes to sustainable improvement of the engineering practices, this results show that professionals within the building environment are interested in sustainability and many times looking for manners to incorporate sustainability in project development. IE perspective was adopted in the analysis of this research, by focusing on the contribution of IE principles and tools for the process of value creation out of sustainability. The suggested IE tools in the VOC framework are LCA, IS and SCP. The following paragraph do summarise the main findings and formulate an answer to sub questions and research question.

First, document review indicates that sustainability strategy is partly realised within ECO. A distinction between the organisational systems, as for example done by Too and Weaver (2014), was made for ECO as well. Resulting in an analysis of the corporate level and the project level in order to research the sustainability strategy of ECO. On the corporate level, the attention for sustainability could be derived from the descriptions on the published reports and web articles. Within the corporate level a lack of specification was concluded, as ambitions and vision was not translated into specific, measurable performance goals. Lack of quantifiable goals makes it hard to develop specific guidance for the project level (which needs input from the corporate level). For example, the reporting of sustainable impact was not an explicit activity in one of the steps within the project approach. LCA turns out to be an important tool on the project level, as scanning the project incoming and outgoing streams to identify hotspots is representing a significant part of the sustainability strategy. When evaluating the corporate sustainability strategy from an IE perspective, it can be concluded that sustainability is still approached as a separate system, while IE encourage to include sustainability in every decision in the project design.

Second, this research looked into the factors that hamper implementation of sustainability strategy. Only little evidence on successful implementation of sustainability in practical cases was found. Although engineers always aim to select sustainable interventions (described as implicit sustainable engineering in chapter 6), sustainability in general is not an explicit topic of discussion. Moreover, as main barriers on the project level, the service-oriented perspective was identified. Because of this service-oriented perspective, costs of projects get additional weight in the decision process. These were identified as factors that have a significant

influence within the project level. Moreover, interviewees indicate that communication is required to reserve time in the project planning for exploring sustainable hotspots in the project design. When taking into account the perceptions of professionals, the stories of the applicants shows a lack of required support from the corporate level. Hence, communication between internal project teams, organisational support and value creation out of sustainability were derived as starting factors (on corporate level) in the VOC framework. The three main barriers are interconnected, as the organisational support positive influences both the value creation and communication of internal project teams.

Third, activities that would stepwise overcome the identified barriers were developed. These activities were derived out of the semi-structured interviews, where respondents were asked about possible stimulation mechanisms for the implementation of sustainability strategy. Further, activities were developed that would enhance the crucial factors within ECO to positively influence the implementation process. For instance, by including activities that would emphasise the communication between internal project teams and or the importance of sharing successful cases. Moreover, action objectives to stimulate value creation out of sustainability were derived by integrating IE tools into VOC framework. IE has an important application on the project level, as the given tool are suggested in the framework as options for value creation. The concept VOC framework contained eleven actions activities (three on the corporate level, eight on the project level) that were formulated and integrated. Next, its contribution was tested by discussing requirements and comparing these to the conceptual VOC framework in a focus group. As a result of this testing step, few additional actions were included in the framework. The additional actions in the framework enhance its contribution as actions on stakeholder management, reward systems, internal and external communication and sharing of performance were added. Moreover, the application of IE tools were combined into a single activity ‘show current sustainable position of client by applying IE tools’.

Last, an answer will be formulated to the central research question of this thesis research project. Activities of the VOC framework supports professionals in engineering field to implement sustainability strategy in organisations, and stimulate the application of this strategy on the project level. For the incorporation of sustainability it is important to communicate the value of sustainability. The current engineering practices are either neglecting sustainable issues or include sustainability implicitly in construction project development. To stimulate the incorporation and accelerate the sustainable transition, the VOC framework can support professionals throughout the phases of construction project development by identifying potential hurdles in the project, capture value within the sustainable interventions of the project, enhance individual drive for sustainability within organisations and align the corporate strategic approach. Although engineering organisations have to face the disadvantage of facing an external project owner, the focus should be on the reservation of time and budget to apply IE tools and identify sustainable improvements. This disadvantage will also make the application of IS and SCP more difficult, as these tools are mainly focused on options outside the project scope. In all cases, discussion on sustainability should not be avoided during meetings with the project owners.

