TOWARDS PROACTIVE DECISION-MAKING FOR SUSTAINABILITY

An application to project delivery of urban utility infrastructure systems

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PREFACE

Over the course of my study years, I have seen an emerging attention for sustainability in the construction sector. Where during my first internship -6 years ago- I experienced that only few efforts were made, fortunately now the topic shows an emerging attention in this industry. During my HBO graduation period, I learned a lot about sustainability strategies in the structural design of buildings. With this gained knowledge and growing interest, naturally it excited me to get the opportunity to dedicate my final graduation research in contribution to sustainability within the infrastructure and airport industry.

What a journey though. Writing this thesis as last phase of my master has gained me a tremendous knowledge in both research skills and substantial knowledge. Although 'proactive' has become a term I rather forget for a little while, I can state that I have challenged myself to a continuous improvement of this thesis. The choice to continue my study with a master has definitely gained me valuable lessons and improvement of analytical and professional skills, which I can further improve during the next step in my career within the infrastructure industry.

Before presenting the results of this research, I would like to thank all who have supported me in during this process. To begin with, a special thanks to the graduation committee of TU Delft. Marcel, I admire your commitment to provide sharp and supportive feedback whenever asked. It is a pity that you could not be involved for the total duration of this research. Fransje, as chairman and first supervisor you have easily dedicated lots of efforts to the progress of this thesis. Thank you for all your interesting input with regard to the world of utility infrastructures, this subject has really opened my eyes. I have enjoyed our discussions and your guidance style. Daan, thank you for your constructive feedback moments and support in practical matters during the last months. This has helped me a lot in reasoning and putting efforts in this report to guide the reader. And last, Erik-Jan, I like how you have enriched the research topic with discussions and stimulating me to rethink the essence. Thank you for your time.

Second, I would like to thank the colleagues at BAM for the open attitude towards this research. Renée, thank you for your endless patience and inspiring help. You have supported me in time, in forming my thoughts to specific descriptions, and also in redirecting me to the core of this research when it was needed. I hope that we'll meet again in a future working environment.

Also, a special thanks to all the people from Schiphol I interviewed for this project. You have provided me openness and much explanatory knowledge in both the topic of sustainability, and the interesting context of strategic partnering. Also, a special thanks to Thijs. Since we moved in together, you have been involved in this process daily, and always with supportive and resourceful insights. Furthermore, thanks to all family members, fellow graduates, and friends who have mentally and substantially helped me through this.

Amsterdam, January 2021

EXECUTIVE SUMMARY

INTRODUCTION

An increasing awareness of sustainability problems urges the need for more sustainable practices within the infrastructure industry. Organisations are determined to have a moral obligation to decrease their operational impacts on society and environment. Responsiveness to sustainability is also urging by regulatory pressures, new business opportunities, and cost factors (Wijethilake, 2017). More importantly, it is deemed critical for organisational resilience and long-term corporate success (Russel & Shiang, 2012; Goel et al., 2019). Corporate active engagement is currently shown in strategic objectives and visions to set directions for more practical levels. However, how these visions translate to the tactical and operational levels of decision-making is still considered a grey area for the extant theoretical body of knowledge. Within the last decade, it has been widely acknowledged that projects form the drivers of change in which project managers can implement a more sustainable orientation (Gareis et al., 2013; Lombardi et al., 2011; Silvius, 2017; Marcelino-Sádaba et al., 2015; Silvius & Kampinga, 2017; Silvius et al., 2012). But for managers of projects, it remains a challenge to practically integrate sustainability into construction projects (Gijzel et al., 2019; Martens & Carvalho, 2017). Utility services such as energy, gas, and water are transported below our feet and therefore invisible, but these infrastructure systems are crucial in servicing our demands of basic needs. Within urbanised areas, these networks are a continuous subject to physical change, due to an increasing demand of facilities within the subsurface, technological development, the energy transition, or the need for changing outdated assets (COB, 2018). While these trends pressure utility networks, these infrastructures require attention in the path towards a more sustainable world.

Epstein (2018) addresses an emerging field of study reporting that the most effective sustainability initiatives regarding organisational performance, are those that are proactive rather than reactive. In practice, organisations currently show proactive engagement on strategic level, however more practical decision-making levels involve an unstructured and reactive attitude. Therefore, the objective of this practice-oriented research is to help improve proactive integration of sustainability in decision-making in tactical and operational decision-making processes, by developing a framework for the adoption of sustainability in future decision practices. The following research question is formulated:

How can sustainability be proactively incorporated within the tactical and operational decision-making processes of utility infrastructure projects?

This research is conducted in the context of a Strategic Partnership between client and contractor. Their collaborative agreements based on Best Value aims for synergy by close cooperation between the partners and valuing professional expertise. Furthermore, the scope of this research is directed towards utility infrastructure project in urbanised areas within The Netherlands, as well as a focus towards the early project phases. The following research questions are answered:

SQ1:	What is the definition of sustainability in the context of utility infrastructure projects?
SQ2:	Which elements need to be involved to proactively implement sustainability on tactical and operational decision-making levels regarding infrastructure projects?
SQ3:	What are the underlying issues resulting in the gap between reactive decision-making and proactive sustainable decision-making?
SQ4:	What interventions are required to proactively embed sustainability within decision-making processes at tactical and operational level?

METHODOLOGY

The topic of this research is considered exploratory in nature as it moves between the research fields of sustainability and project management. Therefore, the literature is used to compile existing concepts and theories and frame how sustainability can be preferably incorporated in current processes at tactical and operational levels of project-based organisations.

This research is conducted by qualitative methods, by means of literature research and case-studies. The focus of this study is mainly directed at diagnostic research to examine the background and underlying issues of the gap between current and desired proactivity levels. Four projects involving utility infrastructure have been preselected as case studies, for which in total 13 semi-structured interviews are conducted to grasp understanding of tactical and operational management decision-making. To minimise the decrement of validity, several methods are adopted: triangulation of resources, observations, and structured interview procedures.

RESULTS

The concept of Sustainable Development as founded by Brundtland (1987) shows the foundation of sustainability, by recognising as a process of continuous change in which present needs can be established without compromising future needs. Derived from the three main pillars of People, Planet, and Prosperity, sustainability can be interpreted on practical levels by a comprehensive overview of aspects. In line with this reasoning, this study does not provide a singular definition of sustainability for utility infrastructure projects. Rather, utility infrastructure projects can be operationalised by trade-offs between societal impact, labour practices, environmental impact, energy, water, spatial quality, soil, materials and resources, and return on investment. By offering an extensive collection of sustainability aspects relevant to utility infrastructure projects, this study aims to extend on the concretisation of people, planet, and prosperity aspects, without sacrificing the uniqueness of this context.

The theory in the domain of organisational sustainability (Willard, 2005; Epstein, 2018; Silvius & Schipper; 2012) distinguish multiple levels of proactivity related to the organisational sustainability performance. A reactive approach is concerned as minimalistic by compliance with environmental or social laws and regulations, whereas proactivity is associated with voluntary exceedance of requirements to achieve more impact. The highest level of proactive behaviour shows a value driven dedication that is concerned with the contribution to a more sustainable society. The comparison of these results show a relation between the level of dedication, the time-orientation in investments, and the level of effectiveness of solutions. The essence by which sustainability implementation is incorporated shows to be measured in different levels of sustainability performance: from compliance, beyond compliance, integrated strategy, to purpose.

To achieve sustainability objectives, all levels of decision-making within organisations possess different influence over the formation and realisation of projects. Tactical decisions allow for direction of investments into the project delivery of sustainable services or deliverables that contribute to a more sustainable society. This is associated with sustainability by the project, in which the purpose of the project is interpreted as sustainable. Decisions made on the operational level allow for minimising the impact of organisational processes, which can be understood as sustainability *of* the project. The results in practice show solutions mostly related to the use of products and resources within the construction processes. Moreover, the principles of sustainability need to be integrated in current project management practices, to become visible by sustainable outcomes. First, the traditional approach of realising infrastructure projects around planning, budget, and costs requires a change towards balancing societal, environmental, and economic aspects in decisions. Also, it requires a long-term orientation in which the total life cycle of products and resources is taken into account. As many stakeholders highly depending on each other are involved during different project processes, sustainability needs to be collectively approached.

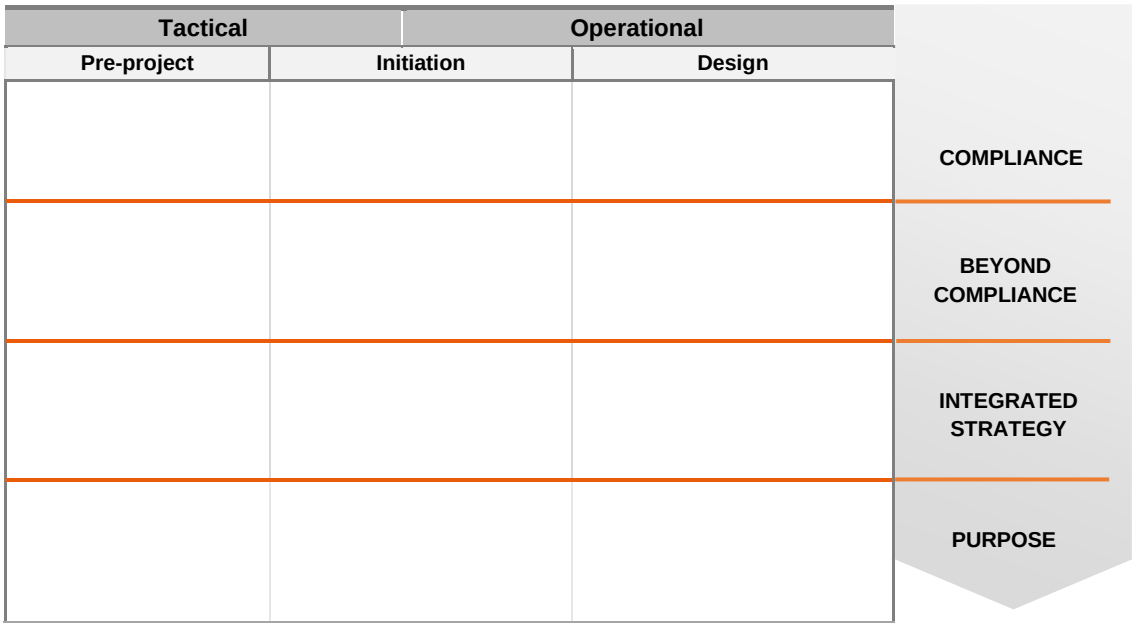
The partnership has set expectations that require dedication in behavioural change from both parties, which makes the concept of sustainability dependent on how both parties fulfil their roles. From the empirical results, both contractor and client have shown proactive behaviour to establish effective solutions by engaging and incentivising (supply chain) stakeholders, directing organisational resources into solutions, taking measures to overcome hindrances form previous limitations, research actively in market opportunities, and emphasizing sustainability in the projects. However, the following underlying barriers for remaining solutions in proactive behaviour have been identified from practice: technical limitations for utility infrastructure, varying interpretations of sustainability, and organisational cultural resistance. Additionally, barriers have been identified in that regards the collaborative practices between client and contractor. These are associated with fragmented decision-making, varying interpretations of sustainability, a lack of mutual ambitions identified for each individual project, and a lack of awareness in underlying project values. Intervention boundaries for these barriers are involved with the creation of a company-wide approach in which project level management is stimulated to involve sustainable considerations. Also, it requires a future-directed mindset in which it is aimed to prevent from future technical limitations. Moreover, it is determined to require a long-term investment approach, in which trade-offs allow for life cycle costs. Engagement of

stakeholders holding decision-power need to be engaged in sustainable ambitions. To overcome barriers in the collaboration, it requires structuring decision-making moments for sustainability within the process. This needs to stimulate mutual building of ambitions, detection of opportunities, and interpretation of sustainability aspects.

USE OF CONCEPTUAL TOOL FOR ANALYSIS OF RESULTS

Based on the gathered elements on proactive implementation of sustainability in decision-making levels, a conceptual framework is developed to test the case studies by analysing sustainable outcomes in terms of their level of effectiveness. The analysis framework introduced by this study connects the different levels of proactivity with a chronological order of project phases, ranging on tactical and operational decision-making levels. This is based on the assumption that the timing of decisions can significantly impact the effectiveness of solutions for implementation of sustainability in projects level of proactivity. From usage of this framework, an overview is created of the number of possible solutions (quantity), the expected effectiveness of solutions in terms of proactivity, and the project phase in which the aimed solutions must be translated into actions.

The purpose of this conceptual framework is to translate the theoretical insights into practical use, which allows organisations to visualise and analyse their level of proactive contribution towards sustainability. In practice, this tool is considered valuable in enhancement of collaboration between partnering organisations, as it stimulates communication of sustainability ambitions, opportunities, and interpretations. The conceptual framework is presented below:



Conceptual framework for analysis of proactivity

DISCUSSION

The following discussion points have been identified in this research. *Sustainability remains a conceptual and value based concept, perceived differently by involved stakeholders in time and place.* From the practical results, it is determined complex to possess one clear understanding of this concept, which can be explained by different interpretations of time-orientation, context specificity of measures, ethical behaviour. The provided sustainability aspects can show a direction in which aspects trade-offs can be made by organisations. The definition of sustainability thus changes over time, and should be adopted as a specific mind-set rather than following a set of concepts or solutions.

Tactical level decision-making may exert influence to sustainability by the project, whereas operations can direct decisions towards sustainability of the project. The results in practice show alignment in the theoretical understanding of tactical and operational solutions. The results shows that most effective solutions are associated with the direction of investments to projects that in purpose contribute to a more sustainable environment. This is also in line with the theory of ***sustainability by the project***, in which the project is

interpreted as a means to establish the strategic sustainability goals. However, achieving this has shown to be highly dependent by the strategic plans. During the operational phases, the practical solutions show a focus towards the change and minimisation of products and resources, such as equipment, materials, and energy use. This can be related to ***sustainability of the project,*** in which minimising impacts of products and processes required for realising the project.

Proactive behaviour within collaboration between partners requires the extension of responsibilities to supporting partner's responsibility. Both organisations have shown high levels of proactive behaviour on tactical and operational level decision-making in their individual scopes, which can be explained by their organisational tactical plans for sustainability overarching to specific projects. During the projects, which show solutions that may fall between responsibilities, not all available sustainable solutions have been implemented as identified during the case studies. It can be argued that within the partnership, there shows to be no defined shared proactive approach towards sustainable outcomes of the projects. As aimed to mutually benefit and learn from each other's expertise, proactivity needs to be enhanced in synergy by supporting each other's responsibilities.

CONCLUSION

For organisations within the infrastructure industry to become highly committed to sustainability, responsibility needs to be taken over decisions regarding their organisational processes. The existing literature explains proactive behaviour towards sustainable outcomes by efforts in terms of a direction of resources, a value driven motivation to change systems at their core, as well as long-term financial directions. However, proactivity in strategic partnering collaborations also requires extending responsibility towards supporting the partner's responsibilities in order to achieve the best outcome for all parties involved. Proactivity is more than the sum of its parts, and the importance of synergy between partners should not be underestimated. The conceptual framework developed in this research provides a practical solution for the collaborative setting between client and contractor, as it stimulates the development of mutual ambitions and substantive opportunities and directions for sustainable outcomes.

Decision-making on a tactical level is concerned with the direction of projects, whereas decision-making on the operational level is concerned with minimising the impact of the operational activities within the chosen direction. For utility infrastructure projects, the tactical level allows for directing investments to overarching initiatives and projects that contribute to the transformation of systems from non-renewable energy sources towards renewable energy resources. By proactively directing resources towards sustainable options, this level has a strong impact on the sustainability by the project. On the operational level, proactive implementation is involved with mutual commitment between project partners to align definitions, ambitions and specifications. Moreover, the operational level is actively involved in the sustainability of the project and how this can be achieved during daily activities.

RECOMMENDATIONS

Involved recommendations for theory are to complementary research in the domain of sustainability by levels of effectiveness of solutions, the influence levels of decision-making by multiple stakeholders within the energy sector, influence of collaborative, proactive behaviour over time within long-term partnerships, as well as leadership styles for sustainable outcomes related to managers on tactical and operational level.

The practical recommendations follow from intervention requirements and focus on the mutual approach between client and contractor. These involve stimulation of the expert role of the contractor by internal stimulation of project managers and their project team in dedication of resources and efforts towards sustainability, improvement of knowledge exchange between departments, internal analysis of future opportunities, and the development of a long-term plan. The client needs to improve the role of the contractor by involving the contractor in the initiation phase of the process, sharing of project values, engaging other stakeholders in the ambitions, and sharing of long-term challenges with the contractor.

LIST OF ACRONYMS

CSR	Corporate Social Responsibility
E&W	Energy & Water (Specialist department BAM)
GHG	Greenhouse gasses
KPI	Key Performance Indicator
PI	Performance Indicator
PM	Project Management
PoR	Program of Requirements
SD	Sustainable Development
SDGs	Sustainable Development Goals
SPM	Sustainable Project Management
TBL	Triple Bottom Line
DNR	De Nieuwe Regeling
UAV	Uniforme Aannemer Verordening
SO	Schetsontwerp (schematic design)
VO	Voorontwerp (preliminary design)
DO	Definitief ontwerp (final design)

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I INTRODUCTION

The world is in continuous change towards a more sustainable environment. While the construction industry positively affects human quality of life by providing structures that meet our socio-economic needs, it has also been declared responsible for 60% global consumption of raw materials (Bribián, Capilla, & Usón, 2011), 40% of energy, and up to 40% of greenhouse gas emissions (Son, Chong & Chou, 2011; Goel, Gaur & Kanesh, 2019). In 2017, the United Nations Environment Programme (UNEP) stated that even though current progress towards sustainable construction is advancing, improvements cannot keep up with the rising demand for new buildings and energy services. Therefore, the industry is challenged in the momentum to transform buildings and infrastructure, as well as to accelerate its progress (UNEP, 2017).

In 2015, the Sustainable Development Goals were agreed upon by 193 nations as long-term global goals for 2030 (United Nations, 2015), and also countries show commitment by settlement of milestones. For organisations, this growing importance has influenced the need for responsiveness. Besides it being a moral obligation to decrease the impact of organisational activities (Silvius et al., 2013), also regulatory pressures, new business opportunities, and cost factors -such as carbon tax- increase the urge to include sustainability by top-level management (Wijethilake, 2017). More importantly, the attainment of sustainability is deemed critical for organisational resilience and long-term corporate success (Russel & Shiang, 2012; Goel et al., 2019). Kivilä, Martinsuo, & Vuorinen (2017) address that this awareness and need for aligning processes with the principles of sustainability is also reaching operational levels. In the management literature, attention has therefore been shifted from understanding *why* implementing sustainability is necessary, towards the question *how* sustainability can be incorporated into organisational systems and processes (Kivilä et al., 2017; Sabini, Muzio, & Alderman, 2019; Silvius & Schipper, 2014).

However, project managers it remains a challenge to practically integrate sustainability into construction projects (Gijzel, Bosch-Rekveldt, Schraven, & Hertogh, 2019; Martens & Carvalho, 2017). In this fast, demanding, value for money society with multiple diverse interests, they have been directing their work to fulfil objectives and expectations (Taylor, 2011). Being viewed as the 'present vehicles for change in creating the future', projects are considered to play a crucial role in contributing to sustainable development of organisations and society (Gareis, Huemann, Martinuzzi, Weninger, & Sedlacko, 2013; Lombardi et al., 2011; Silvius, 2017; Marcelino-Sádaba et al., 2015; Silvius & Kampinga, 2017; Silvius et al., 2012).

Infrastructure projects are typically large complex projects that have profound impacts on society, require collaboration between public and private parties, and involve a diverse set of stakeholders (Kivilä et al., 2017; Silvius et al., 2012). Utility services are divided into water (potable water and sewage), energy (electricity, heat, and gas), and data (telecommunication), transported via pipelines or cables which are predominantly located in the shallow subsurface in The Netherlands (Nederland Circulair!, 2018). Although often 'overlooked', these infrastructure systems are recognised to play a pivotal role in improving the sustainability of cities due to their critical functionality in urban environments (Hojjati, Jefferson, Metje, & Rogers, 2016). Moreover, trends in growing urbanisation, climate change, the energy transition, and technological development, challenge the capacity and transformation for utility networks. While these utility systems are subject to change, the practical implementation of sustainability is largely unexplored.

Although research is emerging in the study of integrating sustainability in project management, it is still in exploratory phase (Martens & Carvalho, 2017; Sabini et al., 2019; Silvius, 2018). According to Kivilä et al. (2017), the pressure to manage projects sustainably will increase causing a need for suitable practices to help managing projects, showing an evident need for studies on these converging themes. Therefore, the purpose of this research is to support involved project managers in integrating sustainability within their project decision-making processes.

1.1 RESEARCH FRAMEWORK

1.1.1 *A partnering approach as research context*

This research will be conducted in collaboration with contractor BAM Energie & Water (E&W). In April 2019, this contractor entered into a strategic partnership with Royal Schiphol Group for a maximum duration of 9 years. During the term of the contract, BAM Schiphol E&W is commissioned to design, execute, and maintain a multitude of utility infrastructure systems at Schiphol Airport, the main international airport of The Netherlands. This means BAM E&W is designated as operator of several utility asset groups, for example the infrastructure for high-voltage electricity, stormwater, potable water, gas, public lightening, traffic installations, but also high voltage stations and water pumping stations.

Strategic partnering and Best Value contract

Partnering or alliancing refers to a collaborative management approach in which soft skills, such as openness and trust, are encouraged between parties to a contract (*Partnering in Construction*, 2012). Within these collaborations, parties become mutually dependent for achieving success, and this requires a change in culture, attitude, and procedures. In case of a strategic partnership, the relationship is dedicated to multiple projects within one contract (*Partnering in Construction*, 2012).

The long-term partnering contract between client and contractor is based on the Best Value (BV) principle: gaining most value for the best price. According to Rijkswaterstaat (2015), the Best Value approach aims for synergy by ***close cooperation*** between partners and valuing professional expertise. Unlike the traditional method in which the client dictates requirements, the contractor is ***'in the lead'*** to determine the approach and guide its client to meet the eligible quality. By ***transparency of performance*** and ***continuous learning*** and improvement, both parties can benefit in profit perspective and quality (Rijkswaterstaat, 2015).

1.1.2 *Sustainability in organisational strategies*

Both involved organisations have set similar strategic objectives associated with their scope of operations:

Sustainability strategy Royal Schiphol Group

Royal Schiphol Group has involved sustainable development in their strategic objectives and intent to increase their competitive advantage, as it aims to operate the most sustainable airports in the world (Royal Schiphol Group, 2019). In their long-term vision towards 2050 for their airports Amsterdam Airport Schiphol, Rotterdam The Hague Airport, and Lelystad Airport, focus is placed on 3 main goals: to integrate circularity, operate solely energy positive buildings, and facilitate sustainable aviation. Key milestones for the first two themes are respectively to become zero-waste and emission free airports in 2030 (Royal Schiphol Group, 2019).

Sustainability strategy Royal BAM Group

Royal BAM Group identifies key focus areas where progress will be monitored going forward (Royal BAM Group, 2018). Their corporate vision towards 2050 is directed at enhancing their activities to become Climate Positive, Resource Positive, and People Positive. This strategy involves respectively the reduction of carbon emissions, elimination of waste over the life cycle of developments, and creation of social value. On September 1st 2020, specialised entity BAM Infrastructures announced an additional ambition to become a circular entity (*BAM Infra Wil in 2025 Circulair Bouwen*, 2020). BAM E&W is part of the infrastructure department, and will also follow these strategies.

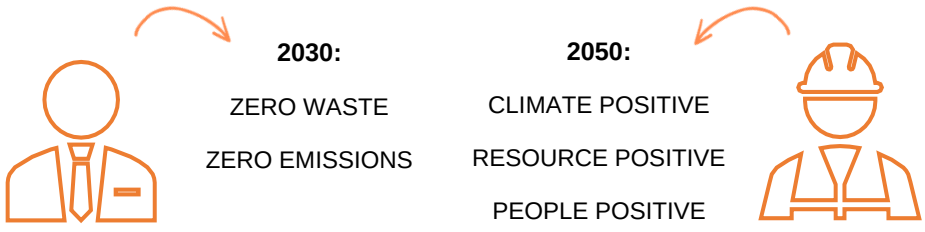


Figure 1 Strategic sustainability visions from client and contractor

1.1.3 *Problem statement*

As society becomes increasingly aware of sustainability revolving around change, there is a need to change business models, products, services, techniques, processes, sources and behaviour (Silvius & Schipper, 2014). On a strategic level, organisations increasingly show proactive engagement with the principles of sustainability (Gareis et al., 2013). Though, for sustainability to manifest in all organisational practices, these strategies need to be adapted towards the tactical and operational level of decision-making (Bertoni, 2017; Chofreh & Goni, 2017). The challenge of capturing and communicating the opportunity of value creation across strategic, tactical, and operational decision-making therefore appears evident (Bertoni, 2017).

Epstein (2018) addresses an emerging field of study reporting that the most effective sustainability initiatives regarding organisational performance, are those that are proactive rather than reactive. In practice, successful construction of infrastructure projects requires close collaboration between multidisciplinary project stakeholders. A continuous search in favourable project delivery models is changing the quest for more cooperative attitudes and changes expectations between parties. The need to adopt proactive behaviour towards sustainability shows to be pertinent by the involved organisations. From both the gap in literature and the communicational problem derived from practice, the subsequent problem statement is formulated:

Organisations within the infrastructure industry increasingly show proactive engagement with sustainability on strategic level, however tactical and operational levels of decision-making are still associated with an unstructured and reactive processes

This does not necessarily mean that sustainability is neglected in the decision-making processes. In practice, the organisation has shown to include sustainable solution in previous projects, although it has not been made explicit how these decisions were considered, or how these solutions contribute to the strategic goals. In the desired situation, all projects are approached by proactive embedment of sustainability during the processes, in which decisions are based on well-informed trade-offs in the right timing.

Why is this a problem for the organisation?