10 Recommendations

As closing part of this research, recommendations for both implementation of sustainability within ECO and future research are developed. Before the opportunities for future research are described, the value of the findings for ECO are further discussed. Although the relevance was already discussed in chapter 8, this chapter contains some specific recommendations that proceed on the conclusions. Recommendations will therefore explain (1) what to keep in mind when following the VOR framework and (2) what additional actions can be taken in order to stimulate implementation of sustainability strategy.

10.1 Action objectives for implementation of sustainability strategy in ECO

ECO is a large company that has a strong and competitive position in the market. Due to the size of ECO, it can be assumed the impact on societies and environment by the services they provide is relevant for national GHG emissions. However, ECO is not the project owner in many cases. Despite the supporting position of ECO in comparison to the project owner, ECO could embrace some principles that would stimulate the implementation of sustainability strategy, keep their business model up-to-date and translate their societal responsibility in reality. Complemented to the factors of the VOC framework, four main considerations are given for ECO, that can be implemented into the organisational culture and sustainability strategy:

1. Take into account that the integration of sustainability into the organisational culture is a time consuming process. Here, it is important to approach this transition from either a top-down and a bottom-up perspective. Search for an approach that would take the best of both perspectives. So, provide a clear sustainability strategy that contain guidance on the project level for employees (top-down), but simultaneously look for opportunities to share their experiences and issues with sustainability (bottom-up). Compare how the corporate and project system are different and search for aligning opportunities. Only when the two systems are in line, the vision and ambition can become core of the organisational culture and be integrated into the practice of construction project development.

2. Focus on small, incremental steps for the incorporation of sustainability. Transition is commonly a slow process, which can take easily over a year. To keep this transition in mind, assign in each project someone that is responsible for bringing up sustainability as an agenda point. This does not have to be a sustainable consultant, but the task (in terms of sustainability) of this person is just to bring it up during the decisions on the project design. In terms of activities of the VOC framework, this tasks would already be covered when following the steps. Moreover, the task of this member is to identify the limiting barrier that is present in case (if so) and have a quick thought

on the solution objectives. This is where the content of the framework will help the project team. Bringing up sustainability can be done in an external setting – when the client is involved in the meeting – but it is also important to do this in internal settings. However, this tasks should be assigned to a project member as soon as possible, preferably within the tender phase. Incremental steps are valuable for the transition process. Note that the point of this consideration point is not a significant reduction of environmental impact of a project, but that a discussion on sustainability and what type of barrier is hampering the implementation in the project is valuable information for ECO as well. This information, which is gathered on the project level, should be shared with the corporate level, but the corporate level should communicate the meaning of this consideration to the project level.

3. Employees are the members that are actually making impact in the field, as they are assigned to the project developing tasks. This means ECO needs to enhance the individual drive for sustainable engineering. Based on what professionals communicated in the focus group, instruments that would enhance the drive of individuals are reward systems by for example sharing platforms. Hence, it is recommended for ECO to provide an online platform were ideas, opinions, information, experiences and hurdles on sustainability can be shared amongst the different employees of ECO. This intervention do not has to be expensive, as ECO already has different internal forums where employees can obtain and share information. As described in the first recommendation, sharing all input from resulting from conversations on sustainability would provide valuable insights in the drivers of project teams for the board of directors and other manager layers on the corporate level. The expertise in engineering is present in ECO, but what can be stimulated is the sustainable desire of individuals to integrate sustainable interventions and share these amongst colleagues. Again, the VOC framework and IE tools that are discussed in this research are proper starting points for the discovery of sustainable hotspots in the projects.