This is considered a dysfunctional situation, because of several reasons. In its relational approach towards handling multiple projects, the contractor has responsibility to measure and decrease the impact of their operations by taking sustainability measures. As current measures are not captured, it is impossible to reflect on and communicate these to the client. In the future, the contractor wants to exert more influence on the tactical decision-making level, which requires sufficient knowledge about sustainability strategies. Moreover, valuable information regarding sustainable measures in different stages of project delivery provides the opportunity to set clear strategies for different processes or to different stakeholders, such as suppliers. The lack of understanding how sustainability is currently incorporated is therefore limiting improvement.

The current project hand-over between the client and the contractor also shows a lack of visible decision-making processes. As shown in the research context, the client currently decides on tactical matters when initiating a project, where after the contractor becomes involved on operational level. In this stage, it is unknown for the contractor if and how sustainability was considered by the client. This issue affects both the client and the contractor, as it limits achieving one of the core goals of their strategic partnership, which is mutual organisational learning. It requires the exchange of valuable knowledge to develop learning in mutually achieving sustainability goals.

What are the underlying reasons?

Commonly cited barriers for the implementation of sustainability in day-to-day work for construction projects are the ambiguous and multifaceted concept of sustainability involving uncertainty and complexity (Frantzeskaki, Loorbach, & Meadowcroft, 2012; Goedknegt, 2013), mutually exclusive outcomes which make it difficult to trade-off the environmental, social and economic dimensions (Bertoni, 2017; Hahn,

Pinkse, Preuss, & Figge, 2015), the absence of a structured approach towards sustainability on different levels (Gijzel et al., 2019; Kivilä et al., 2017; Wu, 2017), and the lack of adopting performance measurement systems (Agarwal & Kalmár, 2015; Goedknegt, 2013; Kivilä et al., 2017).

Silvius (2018) shows that current generic frameworks for project management involve assessment models, maturity models, and checklists. These instruments all share an equal approach in the adoption of sustainability indicators as content. According to several scholars (González-Benito & González-Benito, 2004; Labuschagne & Brent, 2005; Wijethilake, 2017; Wolfgang, 2017), the lack of structured approaches and techniques within managerial processes cause a major impediment for achieving sustainability performance. This way, sustainability objectives tend to remain stuck within the top management department (Wijethilake, 2017). From their extensive systematic literature review, Sabini, Muzio and Alderman (2019) add to this that several theoretical tools and frameworks remain limited applicable for general use.

The sustainability expert working for the contractor adds that specific barriers within the organisation are related to an insufficient awareness to consider sustainability in decision-making processes. The lack of insight hinders the potential contribution and impact to sustainability for alternative solutions in different project stages limiting the managerial decision-makers in the ability to judge alternative solutions based on a holistic set of information. Hence, they remain to adopt a reactive mindset rather than proactive.

1.1.4 *Research objective and questions*

The objective of this research is to help improve proactive involvement of sustainability in decision-making within tactical and operational decision-making processes, by developing a framework for the adoption of sustainability in future decision practices. The result of this research is aimed at creating a manual to guide project managers in the steps towards involving sustainability proactively.

The following research question (RQ) is to be answered:

RQ: How can sustainability be proactively incorporated within the tactical and operational decision-making processes of utility infrastructure projects?

This research question is tested for utility infrastructure projects at Schiphol Airport, and is expected to provide valuable outcomes that can be used for the implementation of sustainability in similar subsurface infrastructure projects within The Netherlands. The following sub-questions are formulated to support answers to the main question, and will be elaborated:

SQ1: What is the definition of sustainability in the context of utility infrastructure projects?

SQ2: Which elements need to be involved to proactively implement sustainability on tactical and operational decision-making levels regarding infrastructure projects?

SQ3: What are the underlying issues resulting in the gap between reactive decision-making and proactive sustainable decision-making?

SQ4: What interventions are required to proactively embed sustainability within decision-making processes at tactical and operational level?

Verschuuren and Doornewaard (2010) state the following two criteria to developing a set of questions: each question (1) indicates what type of knowledge is required, and (2) supports in deciding which data needs to be gathered. Consequently, the sub-questions are drafted as follows:

SQ1: Gain substantial knowledge how the literature defines sustainability for utility infrastructure projects. The answer to this question involves a set of sustainability aspects which are related to utility infrastructure projects. This knowledge is of high importance for the author, as it will be used as input for the empirical research to recognise sustainability definitions and assess issues.

SQ2: Link existing theories and concepts to frame the research boundaries. This question is developed to explore how the extant body of knowledge relates concepts of sustainability, proactive behaviour, and decision-making levels within organisations.

SQ3: Identify underlying barriers resulting in the gap between practical behaviour and proactive behaviour. The third question can be answered by validating the obtained practical results with the theoretical framework. To provide an answer, the sustainable considerations made by project managers are analysed and compared with literature. This involves explanatory knowledge.

SQ4: This question aims to identify the boundary conditions for an intervention design in practice. As a result of the identified barriers, this knowledge involves the essence of solutions.

1.2 THEORETICAL AND PRACTICAL RELEVANCE

This research contributes to the theoretical body of knowledge in several ways. Scientific research relating the themes of project management and sustainability has been growing recently (Sabini et al., 2019; Goel et al., 2019). For project contexts, research focus has predominantly been including the content, whereas less attention has been directed to sustainability integration in the process of delivery (Aarseth et al., 2017; Gareis et al., 2013; Goel et al., 2020; Silvius et al., 2012). Scholars focus on the strategic level of decision-making (Epstein, 2018; Wijethilake, 2017), the tactical level (Herazo, 2012), or operational level (Silvius & Schipper, 2014), however no overview has been created to show the link between these levels. This research is therefore expected to contribute to the body of knowledge by providing insights in the translation between these levels. Another addition to the current body of knowledge is the link between sustainability and the implementation in more relationship-based agreements. According to multiple scholars (Kwak et al. 2009; Pinz et al. 2018; Spraul & Thaler, 2019), the current literature in public-private partnerships address sustainability issues rather implicitly than explicitly. Hueskes, Verhoest & Block (2017) conclude that considerations for sustainability only play a limited role in public-private partnerships. Therefore little knowledge is available on the contribution to these partnerships (Spraul & Thaler, 2019). To the knowledge of the author, literature in strategic partnering and sustainability is completely lacking in literature. This illustrates a need for deeper understanding of process related issues in these contexts. Furthermore, the link between infrastructure management and sustainability has been gaining attention (Goel et al., 2019). However, to the knowledge of the author, no specific relation is made with utility services. An enhancement will thus be added to the overall understanding of sustainability in utility infrastructure projects.

In practice, the competition between builders for achieving sustainably is growing. From a recent examination by Cobouw (2021), almost 75% of builders is currently active in their progress in the energy transition. This increases the need to gain insights in how improvements can be made towards the integration of sustainability in operational processes. As the context of this project is undertaken within a strategic partnership collaboration between client and contractor, it can be evaluated what the role of different actors is in promoting sustainability, to what extent is participated to achieving mutual objectives of sustainability. The contracting organisation is motivated to gain insights in current decision-making processes as well as tactical decision-making by the client to help understanding the current performance of both project partners towards the sustainability goals. Practical results therefore contribute in the project manager's perspective to these processes within a research context for which high level sustainability ambitions are developed.

1.3 SCOPE BOUNDARIES

The following three points of attention are considered as the focal areas of this research.

1) Why urban utility infrastructure?

According to (*Airports as Future Cities*, 2018)[1], international hub airports have developed to become driving economic forces; generating jobs, revenue, and infrastructure. Referring it as 'a city that never sleeps', Schiphol can be compared to a city because of the facilities it offers, such as hotels, shops, restaurants, conference centres, offices, a library, and transportation connections (Royal Schiphol Group, 2019). Similar to cities, airports are highly concerned with assess and safety, related with the need to constantly improve infrastructures and embrace innovations for its 'residents' (*Airports as Future Cities*, 2018).

Spatially, airports can thus be compared to an urban area. For this research, this means that the demand for energy and realisation of utility infrastructure networks at airports experience similar processes and challenges, in which these projects are typically associated with complex areas and a vast number of stakeholders. The aspects of sustainability applied and the variety of possibilities to implement sustainability within these types of projects can be projected on similar utility infrastructure projects within densely populated areas of The Netherlands. The literature regarding sustainability for urban utility infrastructure can be used as input for the definition of sustainable utility.

It should be noted that the relational environment in which utility services are provided at Schiphol Airport is considered different from urbanised areas (Appendix A). Since the privatisation of the energy sector in 2004, a variety of private and semi-private companies are involved with a utility infrastructure project as owner of a specific infrastructure network in one specific location. A municipality as operator of the subsurface needs to take into account all these stakes. For the process part of this research, this implies that the decisions taken within projects in this setting can be argued from different perspectives than in the case of a municipality or Port of Rotterdam, as the latter two are assigned the role of operator of the city or port. Schiphol is owner of the land and has direct influence over the utility services, whereas municipalities are concerned with multiple stakeholders in utility services.

2) Why the early project processes?

To this end, the front-end development phases are considered critical for project success. In Figure 2, Burke (1999) shows that the potential to create value is considered highest within the earliest project phases, as the impact of potential decisions and changes is minimal. The impact of including adaptiveness may differ over time, as the costs to make decisions may increase as a project develops. Goel et al. (2019) identify these early phases as key for integrating concerns related to sustainability.

Following from these theories, it is decided to limit the focus in the operational decision-making levels to the initiation and design phase. For this research, the findings of sustainable outcomes are determined most influential for utility infrastructure systems.

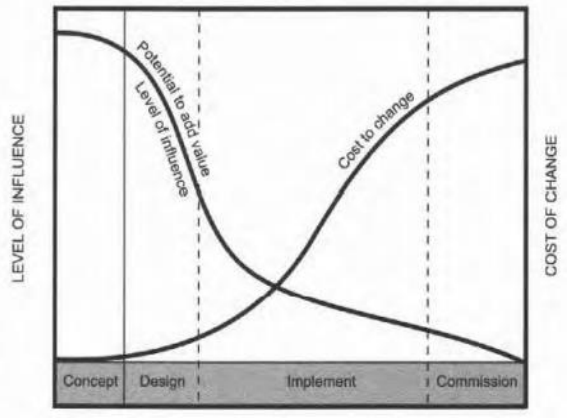


Figure 2 Showing potential to add value and cost of changes (Burke, 1999)

[1] Source adopted from Urban-Hub. Retrieved on May 23, 2020

3) Why the client and contractor perspective?

Partnerships have been developed from the assumption that the public sector lacks knowledge in the most cost-effective ways to deliver public goods (Spraul & Thaler, 2019). Therefore, technical expertise from the private sector is deemed necessary in exchange for a long-term service contract (Forrer et al., 2010). This way, it is aimed to benefit through an effective combination of complementary knowledge and capabilities.

Conducting this research within the perspective of a strategic partnership naturally determines that process-related aspects for decision-making are the result of these contextual processes. This partnership involves two private parties and is developed from the same perspective as stated in Chapter 1.1.1 (A partnering approach as research context). Differences can be associated with the fact that in this partnership, decisions might be more driven by economic growth by both parties. Also, the physical space of Schiphol Airport is prone to fluctuations within the economic cycle. This is related to the fact that the initiation of projects is also dependent on the need for new buildings and energy services. Whereas in a public-private partnership for infrastructure projects, the project result might be more clearly envisioned by the client.

Within these collaborations, client and contractor are highly dependent on each other's attitude towards sustainability. Therefore, the designated behavioural responsibilities within the contract are of major influence within this research regarding proactive behaviour. Both parties possess a different influence on both tactical and operational levels of decision-making, allowing for different endeavours as a contribution to sustainability. Therefore, this research is determined to provide insights in the responsibilities for proactive behaviour by both parties.

Inside scope	Out of scope
Utility infrastructure systems	Other infrastructure systems
Processes within the partnering environment between two parties	Relation to other project delivery models
Client and contractor perspective	Other project stakeholders, such as suppliers, network operators
Initiation and design phase (operational level)	All remaining operational phases: construction, operations, maintenance and hand-over phase.

Table 1 Scope boundaries of research

1.3.1 *Thesis outline*

The following outline is proposed for this thesis document. First, the research methodology is presented in Chapter 2 to reason which methods are used to holistically tackle this research. Subsequently, the literature study is presented in Chapter 3 to answer the first 2 research questions. Then, Chapter 4 encompasses the results from the empirical study and provides an answer to the 3rd research question. Based on the findings, research question 4 is answered in Chapter 5 in providing practical boundaries. Chapter 6 encompasses the discussion and limitations of the results and Chapter 7 follows with the conclusion. Finally, the recommendations are presented in Chapter 8.

2 RESEARCH METHODOLOGY

This chapter substantiates which research methods are used to provide an answer to the research question. In paragraph 2.1, the research type and process are presented in relation to the research methods. In paragraph 2.2 further elaboration is provided to the used research methods.

2.1 RESEARCH TYPE AND PROCESS

To track down how proactive organisations in practice have behaved towards sustainability, a qualitative research method is conducted. This type of research aims to outline experiences, interpretations and meaning of actions within processes of decision-making, and is characterised by a descriptive approach (Yin, 2018). In addition, this research is considered practice-oriented as it aims to build theoretical knowledge through practice, and contribute to an improvement of practice. Verschuuren and Doornewaard (2010) structure five stages of intervention to follow in which practice-oriented research can contribute (Figure 3):

Figure 3 Five stages of practice-oriented research (Verschuuren & Doornewaard, 2010)

After having identified the research problem in Chapter 1.1.3 (Problem statement), the focus of this thesis is predominantly directed at diagnostic research to further examine the background and gap of the problem. According to Crowe et al. (2011), gap analysis makes it possible to detect suboptimal or missing strategies, processes, skills, capabilities, or structures. Based on this knowledge, recommendations can be provided regarding a course of action to achieve practical goals.

For being able to comprehensively diagnose the practical situation in the level of proactive implementation, it is required to holistically understand how sustainability has been implemented in during tactical and operational decision-making processes, represented by substantial outcomes and other detected solutions. This is referred to as understanding the WHAT: what is sustainability and which sustainable outcomes are shown for utility infrastructure? Consequently, the HOW in level of organisational proactivity is analysed. Figure 4 visualises these steps for the diagnosis. In support of this analysis, during the research process a conceptual framework is developed. This framework is tested by means of results from the practical results and consequently reflected upon.

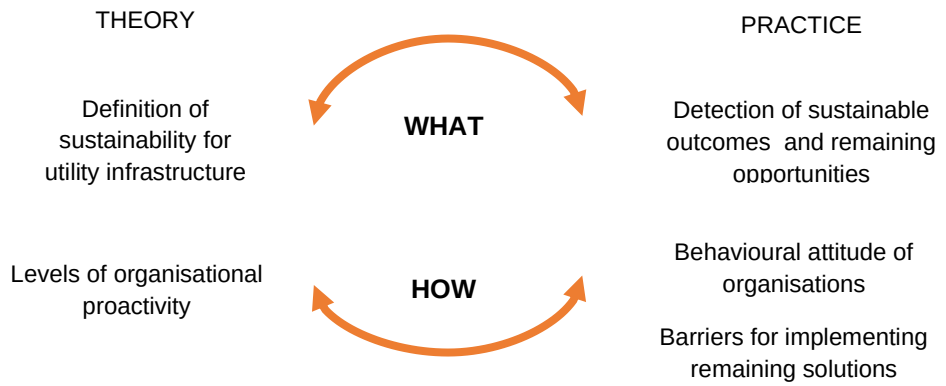


Figure 4 Diagnosis steps for analysis of proactivity

Figure 5 visualises the research process. The following chronological order is followed:

2.1 Synthesize definition of sustainability for utility infrastructure projects

Sustainability as topic of this research is characterised by a subjective nature, bringing uncertainties in how knowledgeable or aware interviewees are with this subject. Therefore, the author requires sufficient knowledge of sustainability in the context of utility infrastructure projects to be able to discuss topics during data gathering and detect solutions which may not have been implemented or forgotten about. This way, scientific knowledge is used as input for the case studies.

2.2 Relate theories in proactivity, sustainability, and decision-making levels

The current theoretical body of knowledge shows absence of clear boundaries relating different concepts of sustainability, proactivity, and the implementation of sustainability. Therefore, the purpose of the literature study is to critically analyse a segment of the published body of knowledge to gain a holistic understanding of the relation between these theories.

In advance of the empirical study, a singular definition of proactivity was gathered in the theoretical framework. However, after having conducted the practical study, it was determined necessary to improve this definition, and to sharpen boundaries between reactive and proactive behaviour in relation with sustainability. Therefore, another search in literature is conducted to support the analysis. As a result of the found proactivity levels, it was determined to frame theories into a conceptual model to support the analysis.

2.3 Gain insights in presence and trade-offs of decision-making for sustainability

As shown in Figure 4, practical research is used to gain a holistic perspective of implementation of sustainability aspects as well as missed opportunities. In line with these solutions, the difference between client and contractor behaviour regarding the process of decision-making is gathered.

3.3 Intervention design

Form the concluding results, intervention requirements for practice are determined as boundaries for an improvement of the current situation. These relate to the essence of proactive solutions.

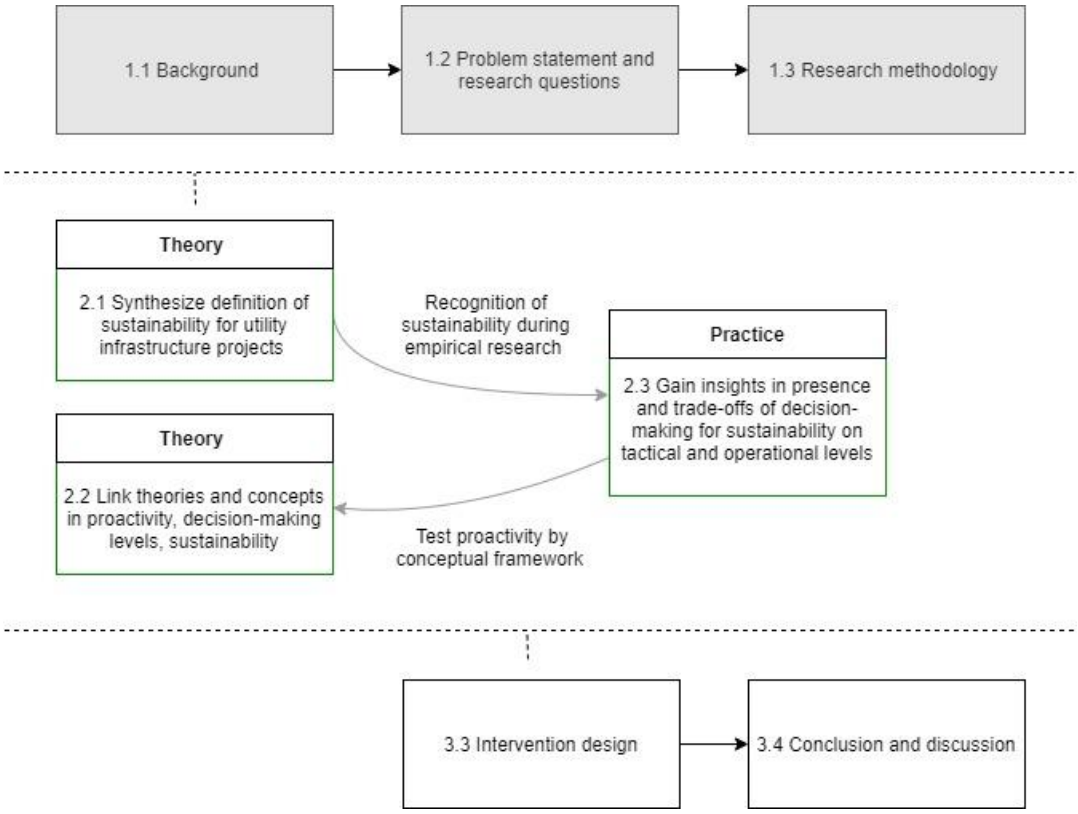


Figure 5 Overview of the research process

This research is conducted by means of literature research and case studies. The first two sub-questions form the theoretical framework of this research and have explored by literature study research. Two main directions within this review have been to (1) gain a thorough understanding of sustainability in the context of utility infrastructure projects, and (2) to provide a theoretical background concerning proactive decision-making on tactical and operational levels. Found scientific literature, books, and theses are gathered by search engines as Google Scholar, Science Direct, and the TU Delft repository. Additionally, literature is found through cross-referencing found articles.

2.1 CASE STUDY DESIGN

Case studies allow for profound insights on multiple practical processes that are confined in time and space (Verschuren & Doornewaard, 2010). Yin (2018) suggests case studies as relevant method when research questions seek to explain contemporary circumstances in which phenomena require in-depth descriptions. The essence in this case study research is to capture why decisions are taken, how these have been implemented, and with what result. The objective of the case study research therefore is to explore the possibilities of sustainability within these tactical and operational processes in a comprehensive manner. This is considered instrumental to capture information on explanatory questions as to *what* gaps exist and *why* sustainability interventions have succeeded or failed.

The approach of this case study method is **retrospective:** the data is collected about a past phenomenon which allows to review certain situations (Crowe et al., 2011). This is considered functional, because it allows to compare the outcomes of the situation with the process. That way, it can be learned how future decision-making processes within the partnership can be approached differently.

The main stages of research activity for planning and undertaking a case study are as follows: Define and Design, Prepare and Collect, and Analyse and Conclude (Yin, 2018; Crowe, 2011). Yin (2018) presents the steps within case study research as follows: (1) plan, (2) design, (3) prepare, (4) collect, (5) analyse, (6) share. This Chapter provides justification of how these steps will be conducted.

2.1.1 *Identification of the case study design*

Critical to the design is to define the case to be studied and set limits (Yin, 2018). For this research, the relevant situation to analyse is the decision-making process associated with sustainability in subsurface infrastructure projects. As each project within its unique context and specifications allows for different sustainable solutions, a substantial number of situations must be analysed to gain a holistic overview of examples of de underlying reasons for implementing sustainability. Therefore, multiple cases need to be analysed to enhance more informative and potentially permits cross-case analyses, in order to identify causal processes and develop theory. These cases are chosen to be assessed only subject to sustainability measures during different project phases, therefore presented as embedded cases.

Each case study represents one utility infrastructure project executed in the context of Schiphol Airport, following the predetermined boundaries as defined in Table 2. To gain understanding of the different decision-making levels, interviews are chosen with key respondents involved who may exert influence within different decisions. In this context, the client is predominantly exerting influence in the initiation phase, whereas the contractor has responsibility over the design phase. For each case study, both perspectives are taken into account by conducting interviews with the project managers of both the client and contractor.

According to Yin (2018), selection of multiple cases should follow a replication rather than sampled logic. The following pre-defined boundaries are determined in Table 2 to increase the replication of cases:

Aspect	Pre-defined boundary	Explanation
Type of asset	Subsurface utility infrastructure	Assets as high-voltage electricity, low-voltage electricity, street lightening, communications, gas, water pipelines diverge in use of materials, design specifications, realisation methods. If possible, equal asset groups should be considered.
Stage project	Finished in detailed design phase (DO)	The required data involves decisions regarding the main choices during initiation phase and design phase
Contract	MC contract 2019	The main contract between the client and contractor involves all project contracts starting from April 1st 2019 and 2028 involving the associated sustainability goals.
Client	PLuS (project management division Schiphol)	The contractor is working for multiple clients at Schiphol. PluS is the project team division of Schiphol and main representative client for projects.
Type of contract	DNR and UAV	Predominantly all projects are logically commissioned to the contractor as a design contract according DNR, following to be commissioned as construction contract according UAV.
Size of project	UAV contract size above 30 000	The size needs to be bounded by the construction contract, since the design contract is involved with incomparable variables. Projects contracted in construction (UAV) above 125.000 need to be realised following specifications (according to Nadere Overeenkomst). According to the manager of BAM, projects between 30.000 and 125.000 are considered mid-large projects.

Table 2 Predefined boundaries for selection of case studies

The following selection of 4 case studies complies with the predefined boundaries, and provides the possibility to interview different project managers for each project (Table 3):

Name	Type of project	Contract	Size	Status
CS1: Renovation Parking P3	Placement of cables and pipelines for new street lightening, camera systems, alarm installations, stormwater, etc, in support of renovation of largest parking garage in The Netherlands	DNR UAV	86 000 +/- 500 000	Finished in DO phase
CS2: VS4 VS2 VS9	Placement and replacement of high-voltage electricity cables between three distribution stations at Schiphol Boulevard (landside and partly airside) to support energy in the future to the new built A Terminal	DNR UAV	50 000 100 000	UO phase
CS3: HS cables VR11 & VR12	Replacement of high-voltage electricity cables at airside as sub project of area redevelopment for construction of new taxiway	DNR UAV	- 80 000	Construction phase
CS 4: HS station DE Buffer	Placement of high-voltage station	DNR UAV	29 000 380 000	Construction phase

Table 3 Selection of 4 case studies

2.1.2 *Data gathering methods*

This multiple-case study research will be collecting data by means of conducting semi-structured interviews, which are according to Yin (2018) helpful in providing explanations and insights reflecting participants relativist perspectives. These involve one-to-one interviews conducted by a rather flexible approach on one general topic, which can be covered in detail. As can be shown in Table 4, for each case study the project manager working for the client and the project manager working for the contractor are interviewed. Based on the level of expertise of project managers and lack of information for some matters, additional interviews are conducted with closely involved professionals within these case studies. Data is collected from experts from the client, who possess influence on more tactical and strategic levels of decision-making. Also, engineers from the contractor are involved for substantial information. These meetings are initiated to achieve detailed information concerning decision-making during the processes.

Code	Case Study	Function	Background	Years of Experience	YoE Schiphol
R-1	CS 3	Design reviewer	BSc Electrical Engineering	6	1.50
R-2	CS 2 CS 4	Design leader	HTS Civil Engineering	32	32
R-3	CS 1	Project manager Schiphol	BSc Hydraulic Engineering MBA	24	3.5
R-4	CS 1	Project leader BAM	BSc Civil Engineering MBA	30	0.75
R-5	CS 2	Project leader Schiphol	BSc Electrical Engineering	34	34
R-6	CS 2	Project leader BAM	MSc Civil Engineering	5	0.25
R-7	CS 3	Project leader Schiphol	BSc Building Engineering	13	11
R-8	CS 3	Project leader BAM	MSc Construction Management	13	8
R-9	CS 4	Project leader Schiphol	BSc Electrical Engineering	25	5
R-10	CS 4	Project leader BAM	MSc Electrical Engineering	7	1.75
R-11	Multiple	Material expert Schiphol ASM			30
R-12	Multiple	Operator of cables and pipelines network Schiphol ASM			33
R-13	Multiple	Project manager at Utilities			4

Table 4 Respondents (data drafted in July 2020)

Moreover, the digital information system was researched in advance to assess how sustainability is communicated or measured in project documents. The overview of analysed documents can be found in Appendix F. The recognised perks of this data collection method associated with this research context is biased selectivity, reporting bias, and impossibility of access (Crowe, 2011). In the digital system of the contractor, all project files within selected project folders are examined. It is also checked with the respondents if the accessed documents provide a holistic display of the decisions taken in the project and if remaining documents are available for analysis.

Protocol Questions

The set of substantive questions asked during the semi-structured interviews can be found in Appendix D. The purpose of this questionnaire is to keep on track during the data collection process and collect the data by means of a global structure. These questions are directed towards all interviewees, supplemented with case-specific questions. As can be shown in Appendix D, the questions are oriented towards the researcher to provide guidance in the purpose of the specific question. The interview questions are globally structured as a means to give the respondent the opportunity to provide own answers in sustainability choices. As it is possible that the respondent is not aware of certain sustainability issues or has different opinions concerning sustainability, further project-specific questions are asked.

2.1.3 *Data analysis*

All interviews are recorded, transcribed, and coded with MaxQDA software. Yin (2018) identifies four general strategies which can be applied in combination for analysis of case studies: to rely on theoretical propositions that led to the case study, working data from the 'ground up' (inductive), developing a case description, or examining plausible rival explanations. Within any strategy he suggests to consider analytic techniques, such as pattern matching, explanation building, time-series analysis, logic models, or cross-case synthesis (Yin, 2018). For analysing the data, the following steps are followed:

- **Open coding:** reading of transcripts and determination of different categories that are in the data
- **Constant comparative analysis**: constant comparison of data to the categories to determine consistency in coding
- **Axial coding:** using codes and memos to show how categories relate: phenomenon, causal conditions, strategies, consequences and connects categories
- **Selective coding:** writing a storyline how the theory explains

2.2 VALIDITY AND RELIABILITY

Case studies can involve multiple sources of information or data collection (Yin, 2018). For data quality, internal validity, external validity (generalisability) and reliability are essential (Fellows & Liu, 2015). Internal validity refers to drawing accurate conclusions from the obtained results; generalisability is defined as the ability to transfer the results to the wider context; and reliability implies that the study may be replicated by others (Fellows & Liu, 2015). To ensure quality in this research, the following is taken into account:

Reliability of the result can be determined by the deviance of data sources as well as the approach of analysing and concluding data (Yin, 2018). Reliability is in this research addressed by triangulation as well as by enhancing transparency by making a case study protocol, as suggested by Yin (2018). This which would guide the case studies based on the results of the first research phase. Triangulation is achieved by focusing on the following different forms of data: document analysis, observations, and interviews.

Generalisability may be challenged due to the qualitative, in-depth approach. This is less threatening for the purpose of this study, as it is considered practice-oriented. To strive for generalisability, an embedded case study approach designed by sampling. Moreover, the internal validity of this research is influenced by potential errors and biases, which need to be minimised. To diminish the risk of participant errors, it is aimed to create equal circumstances for all interviews. First of all, one-to-one interviews are planned to ensure a comfortable setting for sharing collaborative processes. For each case study, interviews were planned on Tuesdays for the project manager of the client, and on Thursdays for the project manager of the contractor. Also, based on the outcomes, validating interviews were held with involved stakeholders to align the outcomes and definitions of sustainability. Also, all respondents perceived a list of subjects one week in advance of the interview, found in Appendix E.

3 THEORETICAL FRAMEWORK

The purpose of this framework is to gain theoretical insights from the existing body of knowledge in how different concepts and theories are related. This chapter is divided into two parts: the *'what'* and the *'how'*. In Part I, the concepts of sustainability in general as well as in the context of utility infrastructure are explored. This is determined the 'what' to answer the first sub-question: '*What is the definition of sustainability in the context of utility infrastructure projects?'* Subsequently followed by investigating the 'how' (Part II), which elaborates current practices on different decision-making levels, and which practices are associated with proactivity. By gathering directive information in relation to the implementation of sustainability, it is expected to form an answer to the second sub-question, which states: W*hat relevant aspects needs to be taken into account to proactively embed sustainability in the project processes?* The final paragraph of this chapter summarizes these findings.

3.1 PART I: DEFINING SUSTAINABILITY BOUNDARIES

3.1.1 *The concept of Sustainable Development*

Identified as a broad concept, sustainability is not associated with a widely agreed definition (Aarseth et al., 2017; Silvius & Schipper, 2014; Kivilä et al., 2017; Sabini et al., 2019). This term is related to the concept of 'Sustainable Development', which can be traced back to the most commonly stated definition by the World Commission on Environment and Development, who defined it as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987). This illustrates a process of change, in which the exploitation of resources and the orientation of investments enhance the potential to meet human current and future needs (Willard, 2012; Brundtland, 1987). Brandon and Lombardi (2005) emphasize that this definition has shown to be meaningful, as it suggests that it is concerned with interventions by human kind into the environment that can be analysed to see whether they have a positive or negative impact on the issues of concern.

The Triple Bottom Line

The operationalization of Sustainable Development involves a collection of aspects that relate to social equity, environmental protection, and economic prosperity (Van Dorst and Duijvestein; 2012, Willard, 2012). In 1994, John Elkington introduced these three narrative aspects of sustainability as the Triple Bottom Line, which are currently known as: **People – Planet – Prosperity[2].** He emphasized that the holistic understanding of sustainability requires a balance of the economic, environmental, and social perspective. With this framework, organisations have been able to examine their impacts, which demonstrates as the set of perspectives evident in assessing, reporting, or other communication tools.

Winter & Knemeyer (2013) emphasize how the economic dimension is primarily quantitative in nature, and focused on return on investments and efficiency, leading to long-term success and competitiveness as the basis of this dimension. Based on this, Eriksson (2014) identifies in Figure 6 the social and environmental dimension as newer and soft factors that are intertwined with each other.

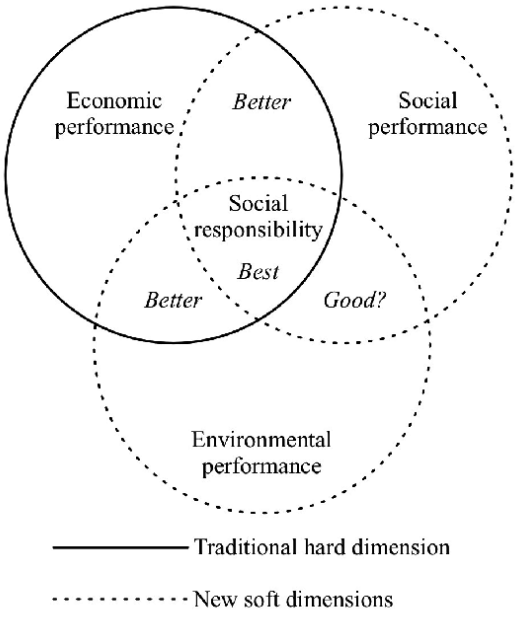


Figure 6 Dimensions of the Triple Bottom Line (Eriksson, 2014)

[2] Since 2002, the term *Profit* is widely recognised as *Prosperity* (UN, 2002). This denomination was altered by The United Nations at the World Summit on Sustainable Development.

3.1.2 *Sustainability and the construction industry*

Most of the spatial interventions created by the construction industry cause significant effects on the environment (Brandon & Lombardi, 2005; Fernández-Sánchez & Rodríguez-López, 2010; Shen, Hao, Wing-Yan Tam, Yao, 2007). Adverse environmental effects from construction activities typically include usage of non-renewable resources and raw materials, energy consumption to extract these materials and manufacture components, generating waste, emitting greenhouse gasses, or polluting in noise and land (Shen et al., 2007; Robichaud & Anantatmula, 2011). This also means that there is high potential to become more profitable, less environmentally intensive, and more efficient in terms of resource usage (Huovila, 2007). When enhancing sustainability in the built environment, a dominant focus is therefore shown to be directed at the environmental perspective (Sabini et al., 2019; Kibert, 2007; Van Dorst & Duijvestein, 2004).

3.1.3 *Sustainability and utility infrastructure*

Utility services are placed for the energy sector and are considered critical assets, as a high reliability of service provision is required (Hojjati, Jefferson, Metje & Rogers, 2017). Like in other countries, these infrastructure systems have been placed in the subsurface of The Netherlands to decrease visual impact, and to protect deterioration from climate issues and vandalism. However, multiple scholars (Bobylev, 2012; Curiel-Esparza et al, 2004; Hojjati et al., 2017; COB, 2018) address how the current pattern has become increasingly complex and interdependent in high-density districts, leading to issues of space scarcity in the majority of big cities. The Dutch Centre for subsurface development (Centrum Ondergronds Bouwen: COB, 2018) lists multiple challenges for utility services regarding i.e. the energy transition, climate change, and growing urbanisation (Figure 7). These pressures imply physical changes or extensions that are needed within the upcoming years – such as intensification of the electricity grid -, while simultaneously, urban space becomes even more scarce due to an increasing demand of facilities underground (Figure 7).

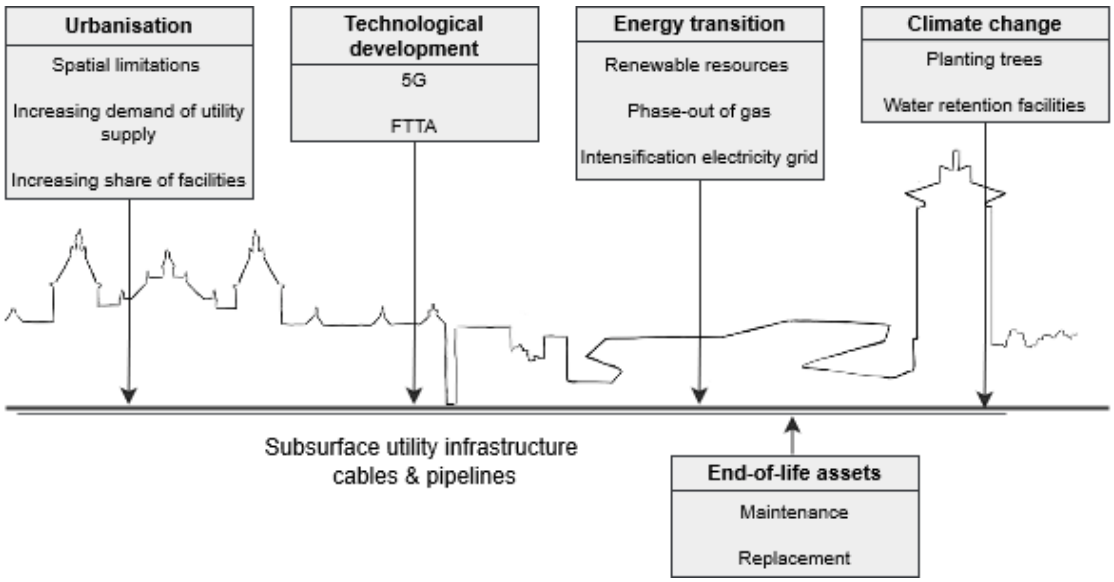


Figure 7 Changing conditions pressuring utility conduits (Own figure. Based on COB, 2018)

The construction, maintenance and replacement works, also known as street works, all require activities below ground and usually involve a significant amount of length crossing areas. Since these works are involved with high direct and indirect cost, and permanent alteration of the finite subsurface, Sterling et al. (2012) and Truffer, Störmer, Maurer, and Ruef (2010) emphasize the need for strategic planning and a selection of projects that offer highest contribution to urban sustainability.

In literature, research in sustainability for utility infrastructure shows a prominent focus on innovative and radical measures, with the intention of enabling next-generation urban infrastructure systems with improved services in efficiency, reduced operational costs and decreased environmental impacts (Karaca, Raven, Machell, & Camci; 2015). More specifically, research is dedicated to assess sustainability between traditional and new design alternatives, such as multi-utility tunnels, and construction technologies, such as trenchless

methods for placing utility infrastructure tubes. The majority of scholars in this domain shows a focus on the identification and/or quantification of sustainability indicators to support these trade-offs, in an effort to bridge the lack of comprehensive quantification tools for infrastructure systems (Sihabudding & Ariaratnam; 2019). In general, the development of these measurable performance indicators have been reported as the main approach for managing and ensuring sustainability (Amiril et al., 2014; Fernández-Sánchez & Rodríguez-López, 2010; Shen et al., 2011; Ugwu et al., 2006). However, criticism to this approach follows from the idea that sustainability indicators relate to the strategy and context of a project. Several scholars (Martens & Carvalho, 2016; Silvius & Schipper; 2015; Tam, 2017) therefore address the inevitability of accomplishing a universal set of indicators.

To support organisations in their process of defining sustainability for utility infrastructure projects in specific contexts, Table 5 illustrates a summary of identified aspects and associated indicators of existing papers as gathered in Appendix B & C. The literature in utility infrastructure is divided in different project phases, which show to allow for variant indicators to be involved. As only a small amount of papers was found for utility infrastructures, a comparison is made in Appendix C linking this context with project management and similar projects. It shows that infrastructure projects show a more extensively researched amount of indicators for equal aspects. Also, it shows that literature in project management highlights more indicators in financial and social aspects.

	Initiation	Design	Construction
People			Labour practices Health & safety
	Societal impact Public health Public participation User satisfaction Accessibility	Societal impact Public health Public participation Accessibility	Societal impact Stakeholder engagement Impact on business, community Noise and dust pollution
Planet	Environmental impact Air quality (CO2)	Environmental impact Air quality (CO2) Noise emissions Visual impact	Environmental impact Air quality (CO2) Noise emissions CO2 emissions Light pollution Hinder Archaeological value
	Energy Energy use & efficiency Carbon dioxide emissions Energy production	Energy Energy use & efficiency Carbon dioxide emissions	Energy Energy use Carbon dioxide emissions
	Material use and resources Energy use & emissions Waste Land use	Material use and resources Energy use & emissions Waste Recycling Contaminants & nutrients	Material use and resources Energy use & emissions Waste Contaminants
	Water Water use and quality Water quantity Water recycling	Water Water use and quality Water recycling	Water Water use and quality
	Spatial quality Land use Climate resilience	Spatial quality Land use Biodiversity Soil quality	Spatial quality Land use Biodiversity Soil quality
Prosperity	Return on investment Value optimisation Life cycle cost Willingness to pay	Return on investment Life cycle cost Resource efficiency	Return on investment Cost management

Table 5 Sustainability aspects and indicators for utility infrastructure projects (Own table, based on literature study Appendix B&C)

3.2 PART II: IMPLEMENTATION OF SUSTAINABILITY IN DECISION-MAKING

3.2.1 *Organisational decision-making levels*

Involving sustainability into an organization involves organisation-wide efforts (Epstein, 2014). Sustainable considerations vary in issues and scope on each level of decision-making within an organisation, and therefore all levels of decision makers are needed to influence the management towards sustainable outcomes (Chofreh & Goni, 2017). Montana and Charnov (2008) distinguish the following levels of decision-making within an organisation, as followed in this research:

- **Strategic level** Strategic decision-making refers to the task in which top management dictates how to sustain competitive advantage and long-term performance of the business. These decisions translate into generic goals and objectives which can be applied to all levels and departments.
- **Tactical level** Tactical decisions are considered medium-term decisions to translate corporate objectives into more specific development plans and concrete actions. These decisions are made by mid-level management, such as departmental managers (Montana & Charnov, 2008). According to Silvius et al. (2012), the tactical level predominantly concerns the selection and direction of investments to certain projects that realise a beneficial change to their strategic objectives.
- **Operational level** To complete the implementation of strategic and tactical decisions of an organisation, project managers decide on the managerial and technical course of daily operations.

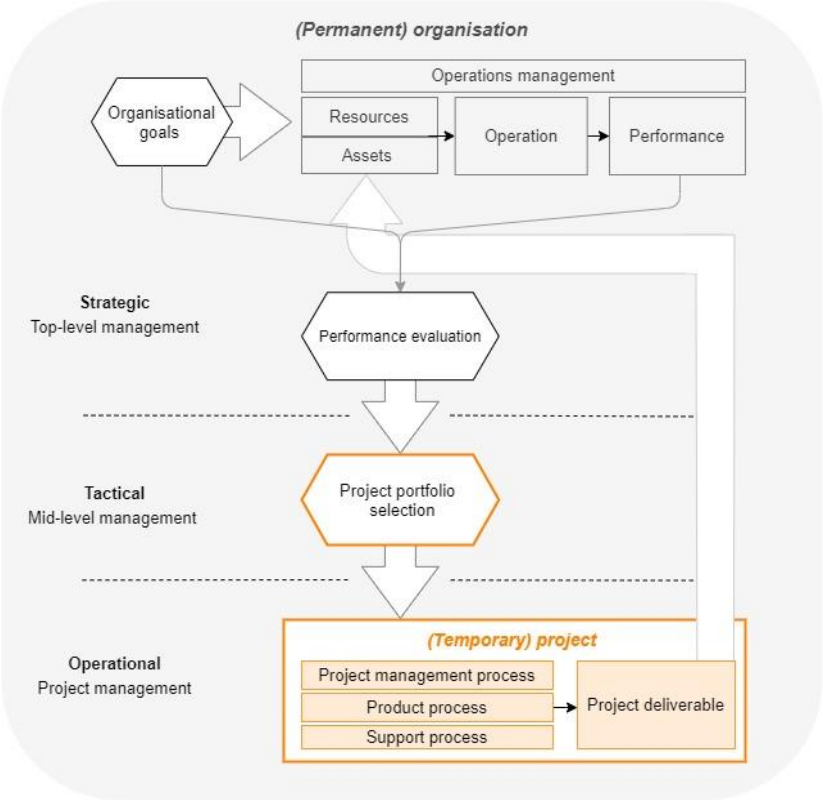


Figure 8 Projects positioned on the tactical and operational decision-making levels of project-based organisations (Own figure, based on Silvius et al. 2012)

Figure 8 outlines the activities on different decision-making levels within project-based organisations. This shows that decision-making for project-related aspects rely on both the tactical level and operational level. In the figure, this is highlighted by the orange coloured boxes.

3.2.2 *Structuring sustainability between decision-making levels*

On a strategic level, sustainability integration occurs by means of an organisational vision, mission, and strategy (Epstein, 2018; Herazo, 2012; Labuschagne & Brent, 2005). Based on his research into different organisations, Epstein (2018) concludes that these strategies are most effectively integrated when top management shows clear signals of commitment in both words and actions. Management at this level is responsible for creating an environment that encourages sustainability (Epstein, 2018).

The tactical level is determined to constitute the link between strategy and operation. To achieve the value defined by their business strategies, organisations need to align project deliverables with their organisational goals (ISO, 2012; Too & Weaver, 2014). Herazo (2012) investigates this link and shows that a focus is needed in the formulation of goals, involving performance criteria that should reflect the organisational values, vision and mission. Several authors (Maltzman & Shirley, 2010; Taylor, 2010; Silvius, 2018; Weninger & Huemann, 2013) add to this that integrating the environmental and social principles will influence social and environmental specifications and requirements of the project's deliverable or output. Each project in its unique project environment and stakeholders involved requires exploration and explicit sustainability considerations at initiation of the project (Gijzel et al., 2019; Lombardi et al., 2011).

On operational level, the execution of projects is dedicated to establishing specific and measurable goals as a response to tactical needs (PMI, 2013). According to Labuschagne and Brent (2005), integration at this level involves the adoption of reporting systems for assessment, monitoring, and evaluation of the business processes.

Sustainability by the project and **sustainability of the project**

Huemann and Silvius (2017) distinguish sustainability **by** the project, and sustainability **of** the project:

The first narrative shows a focus on sustainable products that produce sustainable products or services, such as wind turbines, solar power plants, energy efficiency buildings, and waste reduction systems (Huemann and Silvius, 2017; Sabini et al., 2019). In line with utility services, the transition towards accessible, renewable energy sources is among the key strategies to address climate change (Bagheri, Shirzadi, Bazdar & Kennedy, 2018). This has resulted in an increasing demand for electricity as alternative resource, as well as implementation of new systems, such as hybrid systems or hydrogen. In 2005, Hunt and Rogers stated that projects supporting the energy transition such as greywater recycling, combined power and heat systems, or rainfall harvesting can be determined as sustainable. On the other hand. the second narrative includes those directed at the project management processes, regardless of the product or service being delivered (Huemann & Silvius, 2017; Sabini et al., 2019). Sabini et al., (2019) provides the example of taking measures to minimise disruption for the local environment adjacent to a construction site.

3.2.3 *The need for life cycle thinking*

Several authors show that sustainability in projects can be interpreted from different perspectives. One of the first articles concerning sustainability in projects was published in 2005, when Labuschagne and Brent showed that the integration of sustainability and projects in the manufacturing industry can be considered from two directions: (i) sustainability of the project's deliverable, and (ii) sustainability of the process of delivering and managing the project. Both are important as they can have significant social and environmental impacts, also the process and product aspects of sustainability are highly interconnected (Gareis et al., 2013; Kivilä et al., 2017; Silvius, 2018). According to Labuschagne and Brent (2005), this means considering not only the project life cycle, but also the life cycle of the project deliverable. Putting this perspective in a general context, Silvius et al. (2012) argues that the supply chain of the project needs to be considered, including the life cycle of the resources used in the project, but also the life cycle of whatever the results the project realizes.

Construction projects typically follow a process of initiation, planning (define and design), construction, operation and maintenance, and hand-over . Figure 9 shows the different life cycles involved in infrastructure projects. It shows that when the project life cycle ends, the life cycle of the product and involved resources continues.

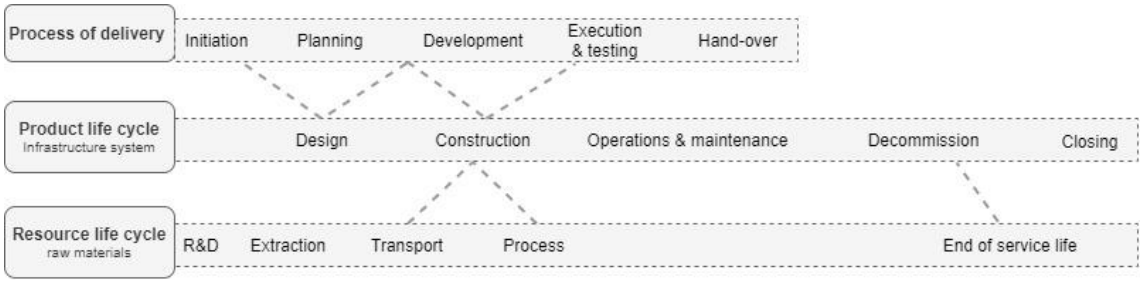


Figure 9 Example of interacting life cycles related to an infrastructure project (Own figure, adapted from Labuschagne & Brent, 2005)

The objectives of the initiation phase are to address why, when, and how to invest for new projects. This concerns preliminary feasibility studies that lead to investment. According to Shen et al., (2007), the design phase is usually classified into preliminary, technical, and shop-drawing design. This stage presents the opportunity to consider the project sustainability performance in selecting its layout, structures and materials. Shen et al. (2007) has shown how to involve sustainability in different project life stages for the industry (Table 6):

Phase	**Impact**	**Sustainability**
Initiation		Define sustainability
Design		Consider sustainability performance in layout, structures, materials
Construction	Minimise waste generation and pollution	Use of resources: equipment, materials, financial Coordination various project stakeholders to work to common goals
Operation	Improving operational efficiency, extend service term, improve social and economic profit	Continuous monitoring to receive feedback about operations Maintenance
Demolition	Minimise generation of waste	Effective plans of project demolition enhances recycling of dismantled materials

Table 6 Implementing sustainability measures in different life cycles (From: Shen et al., 2007)

3.2.4 *The need for stakeholder cooperation*

The construction industry is considered a fragmented sector which involves many project stakeholders, such as governmental departments, public or private clients, consultants, contractors, subcontractors and suppliers (Shen, Hao, Wing-Yan, & Yao; 2007). According to their research, Shen et al., (2007) state that these parties are each involved in different levels of extent during various project stages, and likely focus on their own professions. For the industry to become more sustainable, efforts are required from various supply chain partners to actively work together towards common objectives (Robichaud & Anantamula, 2011; Eskerod & Huemann, 2013; Kivilä et al., 2017; Schuylenburg, 2019).

To implement sustainability, companies possess most influence over their internal organisational structure, business model, and human capabilities as well as financial capabilities (ISO, 2012; Schuylenburg, 2019). The external environment of such a project is dependent on socio-economic, geographic, regulatory and technological background (ISO, 2012). This implies that the influence level is lowest with regard to the behaviour of clients, stakeholders, markets and shareholders. As shown within Figure 10, the execution of projects shows to be positioned on the interface of a company's activities. This involves an additional challenge for organisations to align their decision-making levels with other parties.

Figure 10 Decreasing influence levels of organisations (Own figure, based on ISO, 2012)

Infrastructure projects are typically carried out in public-private partnerships, both the (public) investment party and private sector companies or consortia are necessitated to closely collaborate (Kivilä et al., 2017). Partnerships between the public sector and private sector have been promoted as promising instruments to accomplish sustainability-related objectives (United Nations, 2015; Spraul & Thaler; 2019). Factors such as the long-term duration of the contract, distinct sustainability goals and contractual targets, as well as reallocated responsibilities, stimulate involvement of sustainability. From their research into alliances, Kivilä et al. (2017) conclude that more collaborative partnerships are experienced as enablers for sustainability, as it eases cooperation and promotes sharing of risks and gains.

Within The Netherlands, trends in new project delivery models and associated contracts illustrate a continuous need for more soft skills in project teams to enhance cooperation. Traditionally, project managers tend to 'do as told' by their clients or project owners. This way, they make themselves subordinate to the project owner, and manage the project team around the scope, stakeholders, deliverables, budget, risks and resources specified by that owner (Crawford, 2013; Silvius, 2018). Multiple scholars (Tam, 2010; Silvius et al.; 2012; Crawford, 2013; Silvius, 2018) argue that a change of mindset is required, in which the project manager takes responsibility for the sustainability of their projects. This would mean that they behave as partners and peers to stakeholders, and engage them in a transparent manner to achieve sustainable development.

3.2.5 *The need for balancing social, environmental, and economic impacts*

Within projects, the selection of materials, components and resources should address hazardous substances, pollution, and energy use among several life cycles. Based on these aspects, a selection in the price/quality ratio, as well as the impact of the production supply chain and reusability after decommissioning (Schipper, 2018). This also implies appreciation for suppliers that provide high sustainability performance within supplier selection (Taylor, 2011). To move towards a more advanced stage of sustainability integration and improve the decision-making process, managers require clear understanding of the impacts that are caused by corporate activities on society and environment, as well as the concepts of sustainability (Epstein, 2018). The consideration of different sustainability aspects sustainability of the Triple Bottom Line is related to the strategy and context of the project (Martens and Carvalho; 2016).

Sustainable construction methods imply various methods or practices in the process of construction projects that contribute to less harm to the environment, beneficial to society, and profitable to the company (Shen et al, 2010). For the adoption of new materials, it should for example be understood where materials come from, what their purpose will be for both now and in the future, and how these are going to be processed into components. In Figure 11, Porter (1990) visualises several practices to facilitate the contribution to sustainable outcomes.

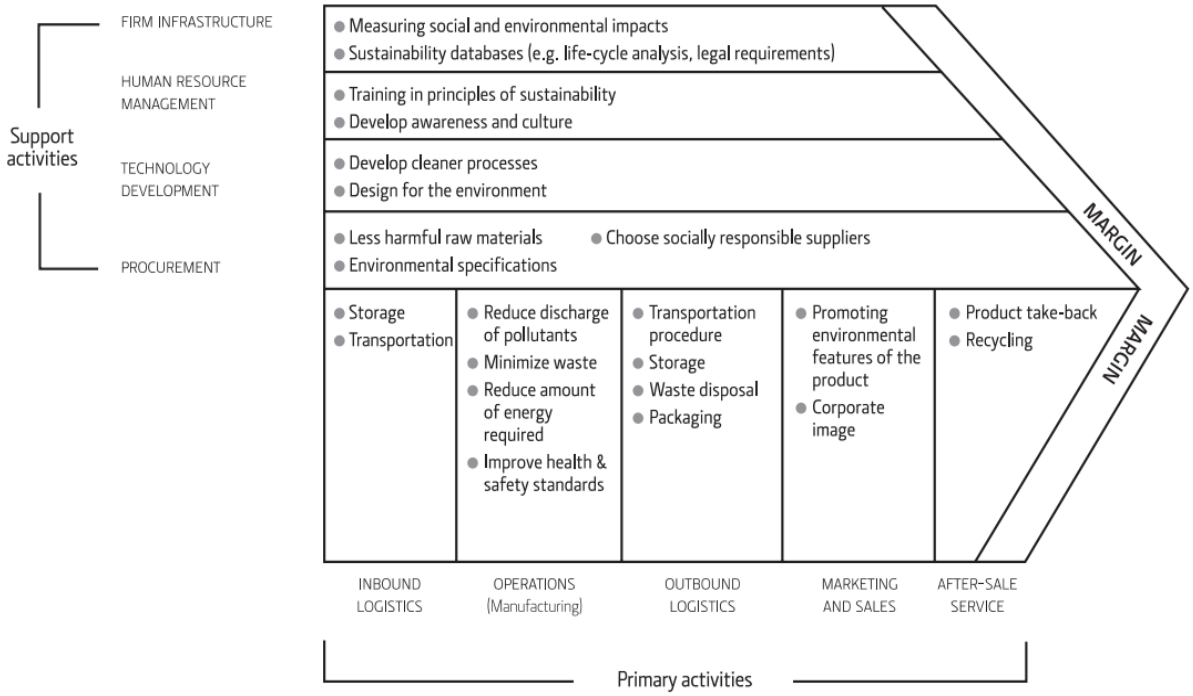


Figure 11 The value chain and sustainability. From: Porter (1990)

Sustainability concepts

Over the years, multiple relating theories, models, and schools of thought have been developed to provide directions in how to downsize the impact on the environment by human activities. Within the construction industry, emerging concepts such as the Circular Economy from the Ellen MacArthur Foundation (2015) are related to downsizing environmental impacts by redefining economic growth and move towards a circular system. This is in line with Willard (2012), who states that *''the unsustainable 'take-make-waste' model needs to be replaced by a 'borrow-use-maintain' business model profitable for the environment, society and organisation''.* Solutions show to be found in new revenue models which are service-oriented.

3.2.6 *A proactive attitude towards sustainability*

According to the ISO 26000 guideline, sustainability requires a proactive and transparent approach of organisations in their handling, considering, deciding, and sharing of intentions to all potential stakeholders (International Standards Organisation, 2010). In the domain of communication, the highly used definition by Wooldridge and Jennings (1995) describes proactivity as: *the ability to take initiative by exhibiting goal-directed behaviour'.* This implies that organisations share timely, clear, and relevant information with their stakeholders in project processes, practices, and reporting (Perrini & Tencati, 2006; Taylor, 2010). "Right" knowledge may be different for every decision – some require only surface knowledge, some require more investigation and an evidence base, some use tacit expertise, and others creative insight, intuition and judgement.

Several scholars in the field of Corporate Social Responsibility define organisational proactive behaviour for sustainability. Willard (2005) laid a foundation for this and developed five stages ranging from reactive to proactive levels of corporate sustainability, as shown in Table 5. In this model, a reactive approach towards sustainability is associated with meeting regulations, whereas different levels of proactivity (Level 3 or Level 4) imply respectively voluntary and committed approaches to become sustainable as a business. Silvius (2018) emphasizes that in a reactive approach, the negative impact on one perspective (usually social or ecological) is traded against the economic perspective. For example, compensation for carbon dioxide emissions by planting new trees, or compensation for work pressure by paying higher wages. A more proactive approach would be to redesign products, services, and processes, to create positive effects on all three aspects (Silvius, 2018). In the final level, a contribution to sustainability is considered as being one of the drivers behind the project, and are included in the justification of the project. Silvius and Schipper (2012) used these comparisons to establish the differences from an operational perspective. The first level - pre-compliance - is not further considered in this research, as it adopts an illegal approach.

From Figure 13, it is implied that all levels ranging between compliance and purpose & passion, may lead to improved situations compared with current states, which can be determined more sustainable as existing situations. This shows that both from a reactive as well from a proactive approach sustainability can be gained. Figure 12 is derived from this table to illustrate main differences between reactive and proactive behaviour as depicted by these theories.

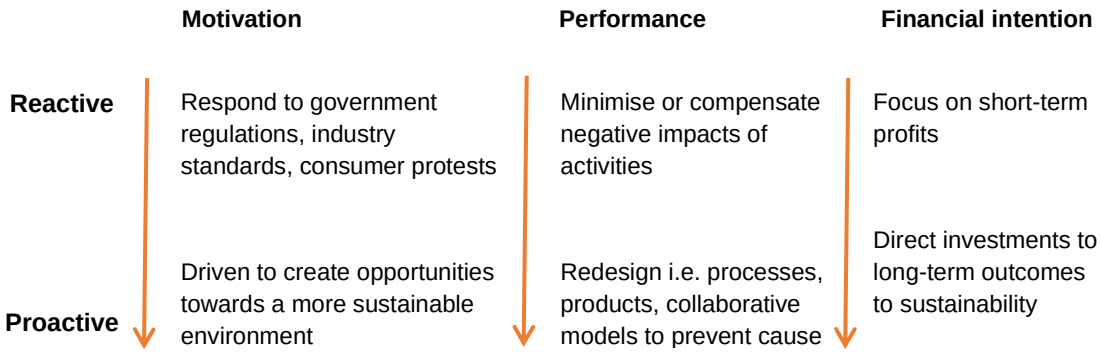


Figure 12 Main derived differences between reactive and proactive organisational behaviour. (Own figure, based on: Willard, 2005; Epstein, 2018; Silvius & Schipper; 2012, as shown in Table 5, p. 32)

Willard (2005) Organisational perspective	Epstein (2018) Organisational perspective	Silvius & Schipper (2012) Project perspective	
- Ignorance with regulations - Illegal and unsustainable - Only focus on short-term profit			**Level 0** **PRE-COMPLIANCE**
- Reactive approach by obeyance to legal regulations - Legal and unsustainable - Approach of linear take-make-waste model	**Managing regulatory compliance** - Reactive by meeting regulatory standards - Environmental policy and plan systems - Minimising cost	- Initiating actions to limit or compensate for impacts on society and environment.	**Level 1** **COMPLIANCE**
- Voluntary movement in operational eco-efficiency[3] - Initiatives marginalised within specialised departments - Less unsustainable		-	**Level 2** **BEYOND COMPLIANCE**
- Enhanced business value - Eco-effectiveness[4] and life-cycle stewardship - Committed in values and strategies - Investment and business opportunity oriented - Borrow-use-return design	**Achieving competitive advantage** - Improve sustainability performance and competitive advantage - Cost avoidance	- Change project delivery and management processes in a way that take away the cause of impacts on society and environment.	**Level 3** **INTEGRATED STRATEGY**
- Values-driven commitment - Successful to continue doing things right	**Completing social, environmental, and economic integration** - Full integration throughout all managerial decision-making levels - Proactive by focusing on sustainability planning	- Project sustainability: how does the intended result contribute to a more sustainable society? - Taking into account both the project's resources, business processes and model, but also the result and benefits themselves.	**Level 4** **PURPOSE & PASSION**

Figure 13 Organisational proactivity levels of sustainability

[3] Eco-efficiency maintains a one-way, linear flow of materials in which products are disposed after its use. Eco-efficient techniques focus on creating less volume, velocity, and toxicity of the material flow system, but are incapable of altering this linear progression. Materials can be reused, however this is more concerned as downcycling, limiting usability (*Efficiency vs Effectiveness*, 2012).

[4] Eco-effectiveness proposes a transformation of products and their material flows, to allow a supportive relationship with ecological systems and future economic growth. The aim is to break through the cradle-to-grave flow, and generate a cyclical flow that enables upcycling of materials (*Efficiency vs Effectiveness*, 2012).

3.3 CONCLUSIONS FROM THEORY

As sustainability is perceived as a broad and ambiguous term, the definition has over the years been formalised and redefined by different concepts and schools of thought. The most commonly agreed concept is Sustainable Development, which illustrates ''*a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are in harmony, and enhance both current and future potential to meet human needs and aspirations*'' (Brundtland, 1987). The three pillars People, Planet, and Prosperity, form a more concrete baseline for organisations to operationalise sustainability in their activities. In the context of utility infrastructure, Figure 14 visualises the **social, environmental**, and **economic** aspects compiled from the extant body of knowledge. These sustainability aspects have shown to be involved in different levels of decision-making by means of several measurable indicators that are context-specific for each decision.

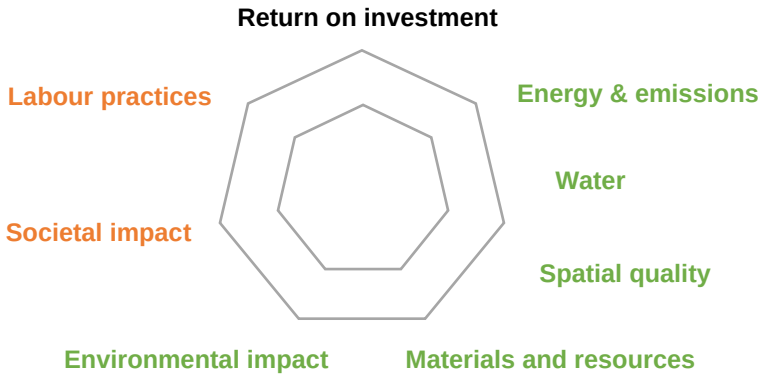


Figure 14 Sustainability aspects for utility infrastructure projects. Own figure, based on Table 5

This research adopts the strategic, tactical, and operational of decision-making as distinguished by Montana and Charnov (2004). On strategic level, top-level management decides on strategies to sustain competitive advantage and long-term performance of the company. Whereas top-level management considers broad visions, missions and objectives, tactical level management decides on specific plans and concrete actions to achieve these strategic pillars. This latter level of management typically concerns selection and direction of investments in the company portfolio (Silvius et al., 2012; Chofreh & Goni, 2017). In the context of infrastructure projects, typically mid-level management of cliental (public) organisations initiate and finance projects, while contractors select projects for tendering and construction. The operational level represents project managers that decide on the managerial and technical course of daily operations. Thus, both tactical and operational levels are shown to be involved with considering projects.

The following elements need to be taken into account for proactive implementation:

- **Sustainability principles**

In the current project paradigm, which is driven by the iron triangle of budget, planning and quality, sustainability considerations have shown to remain underrepresented (Silvius & Kampinga, 2017). A change is required from this scope towards balancing societal, environmental, and economic aspects in decisions (Silvius & Schipper, 2014). Considering sustainability is also determined to encompass a life cycle approach of the resources used in a project, the project processes, and the project's deliverable or output (Gareis et al., 2013; Labuschagne & Brent, 2005; Silvius, 2018). Sustainable construction methods based on sustainability concepts imply various methods or practices in the process of construction projects that contribute to less harm to the environment, beneficial to society, and profitable to the company (Shen et al, 2010). Managers therefore require clear understanding of the impacts that are caused by corporate activities on society and environment, as well as the concepts of sustainability (Epstein, 2018). Moreover, as many stakeholders highly depending on each other are involved during different project processes, sustainability needs to be collectively approached (Robichaud & Anantamula, 2011; Eskerod and Huemann, 2013; Kivilä et al., 2017). This involves transparency and behaviour as peers and partners to align responsibilities.

- **Levels of proactive behaviour**

The level to which organisations integrate sustainable practices into their operations varies widely. Several scholars in the field of organisational responsibility (Epstein, 2018; Silvius & Schipper, 2012; Willard, 2005) address a positive correlation between the sustainability performance level and the level of proactivity. This is developed by five stages ranging from reactive to proactive levels of corporate social sustainability. A reactive approach towards sustainability is associated with a minimalistic approach by compliance with national or local regulations, whereas higher levels of proactivity (referred to as Integrated strategy and Purpose) imply voluntary and committed approaches to become sustainable as a business. Based on these levels, Silvius and Schipper (2012) have tried to establish these differences from a project perspective. In the final level, a contribution to sustainability is considered as being one of the drivers behind the project, and are included in the justification of the project. For this research, four levels of commitment are used to distinguish: (1) compliance, (2) beyond compliance, (3) integrated strategy, and (4) purpose and passion.

3.3.1 *Introducing a conceptual framework for analysis of proactive behaviour*

Based on the gathered elements on proactive implementation of sustainability in decision-making levels, a conceptual framework is developed to analyse sustainable outcomes in terms of their level of effectiveness. As can be concluded from the theory on proactivity levels (Figure 13), the more proactive behaviour is displayed in an organisation results in a higher level of sustainable effectivity of solutions. Therefore, an implicit link can be made between the level of input an organisation embeds in their sustainability efforts and the output measured as level of effectiveness of such endeavours.

Figure 15 presents the conceptual framework for analysis of practical outcomes. In this framework, the level of decision-making (horizontal level) is plotted with the level of proactivity (vertical level). This is based on the assumption that the timing of decisions can significantly impact implementation of sustainability in projects level of proactivity. This framework will be used to analyse the empirical case studies in this research in order to determine how proactive the involved organisations acted during tactical and operational phases in their respective projects. Appendix H supports the use of this framework with examples.

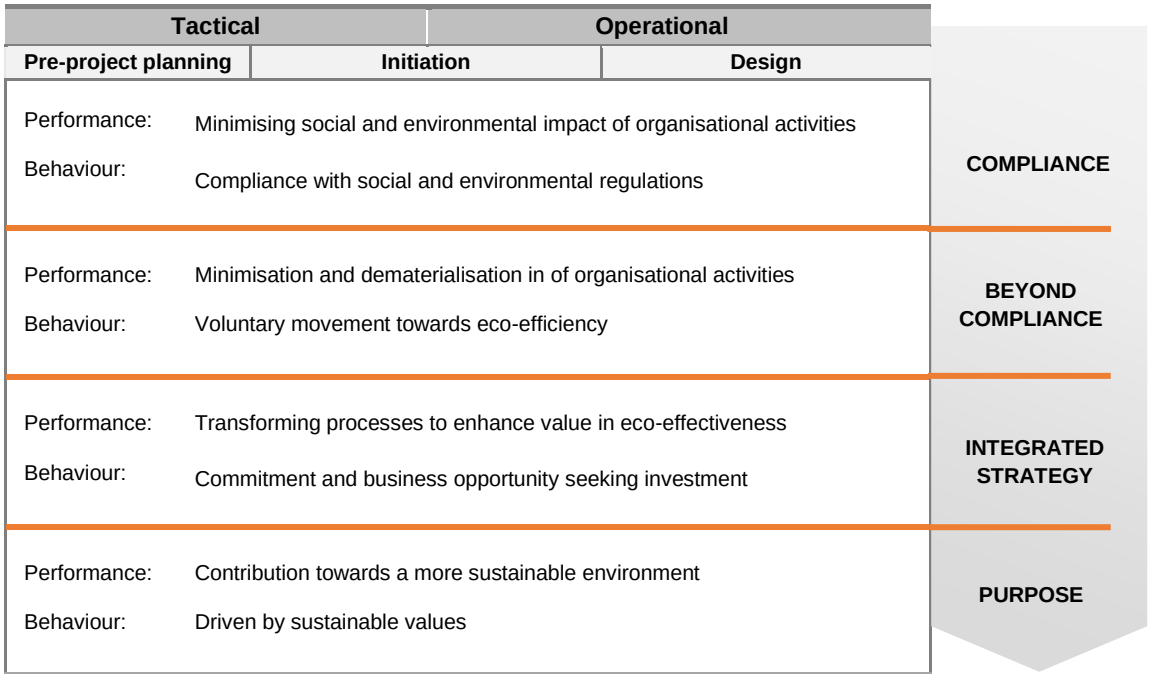


Figure 15 Conceptual framework for analysis

4 RESULTS

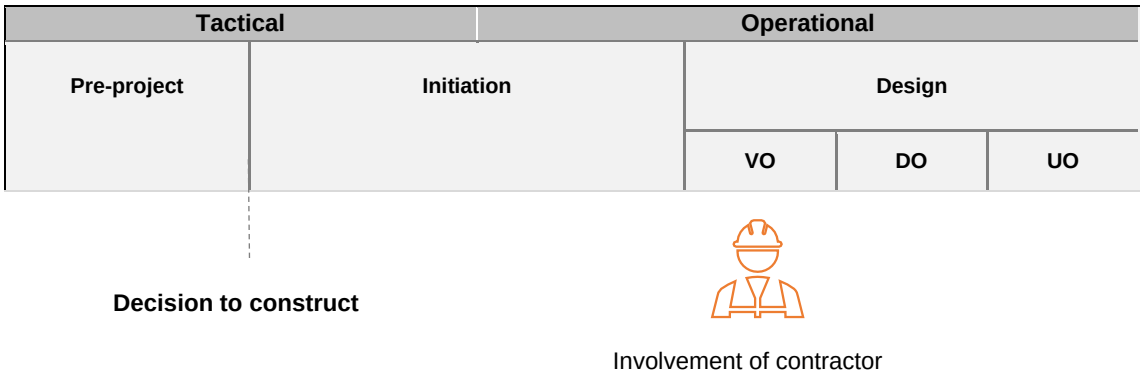
This chapter presents the research findings concerning the analysis of the empirical results, to provide an answer to the third research question '*What are the barriers resulting in the gap between reactive and proactive decision-making?'.* During the interviews, it was gathered which sustainability aspects were implemented, and also which remaining opportunities were detected. The underlying reasons for these remaining opportunities are analysed in order to raise awareness for potential development. Consequently, a diagnosis was aimed for to gain a rather holistic understanding of proactive behaviour towards implementing sustainability within the case studies.

The results are presented in two parts. First, it is shown how client and contractor have implemented sustainable solutions on tactical and operational level. The solutions found in the studied cases are illustrated by the conceptual framework as introduced in the theory. Second, it is presented how proactive both organisations have behaved to reach these solutions.

4.1 SUSTAINABILITY OUTCOMES ON TACTICAL AND OPERATIONAL LEVEL

As shown in the introduction (Chapter 1.1.1), the client and contractor have individually set strategic goals for their organisations. This subchapter shows how these strategies have been translated into tactical plans and sustainable outcomes. The following project phases are associated with decision-making on tactical and operational levels:

- In the pre-project phase, there is no project yet. Rather, these is a need or problem with the intention to change. This phase is involves as phase in which it may be decided to construct by the client as following from strategic objectives.
- During the initiation phase, the client determines the project portfolio and acquires a new project to the contractor. The client usually defines the overall scope, budget, and planning for this project during this phase. When acquiring this initial question, the contractor estimates a budget for the design. The project manager of the client becomes involved.
- In the VO (preliminary design) and DO (technical design) phase, the project manager of the contractor becomes involved to take responsibility for the design and respectively the construction of the project results. The preliminary phase encompasses the most conceptual work, whereas the technical design phase relates to a detailed understanding.



4.1.1 *Client performance*

As shown in the introduction, Royal Schiphol Group aims to operate the most sustainable airports in the world. The strategic sustainability goals for Schiphol Airport are specified by Royal Schiphol Group into more concrete plans, presented by a roadmap in December 2019. Logically, the client is responsible for achieving sustainability in the whole airport area, and prioritise and direct their actions to where most impact can be gained. The roadmap visualises past, current, and future actions towards their goals for 2030. The following actions are associated with utility infrastructure:

- In the transformation towards a zero emission airport, efforts in 2019 were being directed at electrified equipment, charging stations, energy efficiency, and thermal energy storage systems. Plans are also focused at phasing out gas, use of decentralised solar power, an energy neutral terminal, and reducing CO2 emissions by airside operations to zero.
- To establish a zero-waste environment, the airport has presented the following actions: adopting materials passports, design for disassembly, use of sustainable materials, phasing out of single use products, and achieve a material hub.

To contribute to their strategic objectives, Schiphol has implemented the following overarching initiatives:

	Initiatives by Schiphol
	What is implemented?
	Contribution to **social return** by commissioning socially distanced workers with maintenance works This is one example of several initiatives: *'The armatures are transported as bulk to a social enterprise in Amsterdam. They disassemble the light bulbs, clean them, and return them. Those light bulbs are then stored here and are exchanged like that. That process can take up to 2 or 3 times before the light bulb has reached the end of its lifecycle. This is executed for several components at Schiphol as overarching initiatives' (R-7).*
	Transformation towards **renewable energy** at airside in collaboration with airside stakeholders To support the transformation towards use of electricity at airside, Schiphol has initiated several utility infrastructure projects paid from their sustainability budget: *'The whole set of projects is called project ROEV: Realisatie Oplaadvoorzieningen Elektrische Voertuigen. For all operating vehicles at airside, we require charging facilities for electricity. (…) As we aim for zero emissions at airside in 2030, we need to take steps to transform all traditional vehicles in a sustainable way' (R-9).*

Table 7 Sustainability initiatives at tactical level by client

The strategic challenges for utility networks regarding limitation of subsurface space, energy transition, or technological development are involved with the need for physical adaptations to the current infrastructure. These challenges require tactical decisions for system-wide questions such as: how do we replace the gas pipes with new fuels, such as hydrogen? How can we strengthen the electricity grid? What locations are suitable for decentralised production of renewable energy? Can the required placement of new trees form a risk in damaging adjacent utility infrastructures? What do innovations such as optical fibre mean for the change of existing cables in the subsurface?

Other detected possibilities for tactical level initiatives were found in the reuse of existing materials associated with the intention to phase out gas: *'It shames me that we are going to remove the gas pipes, while you could use them as empty tubes for other cables. (…) I understand we need to be careful, but when the gas pipes are empty they can be used for many smart applications' (R-13).*

4.1.2 *Contractor performance*

As stated in the introduction, the strategic partnership involves one contract between two private parties dedicated to multiple projects. To win this long-term partnership contract, the tender team working for the contractor has proactively developed measurable sustainability goals, which the contractor aims to achieve during the contract term (2019-2028). This has resulted in the formulation of long-term Key Performance Indicators (KPI's), and also Performance Indicators (PI's). The latter are considered additional indicators. These KPI's and PI's form overarching goals to each individual project, and are formulated for operational processes as shown in Figure 16. It can be shown that focus is placed on energy and emissions, materials and resources, and social return.

Thus, the contractor has promised to achieving sustainability aspects **in advance** and **overarching** to the individual projects. Agreed **incentives** for realising these (K)PI's are involved when the contractor underperforms (by fines or contract termination) or performs according the principles of the agreement (by extra work related activities). Progress therefore need to be proven and assessed structurally.

Figure 16 Contractual agreements of sustainability towards tactical and operational levels

4.2 SUSTAINABILITY PERFORMANCE DURING CASE STUDIES

In the previous paragraph, it is shown that the contractor has initiated tactical plans for the operational processes. However, this subchapter also shows that the individual project processes were concerned with new, context-specific possibilities. Having assessed a multitude of opportunities for sustainability in these projects, a rather holistic view was obtained to the knowledge of the author for judgement of both parties at the operational level. For each case study, it is presented what the case study entails, which sustainable solutions have been implemented according to the involved project managers of both client and contractor, and which other opportunities were detected during the interviews.

4.2.1 *Case study 1: Parking garage P3*

P3 is the largest parking garage at Schiphol and in Europe, facilitating 13000 parking spaces for passengers that need to park their car for a longer period. The current state of the parking garage and its assets have become deteriorated, leading to unsafe situations and decreased quality. Earlier initiations for maintenance were extended, because of uncertainty of future developments. Now that the project has started, it encompasses redevelopment of the parking spaces, redesign of a centralised traffic structure, and renewal of assets. For utility services, this involves the removal, design and placement of a new infrastructure network in the form of several cable conduits, to facilitate energy demand for public lightening, alarm poles, reporting systems, and other installations. In addition, stormwater will be stored beneath the parking garage in by a storage system of crates and associated pipelines.

For this project, several sustainable solutions were implemented as presented (Figure 17):

Tactical		Operational	
Pre-project	**Initiation**	**Design**	
	Soil quality: minimise contaminated soil by sanitation	**Spatial quality:** anticipate for future developments in area by space reservation in design	**COMPLIANCE**
		Reduction of **energy and emissions** during operations	**BEYOND COMPLIANCE**
		Contribution to climate resilience in area by design of sufficient retention of **water quantity** excess	
	Spatial quality: anticipate for flexibility in design for future developments	Use of most durable and recyclable **materials** in context	**INTEGRATED STRATEGY**
			PURPOSE

Figure 17 Sustainability performance CS1

From the framework, it can be seen that achieved solutions showed to be effective in improvement of the existing situation. These solutions were achieved by voluntary and committed efforts from client and contractor. Proactive behaviour shown by the client was associated with taking initiatives for more sustainable outcomes and supporting in financial resources. The contractor has shown to research and develop ideas and analysis. Decisions were highly influenced by trade-offs between the end-user needs, technical requirements, future developments of the area, and environmental aspects.

Other sustainable solutions were also detected and discussed. For example, placement of charging stations for electric cars were not included, as this parking garage is utilised for long-term parking. Also, reuse of existing cables or pipelines was limitedly possible due to their deteriorated state. However, two other options could have been implemented differently:

8) Decentralised production of **renewable energy** by solar panels

   This example shows how several solutions are involved. According to the project manager of the contractor, this choice is probably constrained by the client for financial reasons: *'There are already PV panels on the current roof, however there would also be more options to search in the adjacent areas for decentralised production of solar energy. Such sustainability initiatives are often not implemented because of the relatively cheap energy price at Schiphol, making such an investment not profitable.' (R-4 BAM).*

4.2.2 *Case study 2: VS2 to VS4-VS9 (High-voltage cables)*

To provide the new to be built A-terminal with electricity, a reorganisation of the current electricity supply is required. The second case study includes the placement and replacement of two high-voltage cables in the subsurface of Schiphol Boulevard, to connect these from and to three high-voltage stations. Three distribution stations located near each other (Verdeelstations); VS2, VS4 and VS9, are altered in their supply of energy by replacing cables from and towards these stations. In addition, measures are taken to enable continuity of energy in case of a terrorist attack at the airport by placing extra high-voltage energy cables.

The following solutions were found in this case (Figure 18):

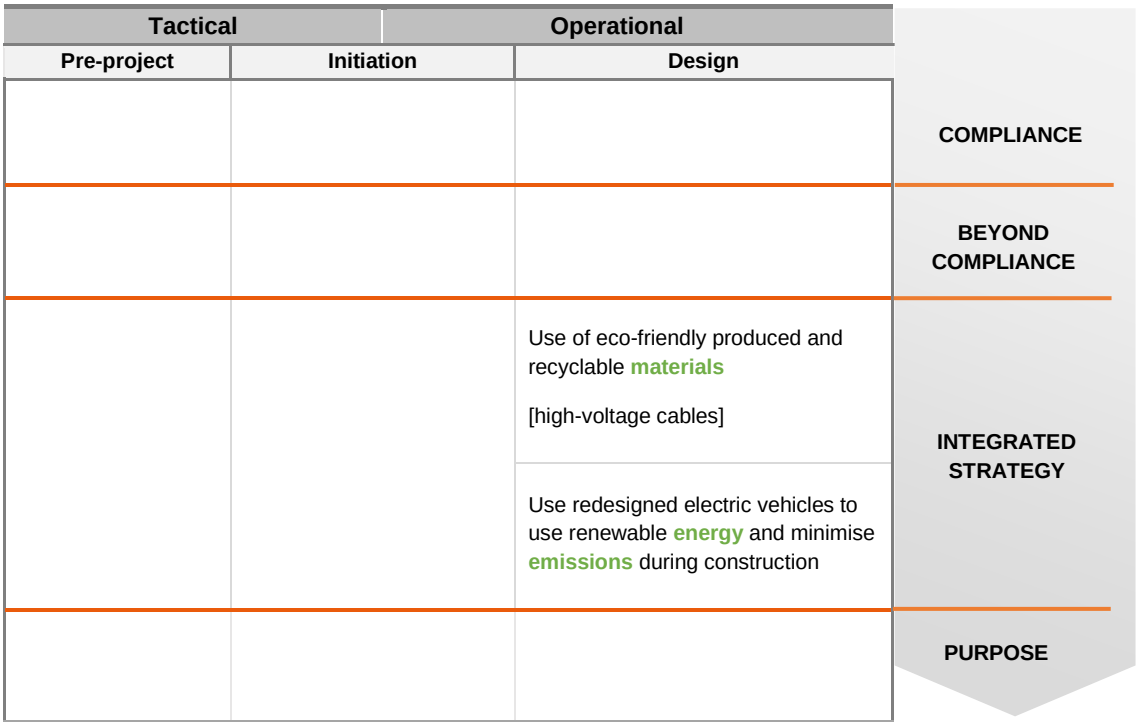


Figure 18 Sustainability performance CS2

These interventions were realised by following the tactical plans of the contractor, and were communicated in the design documents. Furthermore, plans for waste management and minimisation of waste were communicated in these documents for the construction phase.

The use of electric vehicles shows to be proactively initiated by the project manager of the contractor by acquiring knowledge from an expert about possibilities and propose this with the client: *'When I consulted with our sustainability manager about possibilities for this project, we talked about materials and employment of electric vehicles during construction. This is what I discussed over the phone with the project leader of Schiphol, and he was eager for this'. (R-6 BAM)*

For the scope of this project, no other options to become more sustainable were detected by the author nor the project managers. However, another example that was discussed with both project managers shows how technical considerations constrain the freedom of choice for sustainability. The main design choices for utility infrastructure (construction method and route) are highly determined by constructability, constrained subsurface space, and reliability; limiting hinder for above surface operational processes. For this project, two routes appeared to be possible differing in length by 400 metres. It could be stated that the shortest route requires less volume in materials and therefore may be more sustainable. However, these choices are purely determined from technical considerations.

4.2.3 *Case study 3: VDR (High-voltage cables)*

Case study 3 represents a partial project of project VDR, which encompasses all activities related to building a new taxiway viaduct crossing the highway A4. As the new aboveground taxiway is expected to cause settlement of the existing subsurface utility infrastructure, this project encompasses the replacement of several cables as well as the placement of empty tubes for future developments.

For the whole project, the client shows to commit to sustainability in the process by determining and communicating project ambitions, as well as to involve knowledge (sustainability expert) to develop plans. With regard to utility infrastructure, the following solutions are realised according to the involved respondents:

Tactical		Operational	
Pre-project	**Initiation**	**Design**	
		Spatial quality: anticipate for future developments in area by space reservation in design	**COMPLIANCE**
		Reduction of **emissions** during construction by replacing diesel aggregates with electric energy	**BEYOND COMPLIANCE**
	Soil: closing the soil system loop direct reuse of uncontaminated soil	Use of most durable and recyclable **materials** [optical fibre tubes, high-voltage]	**INTEGRATED STRATEGY**
			PURPOSE

Figure 19 Sustainability performance CS3

The project management team working for the client has shown to direct efforts to achieve project ambitions for sustainability as drafted during the initiation phase. One of these ambitions was stated to avoid diesel aggregates at the construction site as much as possible. The found solution to replace this with existing electric energy shows to involve trade-offs between unproportioned financial and technical considerations: *It is so large though, by calculation we would pay tons to place one cable because of these large distances. And only for a few weeks until construction is finished. We have established one voltage cable for construction. It is still difficult though, as it is for temporary use.' (R-7 SCHIPHOL).* The solution shows to be maximised where possible, but constrained by operational decisions.

Moreover, the client shows to have arranged a close collaboration with the soil supplier to adapt their working methods per project and use local expertise: *'Our soil supplier handles the soil: we register the soil, and they tell us where to transport it. Then we pay for deposition and repurchase the soil. That works for smaller volumes. As this project is concerned with such a huge amount of soil, we arranged for a depot for temporary local storage. That way, it remains our soil' (R-7 SCHIPHOL).*

One missed opportunity for establishing a higher level of sustainability was evaluated by both parties:

18) Employing the highest level of recyclability in **materials** for optical fibre tube by selecting supplier.

    This example involved the choice between two suppliers for placing 75 km of optical fibre tubes, for which eventually the choice was directed at the supplier providing the lower level of recyclability. The project manager of the client shows that this choice was made based on past experience in a similar situation. However, he also shows that the organisation has learned from this example:

'We executed this project for Schiphol Telematics and that is where you lose: usually we work for the owners of the infrastructure, such as Liander, or for water or gas. I can consult them in different suppliers, but usually they have conducted tests in which certain suppliers cannot guarantee quality over these long lengths. For cables, product features play an important role so that is difficult to change for the choice. However, what we did establish is to conduct new tests with other suppliers for future projects'. (R-7 SCHIPHOL)

4.2.4 *Case study 4: High-voltage Station DE Buffer*

This case study involves the placement of a high-voltage station and high-voltage cables to provide electricity to aircraft stands. This project is the 6th part of project ROEV: Realisatie Oplaadvoorzieningen Elektrische Voertuigen (Realisation of charging facilities for electric vehicles), to facilitate renewable energy to all involved operational parties for the handling of aircraft. All subprojects scoped for Project ROEV are initiated from the sustainability strategy to transform airside towards an emission free area in 2030. These projects are driven by sustainability: *'The whole project is sustainability, as the mindset is to achieve higher clean air quality on airside' (R-9).* As shown in Chapter 4.2, the client shows to take responsibility for this by directing financial resources and engaging stakeholders. The following is found during the interviews (Figure 20):

Tactical		Operational	
Pre-project	**Initiation**	**Design**	
			COMPLIANCE
		Reduction of **emissions** during construction by replacing diesel aggregates with electric energy	**BEYOND COMPLIANCE**
		Use of most durable and recyclable **materials**	**INTEGRATED STRATEGY**
Project purpose supports transformation to renewable **energy** at airside.			**PURPOSE**

Figure 20 Sustainability performance CS4

The contactor shows to also have implemented tactical plans by fuelling GTL and waste management. With concern to the choice for supplier of high-voltage cables, the project manager shared that the choice was mainly considered from planning perspective due to the dependency of suppliers and the unique specifications provided by the client. This shows that efforts are directed at taking away the cause of dependency on certain suppliers.

'Normally, you have a certain cable ASC 70, which means the grounding protection is 70 mm thick. However, Schiphol requires a thickness of 80 mm, probably to reduce the cause of excavation damage. Though, in practice that 10 mm will not make a large difference. These cables need to be specifically produced for Schiphol, and the planning of the supplier depends on their orders to adapt their machine settings monthly. Therefore, I am dependent on their stock and their planning for production. Currently, I am examining if it is possible to change to the standard thickness to 70 mm' (R-10 BAM).

During the interviews, both project managers stated that no efforts were initiated whatsoever to implement other sustainable solutions. As a reason, they both mentioned this being one of the first projects realised after the new contractual agreements in which sustainability is involved. However, they both indicated other possibilities for this project:

22 Reuse of **materials** for high-voltage station building (R-9) (R-10)

23 Decentralised use of **renewable energy** at HV station
''The HV station is normally fed with 230 V, while it can also be generated by 24 V or by local production of PV panels. For those 3 times per year that somebody turns on the light, you don't need a fixed connection '' (R-10). This also shows that improving solutions can be found by adopting a critical attitude towards the current ways of working, and thinking outside-the-box.

4.3 ORGANISATIONAL PROACTIVE DECISION-MAKING AND BARRIERS

The previous subchapter focuses on which sustainable solutions have been implemented by both parties as overarching solutions to the projects, as well as during the projects. The subsequent part shortly discusses the shown proactivity in attitudes by both organisations. Also, barriers are presented that have shown to limit decision-making processes.

4.3.1 *Proactive behaviour by client and contractor*

The client organisation is responsible for all operational processes at Schiphol Airport, and logically exerts influence over the challenges on each level of decision-making. With regard to utility services and infrastructure, several characteristics of proactive behaviour were identified by examples regarding utility infrastructure on different levels of decision-making:

- Entering into long-term collaborations with supply chain stakeholders to reallocate expertise where appropriate; i.e. with suppliers in soil and operators of utility networks, as well as contractors.
- Engagement of stakeholders in sustainability plans to collectively change. In the process towards renewable energy at airside, Schiphol incentivises its users by means of a profitable compensation policy: *'A policy was determined with all involved stakeholders, and there it is clearly stated: Schiphol will pay for the investment and energy use. We facilitate the energy, and the ground handlers only have to invest in their vehicles. For KLM, the business case is also convenient in saving fuel costs and maintenance costs' (R-9).*
- Active research in new market opportunities; i.e. testing electrified equipment and outsourced research by engineers into the potential for constructing multi-utility tunnels for utility infrastructure.

To achieve their strategic goals associated with the energy transition, the client has thus shown to take responsibility for certain developments. On the tactical level, the client organisation has shown to initiate a project portfolio from their sustainability budget. During the project processes, the client has initiated several ideas to involve sustainability aspects within the design.

Currently, the contractor is predominantly exerting influence within operational decision-making levels. As a result of the contractual agreements, the contractor realises their KPI's by establishing collaborations with suppliers and subcontractors. During the project design process, several opportunities have shown for the contractor to emphasize sustainability in the design.

Based on the analysis on how sustainability was approached and impact was achieved by established interventions, it can be stated that both organisations show a high level of commitment towards sustainability. Both parties are in different ways involved with a project and their difference in responsibilities also lead to different approaches towards enhancing sustainable outcomes. Figure 21 presents identified proactive handlings from the case studies:

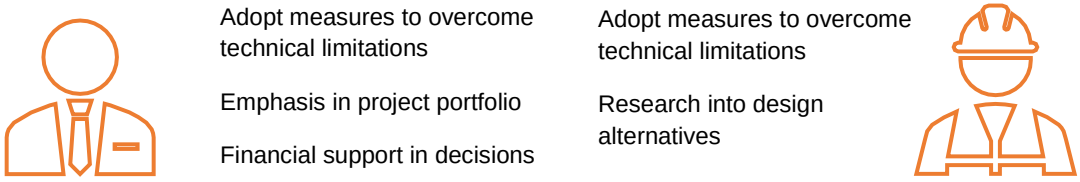


Figure 21 Proactive behaviour client and contractor

4.3.2 *Operational barriers*

The following technical barriers have shown to results in limited opportunities for sustainability. First, placing utility infrastructure requires highly specialised work concerned with high safety requirements and important technical specifications. Operational decisions in the design therefore are highly valued from technical considerations, whereas less freedom is concerned with sustainability. Several respondents concluded that in comparison with other infrastructures, less possibilities are involved with utility services.

Also, for operational level decisions, many opportunities have already been developed over the last decades. For example, utility service infrastructure systems possess long-lasting lifespans up to 70 years, and typically are produced as modular systems, and transported by sustainable and reusable packages. Over the years, new developments for insulation methods and cable materials have resulted in high-quality materials which are currently offered. This shows that the ambition for choices becomes constrained by the current market innovations. To achieve 100% recyclability for high-voltage cables remains impossible to this day.

Moreover, the choices for different product types are limited by the few amount of suppliers in the world and differences in levels of recyclability may barely diverge. '*For an aircraft lamp, these are produced by only two or three suppliers. For a controller, there are only two suppliers in the world.' (R-7).* In combination with the high amounts of volume required for the airport, or preferences due to past experiences, usually there is no choice left between different suppliers. *'There might be a choice between suppliers. However, we also have preference for certain suppliers and then you just order there' (R-8).*

Complexity of measurable trade-offs

The case studies show a variety of solutions in which different levels of effectiveness can be established. Op the operational level, trade-offs between sustainability aspects show to be complicated by mutually exclusive outcomes, values that are unmeasurable in quantitative numbers, or trade-offs between present and future outcomes. Current data software tools which support decision-making in quantification of emissions (such as Milieu Kosten Indicator) are also underdeveloped for infrastructure projects. These underlying issues not only complicate in deciding for example whether there is one clear solution that contributes most, also it shows to be a difficulty in reporting.

As a sustainable solution is recognised in this research as an improvement to the current situation, there shows to be a high dependency on what the 'common' methods and 'current situation' is for a particular project or situation. For example, the use of diesel aggregates at the building site may be a common method for this location, but may not be so for other locations within The Netherlands.

Cultural resistance to sustainability

Sustainability as relatively new involvement in project processes requires attention and may complicate considerations, while the contractor is used to make decisions around i.e. technical constructability, minimising risks and costs, following planning. Sustainability is shown to be perceived by project managers as a subject that only requires time and effort. One project manager from the contractor notes: *'We normally choose from the logical point of view because that is how we always do it; thinking out-of-the-box is not in our nature. Why? Because then we know the risks are managed, as uncertainty may increase costs' (R-4).* Currently, sustainability experts are involved in the process. However, this also relates to the risk that other employees expect sustainability to be realised by the expert. Instead, it should be widely carried.

Certain solutions for sustainability require an out-of-the-box mind-set to continuously criticize current ways of working and think about improved solutions. *''The process needs sustainable considerations in which people are stimulated to think outside-the-box. (…) Don't think: we have been doing this for 20 years, that is the way we do it so it saves me from thinking about it. Stimulate people in this, make it more complex for yourself'' (R-10).*

4.4 JOINT PROACTIVE DECISION-MAKING AND BARRIERS

Where both organisations individually show responsible behaviour for sustainability goals with regard to their organisational activities, the partnership lacks a mutual approach during the processes in which both parties enhance each other's capabilities and expertise, resulting in a higher overall outcome. Referring back to the principles of Partnering and Best Value, the desired -and promised- processes involve:

- A contractor who takes professional leadership over technical decisions. During the process, the contractor shows its expertise by guiding its client in decisions and challenges, predicting performance of different alternatives with trade-offs for quality, costs, duration, and resource allocation. This requires a transformation from a subordinate position towards the client towards becoming an equal partner.
- A client organisation who focuses on the expected project outcomes and its required performance, instead of technical solutions. This requires a change from prescriptive measures towards sharing clear underlying values.

However, the practical results show that where both partners currently pretend to be partners, still a hierarchical relationship is being adopted by both parties. Currently, the client highly influences technical decisions, and the contractor positions itself in a subordinate role to comply with technical specifications. The following two statements illustrate this:

'A lot of components which I need to adopt are prescribed in a Technical Program of Requirements. These specify the type of transformer, the type of controller, the type of high-voltage station. I expect from Schiphol to give us freedom in our choices to realise a product that both fulfils technical requirements and is highly maintainable for our maintenance department' (R-10 BAM).

'BAM P4, for cables and pipelines, support us in our thinking to ease this and make more flexible. (..) You can place a data cable with certain MB power because it is required by the client. You can also think: Schiphol, if you want to extend that area for real estate in the near future, we now advise extra data. Then you help us develop our thinking process for the future' (R-3 SCHIPHOL).

The main window of improvement in achieving a mutual strategy for sustainability is therefore acknowledged by project managers of both parties in changing this behaviour. To overcome these behavioural limitations, it is required that within future projects the process needs an approach from which both parties can develop shared understanding, capacity for actions, and establish fair and open discussion. Deriving from these results, it can be stated:

> To achieve a mutual approach for implementing sustainable solutions, organisations should proactively extend their level of responsibility towards supporting the responsibility of partners.

4.4.1 *Barriers for collaborative responsibility*

The following barriers for achieving mutual enhancement are identified:

Varying interpretations of sustainability

From the interviews, it was observed that more specific definitions of sustainability can be difficult to grasp by project managers. The concept showed to be directly associated with environmental and tangible aspects, such as energy or materials. Where societal aspects such as labour practices and the hinder by construction practices seem to be involved in decisions, these aspects were not per se associated with the definition of sustainability. Recognizing that sustainability is a value based concept, and that the individual project manager has a key role to play, has shown that the values held by project managers will be influential. From the following example it also shows that respondents share different values. One project manager working for the client shows that he values visible solutions: *'We possessed a major roof that we could have filled with solar power panels, that is when you are really sustainable. However, the airport chose to purchase energy from wind power outside the airport. Not visible and local. I think that is a pity' (R-5).* Also, for projects this may be a motivational reason to support organisational image: *'That is important to me; with this project we are located in a hotspot, which also calls for an ideal opportunity to promotion. To place a banner with: BAM and Schiphol are constructing by means of 100% electric energy. That gives a kick' (R-6).*

Lack of mutual sustainability ambitions for individual projects

Logically, both parties are exerting influence on different scope levels. The client influences decisions over a much wider context and needs to direct investments for sustainability as prioritised. However, the lack of expressing ambitions for a project also shows to have caused differences in expectations between the parties. Building on the example of the missed opportunity for decentralised solar power production, the following is stated: '*That is where I miss the sustainability ambition of Schiphol to drive solutions beyond financial considerations and aim for the highest level of sustainability for this largest parking garage of Europe. That discussion is maybe insufficiently brought to the table by us as contractor as I shortly discussed it, but there seemed to be no ambition from the client'. (R-4 BAM).*

This lack of ambitions for sustainability also is shown by the fact that for the majority of projects sustainability is not involved in the budget. Implemented sustainable solutions have shown to reduce investment costs, by i.e. minimising the volume of materials or energy required. Logically, these solutions have been implemented as it is involved with advantageous financial reasons. From the perspective of the contractor, it was mentioned that project decisions involving sustainability are still highly determined by costs. *'Still, costs are highly involved in considerations: what are the investment costs, what can we do for Schiphol to reduce maintenance costs. (..) Currently, in my projects trade-offs seem to not be driven by sustainability' (R-10)*

Lack of awareness in underlying client values for decision-making trade-offs

Where the client values the end-user performance, the contractor initially values project performance. For the parking garage (CS1), the client prominently values the optimal customer experience as the airport facilities will eventually be judged by its end-users. According to the project manager of the client, the project choices are therefore be driven by quality. For utility infrastructure, this influenced the choice for a flexible design system, as well as advanced technology installations to support customer service. This displays the need to understand how the project is driven by underlying values. The contractor is currently limited involved in physical decision-making moments by the client and this complicates constructive passing of information between both parties. The following example shows the importance of effective communication and underlying values of the client: '*A well-reasoned TCO approach is not always found within the details, it also means to dare making choices: what do I consider? It is necessary to clarify in advance why choices will be made, to choose two or three approaches and discuss those. That doesn't mean it will result in that choice, but then you effectively create a mutual perspective with each other. Because if you are investigating everything in detail and send us two options to choose upon, the client is only concerned with the fact that one option costs much more. In that way, we have not found each other. It should be about choosing an approach and select variances that represent our values. That requires to cut yourself loose from: I am not sure yet, so I will not say anything (R-3 SCHIPHOL).*

One of the engineers working for the contractor also emphasized that values are currently insufficiently known, but simultaneously critical to prioritise and trade-off aspects for sustainability decisions. This shows the necessity for alignment of the project values at the start of the project to create a mutual vision.

Fragmented influence of decisions

For realising utility infrastructure, there are many different project stakeholders involved. Different departments within Schiphol Group are involved with the initiation of new utility infrastructure projects. . For certain projects, network operators are involved in the construction process to execute certain specialised works. A specialised engineering company is involved to design electrical parts. The example of CS3 shows that the final decision for different suppliers was made by the network operator: *'Where normally the specifications provide technical requirements, now it stated: the end-user (ST) wants this specific supplier. We still consulted our client in an alternative supplier scoring higher on sustainability performance. However, due to problems with material quality in the past with other suppliers, ST did not consider the other option. This is where an opportunity for us occurred to improve sustainability based on different solutions, and then it is just set aside. That is not stimulating' (R-2 BAM).* This example shows that where the contractor stimulates recyclability as the key sustainability aspect to trade-off, the network operator shows a direction towards long-term quality.

Project managers play a pivotal role as communication partner between client and contractor in making informed decisions. However, it is shown that they become involved when planning, budget, scope are determined: *'We know it should be more sustainable. The difficult thing is: during the initiation phase, which may take up to 2 years, most conceptual ideas are developed. And then they suddenly say: o, we only have one year left to realise this. Budget is mostly determined per volume, then they search a project manager and tell: this is your budget and deadline' (R-5 SCHIPHOL).* It shows that also the alignment between tactical level management and project management lacks a mutual approach towards sustainability.

5 INTERVENTION REQUIREMENTS

From the previous chapter, it is shown that both parties individually show high commitment levels towards sustainability. The analysis also shows that currently integrated solutions are initiated by rather ad-hoc and individual initiations, rather than based on a mutual process in which sustainability has a dominant and integrated position. In order to achieve the latter, the following intervention requirements need to be involved:

Identified barrier	Intervention condition
Cultural resistance	**Proactivity requires an organisation wide approach** Achieving full commitment for sustainability requires organisation-wide efforts in which all employees feel responsible to actively direct efforts to the examination and initiation of interventions. Project managers hold an influential role as communication partner between client and contractor. They need to be stimulated by tactical level management to direct time and knowledge to examining project decisions for sustainability. In addition, all project team members need to be stimulated to enhance their knowledge and capabilities. With sustainability experts to be involved in consultation, knowledge can be passed and agreements can be made in how to communicate this topic between client and contractor. For the client, this means establishing a singular internal vision towards sustainability in projects. Being a multi-headed organisation in which different departments are involved, values may become splintered and insufficiently passed down towards lower levels of decision-making. Therefore, tactical and operational management need to be involved in the process of shaping this vision.
Technical limitations	**Proactivity requires a future directed mind-set** Technical limitations show to be present in any project and are not always feasible to overcome. However, as shown in practice, both client and contractor have initiated changes in processes to mitigate or prevent barriers in future decisions. This demonstrates that both parties have detected issues in the decision-making process and learned by the solution of taking into account supplier limitations. Other solutions for this matter are to share knowledge in market innovations by developing a shared digital learning environment. Changing products and research in future market innovations are key for well-informed decision-making.
Fragmented decision-making	**Proactivity requires engagement of stakeholders in sustainability ambitions** To effectively achieve sustainable solutions, supply chain stakeholders and other affected actors should be engaged in the ambitions set by the client. This way, trade-offs can be based on the best knowledge of other experts of the contractor and/or supply chain. For the client to benefit from the expertise of the contractor, it is therefore required to involve the contractor in their long-term challenges, and involve project managers during the initiation phase of projects.
Cost related barriers	**Proactivity requires focus on long term investments and future benefits** Although finances are a major factor in any project, the collaboration between the client and contractor should find a balance between people, planet and prosperity. By attaching financial values to both people and planet related solutions, decisions will be less cost-driven and more focused on future sustainable benefits. It

requires a long-term orientation in which the total life cycle of products and resources is taken into account.

The barriers related to collaborative behaviour shows a major lack of mutual directions. To enhance the collaborative behaviour between client and contractor, the following is required:

Proactivity requires structured decision-making moments in the process

Involving formal decision-making moments for sustainability during the process stimulates both partners to discuss the topic and align expectations and ideas. If not involved as main standardised method in the process, both organisations will not provide space to take advantage of each other's knowledge. This underpins the importance of collectively setting objectives within each project to align expectations and brainstorm about ideas. To allow for research and examination of reasonable choices in sustainable alternatives, the initiation phase of projects is highly important. Specifically, it should be discussed which opportunities are related to sustainability aspects, how effective these solutions may be, and what ambitions are involved. For the contracting party, this allows for showcasing expertise in guiding the client in related specifications, risks, or analyses.

Practical use of the conceptual framework as introduced in the theory provides a solution in alignment with these barriers. The framework can be implemented by face-to-face contact between project managers of both parties in exploration of opportunities for sustainability and deciding which next steps need to be taken, and which party may take responsibility for these next steps. This way, the tool stimulates mutual discussion and efforts between both parties.

6 DISCUSSION

This discussion elaborates on the interpretation of the results, as well as the found research limitations. As infrastructure project delivery models within The Netherlands are involved with an increasing urge for more collaborative relationship skills between client and contracting organisations, there shows to be an increasing need for research in proactive behaviour to which this research provides insights. The following statements can be made based on the empirical and theoretical study:

- **Sustainability remains a conceptual and value based concept, perceived differently by involved stakeholders in time and place**

The concept of sustainability is widely recognised by the definition of Brundtland (1987), explained as current development in which both present and future needs are taken into account. To make this concept more concrete, organisations adopt a holistic understanding of aspects relating to three pillars as founded by Elkington (1979): people, planet, and prosperity. These pillars each involve aspects and measurable indicators to support operational decision-making. However, literature shows no unambiguous definition of sustainability to be referred to in relation with utility infrastructure. Therefore, from the extant body of knowledge, a summary of sustainability aspects is developed in Table 4. These aspects involve: societal impact, labour practices, environmental impact, energy, water, spatial quality, materials and resources, and return on investment. In comparison with the practical results, it is considered that the theory underemphasises soil (quality and quantity) as an aspect.

The empirical results also show a variety of perceptions and values of individual managers with regard to utility infrastructure projects. It is determined complex to possess one clear understanding of this concept, because of time-orientation, context specificity of measures, and ethical behaviour. Within this research context, sustainability as a concept showed to be predominantly recognised by environmental aspects, such as energy and materials. Implemented solutions for which regulations are followed (reactive), such as soil and anticipation for future development by placing tubes, no direct interpretation seemed to be made with ‘sustainability’. This can be reasoned by the fact that when policies or regulations have been made, these solutions being considered as commonly adopted methods. Moreover, the difference between specific interpretations of sustainability aspects between theory and practice can be explained by the fact that this context is involved with industrial processes rather than an urbanised area. For example, future accessibility of utility services in urbanised areas show to be more pertinent in theory. However, in a continuously changing physical environment which is driven by the economic cycle, long-term solutions to achieve accessibility showed to be less of importance. The case study sample was predominantly involved with high-voltage energy infrastructure, which have shown a high level of effectiveness in product recyclability. Furthermore, as contractual KPI’s between client and contractor are bounded by certain aspects, the practical results are likely to have shown a focus towards these aspects.

In comparison with the theoretical results, these results nuance how complex one singular definition can be on tactical and operational level. The definition of sustainability thus changes over time, and should be adopted as a specific mind-set rather than following a set of concepts or solutions. The provided aspects show a direction in which subjects solutions can be found.

- **Tactical level decision-making may exert influence to sustainability by the project, whereas operations can direct decisions towards sustainability of the project**

Proactivity in terms of effectiveness of solutions demonstrates results in line with shown theory in the position of projects in relation with sustainability. The results shows that most effective solutions are associated with the direction of investments to projects that contribute to a more sustainable environment. Utility infrastructure projects with the purpose of producing or transporting more sustainable energy for the energy transition have been determined as such projects in the studied cases. This is also in line with the theory of ***sustainability by the project***, in which the project is interpreted as a means to establish the strategic sustainability goals. On the other hand, ***sustainability of the project*** is in theory explained as minimising impacts of products and processes required for realising the project. During the operational phases, the practical solutions show a focus towards resources, such as equipment, materials, and energy use. These solutions involve a focus to minimise the environmental impacts of operational processes.

The conceptual framework introduced by this study connects the different levels of proactivity with a chronological order of project phases, ranging on tactical and operational decision-making levels. This framework was used to visualise in which moment certain solutions have been implemented, and how effective these solutions were. By positioning all implemented individual solutions in this framework, an overview of each case study is visualised. The purpose of this conceptual framework is to translate the theoretical insights into practical use, which allows organisations to visualise and analyse their level of proactive contribution towards sustainability.

For practical use, this framework is considered valuable within the initiation of the project, to anticipate for opportunities. This stimulates organisations in creating an overview of the number of possible solutions (quantity), the expected effectiveness of solutions in terms of proactivity, and the project phase in which the aimed solutions must be translated into actions.

- **Proactive behaviour within collaboration between partners requires the extension of responsibilities to supporting partner's responsibility**

The theory concerning organisational behaviour towards sustainability identifies multiple levels of decision-making ranging from reactive to proactive. Reactive decision-making (compliance) is associated with responsiveness towards regulations and standards, a direction of efforts to solely minimise negative impacts, and a focus on short-term profits. On the other hand, the highest level of proactive decision-making relates to a drive to create opportunities towards a more sustainable environment, involving a change in processes or products to prevent the causes of impacts, and a direction of investments towards long-term benefits. The authors directing their research to this subject (Epstein, 2018; Silvius & Schipper, 2012; Willard, 2005) connect these behavioural efforts with the effectiveness of solutions.

Based on the practical findings, several examples show that both parties direct resources (financial, time, and/or capabilities) as a result of their strategic objectives and KPI's (contractor), to achieve sustainable outcomes within their level of influence. Therefore, both client and contractor can be considered proactive in within their individual scopes. However, not all available sustainable solutions have been implemented as identified during the case studies. The underlying reason for this can be found in their collaborative efforts. It can be argued that within the partnership, there is no defined shared proactive approach towards sustainable outcomes of the projects. Currently, the client initiates and takes a leading role within the shaping of sustainable ambitions of the projects, which can be considered as proactive behaviour within the scope of the partnership. The contractor is driven by their set K(PI)'s and shows proactive attitude towards achieving these. However, as agreed upon in the Best Value contract, it is aimed to mutually benefit and learn from each other's expertise. Therefore, it is key for both parties to allow each other to showcase their expertise within the set boundaries and ambitions of the Best Value contract. Currently, the client initiates new projects in which utility infrastructure projects play a role, whereas the contracting organisation becomes involved after scope, budget, and planning are mainly determined. As the contractor is structurally involved in the long-term environment of the airport, the processes within this partnership actually facilitate for mutual input for tactical decision-making. Practical challenges to improve i.e. climate resilience, the energy transition, and aging of infrastructure within this area, show therefore opportunities on tactical level to mutually tackle. In order to maximise benefits of the contractual principles, it is therefore deemed important to involve the contractor earlier in the initiation of the process. This creates time and allows for consideration of all opportunities, as well as determination of ambitions. Simultaneously, the contractor needs to adopt a consulting role and share their expertise on sustainable solutions with the client early on in the process.

Existing literature on this topic places emphasis on the individual organisations and their proactive behaviour. This study shows that individual parties in a partnership do show high levels of proactive behaviour, however this does not translate towards collaborative proactive behaviour. To conclude, this study shows an important limitation in the current literature, which mainly focuses on individual organisations and therefore lacks the importance of collaboration with diverse organisations in the current field of utility infrastructure. Proactivity is more than the sum of its parts, and the importance of synergy between partners should not be underestimated. Therefore, proactivity in strategic partnering collaborations requires extending responsibility towards supporting the partner's responsibilities in order to achieve the best outcome for all parties involved.

6.1 LIMITATIONS

As in any other research, this research has its limitations. The following limitations should be taken into account for the outcomes of this research:

Semi-structured interviews have proved to allow for reasonable understanding of the underlying issues involved with the performance and behaviour towards sustainability. During preparation regarding the case study selection, this subject of examination has shown to possibly involve tension between both organisations (client and contractor), which has limited the number of cases to study within the sample. During the one-to-one interviews, respondents however showed to freely express their opinions on the subject. The downside for this data gathering method has shown to be related to the difference in organisational decision-making level functions occupied by the respondents. The respondents can be categorized in the strategic, tactic and operational level which might influence their ideas and perspectives on proactivity.

- **The tactical and operational decision-making levels are highly dependent on strategic directions**

This research is initiated from a situation in which strategic level management from both parties shows proactive commitment to sustainability in words and actions. Therefore, the research outcomes are adopted from the assumption that strategic commitment to sustainability is present. However, it should be taken into account that without clear direction, support, and motivation from top-level management, it may be unlikely that structured systems will be adopted and high sustainability performance can be established. In that way, the contractor is also highly dependent on the client strategic ambitions and willingness for achieving these, as this determines the project portfolio.

- **Collaborative behaviour naturally evolves over time**

This research is conducted during a period in which client and contractor are becoming familiar with each other's working methods, processes, and behaviour. As it should be taken into account that this change in culture and behaviour requires time, the current behavioural aspects are highly related to the results associated with the first year of collaboration by the principles of Best Value.

Also, the occurrence of COVID-19 changing all working conditions from March 2019 influenced this research. The results of one case study (CS2) regarding the implementation of sustainability outcomes may not show accurate results, as this case was subsequently involved with issues in the transferal between changing project managers. Moreover, within the first 4 weeks of writing this thesis the author was allowed to gain thorough understanding of the working environment of the contractor. Where other research gathering methods may have deemed appropriate for this subject of examination, the reason was influenced by the uncertainty of the working situation.

- **Proactivity is difficult to capture in terms of behaviour**

During the research process, it was considered complex to accurately analyse the exact proactivity in behaviour of different organisations. Especially at the operational level, initiation or perseverance of opportunities have shown to come down to individual efforts, which may be motivated from specific opinions or expertise. In addition, these results differ per individual showcase. The information provided by respondents therefore likely have influenced the perceptions in organisational proactivity. To minimise the risk of construct validity, the practical experiences and solutions are therefore analysed from multiple angles, namely by the what and the how. This way, a comprehensive overview the substantial solutions and the behavioural activities is aimed to collect.

7 CONCLUSION

The motivation for this research was determined by the need for organisations to translate their proactive sustainability strategies to more practical levels of decision-making. Therefore, it was aimed help improve proactive involvement of sustainability in decision-making within tactical and operational decision-making processes. The context of this research involves a strategic partnership between client and contractor for the development of utility infrastructure projects. The following main research question is formulated:

How can sustainability be proactively incorporated within the tactical and operational decision-making processes of utility infrastructure projects?

To answer this question, qualitative research is conducted to explore organisational insights and practical issues regarding the implementation of sustainability at tactical and operational levels of decision-making. By theoretical examination and the input of 4 case studies, the following four sub-questions are answered:

SQ1: What is the definition of sustainability in the context of utility infrastructure projects?

This study does not provide a singular definition of sustainability for utility infrastructure projects in specific situations, due to the fact that this context highly differs from case to case. From the conceptual foundation as defined by Brundtland and Elkington, the interpretation of sustainability can be understood by a comprehensive overview of individual aspects as shown in Table 5. Utility infrastructure projects can be operationalised by trade-offs between societal impact, labour practices, environmental impact, energy, water, spatial quality, soil, materials and resources, and return on investment. By offering an extensive collection of sustainability aspects relevant to utility infrastructure projects, this study aims to extend on the concretisation of people, planet, and prosperity aspects, without sacrificing the uniqueness of this context. By analysing the literature and providing a detailed summary on sustainability aspects, this study provides an improved overview of what has been studied till date.

SQ2: Which elements need to be involved to proactively implement sustainability on tactical and operational decision-making levels regarding infrastructure projects?

The theory distinguishes different levels of proactivity related to the organisational sustainability performance. A reactive approach is concerned as minimalistic by compliance with environmental or social laws and regulations, whereas proactivity is associated with voluntary exceedance of requirements to achieve more impact. The highest level of proactivity shows a value driven dedication that is concerned with the contribution to a more sustainable society. The results show a relation between the level of dedication, long-term investment opportunities, and effectiveness of solutions.

To achieve strategic objectives, all levels of decision-making within organisations possess different influence towards the projects. Tactical decisions allow for direction of investments into certain projects that in purpose contribute to a more sustainable environment. This is associated with sustainability by the project; in which the purpose of the project is driven by sustainability. For utility infrastructure, it is shown in practice that renewable energy sources as result of these projects can be considered as sustainability by the project, which are determined most effective. Decisions made on the operational level allow for minimising the impact of project activities, which can be understood as sustainability of the project. The results in practice show solutions mostly related to the use of products and resources within the construction processes.

The principles of sustainability need to be integrated in current project management practices, to become visible by sustainable outcomes. First, the traditional approach of realising infrastructure projects around planning, budget, and costs requires a change towards balancing societal, environmental, and economic aspects in decisions. Also, it requires a long-term orientation in which the total life cycle of products and resources is taken into account. As many stakeholders highly depending on each other are involved during different project processes, sustainability needs to be collectively approached.

SQ3: What are the underlying issues resulting in the gap between reactive and proactive decision-making?

This research shows that both the client and contracting organisations have shown to act not as reactive as expected as compared with the definitions in theory. Where the client exerts more influence on the tactical level by initiating projects, proactivity towards achieving their strategic sustainability objectives is shown on

different levels by the engagement of stakeholders, active research in market opportunities, and developing of a project portfolio. The contracting organisation shows proactive realisation of tactical measurable key performance indicators as promised by the contract. Individually, both partners have thus shown proactive behaviour towards sustainability.

Where the implementation of tactical plans can be planned for known operational processes, project processes relate to context-specific situations associated with unique solutions. However, within the operational project processes, not all detected opportunities have been implemented as shown by the results. Identified barriers which have constrained the process of decision-making are associated with technical limitations, complexity in trade-offs, cultural resistance, and fragmentation of decisional influence. Also, barriers have shown to be related with the lack of a shared proactive approach towards sustainable outcomes of the projects. This is shown by the lack of mutual sustainability ambitions, the lack of awareness for values, and varying interpretations of the concept. The partnership relies on the Best Value contract, which formalises expectations that require dedication in behavioural change from both parties, which makes the concept of sustainability dependent on how both parties fulfil their roles. Thus, in order to reach a high level of proactivity within the partnership, the client and contractor should involve a mutual and shared commitment towards sustainability objectives. This can be achieved by structuring decision-making moments for sustainability within the current processes, to stimulate both parties early in the process for shared setting of opportunities, visions, and ambitions.

SQ4: What interventions are needed within tactical and operational decision-making processes?

Based on the theoretical foundation and detected barriers in practice, several boundary conditions are required. Interventions require the direction of efforts into an **organisation-wide approach**, meaning that both tactical and operational level management are internally aligned and stimulated to involve sustainability in their considerations. Also, a **future directed mind-set** and **long-term investment approach** are required to overcome technical and respectively cost related barriers. Fragmented decision-making can be overcome by **engagement of stakeholders** in sustainability ambitions.

From the gathered results, it shows that most improvements for this partnering context can be gained in the mutual achievement toward sustainability. From a mutual approach towards sustainability, both parties need to be incorporating a **structured approach** of formal meetings in the initiation process to collectively explore opportunities and to define sustainability ambitions. The conceptual framework as presented in this research can be used as practical tool in stimulation of mutual exploration of opportunities.

How can sustainability be proactively incorporated within the tactical and operational decision-making processes of utility infrastructure projects?

To become highly committed to sustainability, organisations need to take responsibility over decisions regarding their organisational processes. The existing literature explains proactive behaviour towards sustainable outcomes by efforts in terms of a direction of resources, a value driven motivation to change systems at their core, as well as long-term financial directions. However, proactivity in strategic partnering collaborations also requires extending responsibility towards supporting the partner's responsibilities in order to achieve the best outcome for all parties involved. Proactivity is more than the sum of its parts, and the importance of synergy between partners should not be underestimated. The conceptual framework developed in this research provides a practical solution for the collaborative setting between client and contractor, as it stimulates the development of mutual ambitions and substantive opportunities and directions for sustainable outcomes.

Decision-making on a tactical level is concerned with the direction of projects, whereas decision-making on the operational level is concerned with minimising the impact of the operational activities within the chosen direction. For utility infrastructure projects, the tactical level allows for directing investments to overarching initiatives and projects that contribute to the transformation of systems from non-renewable energy sources towards renewable energy resources. By proactively directing resources towards sustainable options, this level has a strong impact on the sustainability by the project. On the operational level, proactive implementation is involved with mutual commitment between project partners to align definitions, ambitions and specifications. Moreover, the operational level is actively involved in the sustainability of the project and how this can be achieved during daily activities.

8 RECOMMENDATIONS

On the basis of the research findings, the following recommendations are directed to the organisation. This chapter encompasses recommendations for further research in the literature, as well as for practice.

8.1 FUTURE RESEARCH

Suggestions for complementary research to this exploratory study are the following:

- Elaborative research in the level of effectiveness by sustainability aspects

The levels of proactivity have shown a link with the effectiveness of sustainable solutions for utility infrastructure projects. Future research could be dedicated to more specific understanding of the comprehensive opportunities for sustainability aspects as identified in this research. For this research, the conceptual framework can be utilised to guide levels of effectiveness for the individual solutions.

- Influence levels over decision-making of multiple stakeholders within the energy sector

This study neglected the perception of highly involved other stakeholders within the energy sector (as identified in Appendix A). With regard to utility infrastructure projects, decisions are expected to be more fragmented within urbanised areas. Therefore, proactivity in terms of achieving mutual commitment within these areas can be further examined.

- The influence of collaborative behaviour over time within partnerships on sustainability performance

This research underpins the importance of collaborative behaviour as addition to the theoretical understanding of proactivity in relation to sustainability. As referring to the limitations, it shows that this research setting requires evolvement over time. The context allows for long-term observational research methods, which can be adopted to measure progress in collaborative behavioural soft skills.

- Leadership styles related to project managers in achieving sustainability

As proactive behaviour has shown to allow for interpretation of individual levels, this was taken into account during analysis. In practice, project managers have shown to adopt leadership styles, which is also acknowledged in literature (Silvius, 2018). This can be further explored in performance behaviour towards sustainability.

8.2 RECOMMENDATIONS FOR PRACTICE

The recommendations follow from the intervention requirements as stated within Chapter 5. As determined, the mutual approach between client and contractor allows for improvement. It is determined that first efforts towards should be directed developing this collaborative behaviour within these operational processes.

Professionality and competitive improvement by the contractor needs to be gained in adopting an expert role towards sustainability. The contractor should thus showcase its expertise towards the client in order to further establish their role in the alliance as well as to create opportunities for more out-of-the-box solutions in future projects. This involves a more critical attitude towards the technical requirements as requested by the client at the start of a project. To adopt a consultant role for sustainability:

- Internal stimulation to project managers and their project team is necessary. The project managers form the representative sparring partner with the client, and interviewed respondents have shown to possess knowledge with regard to sustainable solutions. However, currently no resources are dedicated to support research or educate other project team members in achieving solutions. Where safety as subject is prioritised and needs justification, sustainability should also be critically justified by project managers. As the individual project managers have shown to differently value or find solutions, structural sharing of knowledge can effectively lead to individual performance.
- Improve sharing of knowledge in maintenance specifications between the maintenance and operational department. This way, trade-offs can be improved by life-cycle decisions.

- Internally analyse where problems are currently found during project processes, and which opportunities might be found to minimise the impact on environment and society. The current method of following individual projects shows an ineffective way of realisation.
- Develop a long-term plan in which the end-goals are envisioned and steps to be reached towards Project managers are highly involved during decision-making moments with the client, and therefore need clarity about expectations in behaviour towards the client, so that they can involve and align this with designers and execution workers. Currently, it seems uncertain where BAM prioritises sustainability within the projects. Therefore it is recommended that tactical level management should set expectations for sustainability at the start of a project.
- Incentivise all employees in cultural awareness by making sustainability more visible on the digital system, showing which solutions have contributed to sustainability and in what way**,** involving tips for how different employees can change their mind-set. Understanding how different solutions are gained in a certain project can stimulate other employees in searching for new solutions.

By becoming more critical, the contractor can possibly move the client towards more performance based contracts, which allows for more innovative and out of the box ideas to be implemented in such projects instead of following requirements. To be able to achieve this, the client needs to give the contractor room for improvement by focusing less to the technical requirements. For the client, the following is recommended:

- During transfer of the project scope, clear sharing of the purpose of the project in relation to organisational values is deemed important. By emphasis of the actual importance of projects, the client becomes can base their analyses for different solutions on the basis of these values.
- Involve the client early in the process of initiation for projects in determination of sustainability opportunities and ambitions. At this moment, the contractor is urged to follow the project portfolio developed by the client and exert low influence on decision-making during the initiation. Where the long-term working environment between client and contractor allows for mutual tackling of tactical problems, the contractor cannot take control over decisions when involved after plans are made.
- Engage project stakeholders with high decision-making influence levels in sustainability ambitions. Different departments within Schiphol Group are involved with the initiation of new utility infrastructure projects. It is important that both tactical level management and project management share equal ambitions for projects and clear budget at initiation.

At this moment, the level of influence to achieve sustainable outcomes is limited to the operational processes, as BAM usually becomes involved in the design phase when budget, planning, and objectives are already determined. In the future, the level of influence may be enhanced by becoming integrated on the tactical level to initiate impactful solutions. When collaborative behaviour in the operational processes show to be improved, long-term achievements can be stimulated as follows:

The strategic challenges for utility networks regarding limitation of subsurface space, energy transition, or technological development are involved with the need for physical adaptations to the current infrastructure. As shown in this research, challenges on strategic level in relation to climate resilience or the energy transition. Therefore, the contractor can initiate research for projects on tactical trade-offs and align long-term plans with the development department. Interesting examples are research into the use of gas pipelines, removal of inactive cables, or maintenance works. These challenges can be mutually tackled:

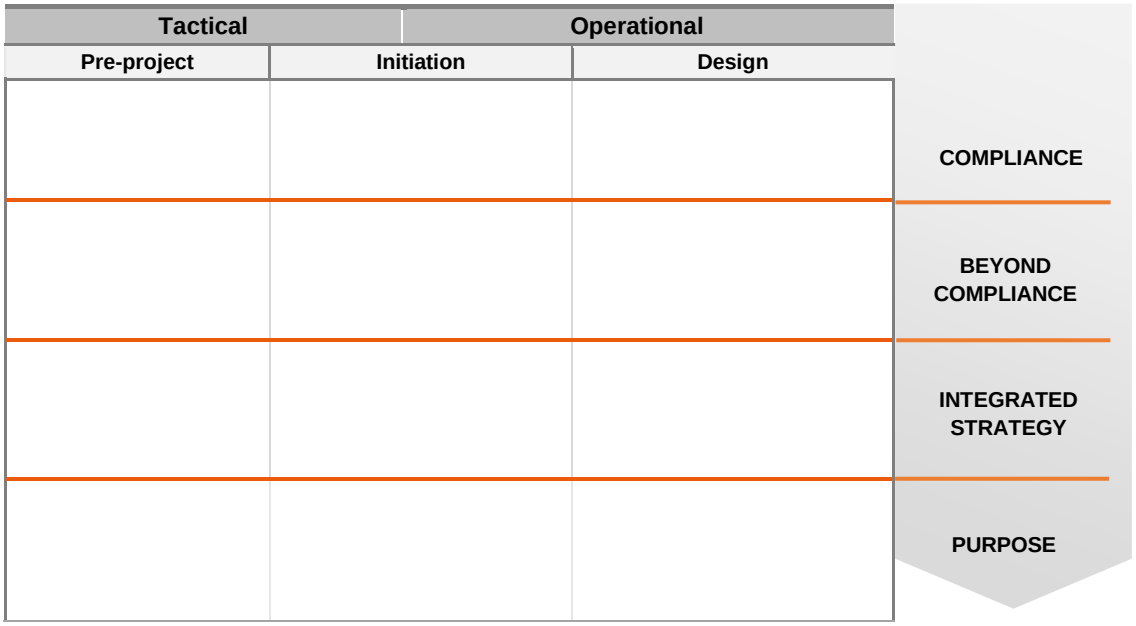
- Sharing of long-term issues and plans by the client. This involves that management of different decision-making levels from the client share thoughts and involve each other in the line of reasoning
- Active search by the client for the initiation of new projects to add to the portfolio. Also, close collaboration in with other contractors can be stimulated to effectively align realisation between above-surface works with subsurface utility infrastructure works.

8.2.1 *Practical use of the conceptual framework*

For the conceptual framework to be used in practice, the following is determined. In purpose, the tool can be used as communication tool between client and contractor during face-to-face meetings. The first step can be taken by tactical and operational management from the contractor to show a proactive role. By analysing which opportunities can be created for the specific project, the contractor can consult the client in the necessary following steps to be taken in further research or implementation, involving possible risks, mutual ambitions, and understanding of the concept. This way, a mutual feeling can be created in the process steps towards sustainability. Also, in showing which opportunities might have been missed already in the initiation phase. As sustainability can be interpreted as an improved situation of the current state, it is needed to analyse the current state of structures.

User complexities of the framework can be directed towards the interpretation of the specified proactivity levels. As shown in Appendix H, individual solutions have different extents of effects in their contexts, which are difficult to measure. Whereas the framework seems to allow comparing the effectiveness between solutions, in reality it is impossible to directly derive solutions from this framework. Therefore, it is merely determined as tool to stimulate brainstorming between two parties, for which the expertise and knowledge of sustainability experts is recommended to involve.

The framework to be used in practice:



9 APPENDICES

9.1 APPENDIX A: SCHIPHOL CONTEXT VERSUS PORT ROTTERDAM VERSUS CITY CENTRE ROTTERDAM

	Schiphol Airport	Haven Rotterdam	Stads centrum Rotterdam
Fysieke aansluiting energie	Openbaar: bedrijfsactiviteiten, infrastructuur, LS	Openbaar: bedrijfsactiviteiten, bewoond gebied, infrastructuur	Openbaar: bewoond gebied, infrastructuur
	Niet openbaar: bedrijfsactiviteiten luchtvaart AS	Niet-openbaar: bedrijfsactiviteiten haven goederenoverslag	
Eigendom energie-infra	Schiphol (Privaat)	Elektriciteitsproducenten, raffinaderijen, afvalverbranding, producenten waterstof	Netbeheerders (privaat & semi-privaat) tactisch/operationeel
Beheerder energie-infra	BAM (Privaat)	Netbeheerders (privaat & semi-privaat)	Netbeheerders (privaat & semi-privaat)
Beheerder ondergrond		Gemeente Rotterdam (publiek)	Gemeente Rotterdam (Publiek)
Derde partij	Energieleveranciers	Havenbedrijf Rotterdam	Aannemer Energieleveranciers
Afnemer energie	Luchtvaartmaatschappijen, reiziger, bedrijven	Afnemers warmte gebouwde omgeving, tuinbouw Afnemers elektriciteit bewoond gebied NL Afnemers stoom chemie	Bewoners, bedrijven
Relationeel	best-value contract Eigenaar – beheerder	Havenbedrijf verhuurder bedrijfsterreinen, bedrijven verantwoordelijk voor aansluiting infra	
Opgaven strategisch niveau	Energie transitie Ruimtegebrek ondergrond Klimaatverandering Technologische ontwikkeling	Energie transitie Ruimtegebrek ondergrond Klimaatverandering Technologische ontwikkeling	Energie transitie Ruimtegebrek ondergrond Klimaatverandering Technologische ontwikkeling

9.2 APPENDIX B: LITERATURE FOCUS IN SUSTAINABILITY INDICATORS FOR UTILITY INFRASTRUCTURE PROJECTS

Literature source	Perspective	Impact factor		
Initiation perspective				
		Environmental	Social	Economic
Adepetu, Adedamola, Grogan, Alfaris, Svetinovic, and de Weck (2012) *"City.Net IES: A sustainability-oriented energy decision support system."* IEEE International Systems Conference SysCon 2012, 1-7. Institute of Electrical and Electronics Engineers, 2012.	Renewable energy generation by different systems	Life cycle emissions (CO2, CO, CH4 and NOx), water treatment and distribution, waste processing and water collection, resource consumption, land use		Revenue generation, finance consumption (Capital cost / O&M)
Ashley, Blackwood and Jowitt (2004) *Sustainable decision making for the UK water industry Sustainable water services*	The Sustainable Water industry Asset Resource Decisions (SWARD) project explores the difficulties when making asset investment decisions, in particular for sustainability.	Resource utilisation (energy use), service provision, environmental impact (air emissions, overflow discharges to the environment)	Acceptability to stakeholders, impact risks to on human health, participation and responsibility, public awareness and understanding, social inclusion	Life cycle costs (capital cost, operational, maintenance costs), willingness to pay, affordability, financial risk exposure
Sterling et al (2012) *Sustainability issues for underground for underground space in urban areas* Urban Design and Planning Volume 165 Issue DP4 / Citations: 91	Sustainability of urban underground space involving infrastructure	land, water, biodiversity, air pollution, visual intrusion, energy use, waste generation, resilience, enhancing overall landscape, reuse for new functions, multi-purpose solutions that are space and resource effective		

Design perspective				
Sahely, Kennedy and Adams (2005) *Developing sustainability criteria for urban infrastructure systems* Canadian Journal of Civil Engineering / Citations 354	Sustainability criteria and system-specific indicators for urban utility infrastructure in the need to design and manage engineering systems (Canada)	Construction materials usage, energy usage, water usage, land use, chemical use, contaminants, nutrients, sludge, GHG emissions	Access to potable water and sanitation services, water quality, public participation	Capital and operation and maintenance costs, service fees, expenditures in R&D, reserve funds
Balkema, Preisig, Otterpohl & Lambert (2002) *Indicators for the sustainability assessment of wastewater treatment systems*	Sustainability indicators for selection wastewater treatment system	Accumulation, biodiversity/land fertility, extraction, integration in natural cycles, land area required/space, odour/noise/insects/visual, optimal resource utilisation/reuse, water, nutrients, energy, raw materials, pollution prevention, emissions, nutrients, heavy metals, sludge/waste production, use of chemicals	Awareness, competence/information requirements, cultural acceptance, institutional requirements, local development, responsibility	Costs, labour
Karaca, Raven, Machell and Camci (2015) *A comparative analysis framework for assessing the sustainability of a combined water and energy infrastructure*	Comparative analysis framework for assessing the sustainability of infrastructure proposals, applying it to Blood of the City system, which combines the provision of energy and potable water	Resource use, environmental impacts, interactions with surrounding environment, chemical and additional material consumption	Social behaviour (household level, community level, national level), social development (job opportunities, social integration)	Investment costs, operational costs, losses and leakage (water leakage, energy loss, energy consumption)
Construction perspective				
		Environmental impact of street works	Social impact of street works	Economic impact of street works
Araratnam, Piratla, Cohen and Olson (2013) *Quantification of sustainability index for underground utility infrastructure projects* Journal of Construction Engineering and Management / citations: 32	Sustainability comparison of urban utility infrastructure installation techniques	CO2, CO, NOx, HC, SOx emissions	Traffic congestion, public safety, noise pollution, fugitive dust pollution, financial impact on surrounding businesses, project duration, loss of ground vegetation, traffic control, preservation of historic sites, waste material	Cost factors for installation and restoration, excavation costs

Hayes (2005) *PHD: Development of a sustainability assessment methodology for UK street works projects*	Quantification of sustainability indicators for urban utility infrastructure street works (UK)	Noise and air pollution, land use, land contamination and hazardous materials, landscape issues, ecology and biodiversity, water resources and water environment, light pollution	Road user delays	Direct costs of design and construction, indirect costs as compensation payments, reinstatement
Hojjati et al (2016) *Sustainable asset management for utility street works* Journal of Construction Engineering and Management / Citations: 6	Sustainability indicators for urban utility infrastructure installation techniques (UK)	Energy efficiency, materials and waste production, carbon footprint, water consumption and pollution, biodiversity	Delay costs to road users, disruption to businesses, disruption to local community, health and safety, costs to local authorities	Direct costs (planning and design, labour and machinery, construction materials, traffic management, planned maintenance, monitoring, access, emergency repairs, decommissioning)

9.3 APPENDIX C: SUSTAINABILITY ASPECTS FOR UTILITY INFRASTRUCTURE PROJECTS

			Literature in project management			Literature in civil engineering infrastructure projects				Literature in utility infrastructure projects					
	Aspect	**Indicator**	**Silvius et al., (2012)**	**Martens & Carvalho (2018)**	**Stel (2019) (thesis)**	**Gijzel et al (2019)**	**Shen et al. (2012)**	**Fernandes-Sanchez (2010)**	**Ugwu & Haupt (2007)**	**Ashley et al (2004)**	**Adeptetu et al (2012)**	**Balkema et al. (2002)**	**Sahely and Kennedy (2005)**	**Hojjati et al. (2016)**	**Ariaratnam et al (2013)**
Economic sustainability	**Return on investment**	Cost management	x	x				x	x	x			x	x	x
		Value optimisation	x	x		x			x		x		x		
		Life cycle cost			x	x	x	x	x	x	x		x		
		Resource	x	x			x	x				x			
		Willingness to pay								x					
	Business Agility	Sustainable business	x	x	x	x									
		Business continuity	x	x	x			x							
Environmental sustainability	**Energy**	Energy use & efficiency	x	x	x	x	x	x		x		x	x		
		CO2 from energy	x	x	x	x	x	x				x		x	
		Energy production		x	x	x				x					
		Renewable energy sources		x	x	x	x								
	Water	Water use and quality	x	x	x	x	x	x			x	x	x	x	
		Water recycling	x	x	x		x	x	x		x	x	x		

		Water quantity								x					
	Material use and resources	Waste generation	x	x	x		x	x	x		x	x	x		x
		Recycling	x	x		x	x	x	x			x			
		Energy use and emissions	x	x	x		x	x		x	x	x	x	x	
		Contaminants nutrients											x		
		Multifunctionality	x				x								
	Spatial quality	Soil quality						x	x			x	x	x	
		Biodiversity						x				x		x	
		Land use				x	x	x			x	x	x	x	
		Climate resilience						x			x				
	Transport	Local supplier selection	x			x		x							
		Transport	x		x										
	Environmental impact	Noise emission		x				x	x			x		x	x
		CO2 emission		x	x		x	x		x		x	x	x	x
		Light pollution						x						x	
		Visual impact						x				x			
		Air quality		x		x	x	x	x	x		x	x	x	x
		Nature development within						x	x			x			x

		Hinder													x	x
		Archeologic value						x								x
Social sustainability	**Labour practices and ethical behaviour**	Health and safety	x	x				x	x						x	x
		Supplier / contractor relationship involvement						x	x							
		Organisational culture management (training education employment)	x	x				x								
		Corporate Social Responsibility		x				x								
	Societal impact	Stakeholder engagement	x	x		x		x						x		
		Relationship with the surrounding	x					x								
		Human rights, fair trade	x	x	x	x										
		Owner and user satisfaction		x				x		x				x		
		Social Return						x								
		Impact on business and community		x				x		x					x	x
		Accessibility						x		x				x		

9.4 APPENDIX D: INTERVIEW QUESTIONNAIRE

Wat wil je ermee beogen?	Inhoud	Wat ga je met informatie doen?
Verduidelijking van onderzoek en bijdrage respondent	Achtergrond interviewer, onderzoeksdoel, bijdrage interviews aan onderzoek, bijdrage project	
Vooruitzicht bieden in opzet interview en mogelijkheden	Structuur interview onderwerpen, aangeven dat respondent tijd mag nemen voor beantwoorden, en vragen mag stellen voor verduidelijking	
Toestemming ontvangen voor gebruik data	Vragen om toestemming audio-opname	Opname als input voor analyse onderzoek
Expertise van respondent is bepalend voor validatie van onderzoeksresultaten	○ Wat voor professionele achtergrond heeft u?	Overzicht van ervaring respondent om mate van validatie te kunnen analyseren
	○ Hoeveel jaren ervaring heeft u in deze functie?	
	○ Hoeveel jaren ervaring bij BAM Schiphol of Schiphol?	
Welke voorkennis heeft de respondent op het gebied van duurzaamheid	○ Heeft u ervaring opgedaan met duurzaamheid in een cursus of opleiding? ○ Heeft u ervaring opgedaan met duurzaamheid binnen projecten?	

Project		
Wat wil je ermee beogen?	**Interview vraag**	**Wat ga je met informatie doen?**
Karakteristieken van project en rol nutsvoorzieningen infrastructuur bepalen	1) Kunt u vertellen over de context van het project? ○ Welke rol spelen kabels en leidingen hierin?	Karakteristieken van project koppelen aan kansen duurzaamheid
Is het project geïnitieerd voor of na de start van het MC contract en wat zijn onderliggende redenen voor de initiatie	2) Wanneer is het project geïnitieerd? (Schiphol)	Vergelijken initiatie project met start contract, redenen achter initiatie weerspiegelen op trade-offs duurzaamheid
Verantwoordelijkheden van respondent achterhalen	3) Wat is uw rol binnen het project?	Analyseren waar respondent directe invloed op kan uitoefenen
Tussen welke projectfasen heeft respondent invloed uit kunnen oefenen op keuzes en welke projectkeuzes zijn voor dit moment al gemaakt	4) Op welke moment in de projectfase bent u betrokken geraakt met het project? ○ Welke projectkeuzes waren toen al gemaakt? ○ Welke projectkeuzes zijn tijdens de initiatiefase gemaakt? (Schiphol)	Cross-case analyse van welke projectkeuzes tijdens initiatiefase en ontwerpfase worden gemaakt, analyse welke invloed verschillende partijen uit kunnen oefenen

	○ Tijdens welke fasen bent u nauw betrokken bij dit project?	
Door welke onderliggende redenen wordt het project gedreven vanuit de opdrachtgever?	5) Welke drijfveren bepalen dit project? ○ Op welke manier heeft dit projectkeuzes beïnvloed?	Project drivers spiegelen aan redenen voor wel of niet implementatie duurzaamheid

Welke kennis heeft respondent heeft met duurzaamheids-ambities Schiphol en strategische doelen BAM, en hoe wordt dit geïnterpreteerd?	6) Bent u bekend met de duurzaamheidsdoelstellingen van Schiphol? ○ Wat is uw interpretatie van de duurzaamheidsdoelstellingen? ○ Bent u bekend met de prestatiebeloftes van de aannemer? ○ Was u al bekend met de duurzaamheidsdoelstellingen en prestatiebeloftes op het moment dat u werd betrokken in het project?	Kennis delen over duurzaamheid binnen context
Op welke manier het besluitvorming proces rondom duurzaamheid is gegaan tijdens de initiatiefase of ontwerpfase van het betreffende project	7) Op welke manier is duurzaamheid binnen het project aangepakt? ○ Op welk moment in de projectfase is hierover nagedacht? ○ Welke oplossingsrichtingen waren mogelijk om duurzaamheid te implementeren? ○ Waarom is voor deze oplossing gekozen? ○ Op welke manier is dit tussen BAM en Schiphol gecommuniceerd? ○ Wie heeft of hebben deze beslissing gemaakt?	Analyseren hoe er proactief met duurzaamheid om is gegaan in het project: op welk moment is erover nagedacht, welke oplossingsrichtingen waren er, wie heeft de keuze gemaakt, hoe is gecommuniceerd tussen beide partijen, in welke mate is er maximaal ingezet op een duurzame oplossing, onderliggende redenatie Analyse van niveau beslissing, is dit op strategisch, tactisch of operationeel niveau
Is er over andere oplossingen nagedacht waar in eerste instantie niet aan is gedacht	**8) Is er verder nagedacht over** beperken van materiaalgebruik, recycling, vermindering energiegebruik, social return, CO2 uitstoot vermindering? ○ Op welk moment, welke oplossingsrichtingen, communicatie, welke beslissing	Indien er over andere dingen is nagedacht, analyseren op dezelfde manier als in vraag 7

Hoe wordt in de praktijk nagedacht over theoretische oplossingen in verschillende fasen en op welke niveaus wordt hier over nagedacht	9) Welke van deze duurzaamheidsaspecten herkent u in de context van Schiphol, en handelen jullie hier actief op?	Vergelijking met interpretatie van duurzaamheid aspecten in theorie
Wordt er op basis van alle informatie nog gedacht aan andere mogelijkheden die potentieel gaven om te implementeren	10) Denkt u dat er andere mogelijkheden waren voor verduurzaming binnen de context van dit project? ○ Op welk moment tijdens het project zou hier invloed op uitgeoefend moeten worden?	
Wie heeft op welke aspecten invloed	10) Zijn naar uw idee door corona of andere invloeden project keuzes in de initiatieffase of ontwerpfase beïnvloed?	
Vanuit contract bepaalde rollen toegewezen, in hoeverre wordt hiernaartoe geleefd als het gaat om behalen doelstellingen duurzaamheid	11) Wat is uw interpretatie van de rolverdeling tussen BAM en Schiphol in het Best Value contract? ○ Hoe ervaart u op dit moment de rolverdeling toegewezen vanuit het Best Value contract tussen BAM en Schiphol als het gaat om de duurzaamheids-doelstellingen? ○ Wat denkt u dat nodig is binnen de samenwerking tussen BAM en Schiphol om de doelstellingen te behalen?	Analyse van verwachtingen binnen samenwerking tussen beide partijen en welke factoren een rol spelen in het faciliteren of impliceren van behalen van doelstellingen
Waar denkt respondent de meeste invloed op uit te kunnen oefenen	12) Op welke aspecten denkt u in uw functie invloed te hebben als het gaat om beslissingen omtrent duurzaamheid?	
Ziet respondent manieren om eventuele gemiste kansen anders aan te pakken of verbeteringen voor implementatie	13) Terugkijkend op de project fase, zou u andere beslissingen hebben gemaakt als het gaat om duurzaamheid?	Potentiële kansen voor duurzaamheid in het project analyseren

Afsluiting		
Wat wil je ermee beogen?	**Inhoud**	**Wat ga je met informatie doen?**
	Bedanken voor deelname onderzoek, Vragen of respondent resultaten onderzoek wil ontvangen	
Respondent gelegenheid geven om eigen vragen te stellen	Heeft u vragen naar aanleiding van dit onderzoek?	
Onderzoek niet per direct afsluiting geven	Vragen of er eventueel contact mag worden opgezocht voor validatie van onderzoeksresultaten	

9.5 APPENDIX E: LIST OF SUBJECTS INTERVIEWS

Doel interview

Het doel van dit onderzoek is om een proactieve benadering te vinden voor het integreren van duurzaamheid binnen projecten omtrent ondergrondse kabels en leidingen op Schiphol. Het interview dient als input voor het bepalen van mogelijkheden voor verduurzaming binnen de context van het project, de benadering vanuit beide partijen en rol in verschillende fasen om invloed uit te oefenen op duurzaamheid. Hierbij wordt onderzoek gedaan naar de initiatiefase en ontwerpfase (VO-DO-UO) van het project.

De volgende onderwerpen komen aan bod tijdens het interview:

- Context project en rol van respondent
- Duurzaamheid binnen Schiphol
- Aanpak duurzaamheid binnen specifiek project: keuzemoment(en), communicatie tussen Schiphol en BAM, redenen voor het wel of niet kiezen van duurzame oplossing, beslissingsmaker
- Duurzaamheid van ondergrondse kabels en leidingen projecten
- Wensen voor een proactieve aanpak van duurzaamheid binnen het project en binnen de samenwerking Schiphol en BAM

Gebruik van data

Anonimiteit zal worden gewaarborgd, informatie is niet traceerbaar naar respondent. Er zal worden gevraagd om het interview **op te nemen;** deze opnamen zullen niet worden gedeeld met anderen.

9.6 APPENDIX F: DOCUMENT ANALYSIS

Code	Document name	Retrieved from:	Date:
D1	Deelmanagementplan Duurzaamheid en Social Return Project: MC 2019 Perceel 4 Ondergrondse infrastructuur (Versie 1.0)	BAM	23-4-2019
D2	Copy of aannamedossier KPI's Perceel 4	BAM	n.v.t.
D3	Verificatieplan KPI's MC2019 Perceel 4 Ondergrondse infrastructuur	BAM	29-11-2018
D4	Ontwerpnota Herinrichting P3: Openbare verlichting (Versie 0.8)	BAM	27-03-2020
D5	To Do: Ontwerp nota P3	BAM	n.v.t
D6	Ontwerpnota RAW VS4 naar VS2-VS9	BAM	2-7-2020
D7	Trade-Off Matrix / Variantenmatrix VS4 naar VS2-VS9 Lange route versus korte route	BAM	29-06-2020
D8	Trade-Off Matrix / Variantenmatrix VS4 naar VS2-VS9 Tracé 4602 in bestaande buizen versus nieuw tracé	BAM	29-06-2020
D9	Trade-Off Matrix / Variantenmatrix VS4 naar VS2-VS9 Boring 4508 versus open ontgraving	BAM	29-06-2020
D10	Werkpakket 5 Rijbaan Q Project: voltooiing Dubbel Rijbaanstelsel (Definitief)	BAM	31-01-2020
D11	Sustainability Roadmap Schiphol Group	BAM	

9.7 APPENDIX G: CASE STUDY DESCRIPTIONS

Case study 1: P3 Parking garage 3

Project context

Project demand:	P3 is the largest parking garage at Schiphol and in Europe, facilitating 13000 parking spaces for passengers that need to park their car for a longer period. The current state of the parking garage and its assets has become deteriorated, leading to unsafe situations and decreased quality. Earlier initiations for maintenance were extended, because of uncertainty of future developments (such as buildings). The project therefore involves redevelopment of the parking spaces, a centralised traffic structure, and improvement of the assets.
RoI utility infrastructure	Placing underground utility infrastructure networks beneath the parking garage before rebuilding the garage flooring.
Required assets utility	Removal, design and placement of a new utility infrastructure network in the form of several cable conduits, to facilitate energy demand for public lightening, alarm poles, reporting systems, and other installations, as well as capacity for stormwater storage in the subsurface with associated pipelines.
Location	On landside at Schiphol North-West, adjacent to the highway A4 and a runway. This is a remote area at which relatively not many businesses or passengers are continuously present.
Project drivers & goals	Quality: optimal customer experience in the sense of high facilitating services and assets. As the current state of P3 is beneath qualitative standards, the project is driven by increased requirements in quality by choosing high quality materials, developing clear traffic routing and enlarged parking spaces. For utility infrastructure, this means a demand in advanced information technology installations such as camera’s and security systems to support customer service.

Case study 2: VS2 to VS4 & VS9

Project context

Project demand:	This project is initiated for assuring continuity of business processes. To provide the new to be built A-terminal with electricity, a reorganisation of the current electricity supply is required. Three distribution stations located near each other (Verdeelstations); VS2, VS4 and VS9, are altered in their supply of energy by replacing cables from and towards these stations. Incoming energy at VS2 is removed and redirected to both VS4 and VS9, so that these stations can supply sufficient energy to the terminal. In addition, measures are taken to enable continuity of energy in case of a terrorist attack at the airport by placing extra high-voltage energy cables which can be directly connected to the distribution stations in case of an attack.
Required assets utility	Removal, replacement and new placement of high-voltage energy cables between distribution stations.
Location	Partly realised at landside on Schiphol Boulevard; in the centre of Schiphol area. Another part of the project is realised on airside. These are areas in which much customers and businesses operations are taken place.

Case study 3: VDR

Project context

Project demand:	The project is a partial project of project VDR (Verbreding Dubbele Rijbaan), which encompasses all activities related to building a new taxiway viaduct crossing the highway A4. As the new aboveground taxiway is expected to cause settlement of the existing subsurface utility infrastructure, several cables need to be replaced. Also, in expectation of future developments in this region, empty tubes are placed.
Required assets utility	Removal, replacement and placement of several cables and pipelines, of which two high-voltage cables owned by Liander.

Case study 4: HS station DE buffer

Project context

Project demand:	This project is part of project ROEV: Realisatie Oplaadvoorzieningen Elektrische Voertuigen (Realisation of charging facilities for electric vehicles), to facilitate renewable energy to all involved operational parties for the handling of aircraft. As the energy infrastructure is not yet available on multiple aircraft stands, this specific project is initiated to realise charging facilities on 9 aircraft stands between the D-pier and E-pier (also called DE Buffer).
Required assets utility	Building a new high-voltage electricity station (Hoogspanning station) and connecting high-voltage energy infrastructure between the D-pier and the station. Another contracting party is operator of the aircraft stand facilities, and connects the infrastructure with the charging stations.
Location	This project is realised on airside, which comes with high requirements for the planning of construction activities. As the airport prioritises continuity of the business operations at airside, norms are set to minimise the disruption.

9.1 APPENDIX H: OVERVIEW OF EXAMPLES FOR CONCEPTUAL FRAMEWORK

Examples per aspect for use of framework

Soil quantity	Soil quality	Materials	Energy
	Adopt measures to minimise soil contamination in reseach and sanitation	Separation of operational waste	
Minimise use of new soil	Adopt additional measures to minimise soil contamination in reseach and sanitation	Minimisation of use of materials Reuse of existing materials	Minimise use of energy during construction processes Use of more clean fuels dan diesel, such as GTL or
	Remove cause of contaminated soil by removing leaking cables causing hazardous materials in the soil. Local contamination of soil	Remove cause of material depletion by transforming products to cyclical life cycle	Remove cause of emissions by transforming current energy sources towards cleaner sources. Such as by use of different motors in vehicles
Strive for closed soil system in which the most extent of soil is locally reused		System in which product is not causing any negative measures Use of biobased materials Life cycle of materials and products connected with contextual situation	Transformation towards a system for renewable energy sources

Soil was found in the national regulations (Wet Bodembescherming) as follows: depending on the local soil quality, suitable measures need to be taken to prevent from negative outcomes for employees and social environment. Therefore, thorough research need to be undertaken in advance. (College van burgemeester en wethouders, 2019)

9.2 APPENDIX H: ANALYSIS SUSTAINABILITY PERFORMANCE

Om de huidige perceptie van duurzaamheid een plek te geven is een indeling gemaakt van wat er gangbaar is (al jaren wordt gedaan), wat in de projecten naar voren is gekomen, en waar nog mogelijkheden worden gezien,

Wat wordt al gedaan op Schiphol?	Oplossing
Energie	
Het contract met onze leverancier voor het leveren van energie dat is ook duurzaam ingestoken. Wij draaien alleen maar op windenergie (R-9)	Gebruik hernieuwbare energie
We doen ook heel veel aan warmte-koude opslag. Daar is ook een aparte man voor bij ons, die dat allemaal in kaart brengt. Technology die daar adviezen voor geeft, en die, dus ja daar komen steeds meer van die warmte-koude bronnen op Schiphol terrein (R-12)	Decentrale energie opwekking en energie opslag
Dat probeert Utility services wel: ze doen zelf wat kleine projectjes, zonnecelletjes plaatsen, wat kleine windmolentjes, heel kleinschalig zeg maar. Maar ze verwachten wel dat we het in het project meenemen (R-5)	Decentrale hernieuwbare energie opwekking
Water	
(..) voor te stellen van joh kijk daar eens naar want dit is qua duurzaamheid een toppertje. Als het gaat om bijvoorbeeld dat waterbeheer op Schiphol; hemelwater bijvoorbeeld. Daar worden buffers aangelegd om die wateroverlast te compenseren dus Schiphol is daar best vooruitstrevend in (R-12)	Waterveiligheid
Materialen en stoffen	
Dan krijg je het echt één op één terug. Hetzelfde doen we ook straks met de grond: er komt nu *h*eel veel grond vrij, omdat dat moet omhoog dus er moet zand op. En die grond ligt in de weg, maar straks moet je je berm aanvullen, je het moet het weer aanvullen dus dan heb je het terug nodig. Dus je gaat nu eerst verkopen daarna terugkopen. Dat hebben we met onze grondleverancier, we hebben zo'n grondhandel die doet voor ons de grond handel (R-7)	Hergebruik materialen
Apart scheiden van kabels en leidingen: plastic apart, kokers apart. Of alles bij elkaar en dan wordt het plastic van de koker gehaald in fabrieken, maar daar heb je wat minder sturing op momenteel (R-7)	Scheiding materiaal

Wat we zelf al doen, maar dat is ook al 20 jaar: alle oude vrijgekomen PWC en HWE materialen, die brengen wij terug naar de Waving, dus dat halen we uit de grond, doen we in een bak, brengen we de bak naar de Waving of laten we de bak brengen. Dus recyclen, daar doen we eigenlijk al heel lang iets mee. (R-2)	Scheiding materiaal
Deze kabels zijn verlegd en de oude eruit. Die gaan naar de recycler die Schiphol ons aan heeft gegeven. Er is hier op landside een groot project bij de toren, dus er wordt een bak ter beschikking besteld en daar moeten wij de kabels in dumpen. Dat gaat de verwerker in (R-2)	Scheiding materiaal
Transformatoren halen we de olie uit, hebben we afstroom (..) van, komt dan bij de vuilverbranding, wordt verbrand en verwerkt op de goede manier. En hetzelfde geldt voor schakelinstallaties die worden uit elkaar gehaald (R-12)	Scheiding materiaal
De kabels en leidingen hebben leveranciers al bij ons weggehaald, dat is hallogeen vrij. Dat is een eis die er eigenlijk al jaren ligt, en die kun je bijna niet meer kopen die kabels, die zijn allemaal hallogeenvrij (R-4)	Milieubelasting materiaal
We zijn al naar kunststofkabels toe gegaan, naar geen oliegevulde moffen; **naar droge moffen** en dat soort dingen. Dat doen we eigenlijk al jaren (R-5).	Modulaire verbindingen
We zijn toen van oude GPLK oliekabels (Geïsoleerd m.b.v. in olie gedrenkt papier) over gegaan naar kunststof, nou van kunststof - dat verouderd ook en dat soort dingen, krijg je veel storingen door water in de ring van vocht - gaan kijken naar andere technieken. De eerste generatie kunststofkabels begin 1990 zo'n beetje; die gingen niet zo lang mee. Vanaf 2000 hebben we hele andere type kabels gekregen, die veel beter geschikt zijn voor de toekomst. (R-5)	Milieubelasting materiaal
Hier staan de schakelaars. Hier zit olie in; dit noemen ze een olie arme schakelaar; er zit 15 liter olie in. Olie arm noemen ze dat. (..) Maar hiervan hebben we gezegd: dat is milieu onvriendelijk, dus dat willen we niet meer. Nou die maken ze ook niet meer dus dat is mooi. We gaan nu schakelen met vacuüm. Dat is een vacuümbuis waar contact in zit (R-12).	Milieubelasting stof
We hebben standaard kunststof kabels die gaan al 30/40 jaar mee, en elektrische verbindingen ook, schakelinstallaties die gaan we op dit moment niet vervangen, we gaan een stukje uitbreiden, dus daar zal je het in de techniek zeg maar niet vinden (R-5)	Milieubelasting materiaal
We zijn ook een kleine 20 jaar geleden begonnen met aluminium lichtmasten, dat was al een beetje bekend. We hadden altijd stalen lichtmasten, dus toen zeiden we ja als we aluminium lichtmasten nemen die gaan 40 of 60 jaar mee of zoiets, je hoeft ze niet te schilderen. Stalen lichtmasten moet je schilderen, dus ook milieubelasting; om de zoveel jaar moet je toch weer bijwerken en dan komen er zuren in de grond, en je moet het schilderen dat heeft ook een bepaalde belasting. Aluminium hoef je niet te schilderen, is makkelijk te recyclen. Staal is ook makkelijk te recyclen, maar dan moet je de verf er weer afhalen. Maar we zagen dat aluminium lichtmasten bijvoorbeeld 60%	Milieubelasting materiaal

duurder waren. Dan moet je wel die omslag maken van, gaan we nu naar aluminium toe? Dat we in de duurzaamheid, dat je het over zoveel jaar het gaat gebruiken, maar dat is toch duurder. Nou dat hebben we wel gemaakt (R-3)	
Bodem	
Hier in de ondergrond hebben we last van PFAS, dat is een goedje wat in de ondergrond zit daar moet je mee oppassen. Dus we moeten meer bewerkingen doen om aan de gang te kunnen; meer grondonderzoek doen, heb je bepaalde grondvervuiling en dat soort dingen, dan moet je weer bepaalde gebieden saneren (R-5)	Bodemkwaliteit
Met die hele PFAS discussie die toen ook – die pakten ze toen 5 jaar geleden al op de luchthaven rond. In 2016, toen was er paniek. Midden in een project dat ik toen liep. Toen moesten we ineens alle (..) van die grond, dus toen lagen er allemaal hopen want toen mochten we er niet meer aanzitten (R-7)	Bodemkwaliteit
Over het algemeen is dat in Nederland zo dat gaat over de Amsterdamse, dat alles op kabels en leidingen gebied in hetzelfde tracé waar je in gaat, die moeten eruit. En zeker de oude GLPK kabels, gepantserde lood kabels, die moeten eruit. Oliedruk kabels, die moeten er ook uit. (R-4)	Beslag op bodem
Dat is echt wel iets wat de laatste jaren goed gaat; dat (..) in het begin natuurlijk niet alles wat vervallen is daar blijft zitten. En nu als je er niet mee werkt, moet je het verwijderen. En daar zijn we hier op zich wel goed in geworden, maar hier ligt nog *zoveel* oud zeer (R-7)	Beslag op bodem
Ik ben bijvoorbeeld ook een voorvechter van het zo schoon mogelijk houden. Vroeger werd er veel meer gerotzooid hè, bijvoorbeeld er was een werk en de oude shit, of het bleef in de grond achter gewoon een hele pijp, of ze trekken een buis stuk en alle scherven en alles dat ligt allemaal nog in de grond, hup zand erover en klaar, ziet niemand meer. Maar ik ben zelf altijd wel een hele voorvechter geweest en ook naar de mannen buiten toe he, jongens: alles wat er in de grond zit of wat er niet in hoort, haal eruit (R-2)	Verontreiniging bodem
Wat we nu aan het doen zijn; we zijn de aanvoerleidingen van Vijfhuizen Nieuwemeer, daar zitten nog oude oliekabels tussen. Die oliekabels ja dat kan niet meer. Er staan overal van die druktanks, olietanks. En dat is gewoon een vat olie en die moet je zo af en toe bijtanken, dus dan vraag je je af van hé verrek, waar blijft die olie dan? Die verdwijnt gewoon in de grond. Die kabels lekken op de een of andere manier. Dus dat is gewoon niet goed voor het milieu. In die kabel zit een voor isolatie zit daar olie tussen. Die kabels zijn z*o* oud, die gaan lekken. Dus dan moeten ze af en toe even een druppeltje olie, dat is niet fijn (R-12)	Verontreiniging bodem
Er zit hier een club die doet voor Liander een onderzoek om die 50 KV kabels een nieuw tracé voor te vinden; dat zijn nu oliedruk kabels, dat worden kunststof kabels. Waar ik net even over sprak is dat we oliedrukkabels van de leverancier proberen te vervangen binnen 1/2 jaar, in plaats van oliedruk kabels naar kunststofkabels die een hogere capaciteit aan kunnen. Je hoeft ze dan niet dikker te maken, je kunt dezelfde grootte aanhouden (R-5)	Verontreiniging bodem

Ruimtelijke kwaliteit	
Wat je wel doet is de mantelbuizen meenemen voor de toekomst, voor de toekomst dat je niet hebt als het op over te breken dat hebben we wel meegenomen (R-4)	Anticiperen aansluiting toekomstige ontwikkelingen
Zoveel mogelijk kabels die passen bij het vermogen die gevraagd wordt, dus niet over dimensioneren want dikkere kabels gebruiken ook extra koper. (..) Elke kabel in de grond is een vervuiling als je het zo mag noemen, en hoe meer kabels hoe meer ruimte je nodig hebt, en zo licht mogelijk kabels toe te passen, dat scheelt ook in de productie. Dat is ook duurzaamheid (R-4)	Functionaliteit systeem passend bij vermogen
Normaal leggen we een weg aan en dan leggen we 30 kokers neer van verschillende doorsneden, een voor gas wat groter, en voor water wat groter, en voor elektriciteit en zwakstroom en laagspanning, leg je bepaalde capaciteit aan voor de komende 20/30 jaar (R-5)	Anticiperen aansluiting toekomstige ontwikkelingen
Met name vooral met K&L funest dat je wilt weten waar je toekomst wil liggen want dan kun je tracés aanleggen, want doe je dat niet dan ligt het *altijd* verkeerd. *Of* het ligt te diep *of* te ondiep, of mantelbuizen liggen niet op een plek waar je straks een weg overheen wilt hebben, of ze komen straks weer onder een voorbelasting, of onder een viaduct, of onder een rijbaan, er is altijd wel weer iets (R-7)	Anticiperen aansluiting toekomstige ontwikkelingen
Normaal leggen we een weg aan, en dan leggen we 30 kokers neer van verschillende doorsneden, een voor gas wat groter, en voor water wat groter, en voor elektriciteit en zwakstroom en laagspanning, leg je bepaalde capaciteit aan voor de komende 20/30 jaar (R-5)	Anticiperen aansluiting toekomstige ontwikkelingen
Je maakt een inventarisatie en dan zeg je van nou ik heb ongeveer een ruimtereservering nodig in dat gebied van 8 meter of 5 meter, dat is maar net wat je verwacht. Dus dat is in feite wat ik aan het doen ben in dat hele toekomstige verhaal (R-12)	Anticiperen aansluiting toekomstige ontwikkelingen
Dat staat bijvoorbeeld in het PvE: daar staat bij dat als je een kruising maakt met een weg (een asfaltweg) dan moet je daar mantelbuizen neerleggen. Een groot pakket mantelbuizen plomp je daar neer, en dan uiteindelijk hebben we dat ook weer in het GIS systeem staan (R-12)	Flexibiliteit toekomstige ontwikkelingen
Wat ik gelijk heb gezegd is, we moeten ook een onderzoek doen om te kijken of er een mogelijkheid bestaat dat we vanaf hier tot hier een soort kabels en leidingen tunnel kunnen gaan bouwen. Nou dat onderzoek heeft Arcadis voor ons gedaan, dus die heeft ook weer heel veel mensen geïnterviewd van joh wat – en ook eigen kennis en ervaring. En hoe zo'n tunnel er dan uit moest gaan zien, hoe veel scheidingswanden en hoe groot zou dat dan worden. En uiteindelijk: wat kost dat? Nou, dat gaat echt niet. Dat is niet. En dan krijg je dus wat die man ook al verteld van de Zuidas; het is zo lastig om het te beheren en om daar nog weer eens een keer een kabeltje bij te krijgen. Dus uiteindelijk hebben we het niet gedaan. Maar ik heb het wel laten onderzoeken, dat niet later dan zou je misschien die vraag nog wel eens kunnen krijgen van: verrek, waarom hebben we niet aan een tunnel gedacht? Gekken. Ja dan kun je zeggen we hebben eraan gedacht, onderzoek naar gedaan, dit waren de bevindingen en daarom hebben we het niet gedaan (R-12)	Anticiperen aansluiting systeem op toekomstige ontwikkelingen

We hebben er onderzoeken naar gedaan, en het is elke keer veel te duur. Omdat er steeds wijzigingen zijn. We hebben het op Schiphol Oost wel vroeger gehad, hadden we ook grote kabels en leidingen tunnels die wel ook onder water liepen Maar toen werd er wel goed over nagedacht, alleen het werd elke keer uitgebreid en toch eromheen gelegd, en een stuk tunnel weggehaald. En dan ga je een gebouw plaatsen, en dan kom je zo'n oud stuk tunnel tegen, moet je dat weer slopen. Ik denk dat het toekomst heeft, maar niet op een locatie waar iets zoveel aanpassingen heeft. (R-5)	Anticiperen aansluiting systeem op toekomstige ontwikkelingen
Sociale relevantie	
Als we het saneren dan melden we het aan als saneergrond, en dan zeggen hun dan moet het naar die handel of naar die hoop of het moet naar die schoonmaakinstantie. Soms laat je het reinigen, dat is goedkoper dan storten. Dus dan reinig je die grond en daarna transporteer je het naar een schone locatie, dan krijg je er geld voor. Dus dat bepaalt een beetje welke milieuclub we inhuren daarvoor ter (..) en die adviseert ons daarin met rapportages en met aanbevelingen (R-7)	Inwinnen en inzetten van de lokale expertise en specifieke kennis om relevante behoeftes van de gemeenschap te identificeren
Dat doen we wel bijvoorbeeld bij armaturen die vrijkomen vanaf het werk. Die gaan naar Panter, dat is een sociale werkplaats in Amsterdam. Die worden daar uit elkaar gehaald door sociale onderneming is dat - dus afstand tot de werkvloer - die gaan dat armatuurtje schoonmaken en die komen gereduceerd weer terug, en die komen daarna, dus dan zit er een hele stapel met armaturen. Die worden hier weer opgeslagen en die gaan zo weer terug worden die uitgewisseld. Dus kapotte gaan weer terug, komen gereduceerd weer terug, en dat kan dan 2 of 3 keer en dan is de armatuur afgeschreven (R-7)	Social return: inzetten van werknemers met een vergrote afstand tot de arbeidsmarkt bij de ontwikkelingen

Wat is binnen de projecten gedaan?	Oplossing	Duurzaam in project omdat	Fase
Bereikbaarheid			
Over kabels en leidingen; ik zeg misschien kunnen we die centrale as dan gelijk gebruiken als een hoofdas voor kabels en leidingen, dat ze bereikbaar blijven, of misschien een of andere centrale goot waar alles ingaat (R-3).	Adaptief infrasysteem	Flexibiliteit bieden voor verwachte toekomstontwikkelingen	Initiatie
Het was puur de reden om daar eigenlijk voor de toekomst een goot te hebben, waardoor je later altijd makkelijk in dat hoofdtracé waar niemand komt, en dat je daarom een goot hebt waar je dan je kabels kwijt kan om in de toekomst makkelijk naar achteren te kunnen komen of het voorlopig volle breedte van P3 (R-4)	Adaptief infrasysteem	Flexibiliteit bieden voor verwachte toekomstontwikkelingen	Initiatie
In het hoofdtracé een 10KV hebben we op een gegeven moment ook gekozen om die in een kabelgoot te zetten, te verplaatsen. Dat je er later ook nog bij kan, dat andere kabels er ook bij kunnen komen (R-4).	Adaptief infrasystem	Flexibiliteit bieden voor verwachte toekomstontwikkelingen	Ontwerp (VO)
Energiegebruik			
We hebben duurzaamheid ook bereikt in het ontwerp door goed te kijken naar aanwezigheidsdetectie van mensen; daar waar geen mensen lopen heb je ook geen verlichting nodig of kun je dimmen, die dimming is ook ingebracht. In die zin reduceren dat er ook wel nog steeds een veiligheidsgevoel is, en dat het beeld van de verlichting niet te grote verschillen gaan krijgen in de totale aanblik van het perceel (R-4)	Energiezuinig ontwerp verlichting	Reductie van energiegebruik en CO2 emissies in de gebruiksfase	Ontwerp (VO)
Voorderest hebben wij in dit geval wel naar duurzaamheid gekeken in verband met het inzetten van materieel tijdens de uitvoering. Dus ook onze onderaannemer weet dat hij met een motor moet komen in verband met je CO2 uitstoot. De kraantjes die er stonden zijn GTL getankt, in die zin is daar wel een beetje rekening mee gehouden maar dat zijn ook onze kraantjes geweest en wij van de BAM tanken eigenlijk allemaal GTL (R-10)	Alternatief fossiele brandstof	Reduceren energie in aanleg en onderhoudsfase (GTL: Efficiënter gebruik, vermindering uitstoot schadelijke stoffen en minder vervuiling op motoren dan diesel)	UO
Materialen			

Er komt nu *heel* veel grond vrij, omdat dat moet omhoog dus er moet zand op. En die grond ligt in de weg, maar straks moet je je berm aanvullen, je het moet het weer aanvullen dus dan heb je het terug nodig. Dus je gaat nu eerst verkopen daarna terugkopen. Dat hebben we met onze grondleverancier (...) Maar we hebben nu *zoveel* kuubs komen nu vrij die we later terug hebben dus nu hebben we een depot geregeld dat we het nu alleen storten en daarna halen we het weer op. (R-7)	Gebruik van lokaal materiaal	Lokaal opslaan en hergebruik van grond vergeleken met terugkoop proces	Project overstijgend
We kijken natuurlijk ook naar materialen; wat is nou het voordeel van een stalen of een aluminium mast in tijd, is ook natuurlijk in de eind levensduur van een component. Is het te hergebruiken? hoeveel CO2 komt er vrij? Niet dat je dat nou altijd zo heel diep gaat uitzoeken; van mijn stalen mast komt er dan op gegeven moment van als ik hem ga shredden dat ik hem kapot maak; kan ik kan hergebruiken? Maar in die zin kiezen we hier voor aluminium masten. Dat heeft het voordeel dat ze minder gevoelig zijn bij een wat meer agressieve omgeving als Schiphol. Waar staal toch veel te lijden heeft ten gevolge van kerosine dampen (R-4)	Milieubelasting materiaalproductie en aanleg	Gebruik van spaarzame materialen en beperken grondstofgebruik	VO
Ik weet bijvoorbeeld dat we op een gegeven moment hoorden van: dat type hoogspanningskabels die zijn nu geselecteerd om in te zetten bij nieuwe aansluitingen om in te kopen, omdat dat een goed recyclebaar materiaal is (R-2)	Circulair materiaal	Sluiten van materiaalketen door toepassing herbruikbaar materiaal	DO
We hebben die specifieke kabel die we moeten gebruiken, die P-laser dacht ik (R-7)	Circulair materiaal	Sluiten van materiaalketen door toepassing herbruikbaar materiaal	DO
Er is in deze maand wel nagedacht over het toepassen van de kabel: P-laser kabel. Dat is redelijk goed herbruikbare kabel, recyclebare kabel (R-8)	Circulair materiaal	Sluiten van materiaalketen door toepassing herbruikbaar materiaal	DO
Maar in het tracé de oude kabels waar we niets aan hebben of waar we wel wat aan hebben om te hergebruiken, die hebben we meegenomen. Hoewel dat beperkt was: het hergebruiken. Over het algemeen was alles wel aan z'n einde levensduur; vervanging moest sowieso plaatsvinden (R-4)	Hergebruik bestaand materiaal	Hergebruik van bestaande producten	VO
Water			

Schiphol heeft natuurlijk een uitdaging als het gaat om een bergen van hemelwater, dat komt overal vandaan. Ik ben geen deskundige op dat gebied, maar er was wel behoefte aan oppervlakte berging van water, en voor een bepaald gebied moet je het hebben. Dat was gevonden in P3 onder het asfalt met kratten. Daar is een investering, voorstel gedaan door BAM, ik had daar een berekening gedaan wat gaat de investering kosten? Dat is bij Schiphol in overweging genomen (..) ja bij die investering die gaan we doen die kratten hier komen onder een deel van P3 worden die geplaatst (R-4)	Ontwerp klimaat adaptief systeem	Borgen van voldoende opvangcapaciteit bij piekbelasting / klimaatadaptatie	Ontwerp (VO)

Andere mogelijkheden	**Oplossing**	
Uitstoot emissies		
Ik denk dat je nu verduurzamen moet op bijvoorbeeld graafmachines elektrisch te gaan maken, of kabeltrek machines, of als je persingen moet gaan maken onder grote wegen of watergangen, dat je dat met elektrisch aangedreven apparatuur moet gaan doen. (R-5)	Elektrificeren materieel	Hernieuwbare energiebron materieel
Zo'n boring maak je met een heel grote booropstelling. Valt daar qua duurzaamheid iets mee te doen? Wellicht een gerecyclede booropstelling maar zo'n ding op elektriciteit te laten werken dat gaat niet, omdat dat gewoon een heel zwaar apparaat is. Zo'n ding zou je wellicht kunnen aftanken met GTL, dan zou je daar een afspraak moeten vinden met je toeleverancier (R-10).	Materiaal van materieel of alternatieve energie	Reduceren energie in aanleg en onderhoudsfase
Milieubelasting materialen		
Je kunt kijken naar type trafo, type verdeler die erin komt staan. In het HS station kun je eigenlijk alleen de assets misschien slimmer maken waardoor ze zuiniger zijn. Dus misschien een zuiniger trafo die minder warmte afstoot (R-9)	Energiereductie koeling transformator	Reductie van energiegebruik en CO2 emissies in de gebruiksfase
Misschien kun je in plaats van dat je dat hokje zwart schildert, wat bij ons standaard is, dat gewoon wit doen zodat dat niet zo warm wordt, zodat je minder koeling nodig hebt. Zo wordt er nog helemaal niet gedacht bij ons. Je hebt een hoofdstation, en dat is zwart, punt. Want dat is al jaren zo (R-13)	Energiereductie koeling transformator	Reductie van energiegebruik en CO2 emissies in de gebruiksfase

Als we daar een HS station neerzetten, dan doen we er een groen dak op, of we leggen er PV panelen op. Heb je toch weer je eigen gebruik van je stationnetje opgewekt (R-13)	Hernieuwbare energie opwekking	Decentrale opwekking energie
En het liefst zie ik dan nog dat we nog een stapje verder gaan: je hebt af en toe ook een wat grotere plek nodig waar je voertuigen gaat parkeren, en dus laadvoorzieningen gaat maken, ook al is het misschien klein: zet er een zonnepanelen-dak op (R-9)	Hernieuwbare energie opwekking decentraal	Decentrale opwekking energie
Als je kijkt naar zo'n HS station zou je misschien ook kunnen zeggen van: nouja, misschien moeten we eens kijken naar, een stap verder, want dat doen we op Schiphol al (..) wel, kunnen we de materialen van het HS station zelf hergebruiken? Dus het station zelf; kunnen we beton hergebruiken of hoe kunnen we daarmee omgaan? (R-9)	Hergebruik materialen hoogspanning station	Sluiten van materiaalketen door toepassing herbruikbaar materiaal
Ik denk dat je kunt kijken naar de leveranties van onderaannemers. Dus jouw station, had die wellicht duurzamer gebouwd kunnen worden met gerecycled beton, of gerecycled wapeningsstaal. Of een speciaal soort toevoeging aan het beton om te zorgen dat het beton milieuvriendelijk wordt (R-10)	Hergebruik materialen hoogspanning station	Sluiten van materiaalketen door toepassing herbruikbaar materiaal
Het hergebruiken van onze schakelaars. Het komt best vaak voor dat wij aansluitingen weghalen, weet je zoals nu gaan we bij AH pick-up point wordt weggehaald. Ik vraag me af wat we met die trafo doen. Ik zeg: sla 'm op en hergebruik m. Maar ik ben bang dat we 'm op de schroot gooien. (R-13)	Hergebruik assets: schakelaars	Hergebruik bestaande assets waar mogelijk
We gaan binnenkort wat gasleidingen vervangen, wat kunnen we ermee als Schiphol? Gewoon niet op een project gooien maar meer ambities eroverheen gooien. (..) Er komt zometeen een kilometer aan gasbuizen vrij, waarschijnlijk zal het PE zijn of een stuk staal zijn. Wat kunnen we ermee? Daarna moet er weer 500 meter terug, kunnen we dat omsmelten, kunnen we dat terugplaatsen, kan het schoongemaakt worden en weer één op één terug? (R-7)	Lokaal hergebruik oude gasleidingen	Sluiten van materiaalketen door toepassing herbruikbaar materiaal
Wat ik bijvoorbeeld *ongelooflijk* zonde vind is dat wij de gasleidingen weg gaan halen. Terwijl je ze ook *heel* goed kunt gebruiken als een koker voor eventueel vervolgkabeling. En vervolgens gaan we een jaar erna een boring doen omdat we daar naartoe moeten met kabels en leidingen. Dan denk ik: laten we daar.. met die omturning van gas: ik snap dat je het goed moet afdoppen en dat je daar voorzichtig mee moet zijn als er nog gas in zit, maar zodra die leidingen leeg zijn kun je ze hergebruiken voor heel veel slimme dingen. Doe dat samen met ST en leg er glas in. Dat soort dingetjes daar is zoveel op te winnen. (R-13)	Lokaal hergebruik gasleidingen	Sluiten van materiaalketen door toepassing herbruikbaar materiaal

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