4. Inspire clients with your story. Most clients, especially in the industrial sector, are not aware of what sustainability mean for them in terms of (economic) value. As told before, it is mainly considered a cost. Nevertheless, it should be a task of ECO to trigger a certain curiosity at the client. An option to achieve this is in line with the ‘show current sustainable position of client’, as ECO could think of a list of indicators that are used to assign a category or score towards the client. Here it is important not only show the current position, but to inform the client on the interventions that can be easily integrated as well. By applying this strategic approach, it would be able to reserve some time for research on sustainable interventions, which enhance the incorporation of sustainability in the construction sector. Following the VOC framework, IE tools have been suggested to inspire the client, determine its current environmental position and identify the hotspots in the design.

10.2 Future research

Adopting IE perspective to investigate the incorporation process of sustainability in construction organisations lead to new insights, as within their scientific environment no publication has designed a framework that includes IE tools to bridge the gap between organisational levels. Recent literature which studies this gap has a particular focus on business management and strategic management perspectives, while not taking into account any of the IE principles. Therefore this research responded to the suggestion of Sullivan, Thomas and Rosano (2018), by applying IE for the implementation of sustainability strategy.

Within the research approach both desk study and data collection in the field was done. Analysis of the cases lead to the conclusion that sustainability needs to be present as explicit topic, and professionals need guidance in both communication (within the project team and with the project owner) and value creation. For further integration of IE in organisations, it is interesting to compare if a similar research approach in a different geographical area or other industrial sectors would provide the same results.

Moreover, within the field of construction management, sustainability is generally considered as a cost. This research made an attempt to link the formulation of corporate sustainability strategy and its application in practice, by explaining how IE tools that can support professionals in the creation of value. As this study only provides descriptions on the tools, the application of the VOC framework was not tested within the field. Therefore, future research should be focused on measuring successful implementation of sustainability strategy (for instance by analysing the environmental impact that is reduced by the tools) into construction project development. In addition, it would be valuable for IE to get insights in which of the tools is most applicable for engineering and consultancy organisations when it comes to construction project design. A common way to do this would be introducing the VOC framework in real cases, instead of discussing it in a focus group.

This research presents and discusses the influence of a wide range of limiting factors. However, there is space left to analyse the mechanisms that affect the implementation. Not only might there be additional factors that have not been found by this analysis, but one could also dive into the black box factors and improve the loop diagram as presented in the research. As the main question of this research is focusing on implementation and stimulation, only a small part of the time was invested in identifying the different background factors that were also related to the barriers. Although this research derived mechanisms that represent the black boxes, this area is a good starting point for future research. This research already identified several barriers on both levels (even for the black boxes), but it would be particularly interesting to continue the loop diagram when considering a social science discipline such as sociology or psychology. These disciplines have the appropriate methods and (behavioural) theory that potentially improve the validity of the loop diagram. If future research gets a better overview of the behavioural aspects limiting or stimulating the implementation of sustainability strategy, the VOC framework can be improved in terms of effectiveness.

As a final remark, future research could further analyse the influence of the conditions of the case. Although this research connects the corporate and project level, only little could be said about the optimal conditions of construction project that would stimulate incorporation of sustainability. Here one could think about size of project team or geographical location of projects. Within this research the consequences of project dynamics – understood as changes conditions in terms of client demands, requirements, policies or information on the project – for the implementation of sustainability strategy can be analysed as well. By combining barriers and solution activities of this research, a proper starting point can be formulated to investigate what the optimal conditions for implementation of sustainability strategies are and how these project conditions can be reached. The latter can be considered as a relevant contribution to the VOC framework.

Reflection

One year prior to this research, I have started the orientation on the thesis. The orientation started at the first meeting with Wouter (which have taken place in September 2019). As from the first meeting until June 2019 I have been defining the scope and main question of this research in the thesis preparation module. However, after I started with my thesis in September 2020, in the first month the scope of the research already changed its direction. Instead of focusing on the changing dynamics within construction projects, the scope was moved on the implementation of sustainability strategy. However, by changing the direction of my thesis, the kick-off meeting was successfully closed at the end of September.

An hurdle for me was to find the core of the research, and to connect all the different elements to this core story. The thesis focus remained broad for a period of several months. Therefore, modifications in the early chapters and research question have been made throughout this project. This is a lesson learned for me, as in future research activities, I will make sure to develop a clear direction of the research and connect intermediate activities. During this process, I will keep the final goal of the project in mind. Personal knowledge on the building environment was little at the start of this research, which explains that the research direction changed somewhat. The biggest hurdle of this research was to integrate industrial ecology into the research. As indicated by my supervisors during the kick-off meeting, the first proposal of my research had more to do with construction management than it was related to IE. To integrate IE into my research, I have once again studied literature that adopted an IE perspective. Based on this review, I found a selection of principles and tools that are eventually integrated in the research. Studying IE literature inspired me to think about what the discipline means for me and how I would like to use it after my graduation.

During the past seven months, it was not always easy to get inspiration for the research activities. In my opinion, this might be a result of the physical restrictions due to COVID-19. As physical contact should be avoided, I was only able to work at the office of ECO for four times. In the remaining months I have been working on this research from my home situation, which made it hard to start spontaneous discussion on my thesis topic. Although I was able to organise meetings online (as I did frequently with my fellow interns), it is still difficult to start discussions with colleagues. In addition, sometimes easy questions took much time, as I needed to wait for the colleague to respond to my email or call. These are issues that would have been less when we were able to visit the office. In some situations, the physical restriction cause motivational issues, as sometimes it is was hard to continue writing and looking for improvements.

As soon as I noticed that my motivation decreases, I started conversation with colleagues from my Masters and other interns at ECO. These discussions really helped me to increase my motivation and make progression in the research. Furthermore, a strict planning with small tasks that have to be executed helped me to keep track of my progress. By dividing a big chapter into small activities, it was more easy to start the writing process. This was a method that helped me overcome hurdles in the research and it provided me a clear overview of the

direction of the thesis. Eventually I am glad with the end result, and I hope my findings will have efficient contribution to sustainability in construction project development.

Overall, I think this assignment gave me a valuable experience in the field of business consulting and engineering and consultancy organisations. Besides the obtained knowledge on industrial ecology application for the incorporation of sustainability, I consider the experience as fulfilling the role of a business consultant as benefits of this graduation project.

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Appendices

A. Semi-structured interview set-up

1. Introduction of myself and state goal of the interview
2. Ask permission for recording
3. Start interview with general questions
4. Introduce case
5. Summarise interview
6. Verify via email
7. Apply improvements to the transcript

Interview questions

Sustainability strategy of ECO

- How are you experiencing sustainability in your daily tasks?
- Are you aware of the sustainability goals of ECO?
- To what extent do you think there is a clear sustainability strategy in each project?
- Do you think ECO is (or should be) considered an important actor for the liveability of the planet?

Project will be introduced

Factors affecting the implementation of sustainability in project development

- How did you experienced sustainability within this project?
- What processes/factors were influencing the sustainability aspects in project development?
- How are they influencing the implementation of sustainability?
    - What causes these factors?
    - And why?
- Do you think there are any additional factors that influence the implementation of sustainability?

How professionals deal with the discussion regarding sustainability

- Was there any discussion on sustainability in this project case?
    - What was the reason for this discussion? (role of customer?)
    - What was the outcome of the discussion?
    - How did you achieve this outcome?
- Was there a clear strategy on sustainability to apply throughout the project?

Implementation of sustainability

- Would there be any methods to enhance the implementation of sustainability into projects?
    - What would be a requirement of such a method?
    - Would a framework that grasps the requirements support this implementation process?

Closing

- Are there any additional aspects of sustainability, which we have not discussed?
- Are there persons/documents that comes to mind, that provide additional information on this case?

B. Focus group set-up and brainstorm overview

Focus group February 17, 12.00 O'clock, 11 participants:

1. Introduction of the goal of focus group
2. Presenting the method, document review and case analysis results to participants
3. GroupMap brainstorm session (maximum of 5 ideas per participant)
4. GroupMap voting activity
5. Present conceptual VOC framework
6. Discussion on what type of requirements are included in the conceptual VOC framework and how can it be improved

Goal of focus group: Obtaining input on requirements for framework and discuss to what extent these requirements are present in the conceptual VOC framework

GroupMap results: