Developing a Catalogue for Sustainable Knowledge Sharing in Public Tenders

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MSc Sustainable Design

Master Thesis
May 2022

AALBORG UNIVERSITET

STUDENTERRAPPORT

Master's Thesis, AAU - Copenhagen
Program: MSc Sustainable Design

Hand-in date: 06/05-2022
Exams dates: 18/05-2022

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Characters including spaces: 239.275 characters
Normal pages: 99,6 normal pages
Pages in total: 102 pages (excluding appendices)
Pages in appendix: 32 pages

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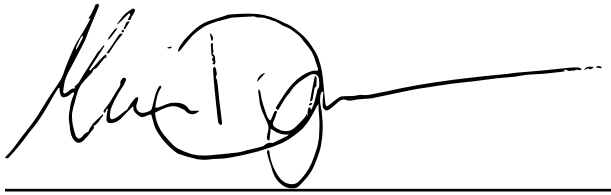

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Abstract

The project the following thesis is written about investigates the complications that currently block the prioritization and involvement of sustainability in the tender process of construction projects. Based on this research, a catalogue of instruments is prepared that reports sustainable initiatives, which aims to contribute information that can usefully alleviate the existing challenge in the industry. The project is intensified and delegated to the project group by the organisation of Banedanmark, with a desire to facilitate sharing of knowledge between developers in the construction industry and create a starting point for an acceleration of sustainable innovation in the industry. The initial research will draw on experience and knowledge from developers within various types of construction projects. Initiatives in the catalogue will thus not only be targeted at developers in infrastructure but will also not report initiatives that are not relevant to these. Based on empirical data collected through this thesis, an obligatory passage point(OPP) is analyzed, which constitutes an overall need for the actors that are a part of the construction industry's network. The OPP that allows sustainability to be given higher priority in the construction industry is analyzed to be a need for quantitative data in sustainable initiatives, which thus becomes a key element in the development of a catalogue of instruments.

Preface

Preface

The following master thesis has been prepared by Sigurd Hoffmann Buhl, Jacob Toft Christiansen and Maria Dyremose who all three are students from the master's program Sustainable Design at Aalborg University. The thesis was started in December 2021 and completed in May 2022.

In parallel with the thesis, a prototype of a catalogue of instruments has been developed, which this thesis will describe the preparation of. The purpose of the catalogue has been for it to serve as the preparation for Banedanmark to develop their own catalogue of instruments, and to do some preliminary research that Banedanmark can later follow up on.

On this occasion, the project group wishes to give their appreciation to Banedanmark, for providing the opportunity to work in an exciting and dynamic field, that is highly relevant to the project group's education. Søren Boas and Jacob Bech Nicolaisen should especially be thanked for being facilitators for the collaboration between the project group and BaneDanmark.

In addition to Banedanmark's contribution to the development of the catalogue of instruments, many different actors from the construction industry have helped to create a versatile catalogue that manages to facilitate knowledge sharing across developers with different organisational backgrounds. A huge thank you to all actors who have contributed with knowledge, ideas and perspectives to the project.

Finally, the project group wish to thank the supervisor of this thesis, Michael Søgaard Jørgensen who has initiated exciting discussions and guided the project group from the beginning to the end.

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1. Setting the Stage

The following chapter provides an introduction to the thesis. Firstly, the overall problem in the construction industry is presented, which constitutes the incentive on which the thesis is based. Subsequently, the thesis is put in context in a description of the goal and scope, where an exclusive focus is placed on how the problem is challenged. The goal and scope will be followed by a delimitation of sustainability that is adapted to the scope of the thesis. Finally, the design process and structure of the thesis are outlined.

1. Setting the Stage

1.1 The Problem of Construction

In the last 10-15 years, there has been a change of focus in the construction industry from energy being perceived as the biggest environmental problem, to today where a huge concern as well involves the amount of CO_2 emitted in the industry. According to Danish Standard, the construction industry is responsible for 30% of the total CO_2 emissions, making them one of the most polluting industries in terms of the greenhouse effect in Denmark (Dansk Standard, 2022). Out of the total CO_2 emission in construction, 28% consists of operating energy, which includes energy consumption for cooling, heating, and lighting (Deloitte Denmark, 2022). The remaining 12% is emitted from the production process involving the use, disposal, and recycling of building materials, which constitute the total life cycle of a building (Hansen, 2021).

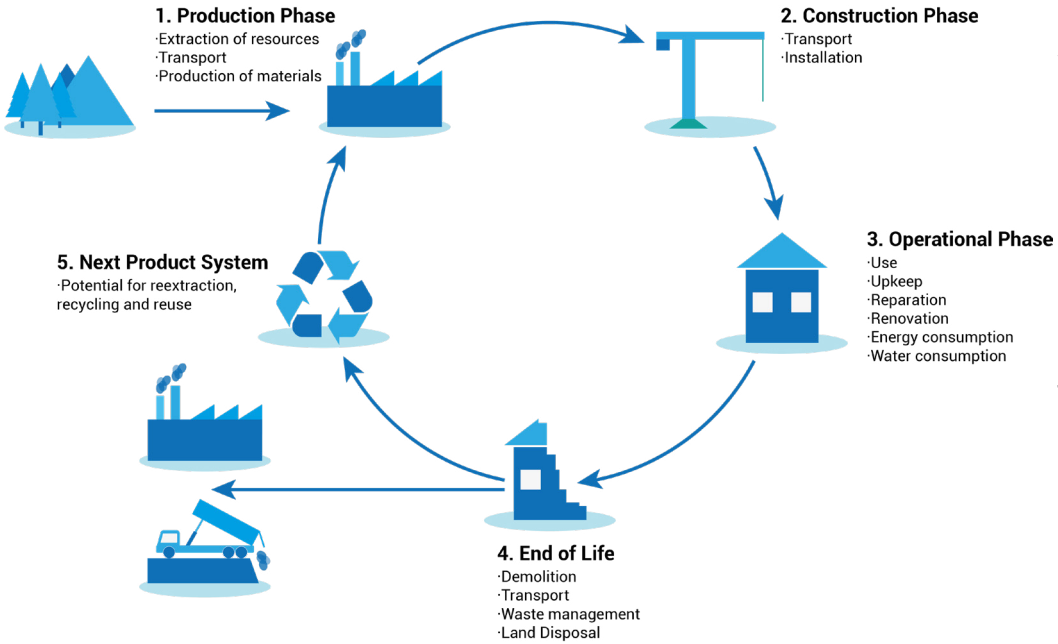


Figure 1: Current material and resource stream in generalised construction (LCAbyg, 2022).

While there has been a positive development of energy consumption in buildings as a larger proportion consists of renewable energy, and in Denmark, greater and greater independence is created from fossil fuels, the same positive development does not apply to the processes that make up a building's life cycle (NG Zink, n.d.). There is a general lack of guidelines and requirements at the various stages of a building's life cycle that can limit CO_2 emissions (NG Zink, n.d.). The industry needs to rethink material life and replacement, as well as the use of long-lasting non-toxic materials, to correct the climate impact of these phases. This is also necessary as the construction industry's waste accounts for over 30% of Denmark's total waste, making the industry one of the most waste-generating (Cirkulær økonomi i byggeriet, 2022). However, there is a great potential for recycling construction materials if they are pure fractions of material. At present, 87% of all construction materials are recycled, primary for road fill (Deloitte Denmark, 2022).

The UN Panel on Climate Change shows that it is necessary to significantly reduce any kind of climate impact over the next 10 years if a temperature increase above 1.5 degrees is to be prevented (UN, 2022). Reducing carbon dioxide in the construction industry is one of several areas of action that need to be prioritised to stay within the planetary boundaries (Steffen et al., 2015). The framework of the planetary boundaries defines environmental limits within which humans can safely operate within. Exceeding these limits can have disastrous

consequences for the environment and can push the earth into a new state. Staying within the planetary boundaries calls for immediate action within those industries that do not yet have guidelines that delineate the environmental impact.

1.2 Future Regulations of the Market

Going forward, more regulations and requirements will be introduced to the construction market. Some initiatives are already in the making. One initiative involves the introduction of Life-Cycle-Assessment (LCA), for quantifying environmental data, which is fundamentally important for setting sustainability requirements. For this purpose, LCA plays a fundamental part as the instrument is applied to analyse and calculate the environmental impact and carbon footprints of all life cycles. Thus, LCA establishes a starting point for being able to standardise and compare the environmental impact of different building projects. To combat the problem of a lack of data comparison basis, LCA will be a mandatory requirement from 2023, and buildings larger than 1000 m2 must comply with a determined limit value for CO_2 emissions per m2 (Teknologisk Institut, 2021). In October 2020, the Økonomistyrelsen launched a strategy for public green procurement (Økonomistyrelsen, 2020). The strategy describes a wide range of initiatives in the procurement- process and area, to ensure a greener procurement with the public sector. The different initiatives that are a part of the strategy have different launch times depending on their adaptability. The strategy is prepared as a consequence of the Danish government's strategy "A Green and Sustainable World" which aims to contribute to at least a 55% reduction in greenhouse gases by 2030, and climate neutral by 2050 (The Danish Government, 2020). The strategy from Økonomistyrelsen effect tendering among all public actors, is based on three focus areas as seen in figure 2.

1.3 The Individual Inclusion of Sustainability

Broadly, the construction industry can be divided into three sections: Building construction, infrastructure construction and industrial construction. Which sustainability initiatives are relevant may vary in the three, as different priorities must be taken into account. Infrastructure

1. Green Action Now

Describes the most adaptable measures involving;

·A 60% purchase of organic food,
·Climate compensation for all state flights,
·A mandatory effort for state punches to consider life cycle costs instead of the price of an item at the time of purchase

2. Long-term Sustainability

Addresses initiatives that require a slower transition. It involves initiatives such as;

·Switching to emission-free cars in the state municipalities and regions,
·State energy savings, Reduction targets for the climate footprint
·An obligation on the part of state institutions to send buyers on competency development courses.

3. Sustainable Knowledge & Tools

This area focuses on informing and concretizing sustainability. It involves initiatives such as;

·An annual calculation and projection of the climate footprint of the total public procurement is carried out, which forms the basis for the determination and follow-up of future reduction targets
·A Guidance is prepared on how to make requirements for longer warranty periods with the aim of extending the life of products.

Figure 2: Author illustration of the three focus areas in the strategy of Økonomistyrelsen (Økonomistyrelsen, 2020).

construction, for example, has a lot of safety measures and may be less willing to experiment with new methods and innovation projects, as it is associated with a greater risk.
Several municipalities and regions in Denmark have politically adopted strategies and action plans for sustainability in their construction, but it can be a complex practice to get initiatives implemented in the construction process, that can fulfil these visions. The description of sustainability in a construction project takes place in the tender, which consists of the requirements specifications and conditions that are made concerning a construction project. Based on the tender, various contractors who wish to undertake the project and be responsible for the execution itself can submit an offer/bid that describes how they can accommodate the requirements in the tender. Sustainability requirements in the tender documents aim to ensure sustainability initiatives in the early stages of construction and to include them in the building program. As sustainability is a relatively new practice for most developers, there is a need for information and experience to be shared between developers, about how sustainability can be integrated into the tender. It is thus necessary to develop instruments that can accumulate sustainability knowledge in construction and tendering, to accelerate a sustainable transition.

1.4 Goal and Scope

Broadly, the construction industry can be divided into three sections: Building construction, infrastructure construction and industrial construction. Which sustainability initiatives are relevant may vary in the three, as different priorities must be taken into account. Infrastructure construction, for example, has a lot of safety measures and may be less willing to experiment with new methods and innovation projects, as it is associated with a greater risk.
This thesis has been prepared based on a collaboration with Banedanmark, and Vejdirektoratet to create a catalogue of instruments that can report sustainable initiatives in the construction industry. Specifically, the thesis emphasises the facilitation of knowledge and experience sharing, between developers within the industry. This includes all three branches of construction. Sharing of knowledge and experience in the industry aims to inspire actors on how sustainability can be included in tenders, and understand the complications related to it. To manage this, the initiatives that make up the catalogue of instruments will reflect different actors in the industry's practical experience with sustainability, as well as their needs. To understand the need for a catalogue, the thesis will based on an actor-network perspective, analyse the concerns of different actors. Thus, the thesis will examine the different actors' concerns and investigate how these concerns can be implemented in a catalogue of instruments. Likewise, the thesis aims to investigate how sustainability can be incorporated in a large public organisation such as Banedanmark, consisting of many internal restrictions and regulations, and how they on an organisational level are blocking the adaptation of sustainable initiatives. The intention and goal of the thesis are summed up in the following statement:
The thesis will answer this research question based on the need for

How can a catalogue of instruments be developed to circulate between actors in the construction industry and facilitate knowledge sharing of sustainable initiatives for public tendering, contributing to accumulating an experience base that accelerates sustainable development?

knowledge sharing expressed by actors in the construction industry, as well as on the delimitation of sustainability set by Banedanmark. Despite the instrument catalogue aiming to inspire actors on how sustainability can be implemented, the finished version of the catalogue can only be perceived as a prototype that can contribute with initiatives and considerations to what a similar catalogue, developed by Banedanmark, could include.

To answer the research question and clarify the purpose of the thesis, the aim is to answer the following two sub-questions:

1. *How can a catalogue of instruments represent knowledge that is relevant for actors across different organisational boundaries?*
2. *What is currently blocking sustainable development in the organisation of Banedanmark, and where exists the room for manoeuvring at the organisation that allows the inclusion of sustainable initiatives.*

1.5 Delimitation of Sustainability

In the preparation of a catalogue of instruments that report sustainable initiatives to actors in the construction industry, there is a need for a clear delimitation of which initiatives are relevant to the catalogue, and thus what is meant by sustainable initiatives. Despite that no universal definition of sustainability exists, various theorists have presented their take on what the term implies. One definition was published in 1987 by The United Nations in the Brundtland Report and frames the term as; "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987 p. 41). Within this broad definition of sustainability, there are frameworks that to a greater extent concretize sustainability by identifying specific focus areas. One of the most popular frameworks is the UN's Sustainability Development Goals, which outline 17 global goals that together aim to end poverty, protect the planet, and ensure prosperity by 2030. These 17 goals create a common global understanding of which focus areas are relevant to creating a sustainable future. Several organisations apply the sustainable development goals to develop internal strategies for how sustainability is to be integrated into the company, by specifying which and how concrete goals are prioritized by the organisation. One of these is the organisation of Banedanmark, which has selected five partial development goals that constitute their sustainability strategy as illustrated in figure 3.

The five sustainability goals that Banedanmark's sustainability strategy is built upon, include social, economic and environmental focus areas. The demarcation of sustainability in this thesis is based on the collaborator's requirements for the catalogue. Banedanmark defines sustainability based on a three-dimensional focus area involving a social-, economic-, and environmental focus, which is like the traditional Brundtland division (World Commission on Environment and Development, 1987). However, Banedanmark is mainly interested in circulating initiatives that focus on environmental improvements, as this area is deficient in the organisation. Consequently, the preparation of a catalogue of instruments will solely convey initiatives that facilitate environmental considerations, and thus sustainability in this thesis will be delimited to this. This delimitates sustainability to involve initiatives that have an environmental focus, and that can be categorized under one of the SDGs shown in Figure 3.
To contextualize and delimit the level of sustainable development, Ceschin and Gaziulusoy's (2016) model of different design approaches, is

BaneDanmarks delimnination and use of SDGs

SDG 9 Industry, innovation and infrastructure

BaneDanmark wants to support the green transition in Denmark, by electrifying railways and will introduce a new signalling system, that can increase the transportation of passengers and goods, by increasing capacity and more precise scheduling within the railway network.

SDG 11 Sustainable Cities & Communities

BaneDanmark wants to reduce noise and particle pollution along railways with initiatives for good neighbourship and sustainable urban areas.

SDG 12 Responsible Consumption & Production

BaneDanmark wants to initiate green and sustainable solutions via procurement and reuse of its waste materials, with the consciousness about the materials being used to maintain the railways are not renewable.

SDG 13 Climate Action

BaneDanmark wants to reduce the railways' CO2 emissions and contribute to the reduction of global warming and climate-proofing of the railway network to keep it robust against climate change.

SDG 15 Life of Land

BaneDanmark wants to protect the many animals and plants that live in the areas of the railways and secure rich biodiversity.

Figure 3: Development goals of Banedanmarks sustainability strategy (Banedanmark, 2021).

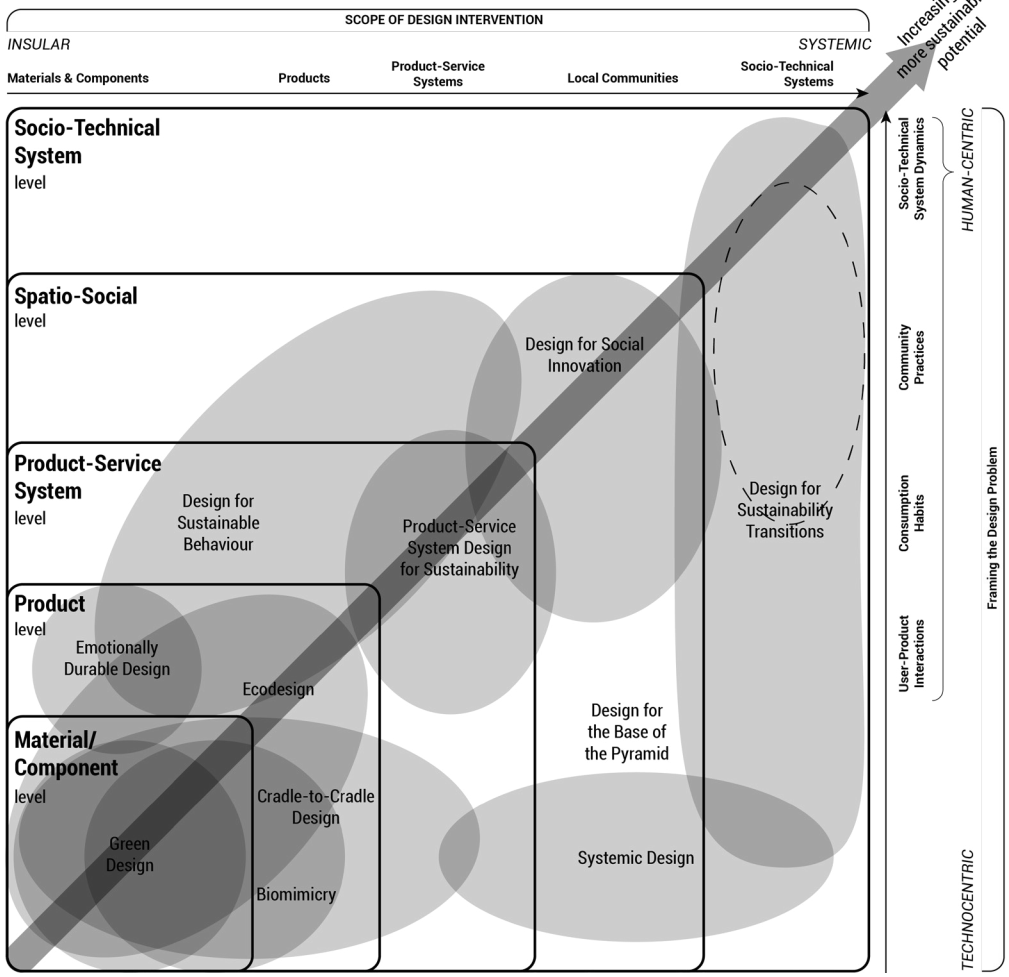


Figure 4: Author illustration of the thesis level of design approach. The thesis' placement is illustrated by the dashed circle (Ceschin & Gaziulusoy, 2016, p. 148).

applied (Ceschin & Gaziulusoy, 2016). Figure 4 illustrates different levels of sustainable development where the horizontal axis constitutes the aspect ratio of a design from insular to a systemic level, and the vertical axis frames the design problem from technocentric to humancentric. In summary, different design approaches can be categorized over five levels, each with different levels of sustainability potential. As illustrated in figure 4, the diagonal arrow shows that the sustainability potential becomes larger, the higher the level of design. This thesis aims to design a socio-technical transition that has the highest sustainability potential. "Designing for systems innovations and transitions focuses on the transformation of socio-technical systems through technical, social, organisational, and institutional innovations." (Ceschin & Gaziu-

lusoy, 2016, p. 138). Contributing with a catalogue of instruments in the construction industry that will help to establish new practices among organisations, municipalities and regions, will support a translation of the network. The catalogue will contribute to an acceleration of a new sustainable system, through the sharing of experience and knowledge. Figure 4 illustrates the level at which the design approach of this thesis is located.

1.6 Design Process

The design process of this thesis was initiated in December 2021 where meetings were held with the collaborator of the thesis - Banedanmark. Here, various topics were discussed concerning Banedanmark's need for research and the project group's interests in various topics that Banedanmark proposed. At the end of December 2021, a topic was decided on involving the preparation of a catalogue of instruments that report sustainable initiatives in the construction industry. As illustrated in figure 5, the design process was planned based on the double diamond model, consisting of four phases; Discover, Define, Develop and Deliver, which the design process roughly has been divided into. However, even though the process has gone through all four phases in roughly the same order, the actual design process proceeded more iteratively than is illustrated through the double diamond model. This is caused by the unpredictability that is a prerequisite before progressing research, where the knowledge space is frequently expanded, and new speculations arise. Likewise, in the definition phase, new ideas and approaches to research may arise that result in a return to the previous phase. The synthesisation of the catalogue of instruments has also been an example of how the process has been iterative, as the individual initiatives have been adjusted based on the knowledge and advice from different actors. Therefore, the application of Newman's squiggle (Gekeler, 2019) can help to describe the design process, by illustrating how the design process is initially changeable and messy after which the direction becomes more fixed, as more knowledge is acquired. The actual design process of this thesis can therefore be illustrated as an intermediate between the structured double diamond model, and the messy iterative process of Newman's squiggle as can be seen in figure 5.

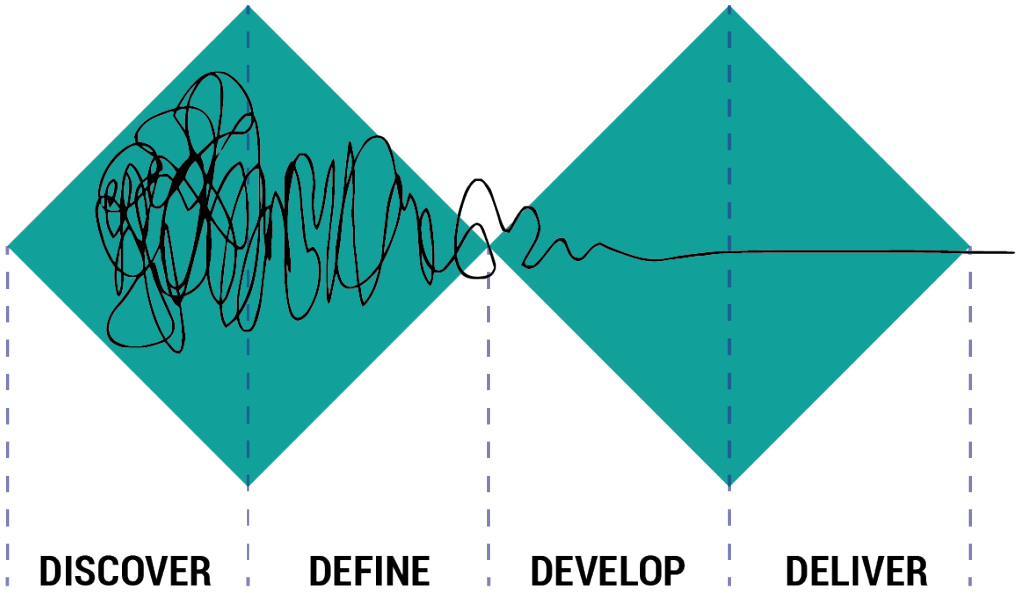


Figure 5: Author illustration of the design process of this thesis.

2. Theoretical Framework

2. Theoretical Framework

2.1 Boundary Objects

According to Carlile, boundaries between knowledge can be categorized as either localized, embedded or invested in practice, within a function. To break these boundaries and introduce new knowledge across them, a syntactic, semantic or pragmatic approach can be applied. Across these, boundaries can be transcended by the introduction of a boundary object. Boundary objects are objects that manage to exchange knowledge across knowledge boundaries and *"objects that are shared and shareable across different problem solving, contexts. […] objects that work to establish a shared context that "sits in the middle"* (Carlile, 2002, p. 451). The purpose of a boundary object is thus to mediate tacit knowledge by synchronizing and aligning knowledge through a common syntax or language (Carile, 2002). The introduction of a BO facilitates a process where knowledge is transformed as individuals represent, learn, negotiate and alter knowledge. (Carlile, 2002)

It is argued in this thesis that a boundary object is used to translate knowledge and create a language for sustainability twice. The first BO used is the survey which collects various initiatives from developers in Denmark. Through this, actors can translate knowledge about sustainability, and get a common syntax for what sustainability entails. In addition, the catalogue of instruments also functions as a BO, as it crosses knowledge boundaries between the developers and the project group, creating a precondition for knowledge to be translated. Going forward, the catalogue will also function as a BO between developers across organisational purposes, as through the catalogue they will discuss the relevance of initiatives across organisational purposes and priorities.

2.2 Intermediary Objects

The ethnography-enriching tool, an intermediary object, is a material object that generates data collection through its circulation from one site to another. These objects evolve through the interaction of different societies (Vinck, 2012). An intermediary object can be considered as a form of material representation that reveals habits, intentions, power relations etc. as well as transforming and mediating knowledge (Vinck, 2012).

The iterative development of the instrument catalogue where various developers are engaged in the development process and change the catalogue through their attitudes and concerns categorizes the catalogue of instruments as an intermediary object. The development of the catalogue through circulation between different developers, who are part of different organisational purposes and priorities, reveals the activities and concerns of actors across organisational boundaries (Vinck, 2012).

2.3 Arenas of Development

This theory is used to discuss and understand the "arena of development" which a notion is to describe the relation between actors that happens due to development. These arenas are different unstable areas between actors, both humane and nonhumane, where constant reshaping and restructuring happens in development. Jørgensen & Sørensen describe development arena as:

"A cognitive space that holds together the settings and relations that comprise the context for product or process development that include..." (Jørgensen & Sørensen 1999 p410).

This report is being used to describe the different actors and agendas within their arenas and how its related to sustainable development. The

purpose is to understand the potential future for the sustainability arena in the construction industry.

2.4 Actor-Network Theory

From an actor-network-theory perspective, issues in this thesis are considered as a result of complex socio-technical networks consisting of human and non-human actors. In this way, an actor can be considered part of a network where the relations between actors determine their position (Callon, 1986). The mapping of the relations between actors only determines a snapshot of the construction of the network, whereas real-life relationships are dynamic and constant changing.

When analysing these actors and their relationship with other actors in the network, there are various matters of concern and controversies between them which contribute to defining the relationship between them. In an ANT context, Callon (1984) describes an obligatory passage point (OPP) which is an attribute that solves concerns for all actors concerning a specific problem. An OPP analysis is therefore central to making changes in a network and reconstructing it so that it benefits a solution to a specific problem.

This thesis analyzes the matters of concern and controversy of actors in the construction industry, concerning what prevents sustainability from having a more central role in the procurement process. This forms the precondition for an OPP analysis, which examines what is necessary to create better conditions for all actors in the network, for sustainability to be prioritized.

2.5 Circular Economy Strategies

Different strategies exist for designing business models. They can be roughly divided into three main categories depending on whether they narrow, slow or close resource loops (Bocken et al., 2016). Strategies aimed at slow resource loops will attempt to delay a system's resource flow and thus extend the life of materials or products. The longer the life of products and materials is extended, the more the resource loop is delayed as it will reduce the need for production. Narrowing resource flows is a strategy to reduce the consumption of resources, thus using fewer resources per product. Finally, the strategy of closing resource loops aims to create a completely circular system where materials are recycled and remain within the system. Ideally, a closed-loop will produce no waste.

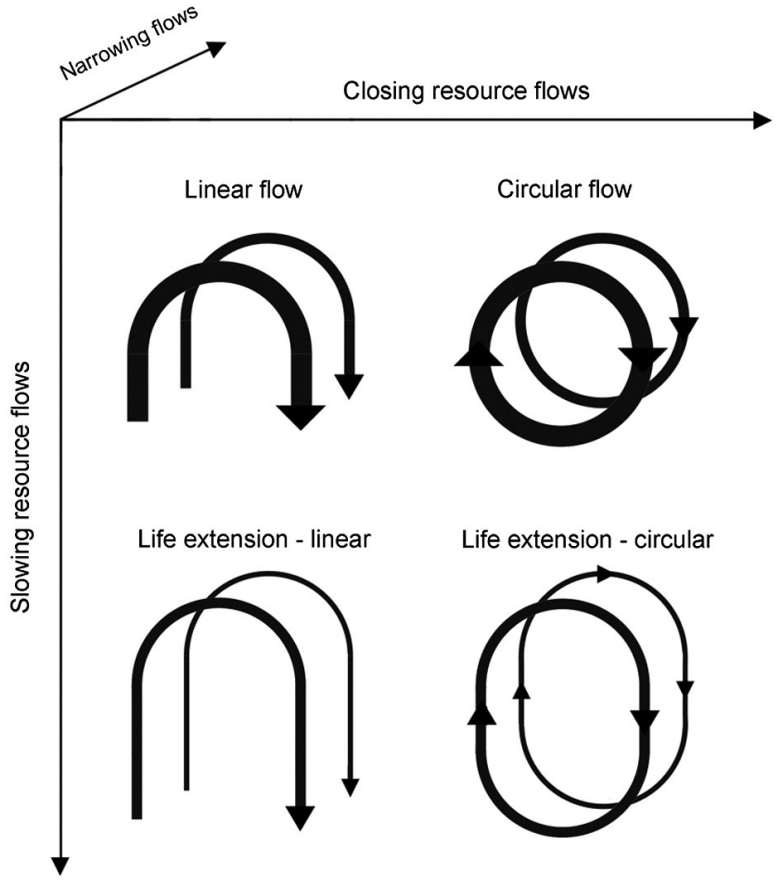


Figure 6: The circular economy strategy's affecting resource loops (Bocken, 2016)

2. Theoretical Framework

In the development of the survey in this thesis, Bocken's design strategies have been used to make some categorizations of sustainable initiatives that different developers may have had experience with. The various design strategies have thus been used to create a language for what can be perceived as a sustainable initiative. The design strategies were chosen to define the sustainability categories in the survey because the project group had repeatedly experienced through interviews and conversations with Banedanmark, that initiatives typically could be categorized within one of Bocken's business model strategies.

3. Methodological Framework

3. Methodological Framework

3.1 Co-Design

Co-design is a method where relevant actors are involved in the design process to make the final product reflect their knowledge and concerns. According to Pedersen (2020), actors' issues and concerns can be effectively negotiated in a co-design process. "Acknowledging that all individuals can be creative, co-design traditions such as participatory design view the designer not only as a creative expert designer who envisions products and solutions, but
also as a facilitator who stages negotiations between actors with oftentimes contested and conflicting values and concerns "(Pedersen 2020 p.61).

Throughout this thesis, the concerns and perspectives of actors have been central to the development of a catalogue of instruments. Specifically, initiatives for the catalogue are included in the catalogue based on their relevance to the various actors that have been involved, and the final version of the catalogue is, therefore, a product of various developers' participation as co-designers. In this process, the project group has acted as facilitators with the responsibility for navigating through the various perspectives and concerns and including the right actors at the right time.

3.2 Survey

A survey can be an effective method of systematic collecting larger amounts of empirical data from a sample of units, to represent a larger population (Groves et. al, 2004). Although there is no definitive procedure for conducting a survey, it regularly consists of a series of questions addressed to a specific segment (Ponto, 2015).

Through this thesis, a survey has been applied to collect sustainable initiatives from all regions and municipalities in Denmark. The data collected through the survey has thus provided a foundation for understanding which initiatives are previously or currently applied by various developers. Likewise, the survey has collected data on the execution of each initiative as well as the municipalities' and regions' experience with the specific initiative. The experience covered both the positive and negative consequences of the initiative, but also a description of how project-specific the initiative is, according to them.

3.3 Affinity Diagram

An affinity diagram is used to organize larger amounts of empirical data so that it is manageable to interpret (Holtzblatt & Beyer, 2017). By arranging accumulated data from research into categories, the diagram can effectively reveal commonalities in data and help to identify key points, problems, or solutions, depending on what is relevant to the study. Since this thesis has conducted many interviews with many different actors, each involving different perspectives, solutions and concerns, an affinity diagram has helped create a structure for a large amount of data. The Affinity diagram, illustrated later in this thesis, creates an overview of how actors' perspectives are aligned and connected across groups of actors. Based on the affinity chart, it was possible to identify matters of concern from different actors in different actor groups and get an overview of whether certain perspectives were specifically representative of a group of actors.

3.4 Prototyping

According to Pedersen (2016), prototyping should be considered "[…] as a sensitising device for analysing translation of knowledge and actors at certain moments in a participatory design process. " (Pedersen, 2016 p68). In this sense, there is a widespread focus on the design interactions that take place in a prototyping process. Comprehensively, Pedersen introduces three processes related to prototyping: Staging, Facilitation, and Synthesis. Staging refers to the selection process that relates to the configuration of the entire space, which includes which actors should be invited to the stage and for what reason. Facilitation describes the use of prototypes as boundary objects representing an OPP, to disseminate knowledge between actors, and through which interessement and negotiation take place. Finally, Synthesis describes the application of the knowledge gained jointly, which is synthesized into a new prototype.

The prototype process as described by Pedersen (2016) through three Sub-processes, is used in this thesis to structure the development of a catalogue of instruments. The conceptualization chapter describes how these 3 sub-phases have been integrated into the development of the prototype.

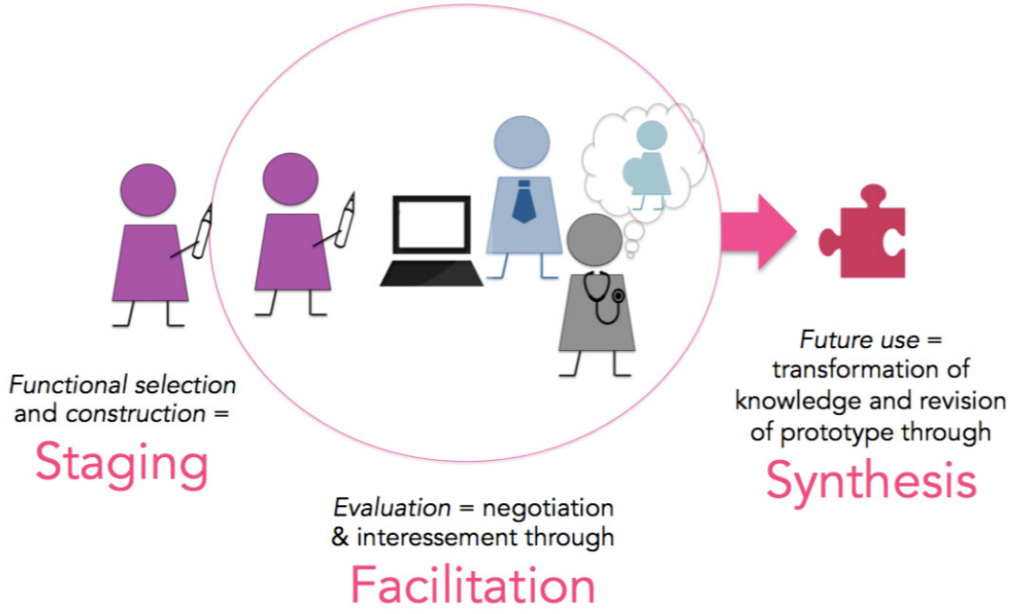


Figure 7: The three steps of prototyping (Pedersen, 2006, p. 67).

3.5 Semi-Structured Interviews

Semi-structured interviews are a way of structuring an interview to gather qualitative data beyond the researcher's knowledge boundary that stays relevant to a specific topic. The interviewer aims to set a direction for an interview, without controlling it to such a degree that answers are not sufficiently elaborated (Kvale & Studentlitteratur, 1994). In practice, it entails preparing open questions that initiate discussions, without leading to concrete answers (Kvale & Studentlitteratur, 1994). Keywords can effectively be used as a reference point in semi-structured interviews to understand the concerns, knowledge, and experiences of different actors (Harrell & Bradley, 2009).

Semi-structured interviews are used in this thesis for collecting data from various actors in the construction industry. Using semi-structured interviews has allowed the collection of data with both relevance and depth from pre-defined topics, but also data emerging from the conversations developed. The interviews aimed to make sure that specific topics were covered but also allowed for other relevant topics to be addressed, that were not considered initially. Thus, the structure has ensured that the needed data was collected, while also allowing other input and perspectives outside the project team's frame of understanding. In the table below a summary of all the interviews in the project can be seen, some of them will be explained in-depth later in the report.

Name, and date of the interview.	Organisation and interviewees position	Reason for interviews. Short summary
Søren Hvilsted (d. 3/2).	Specialises in IT and tendering. Tolstrup & Hvilsted	For this interview we wanted to understand how tender, legislative regulations can affect integration of sustainability. We got insight into how different regulation and tender creation can affects the inclusion of sustainability.
Ilka Bodewadt Lauritzen (08/02).	Tender adviser with specialty in Entreprenurial forms. At VILTOFT Advokater.	We interviewed Bödewadt Lauritsen to get insight in how sustainability can be included and supported in tendering, from a legal standpoint. Furthermore, we gained valuable insight in how responsibility is divided between the developers and contractors.
Magnus Bjerre Clausen (04/02).	Tender adviser, with focus on conflict management. At Poul Schmith/Kammeradvokaten.	In this interview with Bjerre Clausen, we gained knowledge on which technical legal initiatives can be used to further sustainability in the tender material. We gained insight in how legal disputes emerges in relation to tendering and how they are solved. We also gained knowledge on how responsibility is divided among actors when working with recycled materials or other sustainable initiatives.
Kamille Bollerup (18/02).	Region Nordjylland, Tendering consultant.	We conducted this interview to get better insight in how regional administrations function as developers as well as getting knowledge about what sustainable initiatives they employ. Lastly, we talked about their collaboration between municipalities and other regional administrations.
Mark Masana. (17/02).	Team leader of the Tendering Unit in Herning Municipality.	In this interview we talked how Herning runs in tenderers and what they prioritize and implants regarding suitability. We also discussed the position of infrastructure projects between different municipalities, region, and other public actors such Banedanmark and Vejdirektoratet. We gained insight into the influence of political leadership and its effect it has on local public tendering culture.
Carsten Holst Nørgaard & Kim Bruun, (22/02).	Project director & tender manager. Aarslef Rail A/S	Here we talked about how Aarslef Rail implant sustainability into its projects and how they react to developers' criteria's. We talked about how sustainability and innovation have it can be implemented between developers and contractors.

Sabina Holstein, (10/02)	Special consultant, developer advisor, tendering consultant at Roskilde municipality	We talked how Roskilde municipality are implementing sustainability in tenders, and how they have different initiatives working, such as material stocks for recycled materials. We discussed how the implementation and process surrounding sustainability can differ between infrastructure- and building construction and how they can inspire each other.
Rikke Thorlund Haahr, (17/02).	Adviser at Co-Pi- Center for Offentlig Privat Inovation.	In this interview we talk about the relation between public and private actors regarding tenders and innovation. We discussed how actor/devices should stand between public and private actors to help foster innovation and design for both public and private gain.
Christian Axelsen, (23/02)	Project leader for InfraLCA at Vejdirektoratet.	In this meeting we discussed InfraLCA and the effects it could have on tenders. We talked about the integration of LCA into the construction industry.
Magnus Bentsen (08/03).	Chief market consultant at Munck Gruppen.	We discussed how and what is important when addressing sustainability from a contractor's perspective. We talked about how to fit a tender with an initiative, to create room for sustainability.
Morten Sell (09/03).	Manager & Tender Manager, Arkil A/S.	Here we discussed how sustainability is being used in tenders, and how they are working with it. Aswell as their position as contractors in the network. We discussed initiatives and criteria in tenders, and how they interact with actors in the tender process.
Magnus Sølvhøj Hühn, (04/03).	Architect and advisers In Lendager group.	In this interview we talked about adviser's role in implementing sustainability into tenders. We discussed how experience from the building industry could influence infrastructure and the methods and means of implementing sustainability such as certifications and EPDs.
Inger Kafton (22/02).	Project leader building department at Region Syddanmark.	We talked about how they work with integration of sustainability in their tenders, where they mentioned there ongoing work with DGNB education for their team, along with a strategy to use that in infrastructure related projects.
Various (four attendees), Regional Municipality of Bornholm (14/03).	Interview with various employees of the tendering department	This interview included four people working in their tender department. Here we talked about the need for solutions to be considering local factors and how these effect the tendering process. They wanted insight into how other municipalities integrated sustainability, and how that could be used in their local conditions.

Eskil Kwedéris (24/03).	Technical adviser at "Teknik og Miljøforvaltningen" Copenhagen municipality focus on infrastructure projects.	In this interview we talked about how Copenhagen municipality use the catalogue they developed. And how different initiative could be intergraded and the difficulties that follows.
Louise Laumann Kjær, (29/03)	Adviser and founder at Lodo, and Prof. At AAU (Aalborg University) CPH.	In this meeting we discussed our prototype and how and what we should focus on when it comes to integration of data and other sustainability aspect.
Nynne Marie Bech, (15/03).	Environmental consultant at Metroselskabet.	We interviewed Metroselskabet to get knowledge concerning another public organisation that have many similarities with Banedanmark, in the type of construction they develop.
Jacob Bech Nicolaisen, Banedanmark (3 interventions).	Area Manager of in the construction Department of Banedanmark.	We have had several interviews and meetings with Jacob, from the start of the projects to the final prototyping.
Søren Boas, Banedanmark, (4 interventions).	Chief consultant, climate economist.	Boas have been central in problematisation and the followed project. He has been in deck research, prototyping as well as the receiver of our final product.
Ulla Møller Eikard, Banedanmark, (4 interventions).	Strategic procurement consultant.	In the interviews we had we gained information regarding aspect of Banedanmark Enviromental's policy and feedback on our final products.

Table 1: Shows name, position, and summary of all the interviewed actors in the projects. Author made.

4.
State of the Art

The following chapter consists of three sections that together introduce background knowledge relevant to understanding the scope of the project. First, a section will introduce tenders, the rules around tenders and how they can be prepared differently. Next, a section will describe Banedanmark as an organisation and how they understand sustainability. This is important as the catalogue of instruments in this project must target their goals and wishes. Finally, the last section will present how sustainability is currently present in the construction industry, both in terms of existing instruments and initiatives.

4. State of the Art

4.1 Introduction to Tenders

The Public Procurement Act, re-published in 2019 (The Public Procurement Act, 2019), updates obligations related to public procurement between bidders and developers, which defines the terms developers can set for the tender material and establishes an equal competition between bidders. This is done to ensure that public institutions, e.g., municipalities, regional administrations, and governmental agencies, are not influenced by personal, local and opinionated relationships. It also serves to create a standardised way of operating, where all companies within the targeted tendering area, have equal access to make bids and be guaranteed to be evaluated on the same premises.

Due to an increased societal focus on sustainability, the preparation of tenders has likewise been affected, as developers are trying to consider sustainability when preparing their tender, with a gain to both bidders and tenderers. Sustainability has become one of the main consideration in many other industries, such as food and cleaning detergent, where certifications such as Nordic Ecolabel helps to describe and define sustainability requirements for products (Nordic Swan Ecolabel, 2022).

4.2 Structuring of Tenders

Public development over a certain monetary threshold must be put up for bidding through a public tender. Depending on which area of procurement the tender is within, this threshold is of different values e.g., construction, healthcare, services etc. Every construction tender under the estimated value of 40.100.744 DKK (Tærskelværdier 2022 og 2023, 2021), for both national and regional tenders, is being evaluated under Danish law, while tenders above this value are being governed under legislation from the European Union (LOV Nr 1564 Af 15/12/2015, Erhvervsministeriet, 2015).

When preparing tenders, different approaches to making offers include the parameters that are desired and will have different outcomes. One way to structure a tender is by using criteria. Overall, three types of criteria exist, that can be applied in a tender, which are described in the next three paragraphs:

4.2.1 Exclusion Criteria

Exclusion criteria describe certain circumstances in which a contractor may be excluded from bidding for a tender. An example of exclusion criteria could be the exclusion of companies that previously have been bankrupt or the exclusion of companies involved in cases with errors of larger nature. The tenderers' right to include criteria that can exclude these contractors is found in The Public Procurement Act, chapter 11 (2019).

4.2.2 Selection Criteria

Selection criteria are used to sort bidders by including criteria for what bidders should be able to deliver. In these criteria, the tenderer must provide proof of qualifications such as the number of workers, proof of insurance and bank statements.

4.2.3 Award Criteria

This type of criteria can effectively be used to assess the offered solutions concerning either price, quality or the ratio between price and quality. The cost award criterion evaluates bids based on cost calcula-

tions, whereas the lowest price criterion evaluates bids based solely on the pricing. If the award criterion best ratio between quality and price is applied in the tender, sub-criteria can be formulated that specify what is emphasized. Typical sub-criteria relate to price, delivery reliability, service, etc.

The award criteria will define what the contractors compete on (The Public Procurement Act, 2019). When a tender is structured with criteria, the winning contractor will be the one that is the best possible way, fulfil the defined criteria. Sub-criteria can further be divided into part-criteria which specify how the offer will be assessed based on the sub-criteria (Konkurrence- og Forbrugerstyrrelsen, 2016). When the latter award criterion is applied, the tender documents must state how the tenderer weights the sub-criteria, and this weighting must ensure that the sub-criteria are weighed against each other in the way the tenderer wants when evaluating the tenders. To define how award criteria are weighted, different weighting models can be applied, or developers can use their own. An example of a weighting model can be seen in *table 2*.

Offers/ Weight Criteria	Price:		Criteria 1, Quality		Criteria 2, Competences		Total:
Weighting does not differ from bidder	Weighting:	Mark:	Weighting:	Mark:	Weighting:	Mark:	
Bidder 1	60%	5	25%	8	15%	5	5.75
Bidder 2	60%	7	25%	3	15%	7	6

Table 2: Example of a weighing table.

4.2.4 Requirements

Unlike criteria that create competitive advantages for contractors when including them, requirements define what contractors must fulfil to bid on a tender (The Public Procurement Act, §140, article 2, 2019). Thus, the purpose of requirements specifications is to convey the needs of the tenderer. In procurement law, a distinction is made between requirements and minimum requirements. A minimum requirement must be unconditionally met for a tender to be considered, whereas requirements form a competitive parameter as their fulfilment forms the basis for the evaluation of the proposed solution.

4.2.5 Market Dialogue

Before and during the preparation of a tender, multiple rounds of market dialogue between the developer and the contractor, are being instigated by the tenderer. The purpose of these dialogues is for the tenderer to investigate the market involving what new technologies and methods are available from the contractors (Konkurrence- og Forbrugerstyrrelsen, 2018). Through the market dialogue, the developer can thus also get a feel for what the market can deliver of sustainable solutions. During the procurement process, it is normal to have two rounds of market dialogue: an initial dialogue and a follow-up dialogue.

4.2.6 Tender Forms

When preparing a tender, the tenderer may choose between seven tender forms, which affect the procurement/project processes differently (Valg af udbudsprocedure, 2017). A tender form defines the procedure to be followed when a tender is to be performed. All the illustrated procurement processes apply to the construction sector except the dynamic purchasing system, as this tendering form is typically applied in the purchasing of goods that do not need to be customer-made, which is the case for materials in the construction industry. Various tender forms have different advantages and disadvantages attached to them as described in *table 3a & 3b (this and next page)*, and the right one to use for a tender must therefore be assessed individually for the project. The right form of procurement will typically involve the one that ensures the best competition in the given market (UdbudsHuset, n.d.).

Tender form:	Pros:	Cons:	Application:
Public tendering: This tender is open to all, allowing all willing bidders	A lot of actors can bid by pressuring price and quality. Requires knowledge within the field by the creator of tender.	All bids must be judged on an equal premise, with many bids requiring developers to analyse each of the different bids.	This is quite commonly used in the building sector. However, it is not possible to have continuous negotiations with the bidders.
Limited tendering: This tender consists of two phases. A prequalification, and the tender phase.	Reduces the number of bids, and resources used to process them. insures via the prequalification that each bidder is capable and can ensure delivery.	Requires more planning, due to the extra prequalification phase, which should include all capable bidders. The best solution for the project may be by an actor who did not get pre-qualified.	This is commonly used in projects where the developer wants to ensure that the bidders are capable. However, the time and resources saved by analysing fewer bids can easily be relocated to prequalification preventing resources saved.
Tendering with negotiations: This is used in projects where the tenderer can add or change the requirements in the middle of the process.	Allows for the tenderer to have more influence over the project during its development. The developer can create changes after the tender process has ended.	This is more resource-demanding and requires the attention of the tenderer during the entire process. This is more demanding for the tenderer and bidders, due to the possibility of revisions	This is used in projects where the tenderer does not know the exact requirements or viable solutions for the project or the best available technology.
Project competition: In this tender form, there will be a committee to judge each bid on an anonymous basis.	This provides a lot of freedom for bidders to incorporate their ideas and knowledge. Leaving it to the bidder to figure out how to live up to the demands and criteria.	This takes a lot of freedom from the tenderer, and they can be forced to adopt a solution they do not fully agree with.	This form is mostly used in architectural competitions. It is very rarely used in the construction sector, appearing more often in the building sector.

Table 3a: The various tender forms, their pros, cons, and application.

Tender form:	Pros:	Cons:	Application:
Innovation partnership: Is often used in small projects as a testing ground for newer solutions, where both the tenderer and bidder co-create an innovative solution.	This can be used to co-create innovative solutions that do not exist. This allows for the possibility of both public and private innovation.	This requires a lot of resources and a willingness to take a risk, the project can end up useless or non-scalable.	This is sometimes used in construction projects and sometimes results in successfully developing new and innovative solutions.
Competition based dialogue: This is a rarely used tendering form, which is a mix between tendering with negotiations and limited tendering, but with manoeuvrability for the tenderer.	This is used in situations where it is impossible to know the challenges and financial data ahead. Here, it also allows the bidder to discuss all parts of the tender even the price after the tendering has been completed.	This can be difficult to use since creating a tender with the technical settings with other data missing. It can be hard to find a situation where the use of this tender is advantageous.	We have yet to find a construction project being done using this tender form. Since its niche use has little relevance.
Dynamic purchasing system: This is a system where the buyers can shop among goods, but not services, with premade tendering contracts formed in larger coalitions.	This makes it easier for small buyers to get competitive prices on goods, due to it being tendered in larger coalitions.	This is only useable for goods. It also limits the goods being brought to a selection, which is chosen by larger coalitions.	This has no relevance to this project due to this form of tendering not being used in construction.

Table 3b: The various tender forms, their pros, cons, and application.

4.2.7 Types of Enterprise

When preparing the tender material, the developer has three models of enterprise to choose from: turnkey contract, trade contract and main contractor (Patursson & Frederiksen, 2021). A form of enterprise place the different responsibilities, of actors involved in the project. These different ways of conducting enterprise have diverse types of manoeuvrability for the developer and the contractor, as can be seen in *table 4(next page)*.

In a trade contract, the developer has control over most elements of the construction, ranging from aesthetics and technical elements, to managing the economics of the construction. This type of enterprise is not common in public tenders as it is most suited for small scale buildings (Patursson & Frederiksen, 2021).

In a turnkey contract, the construction company has full room for manoeuvre to build the best solution available for the budget provided by the developer. Consequently, the developer must set clear and specific criteria in the tendering material, for the constructors to be able to know what is wanted and prioritised in the tender. In this enterprise form, the construction company has a great deal of freedom to include its own initiatives in the project. Thus, the contractor's knowledge is therefore more integrated in the solution (Patursson & Frederiksen, 2021).
In the final form of enterprise, the main contractor, the contractors', and developers' responsibility is divided between them. Here, the construction company has responsibility for sub-contractors, deadlines, conflicts, and law, while the developers have responsibility for getting building permits and preparing their offer (Patursson & Frederiksen, 2021).

	Main Responsibility All permits, project material etc.	**Room for Initiatives** Contractor	**Room for Initiatives** Developer
Turnkey Contract	Contractor	Here the contractor has a large room for initiating sustainable initiatives	Limited possibilities. The developer can say no, but the contractor has most to say
Trade Contract	Developer	Small room for initiatives. The contractors' role is solely to build the construction	Here, the developer has the full say and responsibility for what is being built and how
Main Contractor	Developers, and the contractor in a building-technical sense. Most common in larger constructions.	Moderate room for influence	Here, the construction is formed by the tendering material and the initiatives that is proposed in the bids

Table 4: Description of contract forms and their scope for action for contractors and developers.

4.3 The Organisation of Banedanmark

The organisation of Banedanmark is a publicly owned company under The Ministry of Transport, which facilitates and develops the Danish railway infrastructure. They operate most Danish railways except for a few that is either private or run by other public organisations, such as Metroselskabet. Banedanmark is subject to a political agenda, which is responsible for the organisation's budget and determines some of its construction projects, such as the new Femern Belt connection (Femern, 2022). The organisation has the recent years gained increasingly funding from the government due to the sustainability potential of rail transportation, as the government wishes to invest in the expansion of sustainable public transport. The budget of the organisation covers both the development and operation of the railways, which requires a range of advisors, operation tools and technical expertise, due to the complexity of administrating and expanding the railroad. Professional advisors are difficult to source from external companies, as only a few advisors nationally are involved with railroads [Appendix A – Interview Bech Nicolaisen, Banedanmark].

Banedanmark prepares a lot of tenders as no in-house contractors are employed to execute the construction projects. In the preparation of tenders, security measures are the main concern, as they can cause catastrophic consequences in case of structural or material failure. Consequently, Banedanmark plans its projects based on what they have experience with and is accordingly less willing to experiment with alternative methods and materials. Highly prioritised parameters in the planning of Banedanmarks projects are the security of delivery, timeframes, and safety measures [Appendix A – Interview Bech Nicolaisen, Banedanmark]. To ensure that the company can deliver on these para-

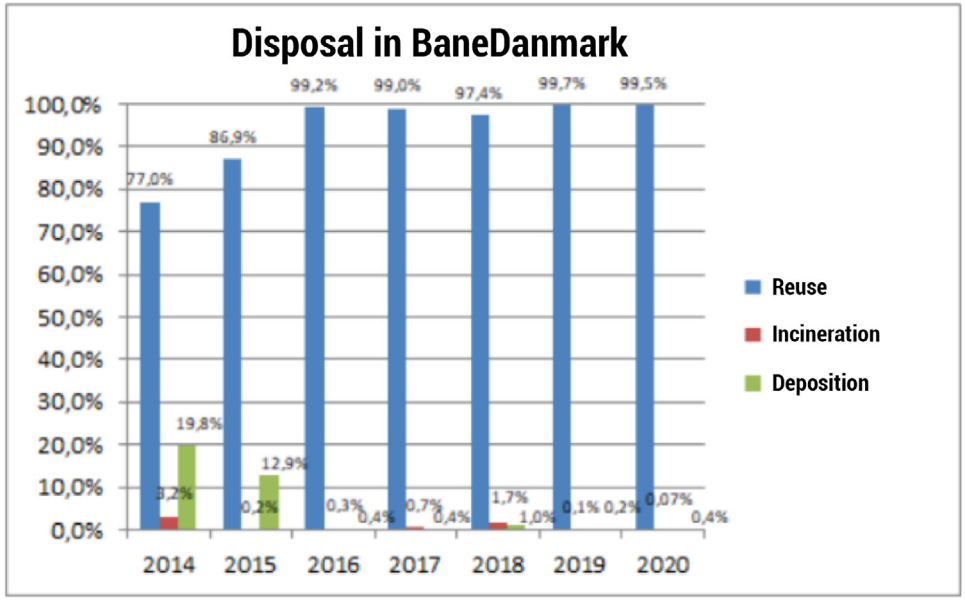
meters, Banedanmark produces its concrete elements in its concrete factory [Appendix A – Interview Bech Nicolaisen, Banedanmark]. This means that the organisation itself determines the quality of concrete, and specifications of the items produced in their construction projects. Due to the public privatization strategy of the 2000s, Banedanmark has had intentions to sell the factory. However, since there are no concrete swells of similar quality on the market, this has not been an option for Banedanmark [Appendix A – Interview Bech Nicolaisen, Banedanmark]. Banedanmark co-operates with an extensive list of organisations, including external contractors, the Danish Transportation Authority etc. to deliver, create and construct projects. The projects that are up for tender, are often large-scale projects, which require workforce and technical experience from contractor organisations. This resource requirement creates a barrier to entry for small contractor companies, as it becomes difficult to win a tender prepared by Banedanmark.

4.3.1 Sustainability within the Organisation

Despite Banedanmark having developed a sustainability strategy based on various SDGs, this has not been based on focus areas where Banedanmark has a high level of environmental pollution. The organisation does not possess data on the pollution of all the environmental areas, but they know that they have challenges concerning two areas in particular.

1. Operation; Challenges associated with operation involve noise caused by the roughness of the rails. Likewise, the soil is contaminated by the maintenance of the rails, keeping them free from weeds and soil formation. In addition, there is also a high energy consumption in operation, especially related to heating of tracks, lighting, and fuel (operation machines and private vehicles).
2. Design and construction work; Environmental challenges to this area involve energy consumption, chemical emissions, waste, and indirect environmental impacts from building materials related to the construction of new railways, by suppliers.

Banedanmark has a large emission profile. This is partly affected by the fact that the company Danish state railways (DBS), is responsible for operating the trains. Consequently, when Banedanmark constructs an electric grid for trains, DSB achieves the environmental gain, in their emission reports. In addition, Banedanmark's environmental report is significantly affected by their production of concrete, soil and steel-heavy construction, despite it contributes to sustainable infrastructure. As the variety of construction materials is low, it is easy to deconstruct and reuse when materials reach the end-of-life stage, as seen in *figure 8.* The chart below illustrates the disposal of the total amount of waste



Disposal of total amount of waste in BaneDanmark, distributed on reuse, incineration and deposition

Figure 8: Illustration of Banedanmarks waste translated by authors (Banedanmark, 2020).

in Banedanmark, divided into recycling, incineration and landfill.

The focus on sustainability within the organisation involves a focus on environmental aspects as well as social considerations such as reducing noise and functionality concerns. The organisation has adopted a sustainability policy, that ensures that each project is individually analysed for possible environmental improvements. These analyses, along with the organisation's demand for product EPDs, help them gather information for the upcoming InfraLCA tool, by providing further data. Banedanmark has an internal ongoing process that aims to support the design of future tenders by integrating sustainable project management (ISO 14001), design optimization, requirements for drivers and machines, adopting new technology, material selection etc. (Bæredygtighedsstrategi 2021, 2021).
This process of sustainable innovation is incited by market regulators such as the general conditions for advice and assistance in construction, "The building regulation for infrastructure construction" (ABR18), politicians, and the Danish Transport Authority however development within the industry is limited by many measures, which is why this is a slower process compared to other industries.

As illustrated in *figure 9*, Banedanmark considers sustainability as a three-dimensional area of action involving: economy, social responsibility, and environmental concerns, where each area is balanced according to each other. Within the environmental area, there has recently been an increased focus on CO_2 reduction. Previously noise and chemical reductions were of the highest priority. Whereas a focus currently involves, CO_2 reductions, where procedures are still being explored and developed.

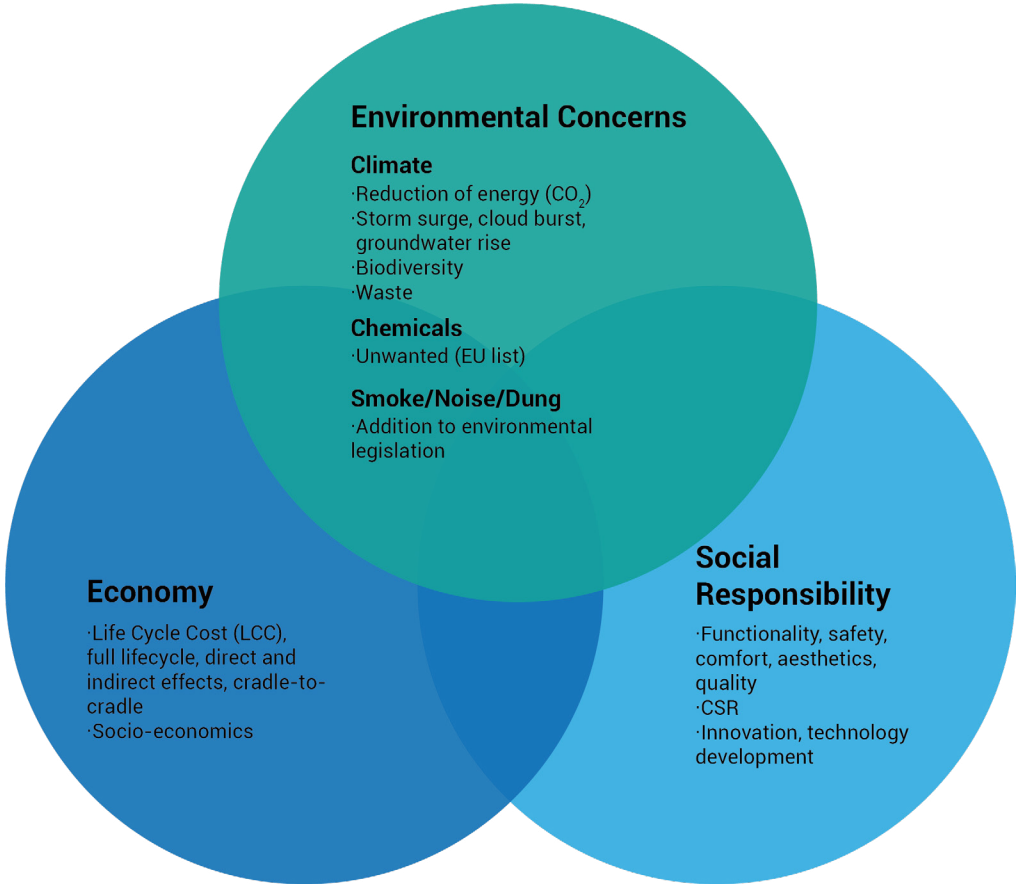


Figure 9: Author illustration of the three-dimensional areas of sustainability within Banedanmark. Based on information gathered from Banedanmark.

Economic considerations involve lifecycle costs, where the organisation aims to procure based on costs that consider the lifetime cost of the materials, rather than solely relying on the purchase price. In the economic aspect, the organisation aims to save costs concerning additional operations. This includes, for example, the recycling of materials. The last area of sustainability is social responsibility, where safety is of paramount concern. This does not solely involve the safety of the passengers and goods, but also security measures regarding the ensuring

of delivery and scheduling. Currently, initiatives such as rewilding areas next to railways are promoting sustainable innovation within the area, and the organisation wish to include further initiatives like this, that do not compromise safety measures.

4.3.2 The Internal Structure of Banedanmark

Banedanmark's organisational structure is based on a philosophical paradox [Appendix A – Interview Bech Nicolaisen, Banedanmark]. It is recognized in the organisation that responsibility cannot meaningfully be imposed on one human being. The interfaces and subject areas are far too complex for that. On the other hand, responsibilities cannot be shared either. The organisation's response to this paradox has resulted in a matrix organisation, where horizontally there are subject areas that have an unambiguous responsibility for ensuring that their subject area is handled correctly in all projects [Appendix A – Interview Bech Nicolaisen, Banedanmark]. This involves both the quality of the organisation's deliveries and the deliveries they get from external actors. Conversely, there is a vertical responsibility to ensure consistency between

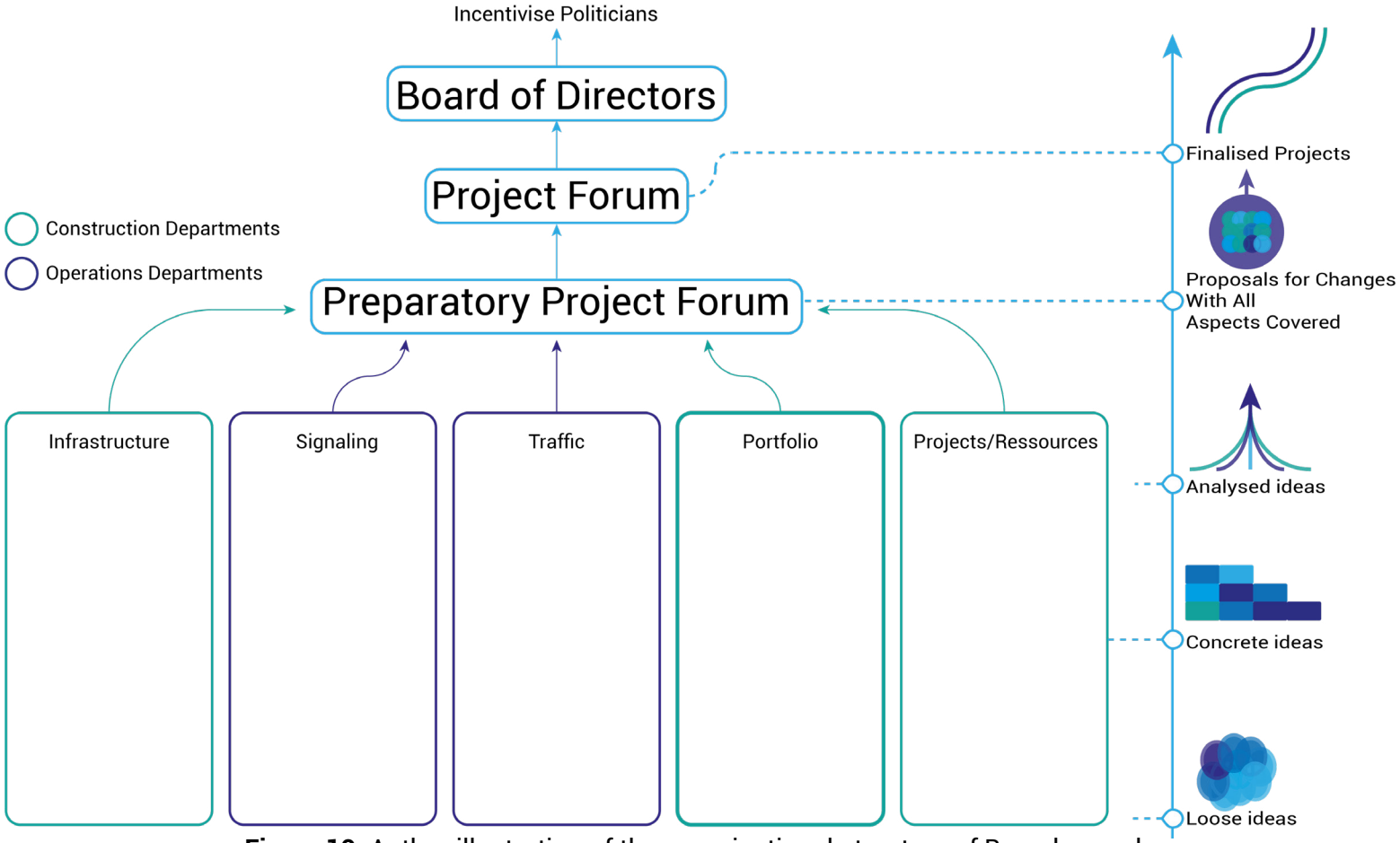


Figure 10: Author illustration of the organisational structure of Banedanmark.

what the disciplines deliver, and what the project needs, which involves deliverables between the subject areas, interdisciplinary interfaces, etc. The process line on the right side of *figure 10* (previous page) showcases the level of complexion and completion in decision making, to be considered at a given level of authority.

The bottom management level consists of different silos containing advisors and experts operating within their respective fields of expertise. This allows them a degree of autonomy to take decisions regarding their field of expertise, however, only to the extent that the decision must not affect other fields of expertise. The internal tasks within the different silos are very detached from each other, and the daily communication between them is therefore very limited. As a result, when the actors in the silos need to collaborate on a project, it usually takes a long time for them to reach a consensus, which drags the projects out over long periods. In cases where a problem or a risk requires decision-making from one or more actors in the preparatory project forum, or if a decision is outside the budget, the Preparatory Project Forum must be involved. Decisions of larger nature typically require that actors of the preparatory project forum are involved. Usually, they are involved when actors within the silos are unable to solve the issue between them, or it requires budgetary restructuring. Likewise, the preparatory project forum is involved when actors in the various silos require knowledge outside their area from actors of other silos. The preparatory project forum then refers to which actors in the other silos are relevant to involve. Sometimes they are asked to make the decision themselves. If a project requires greater financial funding, the next level of management - The Project Forum - must be involved. The Project Forum deals exclusively with decisions that are assessed as of larger nature with higher risks but within the budget frame. These decisions have to, at this point, be very thoroughly specified. The Project forum also has a coordinating function as decisions are also executed in the different silos. They cannot, however, change political pushed narratives if decisions require additional funding, as it exceeds the budget, and the board of directors must be involved. The board of directors can apply for government funding.

A consequence of the organisational structure at Banedanmark is, that the higher management levels often have to be involved in the decision-making processes of the various silos, as the room for manoeuvres of the employees within the silos is limited. The organisation is concerned about changing its structure to a more circular or flat structure, as it may have consequences for the organisation. The projects at Banedanmark are typically long-lasting and extend over many years. Changing the decision-making process in Banedanmark can have consequences on the quality and deadlines for the projects.

4.4 Sustainability in the Industry

This section will describe how sustainability currently is a part of the construction industry. Specifically, the section is divided into two parts. The first part will introduce some of the sustainability instruments that exist in infrastructure construction, and the second part will introduce how this corresponds to the building construction. A distinction is made between the two branches of construction, as there currently exist more sustainability instruments in buildings compared to what is the case for infrastructure.

4.4.1 Sustainability in the Infrastructure Construction

Life-cycle-assessment and InfraLCA

The introduction to Life-cycle-assessment (LCA) in the construction industry has been increasingly prevalent in recent years. An LCA is a tool for measuring the environmental effect of a project or product's life cycle. The measurements of an LCA can be categorized into different kinds of environmental effects, such as local emissions, food souring and CO_2, which are the most common measurements. Compared to building construction, which has established a common LCA tool called BygLCA, no equivalent exists in the construction industry at the national level. However, this is about to change as a new tool called InfraLCA is likely to be introduced in the summer of 2022. The launch of InfraLCA will help to create a common basis and unify the calculation method for construction in the industry, by establishing a common language. The development of InfraLCA had its beginning in 2019 and is expected to be required by law in 2022, but this has been delayed several times and is still waiting for the final regulatory and data processing (InfraLCA, 2022).

Axelsen who is project leader for InfraLCa at Vejdirektoratet, points out the need for tools that quantify emissions in projects. According to Axelsen, improvement of data processing can help actors to improve on areas where the potential for improvement is largest. *"In the Danish Road Directorate, we have a strategy for sustainability, which should ensure that we take the measurements with the biggest effect. To do this, we needed to understand what* CO_2 *emissions we have today regarding all the phases. To do this we developed InfraLCA to see emission in the different phases and look like this in lifecycle perspective"* -(Vejdirektoratet [Vejdirektoratettv], 2021).

Environmental Product Declaration

Environmental Product Declaration (EPD), is applied as an environmental declaration for construction materials, set up by the European standard and ISO, EN15804/ ISO 14025(The EPD | EPD International, 2022). An EPD gives environmental data in all scopes of the LCA, from production to end of life. This includes energy uses, emission factors, resources stream, and other environmental effects. EPDs have been used in the development of tools such as BygLCA and InfraLCA, as well as in the DGNB-certification where DGBN-points are added if the developer uses EPDs. Familiarity and experience with EPDs will help make the launch of InfraLCA, in infrastructure construction a minor conversion for actors and make it easier to adjust to the use of InfraLCA.

EPDs are also used in infrastructure construction to compare material emissions and contribute to the unifying choice of materials by developers and contractors. This reduces the amount of work for the developer, as material qualities have been defined in advance, and thus clarifies the material requirements for the tender. EPDs contribute to some extent to the sustainable transition to creating a baseline for data, as well as a negotiating space and language for environmental product information.

Sustainability in the Building Regulations

Referring to requirements for sustainability, at present the only reference can be made to the building regulations (ABR 18), 2019), which embrace certain aspects of sustainability. The building regulations that specify the Building Act, impose quality and safety requirements. These are, for example, requirements for the execution and design of a building, so that it is satisfactory with fire, safety and health concerns. Likewise, the building regulations impose requirements on a building's

indoor climate and energy (Bolig og Planstyrelsen, n.d.). Sustainability requirements in the building regulations are thus focused on a high-quality assurance of buildings, and not directly on environmental improvements.

Forums of Knowledge Sharing

Certain forums exist where the sharing of sustainability knowledge takes place. It involves forums such as the Partnerskab for Offentlige Grønne Indkøb (POGI), which help municipalities, regions and other public actors, to make procurement sustainable. They contribute with the use of requirements and the general preparation of the tender, where they share experiences among developers. These organisations are engaged not only in construction but in all types of public procurement. Organisations like POGI can promote a sustainable transition and address key stakeholder concerns, for example by providing incentives for entrepreneurs to invest in sustainable solutions.

4.4.2 Sustainability in Building Construction

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Certification in the Building Industry

Within building construction, a multitude of different certifications exist. Some of the popular ones are; DGNB, European EcoFlower and the Nordic Ecolabel. Common for these is they are applied for the construction of buildings but are not applicable to use in infrastructural construction. In Denmark, the use of DGNB for buildings is one of the most popular and applied certifications, and in some cases, a requirement. The municipality of Copenhagen has, for example, made legislation that requires all new buildings with a budget of 20 million DKK or more, to get either a DGNB Gold certification, or the Nordic Ecolabel, and new renovations above 20 million DKK to be certified with DGNB silver (Københavns Kommune, 2020). The DGNB certification focuses both on the environmental, economic and social aspects of sustainability, whereas the Nordic Ecolabel and the European EcoFlower are more focused on solely the environmental impact, such as sustainable sourcing of wood, and the use of non-harming chemicals. The number of buildings certified with the Nordic Ecolabel doubled between 2018-2020 (Ecolabelling Sweden, 2020).

Sustainability Communities

Within building construction, multiple knowledge-sharing groups and centres exist. One of these is the Center for Offentlig-Privat Innovation (CO-PI). CO-PI acts as an intermediary between public institutions (municipalities, regions, governmental institutions etc) and private companies, to enhance the partnerships and improve innovation between these two groups, in three main areas (CO-PI, n.d.):

1. Technology to support welfare.
2. Climate, green transition and environmental supporting initiatives.
3. Sustainable building

Within the public tendering sector in Denmark, municipalities have established cross-municipal alliances. By grouping across multiple municipalities, the purchasing power of the local governmental institutions increases. These forums also function as a means for sharing experiences and knowledge between the geographical borders within the country.

LCA and InfraLCA in the building industry

Smaller developers in building construction, such as Roskilde Municipality, have applied an internal LCA tool to calculate life-cycle parameters in projects. The use of LCAbuild, and LCA, is a lot more prevalent within building construction, than what is currently the case in infrastructure construction (BetterGreen, 2021). By 2023, a national strategy to implant CO_2 per m2 demands on buildings is introduced.

BygLCA follows a European standard for the execution of LCA (EN15978), which is intended to ensure a predetermined basis for LCA calculations, so it creates a uniform assessment basis when used in a tender. LCA was introduced to the building construction a lot earlier than what is the case in infrastructure construction, as there are economic and advertising benefits to quantifying the sustainability potential. Infrastructure construction projects typically consist of public actors, where projects are procured through tendering, which creates a market where buildings do not have to be sold to the citizens, but rather just must fulfil a specific function. However, public developers work internally with LCAs and work corporately to find the means and tools to include it, with the ambition to make the tool more typical to use in infrastructure.

The voluntary sustainability classes

In 2020, the Danish Housing- and Planning Authority launched a voluntary sustainability class to build a sustainable experience ballast through innovation projects and conducted test courses (Bolig- og Planstyrelsen, 2022). Based on this experience, sustainability incentives will be included in the building regulations. The goal is for the voluntary sustainable class to become mandatory in the building regulation by 2023. Entrepreneurs that become a part of the voluntary sustainability class will be guided on how to convert to sustainability through the sustainability class. Developers can participate in both renovation projects, and new construction projects, regardless of the building type. The objective of the voluntary sustainability class embraces three dimensions: environmental and climate quality, social quality, and economic quality.

To qualify a building for the voluntary sustainability class, one must fulfil the following nine requirements:

1. There must be both an initial and final life cycle assessment that assesses the building's overall climate impact.
2. All consumption of resources on the construction site must be measured, recorded, and documented.
3. A total economic analysis of construction, operation and maintenance costs shall be prepared.
4. An operating and maintenance plan shall be prepared to maintain the indoor climate.
5. Evidence of the use of substances of concern must be available.
6. Degassing from the building materials to the indoor climate must be documented with measurements when the building is constructed.
7. Documentation of daylight levels must be provided.
8. Noise from ventilation systems in homes must be documented.
9. The post-layering time in living rooms in buildings must be documented.

5. COLLECTING EMPIRICAL KNOWLEDGE

This chapter will present the empirical data achieved through desk research and interviews with various actors within the network of public tendering. All interviews are conducted to gain knowledge within different fields of expertise and to provide a holistic perspective of the current stage of development regarding sustainable initiatives in tenders, and associated conflicts in that matter. The data seeks to identify different perspectives on why sustainability can be a problematic practice in the procurement process, as well as knowledge and ideas about how sustainability is currently introduced in tenders. Furthermore, the chapter will introduce the survey that functions as a boundary object as it translates knowledge and gives developers a language for sustainability.

5. Collecting Empirical Knowledge

5.1 Circulation of a boundary object

To gather quantitative knowledge and experience about sustainable initiatives from a larger group of developers, a boundary object was sent out to all municipalities and regions in Denmark. The Boundary object (BO) was developed with the purpose of; firstly, collecting concrete sustainability initiatives from developers, and secondly to create a common syntax for sustainability across knowledge boundaries. A BO is *"an object that work to establish a shared context that "sits in the middle""* (Carlile, 2002, p 451). In doing so, a Boundary object attempts to create a language and a common syntax across the boundaries of knowledge. Knowledge boundaries arise as knowledge is structured differently across functions/communities. (Carlile, 2002). Knowledge boundaries define how knowledge can be seen as localized, embedded and invested in practice in addition, there are three different approaches to moving the knowledge across those boundaries i.e., the syntactic, semantic and pragmatic approaches (Carlile, 2002).

By recognizing that knowledge is local, embedded and invested in practice, developers' knowledge boundaries are also considered transversal. Despite the different developers sometimes possessing the same profession and therefore partially sharing the same syntax, each developer is part of an organisation that has its practices, regulations, priorities, etc. where knowledge is embedded in the organisation's structures and practices. Recognizing that knowledge is local and therefore delineated depending on professions. Therefore, sustainability knowledge can be considered outside the individual developer's field of knowledge. This boundary object seeks to provide a common syntax of what sustainable initiatives can involve, as well as help the various developers reflect on what knowledge is invested in their practice that can be categorized as sustainable. The boundary object allows developers to translate knowledge by describing the experiences and actions of the organisation that will later be circulated among other developers through a catalogue of instruments.

The boundary object consisted of a chart which described different categories of sustainability vertically, and questions about the categories horizontally. Developers were then asked to fill in initiatives their organisation has currently or previously had experience with, within the fitting category. The questions that the developer had to fill in for the initiatives in each category, referred to the effectiveness and execution of each initiative. The specific categories of sustainability initiatives were prepared based on Nancy Bockens's circular product design strategies (Bocken et. al, 2016), which were rephrased in the chart, with a focus on construction relevant initiatives. The strategies are designed to either narrow, slow or close resource loops. The slowing of resource flows aims to delay resource consumption by extending the period of use by prolonging the life of the product (Bocken, 2016). When closing resource loops, resources are recycled within the system, and thus waste is prevented as they remain in the loop (Bocken, 2016). Finally, the narrowing of resources aims to save, and therefore reduce resources in a system (Bocken, 2016). *Figure 11 (next page)* illustrates the chart which acted as a boundary object.

After the boundary object was sent out to Denmark's municipalities and regions, which are public developers, the project group received many different examples of how measures fit under the various categories of the boundary object. Despite developers being asked to exemplify

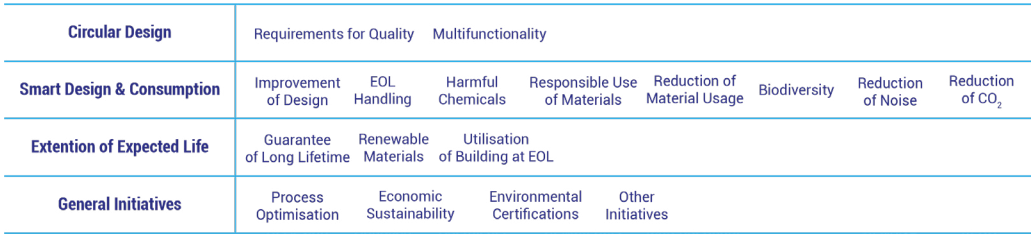

Figure 11: Author illustration of the overall categories of the survey on the left, and the sub-categories within these categories on the right.

initiatives that they had both positive and negative experiences with, however mainly initiatives of positive experience were received. In addition, many developers asked how other developers had responded to the chart and wanted to receive the catalogue when it was finished. Several developers wrote contact information for the right person at the organisation in case other developers wanted to receive additional information about the individual initiatives described. *Figure 12* shows a list of the different categories of initiatives that the project group received from developers through the boundary object, However, the specifications of the individual initiatives are not illustrated. For the full scale, version see Appendix B – Survey Responses.

5.2 Actor Gallery – Conducted Interviews

ThThroughout the project, several actors with different professions have been interviewed. 20 actors have been interviewed, constituting different perspectives on how tenders should be executed. The interviews were planned as semi-structured, and the questions aimed to examine concerns and perspectives to the actor's actor group and location in the network. In addition, the later interviews were based on concerns that previous actors had expressed, to represent actors for other conflicts, and perspectives that have relevance to other actor groups. For

Figure 12: Author's Illustration of the initiatives gathered from the survey. For full-scale version, see Appendix B – Survey Responses.

some of the interviews, a boundary object was used to translate and concretize knowledge from actors. For example, prototypes of the instrument catalogue were used in some interviews to position the actor in a situation where they had to decide on issues relating to specific initiatives in the catalogue. In the following, some of the collected interviews will be presented, grouped accordingly to the respective actor group they belong to. Several times, the project group has tried to arrange interviews with politicians to represent the group of market regulations. Unfortunately, this has not succeeded, and therefore this actor group is not represented, and perspectives from this group are from other actors or desk research. At the end of this section, an affinity diagram will provide an overview of all the perspectives gathered, from all the interviewed actors.

5.2.1 Interviews with Developers

Roskilde Municipality

To initially gain knowledge about how sustainability in practice has been integrated into the tender process, a series of interviews were set up with various developers from municipalities and organisations. Sabina Holstein from Roskilde municipality was the first actor with whom an interview was arranged. Holstein is the project manager for the large municipal construction projects in Roskilde and works in practice with the calculation of square meter prices on the projects, as well as structuring tenders and construction programs in collaboration with other professions. Holstein is only dealing with buildings, and thus there may be some variations in terms of what applies to the construction sector. Roskilde municipality uses DGNB certifications for their building projects, as according to Holstein this is the only certification that inspects all areas of activity (location, process, etc.) DGNB establishes a common language between developers, contractors, consultants, etc., and is already a Danish standard that professionals in the industry are familiar with. The certification can be used to work in a structured and strategic way with sustainability. Holstein gives a concrete example of a kindergarten that was to be built in Roskilde municipality where the tender material and the technical construction program were restructured so that they followed the DGNB division. Traditionally, a standard building program is prepared, where the contractor after the tender involves an auditor to help them fulfil the DGBN requirements most effectively and collect points. Holstein does not follow this order, as she believes it is essential for a sustainable process that sustainability is incorporated into the process from the start. As a consequence, an auditor is involved from the beginning in Roskilde Municipality's tendering process - before the execution of the tender- to help guide the contractors in the most efficient way of collecting DGNB points. Thus, sustainability is a priority from the start as the entire process is based on sustainable advice and influence on the project. Holstein emphasizes the importance of the climate effort taking place from the start, as it is in the load-bearing structure that a climate difference lies. Once the tender is over, it is too late to start practising sustainability in the process.

Sustainable tender in Roskilde municipality is considered a climate effort and equated with quality. As a result, sustainability is measured through quality parameters specified through the DGNB criteria. Holstein emphasizes, on the contrary, that it is never appropriate to think in terms of economics and choose the cheapest tender to prioritize sustainability. To counteract the unequal opposite relationship between sustainability and economics, Roskilde municipality wants fictitious shadow prices that represent a CO_2 tax to include environmental costs

in the prices. To ensure that the contractors' tenders are based on data that can be compared, the municipality provides a recyclable concrete calculator that all the contractors must use to calculate the data the tender is based on. In this way, the municipality ensures that the data is calculated based on the same parameters. The municipality often uses both minimum requirements and sub-criteria. Minimum criteria aim to define a minimum limit the offers must fulfil, while sub-criteria are set to stimulate competition among contractors, so the tenderer can select the most optimal solution.

In the municipality, they have a start-up collaboration with a public housing organisation about a material stock where both parties can store used materials. The purpose is to be able to use the materials in different projects on an ongoing basis by allowing contractors to compete through tenders for the most innovative use of it. Although a specific material can no longer be used for what it was originally intended for, there are many other ways it can be used. In terms of the division of responsibilities of recycled material, Holstein exemplifies two ways of apportioning responsibility. Either the client can take responsibility for the material and the contractor takes responsibility for the installation/use, otherwise, the contractor can take responsibility for both the material and its use. If the tenderer takes responsibility for the material, it enters a process where it is screened for potential challenges and errors such as PCB or chlorine paraffin, as well as strength assessments, and those materials that pass can be reused.

Region of Northern Jutland

Kamille Bollerup is a tender consultant at the Region of Northern Jutland. Her profession makes her responsible for environmentally-focused procurement in the region. She helps to train colleagues in working with requirements in the tender material and she is part of various projects and steering groups that focus on environmentally friendly behaviour concerning consumption and range. Bollerup is also involved in dialogues with the market regarding product development.

The North Jutland region has been a climate region since 2010, which obliges them to reduce annual CO2 emissions by 2%, among other commitments. In addition, the region strives to purchase environmentally friendly products on the condition that it does not compromise on other parameters such as safety and quality. Economically, the region does not consider it a challenge to purchase sustainable products as sustainability has been a focus for so many years, now that environmentally friendly products have become a standard in many markets. It is sometimes forgotten from a political perspective that a region cannot just procure environmentally friendly products as the procurement must be assessed in a holistic perspective where all parameters are weighted in the tender.

Bollerup experiences that the Public Procurement Act to a certain extent blocks the inclusion of a holistic aspect of sustainability in the procurement. When points are awarded to the various suppliers, the Public Procurement Act only allows points to be awarded based on the product, and not what the company otherwise represents. This means that if a company has many environmental initiatives and practices sustainability to a great extent, it must not count in the supply. This makes it difficult to promote companies that are environmentally focused. There is a lack of a broader assessment basis in the tender process, where a client can credit suppliers for their environmental efforts. It would also make sense to set requirements for eco-labels with many of the products purchased, but the Public Procurement Act does not

allow this as many of the eco-labels are expensive and to include the smaller suppliers in the bid, alternatives are acceptable. As a result, it is only allowed to make a requirement for eco-labels that says that a product either has a specific eco-label or equivalent. This means that if the supplier can document that the product complies with the same standard as the eco-label, he is allowed to bid. This complicates the process for the tenderer to a great extent, as it requires that they agree with what all the eco-labels entail in terms of specifications, and they must be able to determine whether documentation from suppliers meets these specifications. All these extra work results in many developers avoiding making requirements on eco-labels as the process becomes too time-consuming.

To include sustainability in the region's tenders, the environmental aspects are set as a sub-criterion, where specific minimum requirements and competition requirements are formulated as well. The minimum requirements and competition requirements that are formulated are usually taken from "the common Nordic packaging requirements" which are a list of requirements that all the regions and some Nordic municipalities together have formulated and chosen to work with, in their tenders. These requirements have been in consultation with the market and adjusted based on suppliers' feedback. Bollerup emphasizes that it is extremely important that the client is specified in the requirements described in the tender, and it is clear what is expected of the supplier. If the tender creator formulates non-specific requirements that can be interpreted differently or give rise to the supplier deciding how they wish to meet the requirement, they will receive a lot of offers from different suppliers that are difficult to compare. Likewise, it becomes difficult for the supplier to know how his offer will be weighted by the tender creator. Internally in the region, they always send their tenders for consultation and receive feedback from suppliers, via a marked dialogue, and in this way, the suppliers help to shape how the requirements from the region of North Jutland will be formulated. In general, Bollerup believes that more resources should be set aside to experiment with tenders and deviate from structuring tenders as usual, as tenders can be a very innovative method of including sustainability.
To require suppliers to calculate the CO2 footprint in their offer requires that the region have knowledge about how it should be calculated, and this is something the region has only just begun practising. Therefore, according to Bollerup, it will probably take time before CO2 calculation is required in the Region of Northern Jutland. The region itself has its CO2 footprint calculated by an external company, the region can see that the calculations do not have a deep level of detail and are generally very superficial calculations. Thus, there is an ongoing discussion within the region about what is valid concerning CO2 calculations.
As a final remark, Bollerup says that knowledge sharing and resources are lacking if sustainability is to be present in the market, in addition to more time to experiment with the tender material. She says there is a need for knowledge to be easily accessible so that a tenderer can quickly and easily seek out information on how a tender can be composed to promote a sustainable agenda.

Metroselskabet

To involve an actor with similar interests and concerns as Banedanmark, a meeting was arranged with Metroselskabet. The meeting was arranged with Nynne Marie Bech who is an environmental- and climate consultant at the organisation. The intention of the interview was partly to understand to which degree sustainability is a part of the organi-

sation, and thus which initiatives they are working on, but also to get their perspective on what knowledge would be beneficial for them to achieve through a catalogue of instruments. Throughout the meeting, the project group also wanted to introduce some of the concerns that the contractors have expressed are blocking sustainable development, as a result of the developer's actions.

At Metroselskabet, sustainable innovation takes place before the tender. Before a tender is made, there is a lot of preparatory work which is not necessarily reflected in the tender, but which has a major influence on the tender being as sustainable as possible. Depending on what is to be offered, the preparation will involve various research, tests, and design optimizations. This preparatory work typically involves identifying the greatest environmental potential of the project, after which relevant focus areas are assessed from a life cycle perspective. The preparatory work affects the tender as the developer gains insight into, for example, what requirements must be set. Currently, Metroselskabet is in an experimental planning process where technical studies are being conducted on alternative use of materials. In this process, it is reassessed whether alternative materials that are long-lasting and less CO2 emitting, can be applied to build high-level railway stations. Bech points out that this preparatory work should not be standardized, but requires an individual assessment of which focus area is relevant, sharing of experience between actors, as well as resource sharing, could make the individual assessment more manageable. In the sustainability team that Bech is part of, they are developing a catalogue of experiences that can inspire the project manager to how sustainability can be included, by reading about how sustainability has been involved in similar projects. The aspiration is, that over time the project manager will not need advice from the sustainability team, as they will learn by experience how sustainability can be integrated into various projects.
Even though right now there is a very steep learning curve at Metroselskabet related to sustainability, it is still a very new phenomenon as a working practice, and thus sustainability cannot be referred to as "how they usually do" as they are still in a learning process. Metroselskabet considers themselves first movers in sustainable innovation, as they test new sustainability initiatives that they learn from. For example, they are testing setting requirements for all construction machines under 2.5 tones to run on electricity, and if the machines are larger, they must be HVO100 driven.

Bech does not believe that Metroselskabet lacks in including the contractor's knowledge in projects. Through innovation projects concerning the future of construction building, the organisation initiates market dialogues with all the actors that are relevant to the specific project, to understand the current ways of operating on the market. A project usually starts as a non-specific idea, on which a feasibility study is made. Through the feasibility study, the project's possibilities and boundaries are examined to a degree where politicians can approve the project. After this, a tender design is made, which means that the project is designed to such an extent that contractors can bid with a realistic price, but the project still appears unfinished. It is now up to the winning contractor to design the project completely, so in this process, the contractor's knowledge is again involved to a great extent. There are also rounds of negotiations for each project where Metroselskabet collect good ideas and proposals, that become part of the tender material. Here you cannot use the knowledge of individual construction companies, as it's against the procurement law, in the case that these

will have a competitive advantage in the tender.

According to Bech, the culture at Metroselskabet has changed a lot from when she started at the organisation. Various project managers are now calling Bech for advice on how sustainability can be included in projects. As Bech does not have the relevant knowledge about sustainability to advise, she acts as a gatekeeper to involve the right people in the project. Bech encourages her colleagues to involve her as early as possible to bring the greatest sustainability potential into the projects. The advisors Bech involved to help include sustainability in a project, often know more than they express, and therefore it has a great effect that they are involved on an equal footing with the employees at Metroselskabet. When these advisors get a sense of ownership of the project and are sufficiently involved, they contribute with very useful knowledge. This inclusion is especially important because the preparation of a tender to a considerable extent requires that the right actors be involved, so the right knowledge is taken into consideration. A developer only knows what can be practised, within their organisation.

Regarding the preparation of the tender material, it is very individual whether it is most appropriate to set sub-criteria or to make minimum requirements. Bech gives an example of this; Some contractors often demand that requirements are made for electrically powered machines. This would create a transformation among the contractors, as they would have to invest in new machines. In this case, Bech believes that minimum requirements make sense, and have a positive effect on the sustainable transition. However, in other cases where a developer wants to use the right concrete specification that reduces to a specific CO2 level, it makes sense to simply deliver the concrete specification so that the final mixture will be somewhere in between. The reason why developers are generally reluctant to set minimum requirements is that they are worried that it will reduce the number of suppliers, and thus the price will increase. It takes a good understanding of the market to set minimum requirements. In addition, it is a concern that minimum requirements exclude equally effective alternatives. Of course, a market dialogue can address these concerns, but sometimes market dialogues also rely on assumptions as some suppliers give a strong impression that certain solutions are common to deliver for all suppliers on the market. Bech adds that requirements based on function can also be useful in tenders as it creates a space for innovation while concretizing certain parameters that must be met.
The knowledge that would be most useful to Metroselskabet to obtain through a catalogue of instruments is initiatives that quantify CO2 savings. Thus, the catalogue should report specific CO2 savings that can be achieved through various initiatives. It would help to make requirements that are not based on assumptions, but data.

5.2.2 Interviews with Contractors

Aarsleff Rail A/S

To gain an insight into the contractors' perspective on what prevents a sustainable practice in the tender process, a meeting was arranged with Aarsleff. As a leading Danish construction group, Aarsleff Rail devises, plans and executes large projects within infrastructure with competence in all track technical disciplines, in Denmark, Norway, Sweden and Germany. The majority of Aarsleff Rail's customer group is public customers, as less than 5% of their turnover is from private customers. The interview was arranged with Carsten Holst Nørgaard who is the

project director, and Kim Bruun who is the tender- and contract manager at Aarsleff Rail.

According to Nørgaard and Bruun, sustainability is not a topic that is neither discussed nor prioritized in tenders. Developers prefer not to include sustainability requirements in the tender as they risk the project becoming more costly, which is problematic as all projects are delimited by a budget. The few sustainable initiatives that take place, are usually because they involve the potential to save money. When requirements for sustainability are placed in a tender, these are usually nonspecific, and descriptive formulations that are difficult for contractors to compete on. Typically, contractors are only asked to describe how they intend to execute the task, which makes it difficult for the contractor to know what is highly weighted to winning the tender. The building industry is more progressive in implementing sustainability into their projects. Especially documenting CO2 emissions from the projects is far more prevalent in the building industry than in the construction industry. The market dialogue is neither characterized by a sustainable dialogue. Often the market dialogue is involved to compare the contractors' recommendations regarding methods, materials, etc. Knowledge sharing between contractors is very unusual at the marked dialogues meetings, as they are in a competitive situation, and thus, the different recommendations from different contractors are rarely one-sided. Knowledge sharing would be more likely to occur if contractors had individual meetings with each other internally. Then the individual contractor might be more willing to share experiences. It would especially help to set minimum requirements in tenders, as it would equalize the competition between contractors to a greater extent, as they all must accommodate the requirement to submit the tender. Requirements for certification of construction projects are not something Aarsleff Rail has encountered. Aarsleff rail does not experience sub-criteria currently as an efficient way of creating an innovative competition that promotes sustainability between the contractors. As the requirements for sustainability in tenders at present only constitute a minimal competitive advantage for contractors because it is weighted by very few points. *Figure 13* illustrates a typical case in which requirements for sustainability are set in a tender, and the weighting of the requirement was such a small part of

Number	Reference to criteria	Description of appendix	Evaluation of appendix
9	LO	Statement of environmental measures. It must be stated which measures the tenderer will take to comply with all applicable rules for re. environmental conditions and an account must be given of how the tenderer will meet the developer's requirements in relation to environmental conditions, cf. CRH6-SAB1, section 9, as well as references to other tender documents mentioned here. It must be stated separately how noise requirements will be complied with using the material described in the tender appendix "process report". In particular: (a) the total expected hourly consumption of electric non-road machinery of less than 2,5 tonnes, see TAG point 02.07.01. (b) the total expected HVO100 consumption (liters) for non-road machinery exceeding 2.5 tonnes, see TAG point 02.07.02. The tender document is expected to amount to a maximum of 6 A4 pages excl. front page, table of contents and possibly appendices in the form of printed matter.	It is emphasized positively if the report describes convincing measures in addition to the applicable rules for the environment and the fulfillment of the developer's relationship to environmental conditions.

Figure 13: *Authors illustration of an example of the requirements for sustainability set in a tender.*

the total assessment that it made almost no difference to Aarsleff Rail in terms of winning the bid, whether they met the requirement.
Thus, the current requirement for sustainability is not something that determines whether the contractor wins the bid. If developers want to create sustainable innovation, they should weight sustainability higher in the weighting criterion – Aarsleff suggested. Another way they suggest was to stimulate entrepreneurs to be creative and include sustainability in their solutions, via setting economic bonuses per. CO2 saving, or per. other sustainability initiatives. Even though sustainability is not something that creates a competitive advantage for Aarsleff, they have initiated initiatives that promote sustainable development. When the company buys new machines, they prioritize buying electric machines. The company also has an ECO-center that covers additional costs associated with sustainable production, and therefore Aarsleff does not have internal consequences of sustainable initiatives being more expensive. These initiatives are taken because the company expects that at some point a change in the industry will happen, and sustainability will be prioritized if not required. In Oslo, for example, there are requirements that all construction work must be electrically powered, and Aarsleff expects to see the same kind of development in Denmark at some point. The problem is that if there are no requirements for sustainability in Denmark, developers and contractors will not spend unnecessary money if no market benefits are to gain.

In terms of recycled materials, the building industry is also further ahead. The problem in the construction industry it is typical that the builder has regulations that do not allow the use of recycled materials, and thus prevents alternative use of materials for the project because they have excessive demands in the tender documents. Often, specific requirements are also made as to which materials may be used. Typically, the developer places these specific requirements for the materials because they are afraid of the consequences of testing new innovative methods, and therefore prefer to structure a tender as they are used to. Nørgaard gives an example where Banedanmark was introduced to use lime cement stabilization where the contractors advised them to use recycled soil that has been lime stabilized, to build into a dam. Banedanmark, on the other hand, only wanted to use materials they had experience with, as they have all sorts of type requirements and approvals, and thus It is, therefore, difficult to change their practice. Banedanmark is structured as a matrix organisation, which is why its operation and its construction organisation are very separated. The project managers in the construction organisation have many concerns when they must hand over their projects to the operation department. In the case of introducing calcium and cement stabilized soil, Banedanmark had great challenges in handing over the project to their operating organisation as they were not interested in a project where alternative methods were to be re-approved. Banedanmark's operation organisation is far too conservative to contribute to change. This distance contractors take from testing new materials takes place despite contractors proposing it and knowing it has been used in similar projects for many years abroad. Contractors must be inspired and learn from similar projects abroad as they can reveal what has worked and what has not worked.

The division of responsibilities is another problem that needs to be solved if a builder should be willing to try out new methods. The contractors usually have a five-year liability for construction, after which the responsibility lies with the client. If the client describes in the tender material which material is to be used, and which supplier it is to be

bought from, it is of course the client who takes full responsibility for the material. According to Aarsleff, recycled materials are the area with the biggest potential to save money. Often when you tear down a building, all the material is taken away and recycled by another smaller builder who does not have such high requirements for material use, and then he gets the benefits of cheap or free materials. You also spend a lot of money on transporting the materials back and forth, which emits a lot of CO2. Gravel and sand are especially materials that need to be recycled as they are costly resources. There is generally also a concern about using materials that are not from one's land register, which according to Aarsleff is not rational as the condition of all materials can be tested.

Arkil Group

Morten Sell is the project manager at one of Denmark's largest construction companies - Arkil Group. The company carries out versatile construction projects across the country. Morten Sell deals with tenders with a special focus on sustainability.

Morten Sell does not consider Arkil Group as a company that prioritises sustainability but includes it, but the same applies to their competitors in the construction industry. Contractors from the building industry are further ahead in this respect, and according to Sell, this is due to developers being better at setting clear requirements in their tenders. Likewise, several tools can be required for the tender, such as the DGBN certification. At Arkil Group, employees are currently being educated to understand how sustainability can be implemented in the organisation, by taking a mini-MBA in sustainable management. Arkil Group has some initiatives regarding social sustainability. At Arkil Group, they offer a course for dyslexics during working hours. Likewise, they have teaching in prisons where inmates are taught content that qualifies them for a job at Arkil Group. When the inmates are released, they typically get a position or internship. Arkil Group has a great success rate with these social initiatives. Sell sees Arkil Group take sustainable initiatives by themself, and the company has also invested in some hybrid machines that generate power from kinetic energy themselves, on which they have achieved fuel savings of 25%. However, as a contractor, initiatives are limited by the fact that it is the tenderer who decides the execution of the project, and therefore they lack some insights into the tender for how the tenderer wishes to include sustainability.

The degree to which sustainability is part of the Arkil Group's construction projects depends entirely on whether the tenderer imposes sustainability requirements in their tenders, and this is rarely the case. When requirements are set, they are typically very ambiguous, and this creates problems for the contractors, as it makes it complicated to know how they are assessed. Developers avoid requirements in tenders because they do not want to risk the project getting more expensive. Even when Arkil Group makes discounts on sustainable implementations - such as discounts on green concrete that has a lower CO2 emission – developers are still not interested. Sell calls for political requirements for developers to include sustainability in their tenders.

Arkil Group, however, has some innovation projects initiated with utilities where they explore sustainable solutions. The utility company pays Arkil Group to explore innovations and methods, after which the innovations are evaluated. Typically, the initiatives turn out to be very successful and include benefits on other parameters, such as economic benefits. Sell gives an example of a robot tile cutter they have devel-

oped which not only saves employees from hard work but also saves time performing the task. As an example of a tender where sustainability was prioritized, Sell tells that the region in the middle of Jutland wrote in their tender that contractors were weighted 15% on specified sustainability initiatives they could present and would not be assessed on unspecific descriptions and declarations of intent. The specified initiatives the contractors wrote in their offer, would then become a part of the contract so that the initiatives were binding.

To include sustainability in tenders, sustainability must be included in the design phase. The design phase is where the greatest sustainability potential lies. Before formulating the tender strategy, the tenderer must think through which solutions to include by doing a sustainability screening. Based on this selection, the tenderer should allow contractors to compete on these sustainability parameters in different enterprise modes. It could be the turnkey contract enterprise model, contractors have free reign to include innovative sustainable solutions without being limited by the tenderer. The status quo is that Banedanmark and Vejdirektoratet are far too locked in their daily practice and enrol lots of requirements and limitations in the tender without involving the knowledge and ideas from entrepreneurs. At present, the tender is price competition and not a sustainability competition, and to change this, Sell believes there is a need for a political influence that forces the tenderer to prioritize sustainability. Sell gives an example of a bridge that Arkil Group was to build in Silkeborg, where the materials used had inappropriate dimensions so they could not be reused at the end-of-life stage. Likewise, the bridge was designed with an expensive and inefficient solution. Arkil group then made suggestions to how the development could be more efficient and cheaper, but Silkeborg municipality had no interest in changing their procedure. According to Morten Sell, Arkil Group should take more initiatives towards a sustainable transition, as it has so far proven to bring economic benefits, and Sell is also convinced that the company will be subject to political pressure going forward. Unfortunately, the company is most likely to adapt if developers either make minimum requirements in the tender or create an incentive for the contractors to be willing to adapt - for example through financial bonuses. Sell claims that Arkil and the construction industry is very agile, and contractors can easily provide sustainable solutions, as long as there is an incentive to do so.

5.2.3 Interviews with advisors

Ilka Bödewadt Lauritzen

Ilka Bödewadt Lauritzen is a procurement lawyer at Viltoft. She advises on all legal issues related to the organisation and conduct of tendering procedures.

In the advisory process, contractors are typically pushed to take a position on what role sustainability should play in their construction. Sustainability in the construction industry is a more complicated process than the inclusion of sustainability when purchasing products. There are many ways of including sustainability, and to many developers, sustainability becomes too unmanageable for them to take a stand. Instead, sustainability becomes a predicate or a status symbol to be put. For this reason, many developers choose to DGNB certify their buildings, as they perceived this as a predefined procedure in which they do not need to be involved in how sustainability is integrated into the project. However, this is not the case as DGNB certification requires that the project meets a certain percentage of requirements related to the

quality of the building, and it is the developer's job to decide how these points should be retrieved. Likewise, the tenderer must decide to what DGBN degree the building should be certified, which requires insight into what quality level the building should have to meet the specific DGNB degree. Lauritzen gives an example of a tenderer who was preparing the tender documents for a super hospital. The tenderer wanted the hospital to be at least silver certified but wrote in the tender that the suppliers should indicate a price for what it would cost them to gold certify the hospital instead. In this case, Lauritzen asked the tenderer if he had considered what they would get for the money they wished to spend on gold certifying the building, as they can adjust on many of the same quality parameters without gold certifying, but for less money. According to Lauritzen, this is a clear sign that there is a need for certifications, and sustainability in general, to be unfolded and communicated at a more adaptable level. It should not be about the developer wanting a building to be represented by a certain sustainability preacher, but about them wanting certain facilities and quality assurances in their building. Sustainability must be communicated at a level where everyone understands what it is about - including the local population as it is their tax money that is spent on sustainability. It will also help the individual purchaser to specify sustainability in the tender so that it is clear to suppliers how sustainability is desired to be integrated into a project.

Lauritzen believes that the reason why developers keep a distance from sustainability is that it is outside their field of knowledge and there exists a fear that sustainability is far too complicated for them to understand. This fear of taking a stand for sustainable initiatives means that developers want suppliers to take a position, as they are more informed about how sustainability can be implemented in different projects. Typically, the tenderer is only interested in what sustainability will cost. For this reason, sustainability incentives are often described in the tender as something very superficial and nonspecific such as "to be executed in the most sustainable way possible". According to Lauritzen, a tenderer must be very specific in the tender in terms of how a project should be sustainable, so it is clear to suppliers how and how much they are weighted for an environmental effort. Specifying how sustainability should be implemented is also important to be able to compare the different offers. For example, if you want suppliers to document their CO2 emissions in their offers, the supplier should explain how it should be calculated, what should be included in the calculation, etc. At present, there are no tools or guidelines for sustainability inclusion in projects, the closest to a unidirectional tool is the DGBN certification.

When a tenderer wants to explore and understand how sustainability can be involved in a project, the market dialogue is an effective way to understand what solutions and opportunities for sustainability currently exist in the market. In addition, Lauritzen recommends that sustainability is placed as an evaluation criterion with a high weighting so that suppliers can contribute with their knowledge about how sustainability could be included in the project. Tender with Negotiation is also a tender form that can be recommended as the tenderer can be in dialogue and negotiate with suppliers - this form of tender often gives ideas to the project the tenderer had not foreseen. A tenderer who wants a tender and associated project that is sustainable at its core should structure a process where all actors - contractors, different advisors, etc. - are involved from the start until the project is finished, and there should be frequent status meetings throughout the process, as unforeseen opportunities or consequences can occur for which decisions need to be reevaluated. Sustainability must be seen as a shared responsibility, and

there must be clear contractual provisions that determine who takes responsibility for various parts.

Søren Hvilsted

A meeting was arranged with Søren Hvilsted who deals with public procurement and contract management at TOLSTRUP&HVILSTED. As a project manager, Hvilsted has completed over 100 EU tenders for all types of public customers.

According to Hvilsted, sustainability is something that has an increased influence on tenders. This is partly because there exists political pressure in terms of what developers must live up to in their tenders. The problem, according to Hvilsted, is that politicians make demands on markets they have not researched. When a politician sets requirements for certain parameters in the industry to become more environmentally friendly, this happens without the person in question having insight into what can be delivered on the market, and thus what suppliers can live up to. The responsibility for introducing sustainability in the tender process should therefore lie with the developers themselves.

Hvilsted uses the market dialogue as a good example of how developers can examine the market themselves and understand what parameters can be changed concerning what suppliers can deliver. In a market dialogue, a tenderer can examine the newest methods to execute a particular task in the specific industry, the delivery capacity of the various suppliers, and the sustainability initiatives different suppliers have previous experience with within the field. Based on the marked dialogue a tenderer can specify a tender according to what is realistic in the specific market.

Hvilsted suggests two methods that can be practised, creating sustainable tenders. First, the tenderer can set a minimum requirement for concrete sustainable initiatives. Minimum criteria set requirements for specific criteria the supplier must fulfil to submit a tender. This is a more problematic method as the tenderer must have in-depth knowledge of the market, as he otherwise risks making demands on something that the suppliers cannot deliver or setting requirements that become an obstacle to the tender being environmentally friendly. Many tenders are cancelled because the market dialogue has not been sufficient, and the developer makes demands that cannot be met. This is because many factors must be connected in a tender process for the tender to be realistic, and it is difficult for a tenderer to anticipate these connections.

The second method is far more innovative. Here, the tender is stimulating competition through sub-criteria that requires suppliers to consider certain initiatives to win the tender. For example, the winning offer may be the one capable of creating the greatest CO2 reduction. In this way, the tenderer lets the suppliers be the ones who define the most effective method of realizing the individual requirement, which is advantageous as the suppliers have the specific knowledge. This method creates innovative solutions that the tenderer could not have foreseen by setting minimum requirements for suppliers.

5.3 Affinity Diagram

To clarify and summarize knowledge gathered through various interviews, an affinity diagram is applied. An affinity diagram is an effective method of organizing material into categories that have relevance to specific topics (Holtzblatt & Beyer, 2017). In the case of larger amounts of data, an affinity diagram can effectively help to scale down the data. The diagram in this thesis is applied to understand which perspectives are represented by different actors, and how frequently they are represented across actors and actor groups. The organisation of data

will also help, later in the thesis, to understand the controversies that exist between actor groups. As illustrated in *figure 14 (next page)*, all the different actors' points of view, were grouped into subjects after which a representative signature of the individual actor was put on the corresponding point of view. The diagram also incorporates the perspectives of actors whose interviews have not been described in the previous section. A screenshot of the affinity diagram can be found in the appendices [Appendix C – Affinity Diagram].

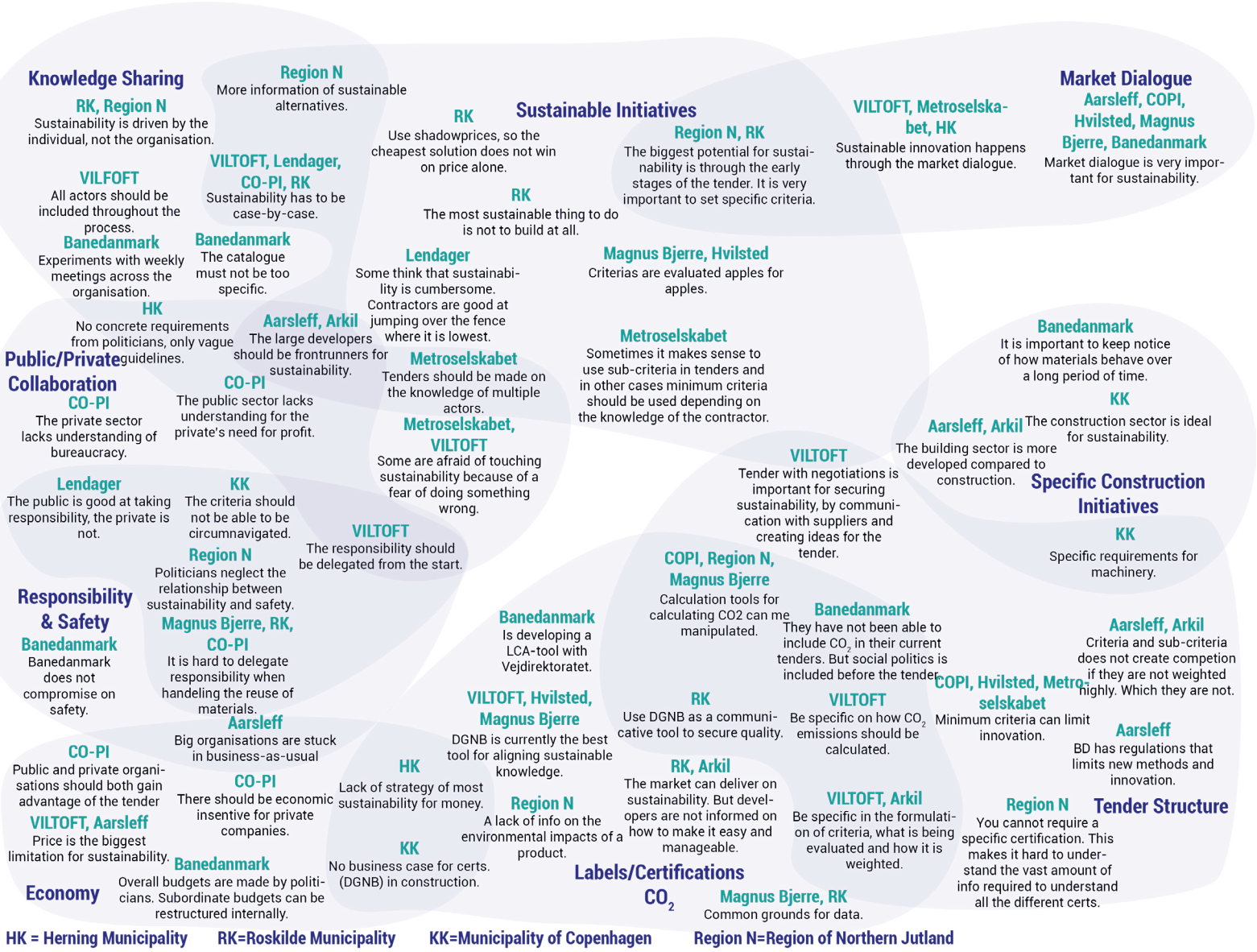

Figure 14: Authors illustration of an affinity diagram consisting of data from actors.

6. Analysis

The following chapter will first present an analysis of Banedanmark where Garth Morgan's Images of organisations are applied to understand how the organisation's structure can be considered an impediment to its development. Based on this, the possibilities of creating a space for sustainability in the organisational decision-making process, through internal structural changes, are analysed. Next, it will be described how the catalogue is considered a boundary and intermediary object, that can act as instruments to facilitate this decision-making process internally in Banedanmark and externally across organizations.

Furthermore, the network of public tendering is presented, which will explain how actors within the network are dependent on each other for the preparation of tenders. To understand the individual actors, an analysis of the matters of concern is carried out, which will help to understand the needs actors have for a catalogue of instruments. Based on the analysis of actor groups' matters of concern, internal controversies have been identified across these actor groups. These controversies help to understand the problem that arises when sustainability is introduced into the construction industry. Next, four identified arenas of the industry are described, each of which represents a shared agenda. The purpose is to show how the introduction of the catalogue of instruments can potentially move these agendas and make them overlap to a greater extent. To draw on the above-mentioned findings, an OPP analysis is finally carried out which aims to identify unidirectional needs between the actors, that allow sustainability to become more present in tenders going forward. This insight will help to understand which sustainability initiatives are essential to include in a catalogue of instruments.

6. Analysis

6.1 The Organisational Challenge of Banedanmark

In terms of organisational development, Banedanmark can be considered a conservative organisation due to its safety measures, which entail a lot of regulations and restrictions, that challenge an innovative process. The organisation's concern, about security regulations, affects their willingness to participate in innovation projects and experiment with new procedures. This limits the organisation's learning curve and hinders the ability to collect experience. To understand Banedanmark as an organisation, Gareth Morgan's images of organisations (Morgan, 1986) can be applied, where organisations are described as metaphors. Metaphors can help to understand an organisation by creating associations with familiarities and framing understanding. Metaphors can be effective [...] *"whenever we attempt to understand one element of experience in terms of another. Thus, metaphor proceeds through implicit or explicit assertions that A is (or is like) B."* (Morgan, 1986, p4) Based on an analysis of Banedanmark's organisational structure, core elements, and principles, Banedanmark fits the description of the machine metaphor (Hansen, n.d. p). The mechanistic approach to an organisation is functional under the same conditions that also apply to a machine operating well, involving; *"(a) when there is a straightforward task to perform; (b) when the environment is stable enough to ensure that the. products produced will be appropriate ones; (c) when one wishes to produce exactly the same product time and again; (d) when precision is at a premium; and (e) when the human "machine" parts are compliant and behave as they have been designed to do."* (Hansen, n.d. p. 11) Conversely, the mechanistic approach to an organisation often have several limitations when they; *"a) can create organizational forms that have great difficulty in adapting to changing circumstances; (b) can result in mindless and unquestioning bureaucracy; (c) can have unanticipated and undesirable consequences as the interests of those working in the organization take precedence over the goals the organization was designed to achieve; and (d) can have dehumanizing effects upon employees, especially those at the lower levels of the organizational hierarchy"* (Hansen, n.d. , p. 11).

Banedanmark applies to the machine metaphor, as they are a specialised organisation with a limited focus area, as they only deal with construction related to railway infrastructure. The organisation is therefore operationally very specialised in delivering products within a defined area. In the execution of construction projects, the organisation mainly focuses on repetitions and procedures to the same quality level, as due to safety parameters they have concerns about changing practices. Despite the organisation's ability to deliver the products, they deal with precision; an element of bureaucracy is also present because the organisation is characterised by regularised procedures and hierarchical conditions. The organisation's focus on stability and reliability complicates innovation and development, which is why new challenges, such as sustainability conflicts, become difficult to manage and integrate into the organisation's structure. Creating change in a machine organisation that is not very agile, is a time-consuming process compared to other types of organisations. This is also verified by their supplier Aarsleff Rail. According to them, the organisation's bureaucratic culture makes them impervious to initiatives that organisations abroad with similar priorities and purpose, is practising and has positive experiences with throughout many years. Due to the machine-like structure of

Banedanmark, exchanging and implementing initiatives and experience from outside partners such as the ones proposed by Aarsleff Rail, are conflicting with the current work practices of Banedanmark.

6.1.1 A Space for Sustainability

The division of Banedanmark as an organisation consists of various communities of practice, each of which has its area of competence. Communities-of-practice "*[…] are fundamentally self-organizing systems [...] members of a community are informally bound by what they do together [...] and by what they have learned through their mutual engagement in these activities"* (Hansen, n.d, p. 2). This communities-of-practise is seen in Banedanmark in the different silos that constitute the bottom level of Banedanmark's hierarchy. Each silo has its practice and common goal, but these are very different from each other. For example, there is a gap between silos dealing with operations and construction, as they have different perceptions of how projects can and must be executed, and different perceptions of safety assessments concerning this [Appendix A – Interview Bech Nicolaisen, Banedanmark].

To analyse a space that allows a sustainable inclusion within the organisation, it is first recognised that *"[…] working, learning, and innovating are interrelated and compatible and thus potentially complementary, not conflicting forces"* (Brown, et al. 1992, p. 40). With this perspective, the following will try to understand how the organisation through learning and work can achieve innovation towards sustainable development. According to Wegner, *"[…] an effective organization comprises a constellation of interconnected communities of practice, each dealing with specific aspects of the company's competencies — from the peculiarities of a long-standing client to manufacturing safety, to technical inventions. Knowledge is created, shared, organized, revised, and passed on within and among these communities."* (Wenger, 1998, p3).

Looking at the different communities of practice within the organisation of Banedanmark, circulation and the synthesisation of knowledge between the communities, is a challenge. Examples of this challenge can be seen in the fact that it is difficult to hand over projects from construction departments to operations departments because across the different silos different communities-of-practice is constituted. These different communities of practice result in a misalignment between the silos and create inconsistencies in how projects are being handled in the respective silos. Likewise, the necessity of vertical communication, where information flows through actors higher up in the organisational hierarchy and down to the other silos as a means to establish horizontal communication, indicates that there is a problem with the optimisation of knowledge sharing and communication across the silos.

By recognising that innovation is dependent and inherent in learning and working (Brown, 2008), it is also recognised that Banedanmark must create a space for sustainable innovation through these practices. Sustainable initiatives can be difficult to facilitate across different silos as initiatives must travel upwards, to the manager of the area. before they can be considered and possibly changed by another silo. Consequently, initiatives are not being made cross-disciplinarily, but rather made within one silo, and then considered by another silo, once it already has reached a level of maturity. Alternatively, projects can be synthesised across silos from the start, so the different silos' concerns and practices are reflected within.

A lack of collaboration between the silos contributes to a boundary being established between the communities of practice. This insufficiency creates a condition where cross-disciplinary collaboration in project development becomes harder, as well as adding on further challenges that makes collaboration between silos more rigid and tougher. The communicative difficulties that create different practices and make projects difficult to hand over, call for a more agile structure in the organisation, that is more risk willing and cross-disciplinary.

When there is an obvious need for horizontal communication in an organisational structure, an organisation will usually have to establish structural arrangements that allow direct communication across organisational units (Thorsvik, 2002). It can be practised by creating liaison communication roles, which are positions to which a special responsibility for communicating with the other units in the organisation, is attached (Thorsvik, 2002). Alternatively, meetings can be arranged with representatives from each organisational unit (Thorsvik, 2002). It may be appropriate to create a matrix structure where project groups are established, that connect different units in the organisation when meeting activities have a large scope (Thorsvik, 2002).

If structural arrangements are set up between the silos, that allow communication across them, it may encourage joint learning and working. Increased cooperation and enrolment of the actors within the different silos, contribute to an understanding of which actors in the other silos are gatekeepers for specific areas. This could avoid the vertical involvement of the higher levels of the hierarchy, that currently take place, as actors would be able to address the right person in the right silo, directly. Increased cooperation could usefully help to set a framework for how and which sustainability initiatives potentially could be included in projects. Consequently, a horizontal cross-cutting collaboration between the different silos of Banedanmark, which each constitute a community of practice, could be established. *Figure 15* illustrates what the structure of such cross-cutting collaboration could look like.

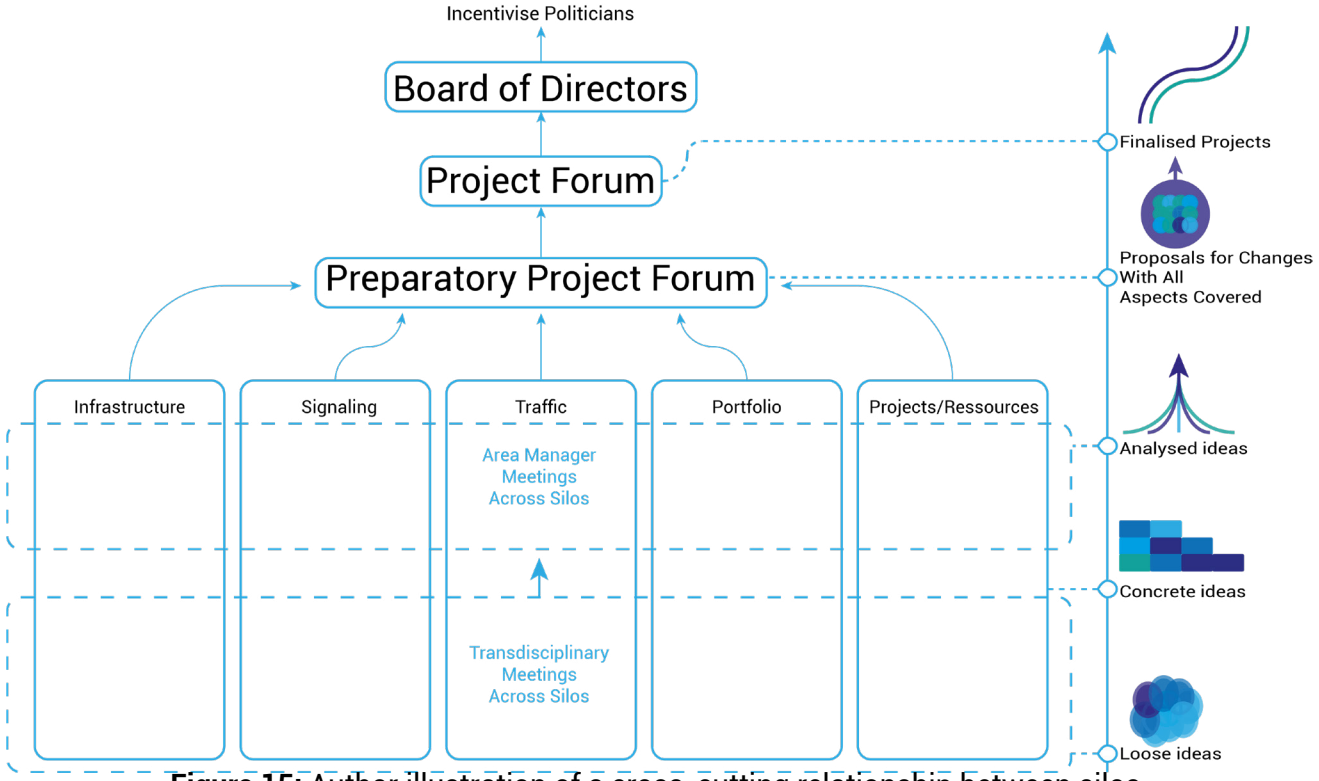

Figure 15: Author illustration of a cross-cutting relationship between silos.

6.1.2 The Catalogue of Instruments as a Boundary Object

For the organisation of Banedanmark, communities across the organisations where knowledge about the inclusion of sustainability can take place are, as mentioned in the above section, necessary. Due to concerns about safety measures, the organisation is reluctant to be the first movers on sustainability and try new methods. Therefore, it necessitates that the organisation can learn from the experience and knowledge of other organisations. As an instrument to facilitate this joint learning and working between silos, the catalogue of instruments will contribute to this by acting as a boundary object.

Within the organisation of Banedanmark, the catalogue of instruments will function as an object that lies between the different silos, that constitute different communities of practice. The catalogue will function as an object that creates the prerequisite for retrieving and translating knowledge between actors across the silos. The catalogue will create a starting point for communicating and sharing knowledge and concerns, by creating debate and discussion about which and how initiatives from the catalogue, can be included in projects. The object will translate knowledge across both a syntactic, semantic and pragmatic boundary (Carlile, 2002). It does not only create a common syntax for sustainability but also *"[...] provide a concrete means for individuals to specify and learn about their differences and dependencies [...]"* (Møller, 2013, p. 37), as actors need to reach consensus and be enrolled in each other's practices and concerns for the project to be executed. This creates requirements for the catalogue of instruments and the contents within, that it must be able to translate knowledge, not only 1-to-1 but also translate knowledge in a way that can be understood across multiple boundaries of knowledge.

6.1.3 Catalogue of Instrument as an Intermediary Object

Within the established network of public tendering, the aim is to establish a new relationship between the identified actor groups; developers, advisors, regulators and contractors, by introducing the catalogue of instruments as a new actor in the network. This actor will have a knowledge-sharing role and have the function of an intermediary and boundary object (Vinck, 2012). This role is facilitated by representing data from the actor groups through the dissemination of knowledge and initiatives, that support the vision of future sustainable public tenders. Thus, it is communicated which and how new sustainable initiatives can be included. The catalogue of instruments' ability to function as a mediator (Latour, 2005) is yet to be seen. Latour (2005) distinguishes mediators from intermediaries, as mediators having: *"No matter how apparently simple a mediator may look, it may become complex; it may lead in multiple directions which will modify all the contradictory accounts attributed to its role"* (Latour, 2005, p. 39). Consequently, this means that even though the catalogue of instruments' role within the network might seem simple at first, it may be able to open up an area of possibilities within public tendering and redistribute the distribution of agency in the tendering process, to give agency to actors that currently possesses less agency. Likely, the catalogue of instruments will only be able to function as a mediator and not as an intermediary. The intermediary object function as a mediator, as it actively translates and transforms the knowledge between the actors in a language and setting common to all. This is due to the construction of the catalogue where knowledge and experiences from multiple actor groups are represented in the catalogue, in a position that can benefit all actor groups. To summarise, the catalogue of instruments will be situated on the knowledge boundary between the identified actor groups within the

network, which due to the plasticity and its' ability to transform knowledge, will function as a mediating intermediary object. Furthermore, it will be able to redistribute agency between actors through the specific knowledge it mediates.

Across organisations, the catalogue will facilitate knowledge and experience sharing, which will be integrated and part of the catalogue. The catalogue will thus be constantly changing as actors can further develop it through descriptions of their experiences with concrete initiatives, advice and knowledge. The catalogue shall thus function as an intermediary object (Vinck, 2011) which through collective equipping, is added new properties that will help to shape the design space and collective work (Vinck, 2010). It is argued that the catalogue will be able to effectively disseminate tacit knowledge about sustainability between organisations, as it requires developers to describe specifications about sustainable initiatives, and put a focus on sustainability in construction projects.

6.2 The Tendering Network

Following will specify how actors in the construction industry is connected in the tendering system, and how their arena of influences affect the system. From initial research, the relationship between actors, as well as their dependence on each other has been explored, which this section will describe and illustrate. The system will be analysed with the framework of the Actor Network Theory (C. Storni, 2015) to categorize the actors of the system. With an actor-centered approach, this section draws upon the framework of arenas of development, that analyze how established systems, where actors' concerns and controversies establish arenas, can be challenged (Jørgensen, 2017). While this section will provide an insight into which arenas exist in the network, an analysis of how these arenas can be challenged will appear later in the report. Both humane and non-humane actors are included in the system, and grouped according to their position, and thus their influence on the system. The position of different actor groups is unaffected by the chosen tendering form, however their influence on projects can differ, as well as their tasks. Similarly, regardless which model of enterprise is offered, the position of the different groupings remains unchanged. Consequently, this section will not differ between types of tendering or models of enterprise, but solely focus on the grouping of actors that are a part of the system and the relations between them (See section 5.2.3 - Interviews with advisors & [Appendix D – Interview with Bjerre, Kammeradvokaten]).

6.2.1 Grouping of actors within the network

Developers:

This group of actors is defined by their position as tenderers, which is often a publicly controlled entity, that is subject to a political agenda. How, and to which degree the individual tenderer is subject to political pressure varies a lot as it depends on the entity, the tenderer is a part of. The political influence determines both the degree to which sustainability must be prioritized by the individual developer, but also the budget on which construction projects must be financed. Likewise, there may be certain conditions set by politicians that delimit the developer's room for manoeuvre. Despite sharing the same position in the system, each of the developers has different practices and processes regarding the preparation of their tender. Likewise, within these processes, the developers have different actors involved in terms of advisers and others that might contain valuable knowledge for the project.

In this thesis, several developers such as BaneDanmark, Vejdirektoratet, Copenhagen municipality, Metroselskabet, and several regions and municipalities, are involved. Typically, each of these developers is managing a variety of tenders related to different projects, however, their position and relation to actors in the system will only be assessed in relation to tenders related to construction.

Contractors:

The contractor group entails all the construction companies of different sizes. Contractor companies play a central role in the construction industry as they are responsible for the execution of the projects. To become part of a construction project, different contractors can bid on the developer's tender. The contractor that manages to make the most adequate offer, wins the tender. Which parameters the contractor must live up to win the tender, depends on what the developer finds important to include in the tender.

The contractors are to a large extent subject to the developers, as their companies are dependent on them being able to fulfil the requirements, the developers have for their projects. If a construction company to a less extent, can't deliver what is required, the company is disadvantaged competitively. The contractors have a unique position in the system in terms of initiating a sustainable transition because they possess an experience base that makes them very useful in terms of creating incentives for sustainability. The construction companies involved in this project are some of the largest in the industry, as it requires a particular size and resources, to bid on BaneDanmark projects. Consequently, this grouping will reflect the position of larger contractor companies.

Advisors:

The group of advisors consists of many different types of advisors that are relevant to different projects. The advisors may have different roles in projects, but common to them is, that they possess expert knowledge, that makes them important for a project, or the preparation of tenders. This expertise knowledge makes other actors such as developers and contractors heavily dependent on them, for projects or processes to be carried out as intended.

Market regulators:

The market regulators consist of actors that set the premise for the market. This grouping of actors are gatekeepers within the system, and they constitute the framework for the rules and conditions under which the remaining actors must operate. Actors that are a part of this group entail Konkurrencestyrelsen, who defines the rules of tendering such as regulating how communication and knowledge sharing should take place between actors. Konkurrencestyrelsen's goal is to create a competitive and fair market.

Elected politicians, at the national and EU level, can affect the rules of tendering. However, they can also set budgets for public developers, such as Banedanmark or municipalities. These budgets can push developers to save money or spend money depending on the political movements.

6.2.2 Circulation of knowledge within the network

Figure 15 below aims to illustrate how relations/knowledge in a tender network abound between various actors who are part of the network. In *figure 16*, relationships between human and non-human actors are marked with green arrows, and relationships between human actors are marked with blue arrows.

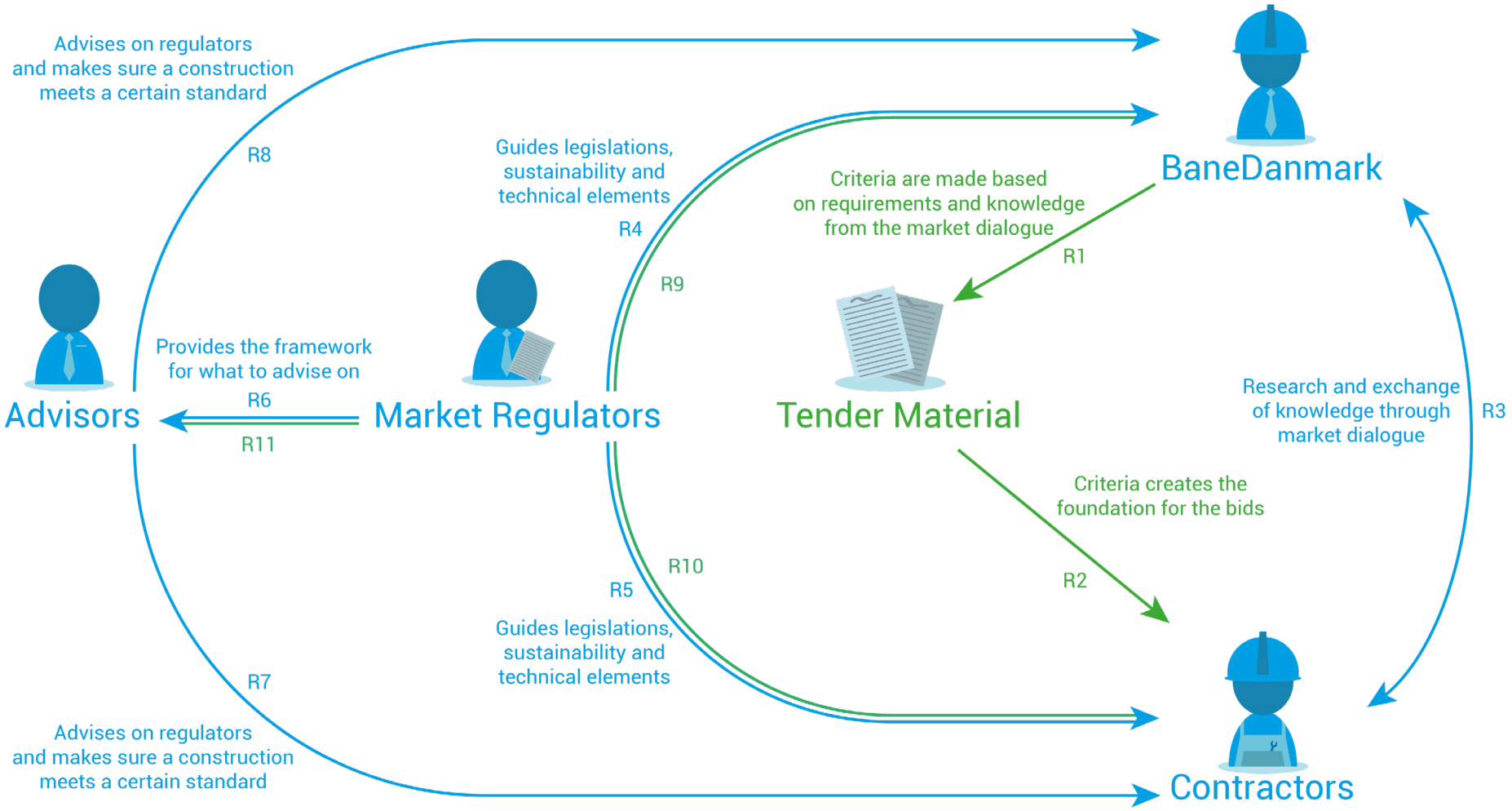

Figure 16: Author illustration of the relationships between actors in the network.

R1 – Developer and the tender material: The tenderers who represent the group of developers in the illustration are responsible for preparing the tender material. To construct a tender material that has been thoroughly prepared and takes various actors' concerns into account, it is important developers can include knowledge from relevant actors before the tender material is prepared (see section Metroselskabet, Ilka, Roskilde). In this regard, the developer must collect the relevant knowledge from relevant actors, for the tender documents to reflect the knowledge that can enable the developer's intention for the tender.

R2 - The contractor and the tender material: The tender material sets the frame for how the contractor can operate, and how much influence the contractor has on the construction project. If the tender material has not been prepared to involve the contractors' relevant knowledge, it is less likely that the project will be executed optimally, as they contain the relevant ballast of experience. The preparation of a tender that manages to include contractors' knowledge, may to a higher extent, stimulate innovative progress. In this relation, a tender material must manage to balance between the developer's knowledge, involving certain parameters that must be fulfilled in the construction project, and the contractor's knowledge of how these can be executed most optimally.

R3 - The contractor and the developer: Before a tender is constructed, a thorough market dialogue should be established. The market dialogue helps to inform the developer about what the market can deliver, and what the latest innovative methods within the relevant area, entail. The market dialogue stimulates competition between contractors as it equips the developer with knowledge concerning what requirements and prerequisites a tender can or should be based on. This clarifies for the developer, which parameters contractors can compete on, and thus how the tender is to be made.

R4 – Market regulators and the developer: Market regulators such as the Public Procurement Act, regulate how developers may communicate with the contractors, as communication must not create competitive advantages for some suppliers. Therefore, the knowledge included in the tender must reflect a broad market dialogue with varied knowledge from different contractors. Likewise, the Public Procurement Act limits the conditions for how the tender material may be constructed, and thus which parameters may be required, it also sets requirements for what information must be available in the tender material.

R5 - Market regulators and the contractors: Market regulators involve both human and non-human actors. As the Public Procurement Act is an EU directive that has been introduced in Denmark as legislation, both the EU, politicians and the Public Procurement Act are defined as market regulators. The Public Procurement Act regulates the contractor's interaction opportunities as it sets requirements for formalities regarding how quickly contractors must respond to tenders, as well as, how and when contractors must communicate with the developer. The building regulation is also a market regulator that defines which quality- and building requirements the contractor must meet, thus narrowing the field of operation.

R6 - Market regulator and the advisors: Market regulators such as the Public Procurement Act regulate how advisers, such as public procurement advisers, should advise other actors in the network.

R7 - Advisors and contractors: Depending on the model of enterprise the contractor is employed on, the interaction with advisors will be more or less included in the contractor's work. If the contractor is employed under a turnkey contract, where the contractor has all the responsibility, the knowledge from consulting advisers will probably have to be included to a larger extent. Which advisors the contractor involves depends on the specific project, but can be sustainability advisors, or advisors on construction technical details. Tender advisors are also relevant for contractors as they can be hired to prepare the contractor's offer to the developer.

R8 – Advisors and developers: Advisers are sometimes requested by the developers before the tender material is prepared. In such cases, the advisers are typically involved in the planning and design of the construction project. How and which advisers are involved varies depending on the developer and what knowledge is relevant to the construction. Tender advisers are also used by the developers for the preparation of the tender material, to ensure that the tender does not violate the Public Procurement Act.

6.3 Analysis of Matters of Concern

To get an overview of the collected data and contextualise it, an affinity diagram was applied to summarise the data. This made it possible to see the similarity of statements across the boundaries of the various actors' knowledge. After gathering the empirical knowledge and contextualising it according to affinity to other data points, actors were grouped into their respective roles in the public procurement network, after which the knowledge and the intentions of the different groups were analysed, to understand the Matter of Concerns (Brodersen, Pedersen 2019).

Developers

The first group to be analysed was the developers, including various municipalities, regions and major infrastructure organisations such as Banedanmark and Metroselskabet. As public actors, it is a common prerequisite that they must have a high standard of delivery, as construction projects are under tight public observation since the daily lives of many citizens depend on using these facilities. Consequently, time, money and quality are of the highest priority. This creates a problem regarding what is prioritised in the tender, and usually, sustainability is deprioritised or not an issue at all. *"You should experiment more with tenders than you do today - you can be super innovative through your tender. Unfortunately, there is a lack of resources to test how to make tenders greener."*[1] - Region of Northern Jutland (Affinity Diagram & [Appendix C – Affinity Diagram]). The developer is concerned about making criteria for sustainability in the tender, as they are not subject to a delivery on this parameter from higher instances, which is the case concerning other assessment parameters such as; price, quality etc. *"Politicians forget that when one wants sustainability into an industry, it has to play along with other parameters such as quality, security and more."*[2] -Region of Northern Jutland (Affinity Diagram & [Appendix C – Affinity Diagram]). To ensure that the developer can deliver on the

1 "Man burde eksperimentere mere med uddud end man gør I dag – man kan være super innovativ gennem sit udbud. Der er desværre mangel på ressourcer til at afprøve hvordan man gør udbud grønnere." -Region of Northern Jutland (Affinity Diagram & [Appendix C – Affinity Diagram])

2 "Politikere glemmer at når man vil have bæredygtighed ind i en branche, er det nødt til at spille sammen med andre parametre såsom kvalitet, sikkerhed med mere." -Region of Northern Jutland (Affinity Diagram & [Appendix C – Affinity Diagram]).

assessment parameters on which he is forced to, he will not impose sustainability requirements in the tender, as this may compromise with other parameters. The developer considers requirements in tenders as an obstacle to sustainable innovation, as specific requirements for how the contractor should deliver a sustainable solution, could exclude other alternatives that could be better. Developers see the contractors as the right person to assess how a task should be solved, and therefore the contractor should be the decision-maker regarding how sustainability is included in projects. As a way for the developers to stimulate this space for innovation, Aarsleff Rail among other, reasons for avoiding the use of sub-criteria in the tender, embraces a broad option of solutions, such as the criteria represented by Aarsleff Rail, where they are only asked to explain how they intend to execute the task (Section 5.2.2 – Aarsleff Rail). For this purpose, the market dialogue plays a fundamental role for the developer, as they through the market dialogue can gain an understanding of what opportunities exist in the market, thus what can be expected from the contractors. The three main concerns of the developers can be seen in *figure 17*, below.

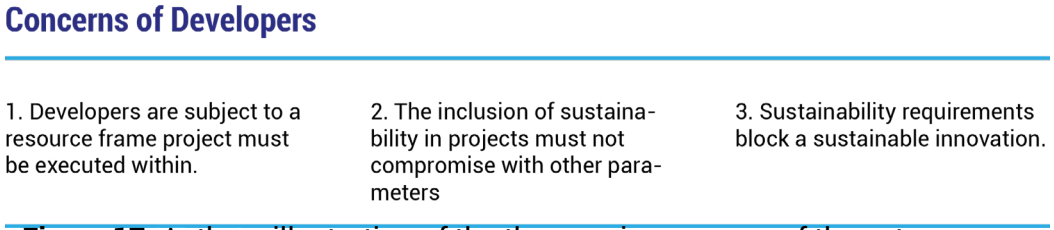

Figure 17: Authors illustration of the three main concerns of the actor group, developers.

Contractors

To represent the concerns of the contractor group, Munk Group, Aarsleff Rail, and Arkil has been analysed. Common to this group of actors is the desire for a transparent procurement process. Transparency in this context involves developers concretising how sustainability should be executed in projects, and what is important regarding this. According to the contractors, when sustainability is set as a sub-criterion it is often described as too unspecific and is not weighted high enough to create a competitive advantage for the contractor. Unspecific criteria make the contractors unsure of how they are evaluated and thus make it uncertain how they should perform to win the tender. Consequently, it is deprioritised in favour of assessment parameters on which they can secure market advantage. *"Part- and sub-criteria do not create competition between contractors unless it is given high weight in the tender."*[3] -Arkil (Affinity Diagram & [Appendix C – Affinity Diagram]). As this group of actors consists of private companies, it is a prerequisite that the involvement of sustainable initiatives is profitable for the company. Therefore, it becomes crucial for the contractor that the developer either sets minimum requirements for sustainability or establishes economic benefits for the inclusion of sustainability in solutions if sustainability should be a priority for them. If developers set minimum requirements in tenders, the competition between contractors would be stabilised, as sustainability becomes a prerequisite for bidding on the project, and thus cooperation and knowledge sharing between the contractors will also be stimulated. The three main concerns of the contractors can be seen in *figure 18*, on the next page.

3 "Del- og underkriterier skaber ikke konkurrence imellem entreprenører hvis ikke det vægtes højt i udbuddet" -Arkil (Affinity Diagram & [Appendix C – Affinity Diagram]).

Concerns of Contractors

1. Sustainability is deprioritized because it is formulated as non-specific criteria, which makes it difficult to know what is being assessed and prioritized in the tender.

2. Sustainability is not weighted enough to create a competitive advantage.

3. Including sustainability in projects requires that it entails a market advantage.

Figure 18: Authors illustration of the three main concerns of the actor group, contractors.

Advisors

The group of advisors includes both technical-, tendering- and legal advisors. Common for these is, that they are third-party actors that are paid to either advise on the tendering process, or in the case of legal advisory, solve eventual conflicts after the construction is conducted. Depending on the advisor in question, they usually have an area of responsibility they must fulfil related to the preparation of a tender. According to the group of advisors, developers are very uninformed about sustainability, and there is generally a lack of knowledge regarding what the term entails. “Sustainability has become a big and scary thing that the developer does not know anything about - there is a need to make sustainability and the certifications more digestible." -Bödewadt, VILTOFT Advokater (Affinity Diagram & [Appendix C – Affinity Diagram]). As a result, developers do not wish to make decisions on how sustainability can or should be present in the project. It is the advisor's impression, that sustainability becomes too extensive an area to deal with for most developers, and thus the responsibility is abdicated to the advisors or the contractors. To get developers to take responsibility for how sustainability should be included in a project, advisors often try to reformulate and create a language for what sustainability means when it is to be implemented in a project. Advisors find it easier to advise developers when there are specific tools that can be applied for the process, which to some extent, depending on the construction project, can be done through DGNB-certification. However, this still requires developers to decide which way the project should fulfil some of the requirements in the certification. The two main concerns of the advisors can be seen in *figure 19*, below.

Concerns of Advisors

1. It takes a lot of advising to get developers to decide how sustainability should be present in their projects.

2. Quantitative instruments are missing in the advising process.

Figure 19: Authors illustration of the two main concerns of the actor group, advisors.

Market regulators

The final group is the market regulators. This group consists of larger national- and geopolitical institutions such as the EU, UN, and governments. The representation of this group of actors is deficient in the data of this thesis, as it has not been possible to arrange interviews with actors representing this group. The group's concerns have only been described to a limited extent by some of the interviewed developers. These rationalise politicians' lack of requirements for sustainability in tenders, with the fact that politicians are aware that this will require financial support from them, and this financial support can be difficult to obtain. The main concern of the market regulators can be seen in figure 20, below.

Concerns of Market Regulators

1. It is problematic to find the funding for developers to include sustainability.

Figure 20: Authors illustration of the main concern of the actor group, market regulators.

6.4 Analysis of Controversies

In the following, an analysis of the controversies between the key actor groups – developers and contractors - is conducted. From an ANT perspective (Storni, 2015, Latour, 2005), controversies between actors are used to identify a space for change. In this thesis, controversies between actors are analysed to gain an understanding of what is currently blocking sustainable development in tenders, within the construction industry. Combining this with an understanding of actors' concerns and the possible arena for development helps to address potential controversies. To understand the controversy, Venturini's (Venturini 2010), edition of the Actor-Network-Theory is applied, which builds further on the understanding of controversies to be covering all opposing's concerns, as well as another disagreement as seen in the quote below.

"The notion of disagreement is to be taken in the widest sense: controversies begin when actors discover that they cannot ignore each other, and controversies end when actors manage to work out a solid compromise to live together. Anything between these two extremes can be called a controversy." (Venturini 2010 p261.)

These controversies need to be resolved to support a solution that contributes to a construction industry where sustainability is given higher priority. However, when some of them are resolved, new ones arise due to various concerns from the actors. Through empirical research conducted in this thesis, controversies could be identified between developers and contractors. There is a potential to resolve the controversy between these actor groups, but the solutions may overlap with concerns and potential conflicts from other actor groups, as pointed out by CO-PI [Appendix E – Interview with CO-PI].

6.4.1 Controversy Regarding Laws.

This controversy is a direct result of the legislation surrounding public tenders. In the current law, the tender material and specifications must not be formulated in a way that can result in excluding potential contractors or favouring specific certifications (See section 5.2.3 - Interviews with advisors). However, this has the potential consequence of severely limiting the exploration of new innovative and sustainable solutions in construction. For example, the tenderer can only set project-specific requirements in the tender, that do not require a specific third-party verification. The reason for such limitation in tenders is that smaller construction companies should be able to bid on projects. With the introduction of InfraLCA, Vejrdirektoratet is addressing this controversy, as the instrument can contribute to replacing the use of expensive certification. The InfraLCA software is free and "easy" to use, which could help to solve this controversy. However, due to the lack of certifications in construction, these controversies also extend to expensive LCA consultants or EPDs, which could lead to similar controversies.

6.4.2 Controversy Regarding the Preparation of Tenders

Another controversy stems from the fact that contractors consider an increased focus on implementing sustainable initiatives, as a complication for winning the bid. This is due to the price being prioritized over sustainability by developers. Focusing on sustainable initiatives risks increasing prices, making it favourable for contractors to propose cheaper solutions that de-prioritises sustainability. This controversy is also based on the duality of concerns between the groups, with developers wanting the lowest possible price and contractors wanting safe and high profits [Appendix F – Interview Munck Group]. This creates a situation where the controversy is hard to resolve, especially if it requi-

res extra resources/funds for the developers. In this case, market regulators controlling public funding must be involved. However, a potential solution could also be to identify sustainable initiatives through experimentation with sustainable solutions with no extra costs involved for developers. This could require the involvement of advisors for internal sparring, to include additional professional knowledge and accelerate innovation [Appendix G – Lendager].

Another controversy concerning the preparation of tenders is between the contractors and the developers, which is caused by a disagreement about how specific and transparent tenders should be. Criteria in tenders are either described too broadly, or else it appears too unambiguously in the criteria what the developer prioritizes in a solution, and thus what the contractor is assessed on. Moreover, contractors are very focused on how to pick the low-hanging fruits when preparing their bids, which is also a product of non-specific criteria that give rise to contractors skipping where the fence is lowest. Developers risk that entrepreneurs incorporate an absolute minimum of sustainability into their solutions, instead of focusing on sustainability value.

6.4.3 Controversies Concerning Knowledge Sharing

According to the contractors, knowledge sharing in their industry is problematic, as it can result in competitors gaining advantages related to winning tenders. This controversy is largely characterized by developers setting criteria in their tender, rather than minimum requirements. If developers chose to set minimum requirements, it would reduce competition between contractors, as the knowledge shared between them, would simply create the prerequisite for contractors to participate in the tender, and not benefits related to winning.

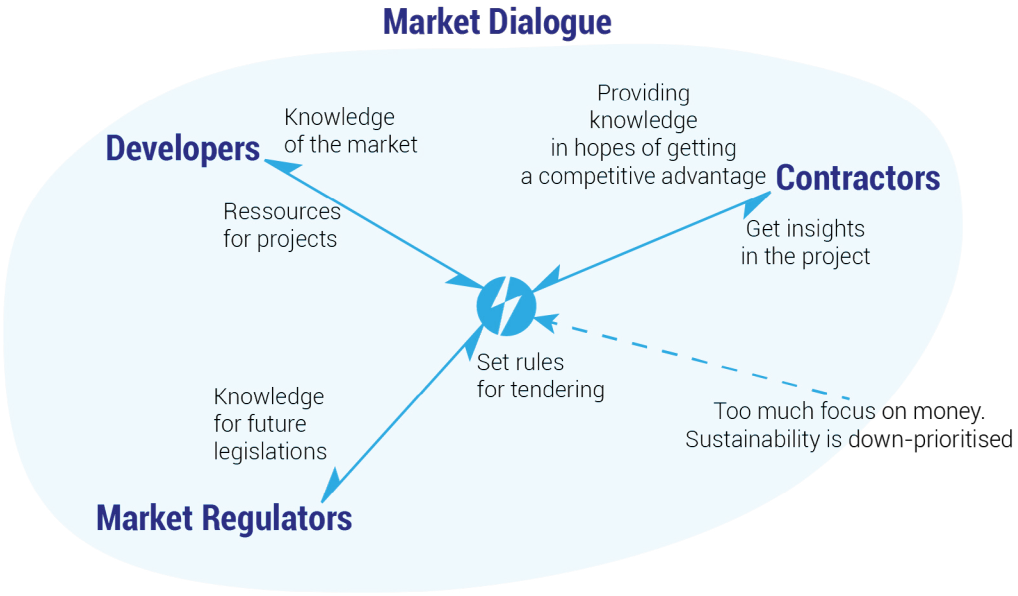

Figure 21: Author illustration of the relationships in the market dialogue and the identified controversies.

6.4.4 Controversies Regarding Responsibility of Sustainability in Tenders

A final controversy between contractors and developers involves a lack of clear distinction between who is responsible for sustainability being involved in projects. This has created a schism between the contractors and the developers. According to the contractors, it is the developers' responsibility to clearly state how sustainability should be included in the construction industry. Since the developers are the employers, it should be their decision what and how the construction is to be carried out, and this also applies to load-bearing solutions. It is also a matter of the developer being the actor who determines the resources allocated to a project, and therefore they should also define how those resources should be distributed. If the contractors themselves had to decide which or how sustainable solutions are implemented, it can cause a

need for more resources to be allocated, which is beyond their scope of action.

On the contrary, the developers believe that the contractors should be responsible for creating a progressive development towards sustainable construction, as they possess the relevant knowledge and experience around sustainable solutions, their costs, etc. The controversy surrounding responsibility is also seen in terms of whether the quality of sustainable solutions in construction, manages to be similar to the current quality. An example of this is the use of recycled materials. Here a controversy arises concerning who takes responsibility for whether the materials can last the intended number of years.

In this controversy, there is great potential for a solution that can conduit the inclusion of sustainable knowledge, as the actors have closely related desires. Adaptation could therefore result in promoting sustainable development if a process is facilitated to resolve this controversy.

6.4.5 Arenas of Development

This section explores the concept of Arenas of Development within the area; public tendering in construction. The arenas of development are applied as a framework to explore how actors' arenas - consisting of their agenda, knowledge and concerns - affect and overlap. The different Arenas of Development collectively constitute a common shared Matter of Concern (Jørgensen & Sørensen, 1999). These arenas are not physical or geographical spaces, but cognitive spaces that: *"[...] holds together the settings and relations that comprise the context for product or process development including:*

A number of elements such as actors, artefacts, and standards that populate the arena,
A variety of locations for action, knowledge and visions that define the changes of this space, and
a set of translations that has shaped and played out the stabilisation and destabilisation of relations and artefacts." (Jørgensen & Sørensen, 1999, p. 410).

Throughout research conducted in this project, four Arenas of Development have been identified, from actors connected across different actor groups. These actor groups are created based on the interrelated and shared agendas between the actors (Jørgensen & Sørensen, 1999). The four identified arenas of development are as follows:

1. Public Institutions
2. Environmental Concerns
3. Building Sector
4. Construction of Infrastructure

Although the actors are grouped based on their shared agendas with other actors, one actor can be a part of multiple Arenas of Development at the same time. One important clarification to make, is that these boundaries between the arenas and the visualisation thereof are only snapshots of a temporarily limited configuration, as the reality of these shared agendas is ever-changing (Jørgensen & Sørensen, 1999).

The actors that were identified to be situated within the arena of Public Institutions all share the agenda of representing the populations' opinions and wishes through democratically chosen representatives, and

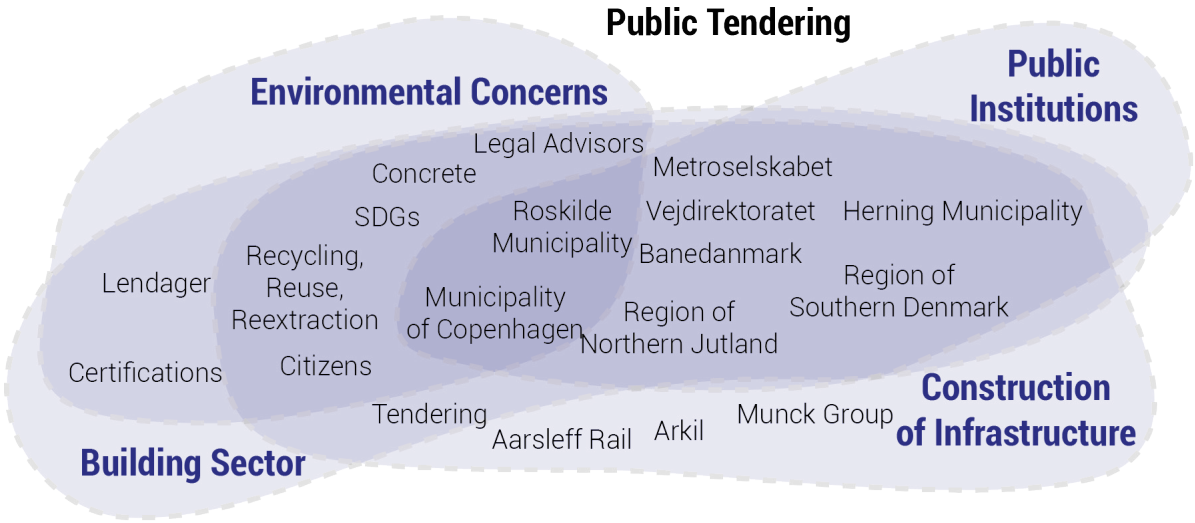

Figure 23: Author illustration of the four identified Arenas of Development within public tendering.

investing public funding to better the living conditions for citizens (see *figure 23*). As a result, the individual institutions' stance on political questions such as sustainability can change over time, due to the democratic processes. The actors within the arena, Building Sector, all share the common agenda of constructing buildings for the public. The third arena identified is the Construction of Infrastructure. This arena is like the Building Sector arena but has a different type of construction in mind, and the concept and implementation of sustainability are not as developed in this arena, as compared to the building sector. As we see in our fourth arena, the Environmental Concerns arena does not overlap as much with the Construction of Infrastructure arena as it does with the Building Sector. The shared agenda between these two arenas concerns a focus on reducing CO2 emissions from the construction industry. As illustrated in *figure 23*, there is a lack of overlap between the Environmental Concern arena and the Construction of Infrastructure arena, but also a lack of overlap between the Environmental concern arena and the arena of Public Institutions.

This thesis examines how the boundaries of environmental concerns can be expanded, to encapsulate more of, and gain favour within public institutions and infrastructure construction. One approach could be the introduction of a new actor who can take the more developed knowledge of sustainable initiatives from other actor-worlds/arenas such as the construction sector, and disseminate/translate this knowledge to the other development arenas (see *figure 24*).

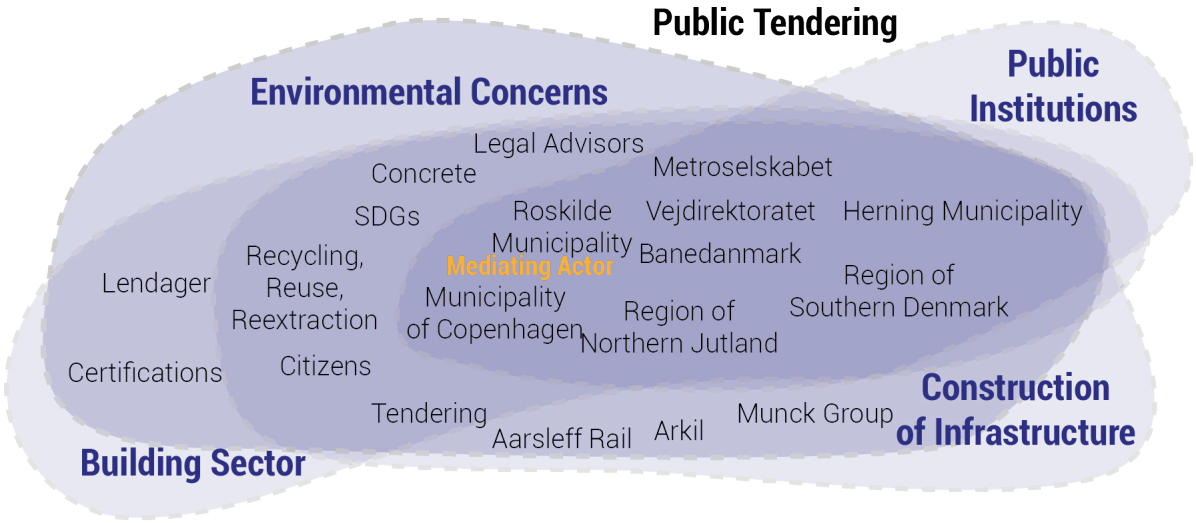

Figure 24: Author illustration of the envisioned expansion of the arena Environmental Concerns by introducing a new mediating actor (orange)

6.4.6 The Obligatory Passage Point

An understanding of the various matters of concern, and controversies that exist in the network, can be applied to perform an obligatory passage point analysis (OPP) (Callon 1984). An OPP analysis aims to find the point that connects the actors' need for a solution. Thus, an OPP tries to find a common denominator for the actors, that makes a solution possible.

In this OPP analysis, the aim is to find a common point of view that reveals what means is important to possess in a catalogue of instruments, that would make sustainability a higher priority in tenders. Of all the actors in the network, market regulators have been the group of actors whose needs and goals have been most difficult to decipher. This is caused by the group is not represented sufficiently in the data and there is not the same level of homogeneity within this group. On the other hand, with a great homogeneity, the goal of developers and contractors has been largely unambiguous.
Despite this, it is important to emphasise that individual actors in the groupings may have different obstacles and goals, which are a prerequisite for organisations to differ in their priorities and structures. However, it has been possible to identify a basic understanding of what information there is a common need for. Through the identification of needs, OPP can help create new alliances as it reveals a need in the development that is not covered.

As can be seen in *figure 25 (on the next page)*, the passage point that contributes to solving the challenge of creating more sustainability in tenders was analysed to be the "circulation of quantitative assessment parameters for sustainability; ". The circulation of quantitative data concerning sustainability that acts as an OPP involves various quantitative assessment parameters such as; risk assessments, budgets, CO2 savings, etc. A transition towards a more sustainable system is therefore considered to be highly dependent on actors being able to obtain quantitative knowledge about the consequences or gains of sustainable initiatives. In the following, a description of how the OPP meets the concerns of different actors will appear.

R1: For advisors, the quantification of initiatives provides a concrete tool to advise developers on how sustainability can be included, without compromising the resource frame of the project that the developer is subject to. As the quantification of sustainable initiatives considers the developer's concerns, such as the price level, the developer is more likely to decide by himself how sustainability should be included, and stay within the resource frame of the project. This makes it less up to the advisor to translate what sustainability in a project entails. For sustainability advisors, it will help ensure sustainable inclusion as concrete requirements can be made for CO2 savings or other sustainability parameters. For tender advisors who prepare tender documents for organisations, it will be easier to ensure that initiatives in the tender comply with the restrictions that the advisor is subject to, by the organisation.

R2: With the quantification of sustainable initiatives, the developers will gain an understanding of how sustainability can be included in projects without compromising on other parameters, to which they are subject. Sustainability can thus be adapted to the degree the resource frame of the project allows. Likewise, it will be easier for the developer to set specific minimum requirements in the tender that are within the resource framework and fulfil a concrete level of sustainability. For this, a

quantitative assessment basis will give the developer a realistic insight into what can be required in the tender, within the resource framework.

R3: By giving developers a tool to set concrete realistic objectives for sustainability levels, it will create a transparent assessment basis for the contractors and insight into what they need to deliver and what they are assessed on. By giving contractors insight into the level of sustainability they are required to deliver, and thus what they are assessed on, contractors will gain a larger focus on this, and the entrepreneurial market will be stimulated to think in terms of sustainable solutions. However, it should be mentioned that this transition is also dependent on how much sustainability is weighted in the tender.

R4: For market regulators, the quantification of sustainable initiatives will mean that the developer can include sustainability to a degree that stays within the defined budget, without requiring funding from politicians. In addition, it also creates a foundation for politicians the other way, to make demands on the inclusion of sustainability that falls within the current resource frame.

The obligatory passage point; circulation of quantitative sustainability initiatives is, as mentioned above, fundamentally important for the various actor groups if sustainability is to be presented more in tenders. Consequently, the OPP also constitute of fundamental importance for what needs to be reported in a catalogue of instruments. The defined OPP thus sets the frame for what the main focus should entail in the conceptualisation of the catalogue.

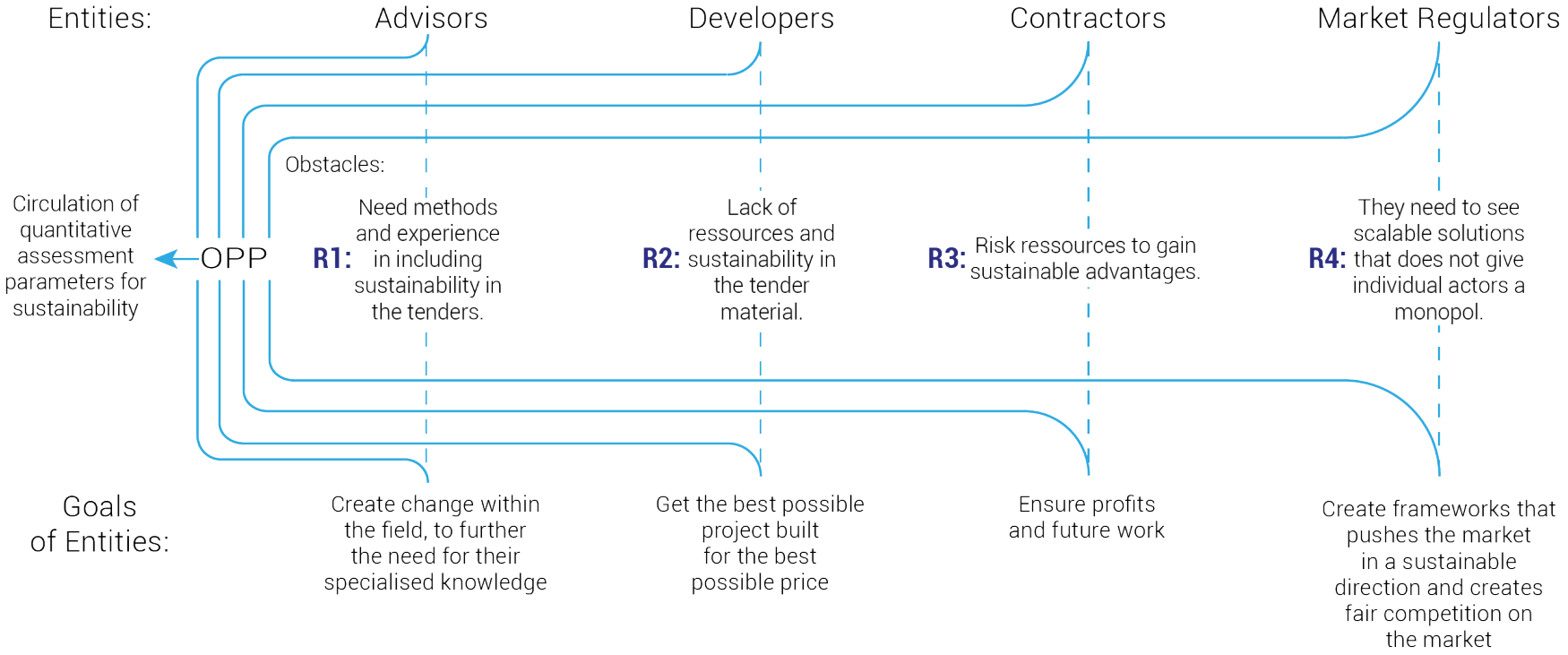

Figure 25: Author illustration of the obligatory passage points in the construction network.

7.
Conceptualisation

In the conceptualisation chapter, all the factors that have contributed to the development of the catalogue of instruments will be presented. Initially, the elements that have shed the foundation for the development of a first prototype, will be presented. Firstly, the survey of this thesis has contributed with concrete initiatives for the catalogue, which have been selected on their relevance to actors' reports. Next, a section will introduce, how various actors' matters of concern, as well as additional information from interviews, have provided indications of do's and don'ts, to what the catalogue should include and exclude. Furthermore, additional catalogues, developed by other researchers, that have helped inspire the setup and layout of the catalogue, are presented.

These three data sets provide a foundation for the first prototype to be developed, creating the prerequisite for the prototype to be used as a boundary object and an intermediary device, that was iteratively circulated between different developers, and modified based on their feedback. The prototyping of the catalogue is considered and described as a process involving three steps; staging, facilitation and synthesis. These three steps together create the starting point for how the prototyping process is influenced.

7. Conceptualisation

7.1 Initiatives from the survey

The survey, which was sent to all municipalities and regions in Denmark, has been central to the development of the catalogue of instruments, as sustainability initiatives as well as related data such as advantages, disadvantages, and resource consumption, were collected. The survey has thus, in addition to initiatives collected through interviews, created the prerequisite for a selection of initiatives to be made.

As many initiatives were small and similar, they were divided and restructured, as the project group wished to combine them. Roughly, initiatives were put together based on their similarities, but also with regards to their resource needs, and effects. As different assessment parameters in the form of quantitative data had to be included in each action, it was necessary, that combined actions could be categorised under the same assessment parameters. The intention was to involve a sustainability expert to specify whether these combinations of initiatives are to some extent of the same nature, concerning the assessment parameters that have been set. The combination of initiatives led to the preparation of three whole initiatives, each of which consisted of a combination of smaller initiatives from different actors. The remaining initiatives from the survey were not further developed, due to the project's timeframe, and because the initiatives were more difficult to combine categorically or regarding the defined assessment parameters.

Figure 26: The three initiatives from the survey respondents.

7.2 Including Actors' Matter of Concern in our Catalogue

Through the section "the analysis", various actors' Matter of Concern (MOC) (Brodersen & Pedersen 2019) was identified within the confinement of public tendering. Through the conceptualisation, we wish to address these matters of concern, by including initiatives in the catalogue, which can account for these Matters of Concern. This is necessary for the catalogue to be able to remain relevant to a wide range of developers, and thus facilitate knowledge sharing. Consequently, the conceptualisation is focusing on the incorporation of the identified matters of concern, to ensure that actors of different organisational backgrounds, can use and adapt from the catalogue. The analysis identified an OPP that is representative of a solution for the different actors' MOC. Even though initiatives included in this catalogue aim to address various matters of concern, the MOCs that specifically address this OPP are especially represented in the catalogue through various initiatives.

Besides the identified MOCs, throughout the research of this thesis, actors have expressed specific requests, ideas, or other relevant information which involves useful considerations for the development of the catalogue. A lot of this data is related to the actor's MOCs, as it reflects proposed solutions or improprieties related to a specific MOC. The various information from actors that are useful for the development of the catalogue, is not only related to the MOCs of the actor group, but also those of other actor groups. The following will describe which MOCs and related information, have been used within each actor group, for the development of the catalogue.

7.2.1 Developers

To develop a catalogue that is useful to various developers, the catalogue should address the identified need for quantitative data, such as price levels, time and quality. Public developers are often budgeted by governance, such as politicians, and therefore the catalogue should help them gain insight into the possible gains and economic consequences. Various requests that developers have expressed a need for a catalogue of instruments to report can be related to one of the following MOCs illustrated in *figure 27*.

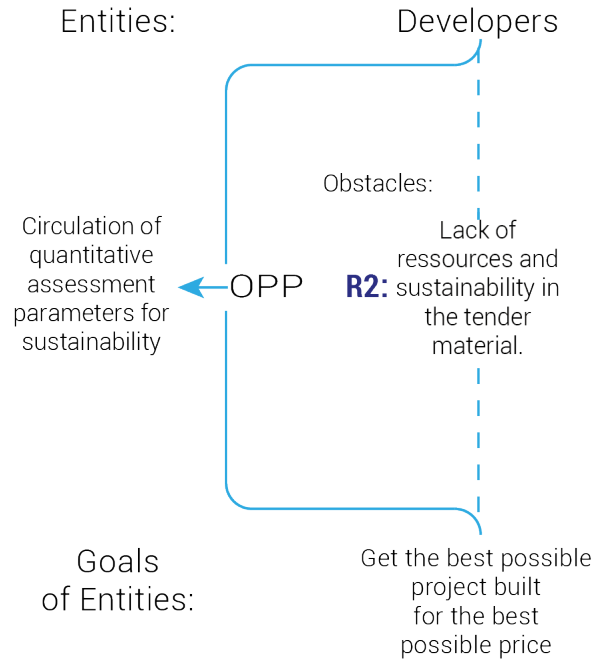

Figure 27: Authors illustration of obstacles and goals of developers.

Firstly, the need for product information to become more specific was requested by developers, which means that it should become more transparent where products are produced and that their life cycle is accounted for. Secondly, developers must make concrete demands in their tenders (See section, 5.2.1, Bollerup, Region of Northern Jutland), and this is therefore also an important aspect of knowledge sharing. To set specific requirements in the tender, a developer can effectively be inspired by the Nordic packaging requirements (See section, 5.2.1, Bollerup, Region of Northern Jutland), or DGNB [Appendix H - Inger, Region Syddanmark]. Likewise, Experimentation with tenders is important, according to developers, as a lot of knowledge and innovation are generated. Experimentation processes are therefore beneficial for other developers to gain insight into relation to failures and successes (See section, 5.2.1, Bollerup, Region of Northern Jutland). The market dialogue is also an important prerequisite for the preparation of the sustainable tender, as it contributes to understanding how the tender should be formulated and what is realistic regarding making requirements. However, it is also a difficult process because suppliers can provide misleading information, in favour of what they can provide (See section, 5.2.1, Bech, Metroselskabet). Initiatives regarding the effective market dialogue are therefore in high demand with developers (See section, 5.2.1, Bollerup, Region of Northern Jutland). As the quote below indicates, price and sustainability potential are important parameters to assess initiatives on. For initiatives to be relatable to the financial budget to which developers are subject, price assessments are important [Appendix I – Interview with Masana, Herning municipality] & [Appendix J – Interview with TMF of the Municipality of Copenhagen]). Since developers do not have much expertise knowledge concerning sustainability, it would also be relevant to gain knowledge about which focus areas possess the greatest sustainability potential.

"The problem of getting more sustainability in tenders: economics: sustainability is usually more expensive, in addition, there is a lack of

knowledge about what is actually sustainable." - (Masana, Herning Municipality).

7.2.2 Contractors

A concern among contractors is the need for data-based evaluations of tenders alongside clear requirements from the developers;

"One problem [withing tendering] is that the criteria are not described clearly enough when regarding sustainability, […]. But it is an area where change is happening fast." - (Sell, Arkil).

Another concern is related to the possible gains from including sustainability in projects, which is unclear and is far from standardised. Since sustainability is not prioritised enough in the tender material, it does not give a market advantage to the contractors. This leads to sustainability being downgraded by the contractors.

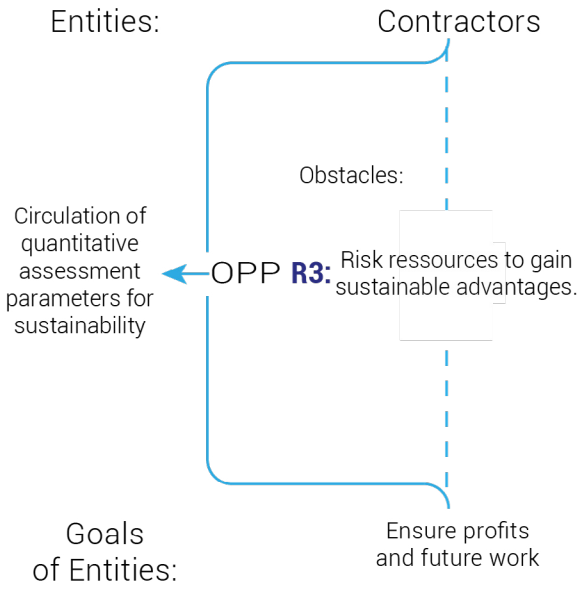

Figure 28: Authors illustration of obstacles and goals of contractors.

A result of the contractors' concerns, as well as the fact that they were introduced to other actors' concerns, lead to concrete suggestions related to how tenders could be structured differently. When contractors were introduced to developers' request for information about which area of action implies the greatest sustainability potential, they pointed out that recycling materials have great potential for creating a sustainable change (See section, 5.2.2, Aarsleff Rail). Related to their concerns, the contractors wanted tenders in the future to make minimum requirements which are further described concretely so that it seems transparent what the supplier can win the tender to meet (See section, 5.2.2, Aarsleff Rail). If sustainability is to be included by them, the minimum requirements should also include the sustainability elements that are to be prioritised (See section, 5.2.2, Sell, Arkil Group). To establish consensus between developers and contractors regarding which sustainability requirements should be included in the developer's tender, developers should be better at including sustainability as a topic in the market dialogue, which a catalogue of instruments could help developers to practice. Alternatively, the contractors' concerns can also be addressed by contractors receiving financial benefits by including sustainability (See section, 5.2.2, Sell, Arkil Group).

7.2.3 Advisors

Consulting sustainability can be a difficult process when no toolkit addresses the developer's understanding framework. For advisors to be able to get developers to decide for themselves how sustainability should be included in projects, data indicates that the developer needs sustainability to be manageable, and measurable regarding those parameters the developer focuses on, such as price, timeframe, and environmental conservation, etc.

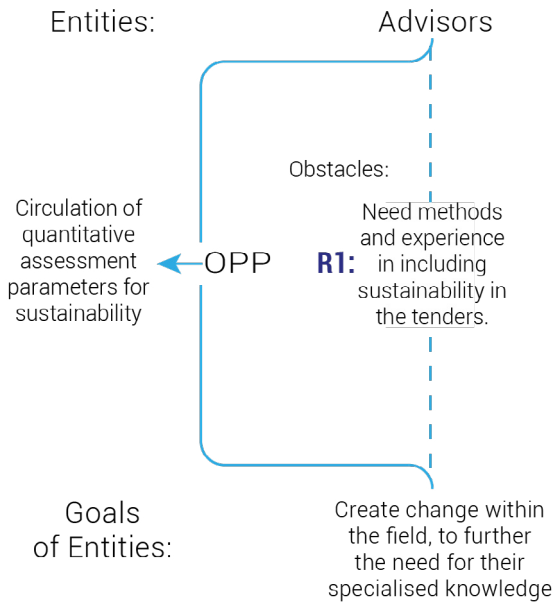

Figure 29: Authors illustration of obstacles and goals of advisors.

A challenge for advisors involves the lack of concrete tools to advise developers (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT). Alternatively, certification schemes are used in certain projects to address sustainability, so that the developer has something concrete to relate to. However, there are many decisions to make when using certification schemes, as it is a broad tool with many different areas of entry. Quantitative data about sustainable initiatives that are within the developer's field of expertise will presumably help to make decisions about sustainability because it avoids concerns about price, time, effect, etc. as this is defined in advance (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT). Likewise, it is important for advisors that data is comparable and can be assessed on an equal footing, which also calls for the addition of tools that can standardize data (See section, 5.2.3, Hvilsted, Tolstrup & Hvilsted [Appendix D – Interview with Bjerre]). According to advisors, developers must learn to think in terms of added value when it comes to sustainability, rather than focusing on a predicate such as a sustainability certification mark or diploma to represent a project (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT).

In addition to information related to the advisors' MOCs, other information from advisors was also beneficial for the development of the catalogue. Firstly, advisors described minimum requirements as a barrier to innovative progress as there is no competitive element between suppliers that stimulates them to develop new and better solutions (See section, 5.2.3, Hvilsted, Tolstrup & Hvilsted). However, the market dialogue is essential for developers to understand where the competitive element between suppliers should be laid, as it provides an understanding of what the market can deliver and therefore what the developer can expect from suppliers (See section, 5.2.3, Hvilsted, Tolstrup & Hvilsted & [Appendix D – Interview with Bjerre]). In addition, the advisor described the SDGs as difficult to consider when planning a project, as they are too flighty for developers to use to define how sustainability should be included in projects (See section, 5.2.3, Hvilsted, Tolstrup & Hvilsted & [Appendix D – Interview with Bjerre]). The inclusion of sustainability in projects must be assessed regarding how it fits the individual project, and therefore standardized solutions should never be made for project types (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT). According to advisors, the description of a tender should be as concrete as possible so that it seems clear and transparent what the developer is assessed on, and what is in high demand for the developer (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT). In addition, the preparation of the tender should involve all relevant actors from the beginning, i.e., in the planning process of the tender itself, until the project is executed and completed (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT). This is important because the process from the start of a project until it is

completed, is dynamic and constantly changing. Therefore, there will constantly be new decisions to make for different actors (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT). In particular, sustainability must be introduced from the very beginning of a project for it to be sustainable at its core, as, according to advisors, the greatest sustainability potential lies before the preparation of the tender (See section, 5.2.3, Bödewadt Lauritzen, VILTOFT).

7.2.4 Market Regulators

Unfortunately, statements from market regulators in this thesis are flawed, and therefore the catalogue only reflects their concerns through the developers' description of what it entails. According to the developers, politicians are not willing to set demands for sustainability, as it can compromise the budget they have set for the public developer (see section XX, Arkil). The sustainability requirements must necessarily apply to all developers for competition to remain equal, and therefore sustainability demands require that all developers can meet the demand.

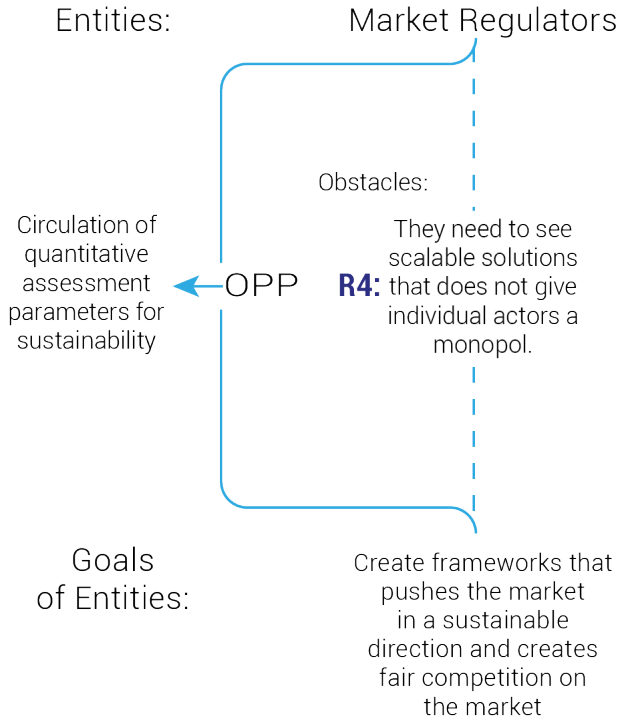

Figure 30: Authors illustration of obstacles and goals of market regulators.

7.2.5 Implementing the Actors' Data Into the Catalogue

Based on the actors' matters of concern and further information from interviews consisting of advice, ideas, discouragements, and general comments that were beneficial to the development of the instrument catalogue, concrete measures and attributes for the catalogue were developed. The following will describe how this information has been applied in the development of a first prototype, and for concrete initiatives for the catalogue. *Figure 31 (next page)* shows how knowledge and information have been applied in the catalogue and which actors group that information and knowledge come from.

R1: The first initiative that was described based on actor data, was the structuring of the sustainable tender. This initiative reports on how developers can construct a tender that accommodates both the developer's own and contractors' concerns. This initiative describes considerations related to when the developer should consider including minimum requirements vs. sub-criteria, as these can have different impacts on the degree and whether sustainability becomes a priority in the tender. As a supplement to set criteria, contractors' suggestions on how sustainability can be prioritized in a project through financial bonuses per sustainability unit, are also included. The initiative calls for tenders to be formulated as concrete and transparent as possible, which means first and foremost that it becomes clear what the developer wants in a project, and values, but also that requirements are set for how contractors should document that this is provided for, in their offer. Uniform documentation of how tenders are calculated and accounted for, creates comparable data and contributes to a transparent tender. To formulate specific requirements, the initiative provides some ideas for how the developer can draw inspiration from already existing

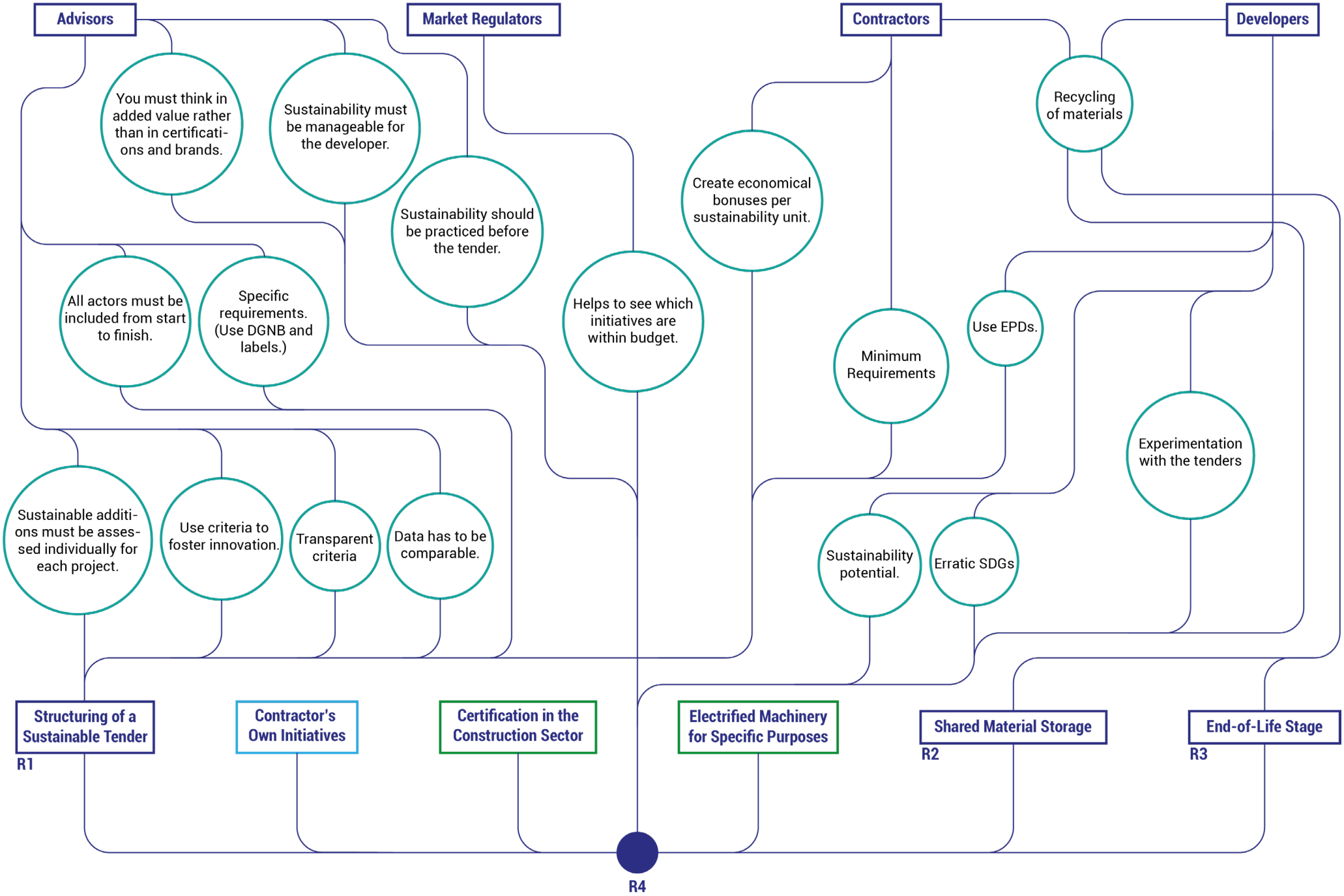

Figure 31: Author illustration of the application of data from interviews, for the development of the catalogue.

tools. Here, EPDs and certifications can be used as inspiration for how requirements and/or criteria, can remain specific in the tender. The initiative also describes how actors have experience with the structuring of the process, for sustainability to have the greatest development potential in a project. This includes both how early in the process sustainability should be integrated, as well as which actors should be included in the process and when. As initiatives must be assessed individually per project, the initiative is formulated so that it does not encourage a specific way that projects should be executed or how tenders should be prepared, but rather attempts to create reflections with the developer about what he or she should consider when planning the tender.

R2: As illustrated in Figure 31, a hub is formed which represents data that has generally been implemented throughout the catalogue. The catalogue is first of all developed so that it manages to address developers. The catalogue does this partly by presenting quantitative data where the developer can decide on sustainability regarding the parameters that represent his concerns (price, timeframe, impact, etc.) In addition, the catalogue translates other actors' knowledge and experience with sustainability, which will make the individual developer wiser about what sustainability involves. The catalogue also helps developers to assess which initiatives are within their budget and timeframe, which can potentially reduce the need for market regulators to contribute with greater funding, and for developers to include sustainability without it having to be a requirement from market regulators. The catalogue also facilitates that developers' experience with sustainability is disseminated, which will create an incentive for other developers to experiment with sustainable initiatives. Furthermore, the catalogue stimulates developers to think in terms of added value rather than thinking about certifications and brands. The catalogue does this by having quantitative data where developers can assess the relevance of an initiative, regarding its environmental impact, and how much support the developer gets for the money, rather than the project being awarded a predicate where the developer does not understand what this predicate entails. Finally, the catalogue consistently calls for sustainability to be practised before the tender is prepared, and as early in the process as possible.

R3: The end-of-life initiative reports considerations regarding how the disposal of materials takes place [Appendix K – Catalogue of Instruments]. For the preparation of this initiative, the knowledge of both developers and contractors has been used. The developers' contribution has primarily been about the fact that already in the planning process it is clear which materials can be recycled, how frequently it needs to be replaced, consideration related to the use of alternative and less CO2 emitting materials, etc. In addition, specific ideas for what developers can do with materials at the end-of-life stage, such as the application of soil stabilization, have been drawn from both contractors' reports, and the conducted survey.

R4: The initiative Shared material stock, was prepared primarily based on developers' and contractors' reports. The initiative describes several possibilities about how materials can be shared internally between developers and/or between developers and the population of the municipality. Several developers had experience with sharing material storage but described various considerations that are important for the measure to be as environmentally saving as possible, as well as other organisational provisions [Appendix K – Catalogue of Instruments].

Furthermore, several advisors have also expressed that the division of responsibilities must be determined when several actors collaborate on building materials [Appendix D – Interview with Bjerre, Kammeradvokaten], & See section, 5.2.3, Bödewadt Lauritzen, VILTOFT).

7.3 Identified Quantitative Data

Since the identified OPP for the inclusion and prioritization of sustainability in the construction industry involved the circulation of quantitative data, the catalogue must manage to share this knowledge. Therefore, the assessment parameters that actors through interviews and the survey have expressed were important regarding sustainable initiatives, as presented in *figure 32*. It is important to point out that these are only a sample of what quantitative data could be relevant to the catalogue.

7.4 Inspiration to Prototype the Catalogue of Instruments,

For the setup and layout of the first prototype, inspiration was drawn from already existing catalogues of instruments. As the project group was aware that they had to have the catalogue's ability to report sustainability initiatives to different developers, this put a focus involving how other catalogues manage to create a visual and user-friendly design. The setup of the catalogue should ideally ensure that initiatives did not address specific developers, as the purpose of the catalogue is to create knowledge-sharing across developers with different organisational backgrounds. The following will reveal which other catalogues of instrument's inspiration have been taken from, as well as which features have been taken from the various catalogues.

Developers	Contractors	Advisors	Market Regulators
Developers need: •Price for the construction, •CO_2 emissions, •CO_2 emissions per m^2 •Price per ton CO_2 emitted. •Total Cost of Ownership •Noise pollution •Other health concerns	Contractors need: •Price for the construction •CO_2 emissions •CO_2 emissions per m2, •Price per ton CO_2 emitted •Estimated working hours required •Amount of fuel required (fossil and HVO fuel) •Number of apprentices required.	Depending on the type of advisor, the advisors need: •Price for the construction •CO_2 emissions •CO_2 emissions per m^2 •Price per ton CO_2 emitted •Total Cost of Ownership.	According to some developers interviewed, market regulators need: •Price for the construction •CO_2 emissions •CO_2 emissions per m^2 •Price per ton CO_2 emitted •Total Cost of Ownership.

Figure 32: Author illustration of the identified needs for quantitative data.

7.4.1 Energistyrelsen's catalogue of instruments

Energistyrelsen's catalogue of instruments from 2013 reports the potential and costs for climate initiatives. The various initiatives included in the catalogue are divided into different headlines that report different information about the initiative, as can be seen in figure 31. This makes it easier to find the relevant information without having to read it all. This textual setup was relevant to the catalogue of this thesis, as developers with different preconditions will quickly be able to get an overview of whether an initiative has relevance for their project.

Tilskud til og certificering af samarbejder om virksomheds- og kommunesamarbejder om grøn erhvervstransport

Beskrivelse
Tiltaget består af tilskud til en certificeringsordning for grønne transportkommuner og virksomheder og en indsats for brugen af brændstofbesparende tiltag i transporterhvervet, f.eks. dæktryksindikatorer og hastighedsbegrænsere.

Forudsætninger
Erhvervstransport udgør en væsentlig del af transportarbejdet og giver således mulighed for en systematisk indsats, der kan reducere CO_2-udledningen herfra. På baggrund af de eksisterende erfaringer med certificeringsordningen for grønne transportvirksomheder og kommuner er der et godt grundlag for at udbrede den systematiske indsats for CO_2-reduktioner.

Det er i beregningen forudsat, at 500 virksomheder og 60 kommuner bliver certificerede inden 2020. Med hensyn til virksomhederne antages disse at have en gennemsnitlig vognpark på 10 lastbiler og en årlig udgift til at reducere CO_2-udledningen på 12.000 kr./år pr. virksomhed. Hvad kommunerne angår, antages en årlig udgift på 60.000 kr./år. Niveauet af udgifterne er vurderet ud fra erfaring med omkostninger til tiltag, der typisk indgår i handleplanerne i forbindelse med certificering i de første år. Potentialet for CO_2-reduktion er beregnet på baggrund af viden om kommuners og virksomheders bilpark og transportarbejde, og en årlig reduktion heraf på min. 2 pct. årligt.

Sideeffekter i form af reduceret luftforurening, dvs. NO_X, partikler og SO_2, er ikke medtaget i beregningerne.

Beregningsresultater
Den lave skyggepris skyldes især potentialet for besparelser på brændstof, som antages at være højere end udgifter til energibesparende udstyr og kampagne task force.

Figure 33: Division of text at Energistyrelsens catalogue. (Danmark. Tværministeriel Arbejdsgruppe et al., 2013, p. 43).

As illustrated in figure 34, Energistyrelsen's catalogue also included various tables in which data was represented regarding some parameters. Through these tables, quantitative data was represented which form an overview of the initiative's resources and costs. The project group wanted to make similar representations of quantitative data, as research has indicated that actors in the construction industry assess the relevance of initiatives based on this type of data. The forms will, therefore, in the same way as the division of the text, create a quick overview of the initiative's relevance for a specific project.

Virkemiddel	Reduktion, ton CO_2-ækv. 2020	Skyggepris inkl. og ekskl. sideeffekter Kr./ton CO_2-ækv.	Nettoomkostning, Annuitet, mio. kr./år		
			Stat	Erhverv & kommuner	Husholdninger
Erhvervstransport og virksomheds- og kommunesamarbejder (tilskud og certificering)	30.000	-585	22	-31	

Figure 34: Scheme of quantitative data (Danmark. Tværministeriel Arbejdsgruppe et al., 2013, p. 43).

7.4.2 Trafik- og Byggestyrelsens Catalogue of Instruments

To establish a syntax that addresses all actors within the construction industry, several professional terms from Trafik- og Byggestyrelsens catalogue were used in the catalogue of this thesis. According to Carlile (2002), the establishment of a common syntax between actors is very essential for knowledge to be translated. Thus, it was important that the catalogue of instruments of this thesis manages to establish a language that is agreed upon by the actors. Table 5 illustrates examples of some of the terms implemented in this project's catalogue of instruments.

Danish	English	Source
Miljøvaredeklarationer (EPD)	Environmental Product Declaration (EPD)	European Standard: EN15804 (Byggeri København & Københavns Kommune, 2022)
Miljøpotentiale	Environmental Potential	(Byggeri København & Københavns Kommune, 2022)
Tekniske Forhold	Technical Conditions	(Byggeri København & Københavns Kommune, 2022)
CO_2-skyggepris	CO_2 Shadow Price	(Danmark. Tværministeriel Arbejdsgruppe et al., 2013)

Table 5: Professional terms from Trafik- og byggestyrelsens catalogue.

7.4.3 Copenhagen Municipality's Catalogue of Instruments

Through the research of this thesis, different actors have expressed a need for different types of quantitative data, initiatives should include. However, to be inspired to which additional quantitative data could be included, Håndbog I Cirkulær Økonomi was used as a source of inspiration. Specifically, the assessment parameters' environmental potential was implemented in the project's catalogue, with inspiration from Copenhagen's municipality. In addition, descriptions of the goals and technical conditions of projects were also taken from this catalogue (screenshot shown in *figure 35*).

GLASULD, nedrevet fraktion og nyt materiale	
Resumé	Nyglasuld indeholder en genanvendelsesprocent på op til 90% af renset knust glas. Glasuld smeltes ved 1500 grader ved brug af jomfruelige ressourcer og ved 1200 grader med brug af genanvendte glasfraktioner, som bl.a. glasskår. Glasuld genanvendes som materiale i lecasten, ellers deponeres det.
Mulige mål	Undgå brug af glasuld medmindre det er højst nødvendigt eller med mindre, en LCA- og LCC-analyse kan bevise, at det giver mening at bruge glasuld eller det fremgår, at glasulden laves med grøn energi, og at den som minimum kan genanvendes til f.eks. lecasten bagefter. Vær opmærksom på, at der skal tages højde for skimmelsvamp, når der ikke bruges glasuld eller stenuld. Alternativer til glasuld undersøges.
Cirkularitet	Glasuld består op til 90% genanvendt renset glas/glasskår. Købes som ny glasuld. Glasuld kan recirkuleres, men det kræver en bearbejdning for at indgå som ressource i lecasten.
Modenhed	Høj. Recirkulering til lecasten har en middel modenhed, da der er større efterspørgsel end tilgængelighed på genanvendt glasuld.
Miljøpotentiale	Høj CO_2-udledning pr. kilo materiale.
Tekniske forhold	Behandles som traditionel glasuld.
Tid ift. byggefaser:	Standard
Økonomi	Standard

Figure 35: Examples of quantitative data. (Byggeri København & Københavns Kommune, 2022, p. 29).

7.5 A first prototype

Based on actors' matters of concern as well as other information from interviews, the survey and inspiration from other catalogues of instruments, the first edition of a prototype were developed. The purpose of the development of this prototype was to have a version of the catalogue that could be further developed by allowing it to circulate between different actors and change based on their feedback. This first edition of a prototype included five initiatives, as illustrated in Figure 36.

Figure 36: The five initiatives of the first prototype.

7.5.1 Prototyping a first edition

The Prototyping process of the catalogue was inspired by Pedersen (2016) who considers prototyping as a means of knowledge sharing and development: *"Prototyping is described as a learning process where the prototypes are the vehicles for learning"* (Pedersen. S 2016, p. 52).

Throughout the prototyping process, the catalogue of instruments went through five iterations. These iterations were all based on knowledge and feedback gathered from different actors. We used Pedersen's (2016) methodology for prototyping, consisting of three steps; First, we used staging to go through a selection process of whom we should interview to get the necessary information for the catalogue of instruments. To facilitate the interventions, the catalogue of instruments was used as a boundary object to translate knowledge between the project group and the actor. Through each intervention, we synthesised new initiatives and changes based on the knowledge gained from the inter-

vention, which we incorporated into the catalogue of instruments.

Prototype 1: with Banedanmark, Søren Boas, climate economist, Banedanmark.

To initiate the first iteration of the prototype, a meeting was arranged with Banedanmark. For this iteration, the project group was specifically interested in gaining feedback on whether the catalogue is aimed at the developers as a group of actors to a greater extent than others. The preliminary development of the catalogue was intended to target developers such as Banedanmark, as this group of actors would probably benefit most from the catalogue in the preparation of tenders. The meeting was held with Søren Boas who initiated the project to develop a catalogue of instruments.

For the catalogue to be appealing and address developers, Boas had ideas for how the catalogue could become more user-friendly. For developers to seek initiatives that are relevant to them specifically, Boas suggested that a scheme was prepared initially in the catalogue that gave an overall insight into the assessment parameters of all the initiatives. This would allow developers to easily find the initiatives that were relevant to them. This idea was integrated into the catalogue as illustrated in *figure 37*.

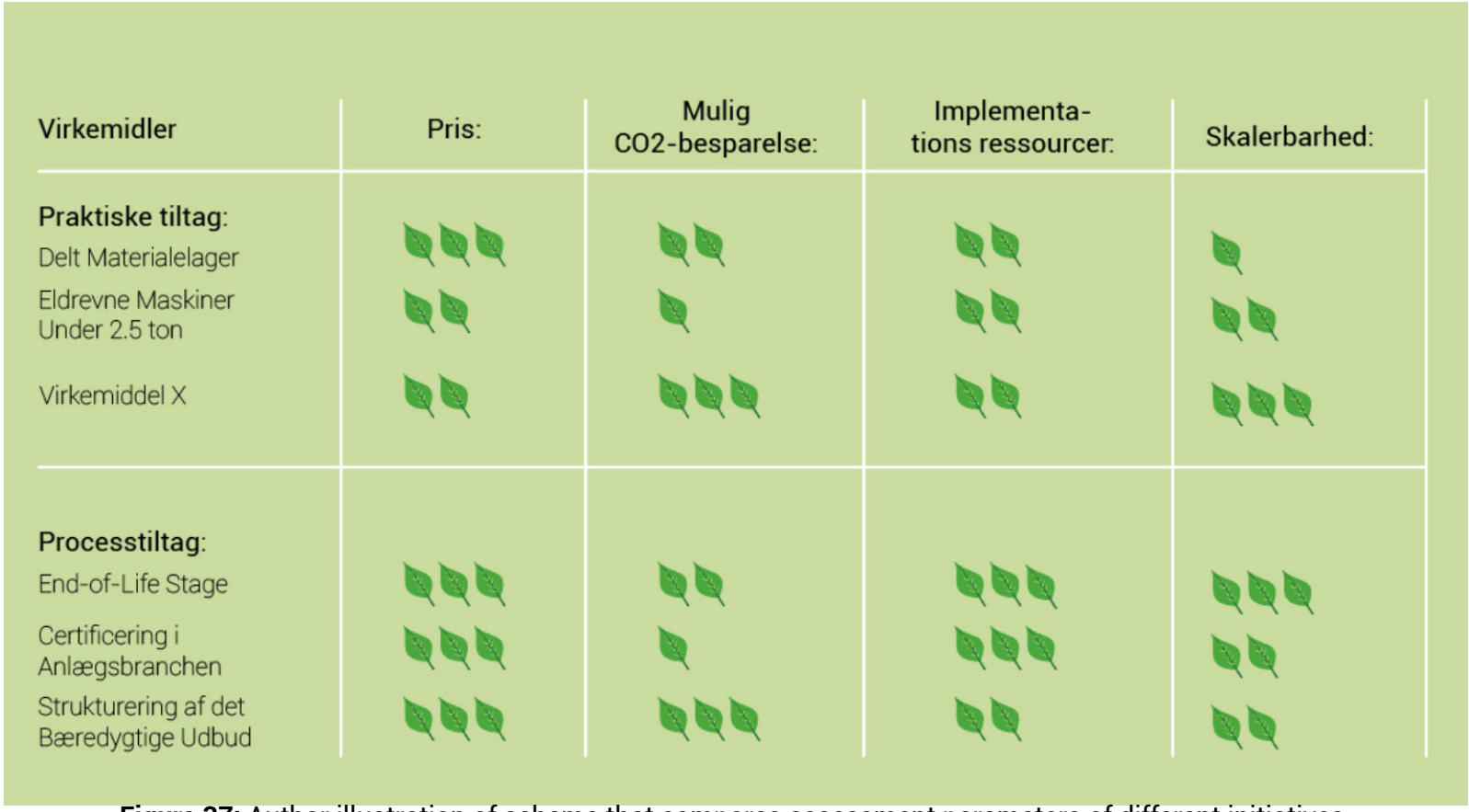

Figure 37: Author illustration of scheme that compares assessment parameters of different initiatives.

Prototype 2: With Metroselskabet, Nynne Marie Bech, Environmental consultant.

The second iteration was held with Nynne Marie Bech from Metroselskabet, which is part of the organisation's Environmental Department. Bech was very enthusiastic about the individual schedules of assessment parameters, that were included in several of the initiatives. She emphasized the importance of assessment parameters such as price per ton of CO2e reduced, included in all initiatives, as was the case in the electric machine's initiative. As the economy is often key in the decision-making process, and this parameter provides accurate information about how much sustainability the developer gets for his money. *"Relevant knowledge in a catalogue of instruments would be to quantify CO2 savings."* - (Bech, Metro Company (Affinity Diagram & [Appendix C - Affinity Diagram])). Based on Bech's emphasis on the assessment parameter price per CO2 savings as important knowledge, this parameter was added to all the remaining initiatives in the catalogue.

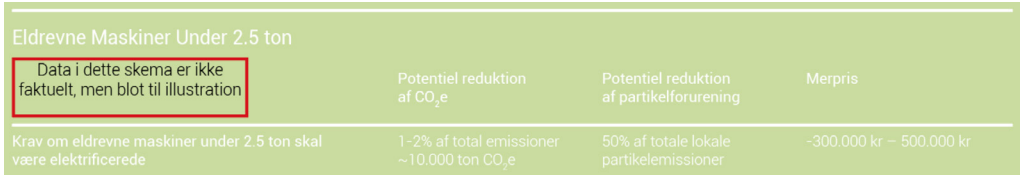

Figure 38: Author illustration of info box with CO2 reduction and price.

Prototype 3: With Banedanmark, construction project manager Jacob Bech Nicolaisen

In the third iteration, a meeting was arranged with Jacob Bech Nicolaisen, who is the construction project manager at Banedanmark. The project group specifically wanted to discuss how the current prototype manages to address Banedanmark as an organisation, regarding how they want to use the catalogue. This was important because Banedanmark as an organisation may need to include specific assessment parameters in the catalogue, as they have separate priorities and purposes compared to other developers. (Affinity Diagram & [Appendix C – Affinity Diagram]).

Bech informed that when new initiatives are to be included in the tender, the risk is a key factor for them, and the confirmation of long-lasting solutions is crucial. Consequently, an additional assessment parameter was added to the catalogue, representing a risk factor of a project. Similarly, the syntax and process terms to be used in the future negotiation rooms were discussed, which provided insight into how an improvement could be established regarding helping the translation of other construction managers. As a result, the division of initiatives was categorized according to how ABR18 divides the construction process, as can be seen in *figure 39*. Likewise, these phases were also included in the scheme of compared assessment parameters, as illustrated in *figure 40*. This allowed developers to get an overview of where in the construction process the individual initiative belonged. Bech confirmed to the project group that initiatives included in the catalogue must be relevant to different actors and should therefore report initiatives that can be adapted by the organisation with different priorities and objectives. This iteration also led to a new initiative being added to the catalogue. Bech considered it important that the catalogue further focused on the involvement of the contractors' knowledge and believed that this should act as an initiative alone. Therefore, the initiative "The contractors' implementation ideas" was prepared, which encourages contractors to add sustainability add-ons to a tender [Appendix K – Catalogue of Instruments]. In addition, in the initiative, there are gathered some examples of implementation ideas that the project group has received from contractors through data collection, which can give developers an

idea of how the contractors can contribute to the sustainable inclusion in projects.

Figure 39: Author illustration of the project phases from ABR18, translated from Danish: Preliminary Phase, Programme Phase, Suggestion Phase, Project Planning Phase, Execution Phase, Use Phase, Reuse/Disposal Phase.

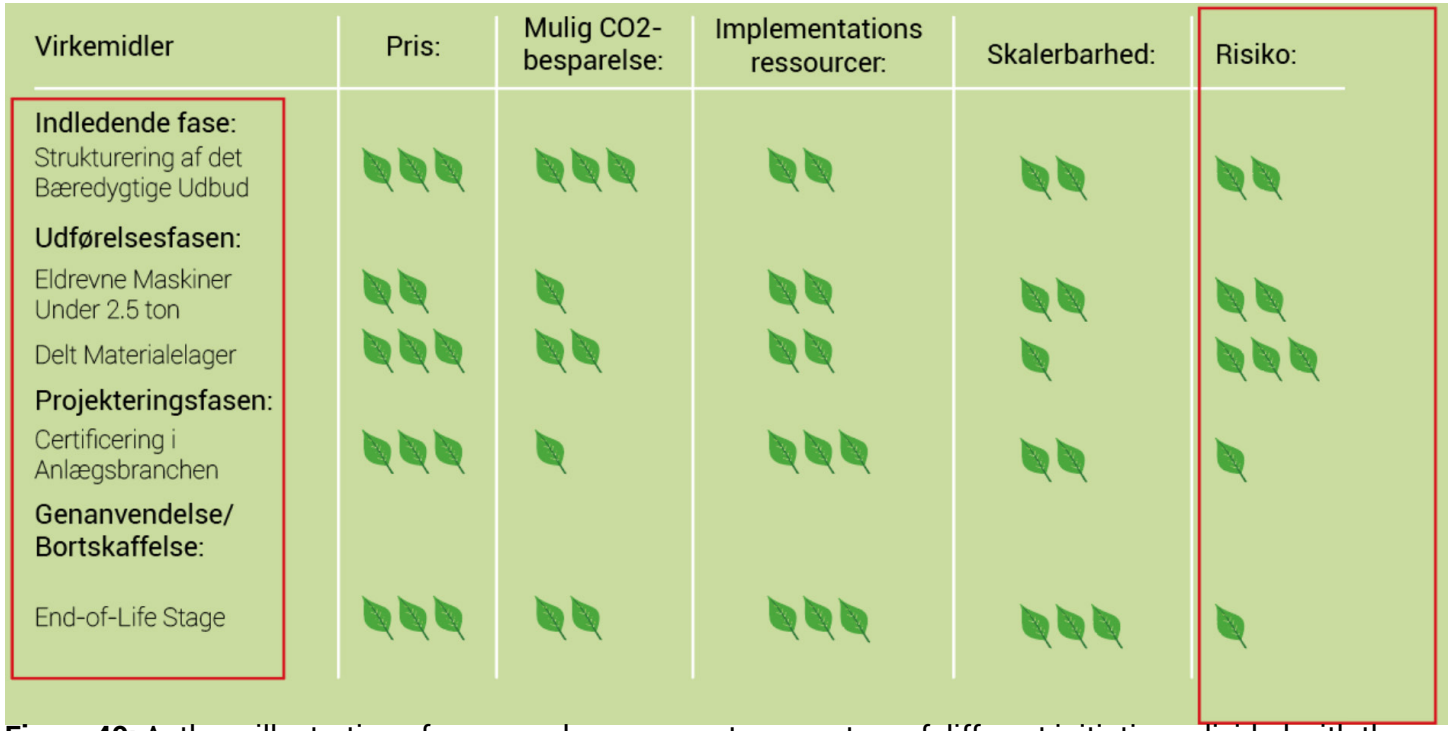

Figure 40: Authors illustration of compared assessment parameters of different initiatives, divided with the phases from ABR18.

Prototype 4: with the Municipality of Copenhagen, Teknik- og Miljøforvaltningen. Eskil Emil Kwedéris

As Copenhagen municipality several times was designated as a frontrunner, through interviews with various actors, a meeting was arranged with Eskil Emil Kwederis who has previously worked with catalogues of instruments within the municipality. Kwederis told that all the initiatives from the project group's catalogue of instruments, except one of them, were already to some extent practised in the municipality of Copenhagen's tenders. Based on this, a discussion was initiated regarding the adaptation of initiatives by different developers, which led to minor changes being added to the initiatives in the catalogue.

Kwederis made the project group aware that quantitative data on various initiatives will depend a lot on internal decision-making processes concerning a specific project. Therefore, estimations concerning a single initiative are difficult. Kwederis identified the assessment parameters, price and CO2 savings, as two parameters that are particularly dependent on internal decision-making processes, and therefore the catalogue regarding these two should to a greater extent report which internal decision-making processes influence price and CO2 savings, in different projects. The project team was aware that the quantitative data in initiatives could vary a lot with the project and the decisions made in a project, and to some extent, this has been considered in some of the initiatives. This has been done by including advice on which decisions can create savings in CO2 and price. An example is the "Shared Material Storage" initiative [Appendix K – Catalogue of Instruments], where developers who want to share a stock should be geographically close to each other, to reduce CO2 emissions associated with transportation.

A minor adjustment to the catalogue was also that the "Electric machines" initiative [Appendix K – Catalogue of Instruments] should not encourage developers to set requirements for the use of electric machines when using machines that are under a certain weight, as contractors can get around this by simply using heavy machinery. Instead, a call should be that developers should require machines for specific functions to be electrically powered.

Prototype 5 with Louise Laumann Kjær, Sustainability Consultant & Prof. Aalborg University

As the sustainability potential of initiatives is very important regarding what the project's catalogue should report, the project group involved a sustainability advisor to get concrete feedback on which adjustments can make the catalogue more focused on reporting which initiatives have the greatest environmental impact. For this purpose, a meeting was arranged with Louise Laumann Kjær.

A first addition made based on this iteration was the inclusion of a pre-phase where considerations are made about whether developers can avoid having to build, as this is the most sustainable choice. It can either be done by finding unused buildings or considering alternatives such as containers etc. Kjær also emphasized the need for information regarding how materials can be degraded which led to the inclusion of the waste pyramid as illustrated in *figure 41*. The presentation of EPDs in the catalogue was a little bit misleading according to Kjær. An EPD should not be considered a sustainability predicate in itself, but rather a documentation of a product's environmental properties. For a product to be categorized as sustainable, the developer must decide on what characteristics the EPD must meet. As a result, the catalogue was adjusted so it suggested that developers using EPDs set clear limits for how much a product may deduce.

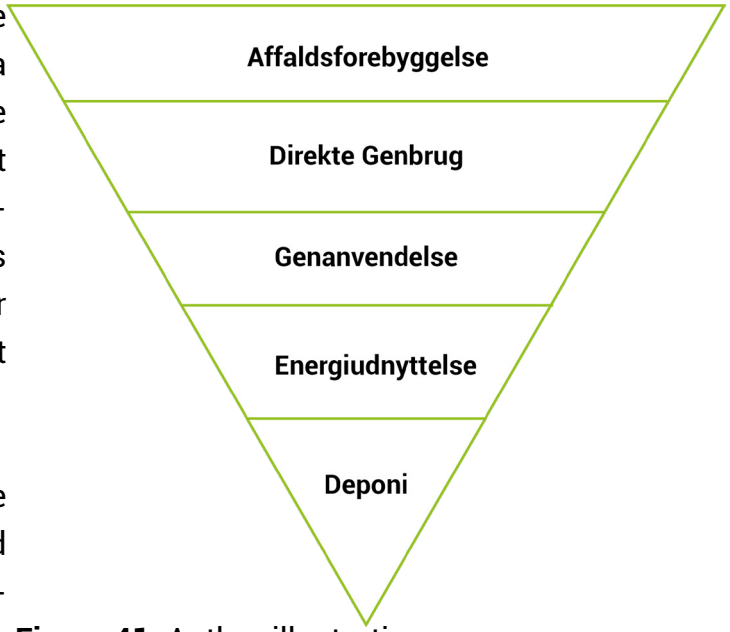

Figure 41: Author illustration of the waste hierarchy

After the prototype was adjusted based on these five iterati-

ons as illustrated in *figure 42*, it was not further modified, resulting in a final version of the prototype. This leaves the remaining investigation related to the development of the catalogue, to Banedanmark to continue with, which is why the project group wanted to gain insight into what, according to Banedanmark, the project group has succeeded in getting the catalogue to facilitate, as well as what shortcomings the catalogue according to them has.

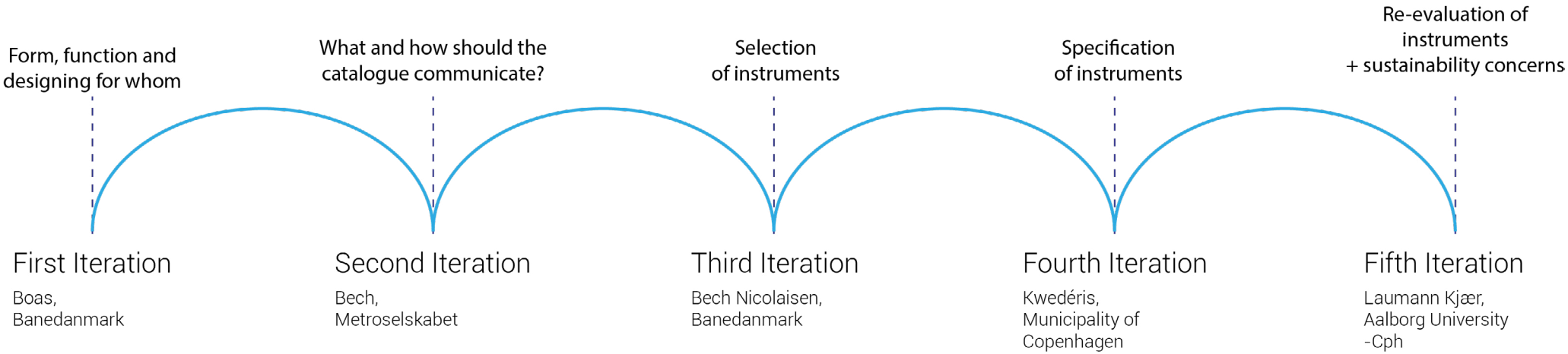

Figure 42: Author illustration of the fifth different prototype stages of the catalogue.

8.
The Project in a Future Perspective

As the final version of the prototype is not representative of what a final catalogue of instruments should contain, this section will be looking into the future development of the catalogue. The section will first present feedback from Banedanmark, related to which initiatives from the catalogue they especially found interesting, as well as potential changes to the initiatives. Next, a section describes what a working procedure for the further development of the catalogue might look like, with considerations as to which research areas are flawed in the thesis. Lastly, a plan/roadmap for Banedanmark is illustrated, related to further development of the catalogue.

8. The Project in a Future Perspective

8.1 The Last Prototype of the Catalogue

After the catalogue was adjusted several times based on the feedback of various actors, a final version of the prototype emerged [Appendix K - Catalogue of Instruments]. This prototype was to be handed over to Banedanmark to inspire the organisation on how to develop their catalogue, and the project group wanted to get feedback on whether it managed to report useful knowledge for them. Despite the project group did not have the time frame to further develop the catalogue, the intention of receiving feedback on the final edition of the catalogue was to get an impression of whether the catalogue has remained relevant for Banedanmark, despite its influence from other developers. This could provide indications of the problems related to knowledge sharing, as different actors could potentially have different wishes and therefore opposite inputs for the catalogue. Two meetings were set up with Banedanmark. The first meeting was arranged with Chief Consultant, climate economist Søren Boas, and the second meeting was arranged with the strategic purchasing consultant in Banedanmark, Ulla Møller Eikard. The feedback from the two meetings is presented in 8.2.

8.1.1 Feedback from Banedanmark

Banedanmark was generally very positive toward the last version of the prototype, and according to them, it was formulated and structured holistically, addressing different developers, but remained relevant to Banedanmark. Banedanmark found it relevant that the catalogue reported initiatives for all phases of the construction process, as it provides a wide range of initiatives of different nature that address different developers. Overall, the catalogue provides an insight into how other developers work with sustainability, which is important for Banedanmark for creating a negotiation space where the right developers are involved in the development of a new catalogue that can mediate information internally between departments, as well as between Banedanmark and other developers. The specific feedback and ideas for improvements Boas and Eikard provided on each of the initiatives in the catalogue are presented here.

8.1.2 Feedback - Structuring of the Sustainable Tender

The initiative manages to provide a good description of how tenders can be structured optimally, and how decisions early in the process influence emissions in the later phases. The initiative is relevant for Banedanmark as they lack a general management structure within sustainable tenders, as all tenders have the same procurement paradigms. Improvements in this initiative involve more data about what EPDs should contain and how they should be used, as well as the importance of EPDs to performing an LCA. In addition, the initiative could be improved by including reflections on contract structure and content, and their advantages and disadvantages. In addition, even more, attention should be paid to the use and EOL stages, as these are the stages that have a high potential for reducing emissions.

8.1.3 Feedback – The Contractors' Implementation Ideas

This initiative is very relevant, despite its simplicity. At its core, it is merely a market dialogue. However, the market dialogue is crucial for involving initiatives from the contractors and, depending on the form of the contract, has different options. The involvement of contractors will

also give good indications if a tender should use requirements or criteria and how they are to be assessed.

8.1.4 Feedback – Electric Machines for Specific Purposes

The positive thing about this initiative is that a market for light electric machines already exists, so developers just need to set criteria for the use of electric vehicles. Banedanmark has an obstacle with the use of electric machines, as they normally cannot get electricity supply to the places Banedanmark operates. Banedanmark cannot exploit the railway's electricity, and they usually operate in the countryside, where the supply, for the machines, is not easily accessible. The initiative is, therefore, less relevant to Banedanmark as an organisation. Boas proposed to create a separate chapter in the catalogue of instruments, that includes all initiatives related to the practices that occur on, or around the construction site. This chapter will cover initiatives such as electrifying light machinery but may also include initiatives such as the use of solar panels and the insulation of construction workers' trailers.

8.1.5 Feedback – Certification in the Construction Industry

This initiative can address the use of multiple certifications and brands as sources of inspiration by exploring some of those used abroad. PAS2080 (Construction Leadership Council, et al., n.d.), CEEQUAL (BRE Group, 2022) and ISO 50001 (ISO, 2018) were mentioned as important inclusions to promote sustainability. According to Boas, PAS2050 (GHG Protocol, n.d.) is currently not used in Banedanmark, as it is too expensive, but the initiative could however report how - as is the case with DGNB – PAS2050, it can be used as inspiration for specifying the requirements and criteria in tenders.

8.1.6 Feedback – Shared Material Stock

Boas and Eikard expressed that this initiative was very relevant for all developers. Banedanmark as an organisation already has a lot of storage space for surplus materials from the construction. As the organisation has very high-quality requirements for materials, there is potential for other organisations to reuse Banedanmark's materials when the quality of the materials is no longer high enough for the organisation's needs. They are currently taking inspiration from ProRail, from the Netherland, as they have developed innovative concepts for how storage facilities in construction can be carried out. They proposed that Vejdirektoratet could use Banedanmark's used concrete by crushing it and use it to stabilize roads.

8.1.7 Feedback – End-of-Life Stage

According to Boas, there is a lack of detail in this initiative. It is missing some concrete examples of initiatives that the developer can include in the tender documents. Boas also added additional comments regarding the EOL-Stage initiative, which should also include more information on the circular economy and the EOL stage could be a chapter on its own. This is true for the proposed chapter of initiatives for the construction site

8.2 Further Development of the Catalogue

The last prototype of the catalogue aims to include initiatives that are partly relevant to Banedanmark but also to other actors involved in the research of this thesis. Furthermore, there is still a lot of work to be done before the catalogue is complete, as the initiatives currently included in the catalogue, are only a small sample to represent examples of

initiatives that various actors found relevant. As Banedanmark will develop its catalogue of instruments accumulated on the founding of this project, they will in the future be the facilitators for incorporating initiatives and other considerations into the catalogue. It is therefore recommended that Banedanmark enrols other developers in the selection of initiatives for the catalogue, as it has been shown in the research of this thesis that different initiatives have different relevance depending on the type of project (see section 5.2.3 interview with advisors), and different assessment parameters have different relevance depending on the organisation's priorities and purposes [Appendix A – Interview Bech Nicolaisen, Banedanmark]. To do this, a first step involves the selection of which type of developers should be part of the catalogue and therefore part of knowledge sharing. Excluding some types of developers will restrict knowledge sharing across organisational differences and/or different projects, depending on who is being excluded. As research in this project indicates, actions across projects and types of organisation are relevant to share as they can be implemented in multiple contexts. Although the preparation of the catalogue will be more straightforward and the catalogue could be addressed more specifically to a type of project and/or organisational objectives, it will also de-limit knowledge sharing to some extent. It will therefore involve a major investigative work for Banedanmark to define which developer should be involved in the preparation of the catalogue to create a balance between the catalogue reporting a broad knowledge sharing, while at the same time keeping the catalogue transparent and relevant to all developers, who are part of the knowledge sharing.

The selection of initiatives should be made cooperatively with all developers that are a part of the knowledge sharing, to discuss the relevance of initiatives in different contexts. In the development of the catalogue, it is not only necessary to select which initiatives are to be included in the catalogue, but also how the categorization of initiatives should be presented through the catalogue. The categorization of initiatives will have an impact on how the catalogue reports the initiatives included in it, and it may have an impact on the extent to which the catalogue manages to facilitate knowledge sharing. If the catalogue is divided, for example, regarding organisational priorities, or regarding project types, the catalogue will to a lesser extent facilitate knowledge sharing across organisational assessment parameters, or different project types.

In the conceptualisation phase, it was explained how empirical data from the research were implemented in the catalogue. However, the research group was able to identify a focus area that was not adequately covered through the development of the catalogue, which was, the effective market dialogue. Several actors stressed how important the market dialogue is to understand what the market can provide for sustainable solutions, thus what should be required in the tender. Furthermore, developers expressed that the market dialogue is often difficult to facilitate so that it gives a real insight into the market because contractors give a misleading picture of the market, to their advantage (See section, 5.2.1, Bech, Metroselskabet). No resources were allocated to investigate how an effective market dialogue is facilitated, as this alone would require extensive research, and was therefore outside the project's timeframe. The effective market dialogue is, therefore, black-boxed in this research, which means that this is also an unexplored area that Banedanmark could devote resources to investigate.

Figure 43: Author illustration of the black boxed market dialogue, where only the input and output are known, but not the process itself.

Another focus area to which Banedanmark is encouraged to devote resources, in the development of a new catalogue, involves research in relation to the quantification of data. This thesis has specified some of the assessment parameters that developers and contractors found important, but specifications in relation to the different assessment parameters in the initiatives are deficient in the catalogue. This means that resources should be allocated to investigate specifically how to price savings, CO2 savings, etc. are best achieved through decision-making processes in various initiatives.

8.3 Roadmap for the Catalogue of Instruments

To summarize and create transparency for the development of a catalogue of instruments, a roadmap will describe an action plan for the process. A roadmap is a visualization of elements related to design innovation, on a timeline (Simonse, 2018). Through this port Portraying, a roadmap can support decision making and help organisations and designers to "… devise creative responses to future strategic challenges" (Simonse, 2018, p10). Roadmaps are helping creating innovation in organisations as the decision-making process for a roadmap involves the creation, exploration, and convergence of ideas around the future (Simonse, 2018). Although the purpose of a roadmap is to outline future visions, it is not an accurate representation of reality, and the current process may differ from how it is visualized in the roadmap.

This roadmap describes relevant steps that must be executed to realize the development of a catalogue of instruments. The roadmap is divided into different steps on a timeline, each of which concretizes what needs to be done, why this is important and who should facilitate each step. Recognizing that Banedanmark is a large organisation where change processes can extend over long periods of time, the roadmap will not describe an exact time schedule, as this should be planned by Banedanmark itself. Instead, the different steps will appear in the order in which they should be executed. The roadmap is based on how a catalogue of instruments, according to the research of this thesis, should be developed, but several steps also possess certain flexibility and choices to be made by Banedanmark. Thus, the roadmap should be understood as a guideline for what a development process of the catalogue could look like, with a focus on, what is relevant to involve and consider.

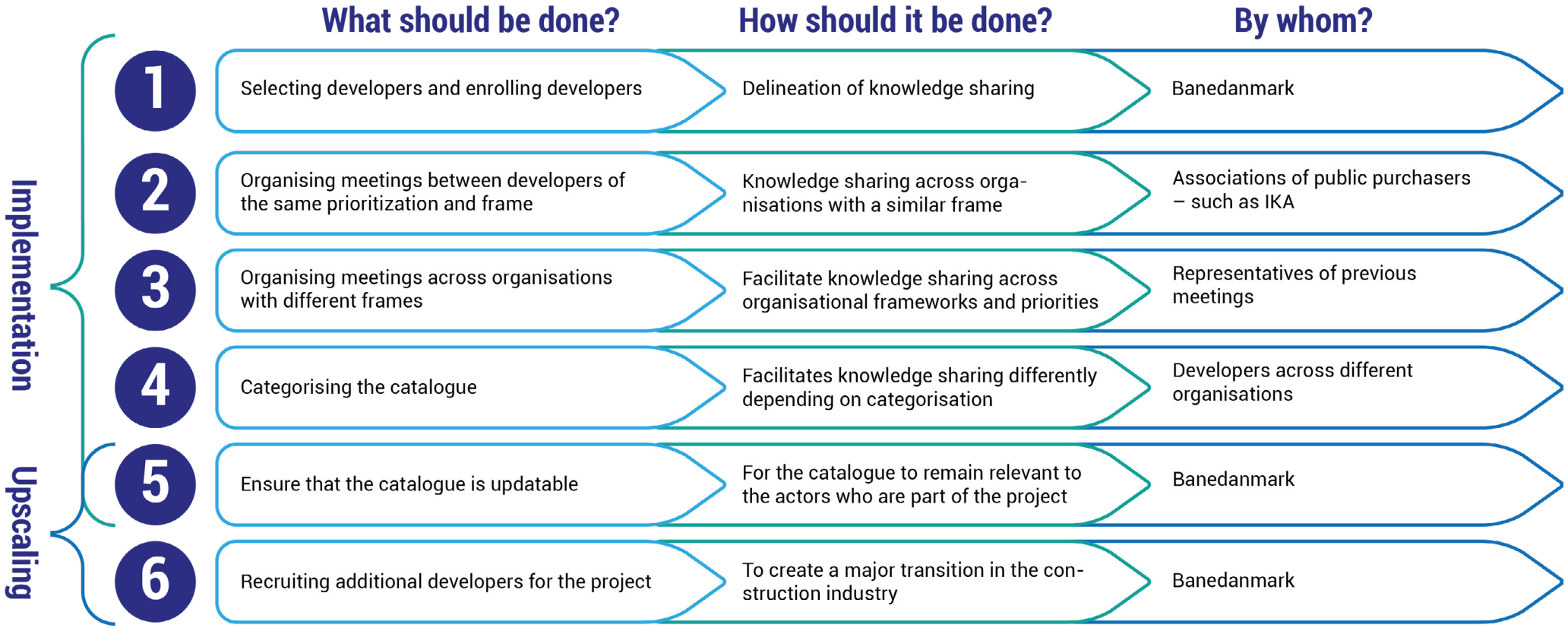

Figure 44: Author illustration of roadmap.

1. Firstly, a selection of which developers are to be enrolled in the project must take place, and thus, as mentioned earlier, there will also be a delimitation of which initiatives are included. To ensure that this selection takes place with respect to different priorities and perspectives of Banedanmark, all the silos should be involved in this process. Once Banedanmark has taken a position on this, these developers must be enrolled in the development of a catalogue of instruments.
2. After the right developers have been enrolled in the project, meetings can be arranged where various initiatives can be discussed. It can be a difficult process for many different developers to collaborate, and therefore it is advantageous to establish smaller meetings first between developers who are closer to each other in terms of priorities and organisational similarities. At these meetings, developers of the same priorities can initially discuss which initiatives are relevant to them. As forums already exist where regions meet internally (K See section, 5.2.1, Bollerup, Region of Northern Jutland), as well as meetings where municipalities meet internally [Appendix I – Interview with Masana, Herning municipality], these forums can be used to introduce a discussion on sustai-

nable initiatives.

3. After similar organisations have discussed relevant initiatives and experiences as well as the assessment parameters on which the initiatives should be evaluated, representatives from each of these internal meetings should be gathered to discuss the initiatives with each other across organisational differences.
4. A consensus among developers of different organisational priorities and purposes will allow the development of the catalogue of instruments to begin. Advisers of different expertise should be involved in this process. Sustainability advisors will be able to help quantify actions depending on what assessment parameters developers have agreed on. Tender advisers will be able to contribute with how initiatives should be put out to tender to stimulate sustainable innovation without risking that sustainability is downgraded.
5. After the catalogue has been developed, it should be ensured that the catalogue can be updated continuously so that initiatives do not become obsolete and irrelevant to the developers.
6. To spread the word about the development of the catalogue of instruments, and mobilize additional developers, Banedanmark should create awareness about the project and its effects. Workshops about sustainability in the construction industry could therefore be established, where developers are invited. Through these, events can be facilitated, through which new developers can discuss their need for knowledge sharing and be recruited for the project.

9. Discussion

This section will discuss four different aspects of the project. First, a discussion will direct the preparation of a sustainable tender, concerning the findings of the research. Then the focus is aimed at some of the considerations that need to be made regarding the fact that there is a change of facilitator of the catalogue when the project group leaves the project, and how it can influence its further development of it. Furthermore, the section touches on the problem of knowledge sharing in a large organisation such as BaneDanmark, and what a possible method of progress to improve this, could look like. Eventually, the influence of market dynamics on the construction market will be discussed regarding sustainability having a greater impact on the market.

9. Discussion

9.1 The Preparation of a Sustainable Tender

From the perspective of various actors, this project illuminates some of the considerations that are important in the preparation of a sustainable tender. Since construction projects are an organic and variable process, a standardised recipe to "a sustainable tender" cannot be described through a catalogue of instruments, but it can help to inspire developers to which initiatives could have relevance for their individual projects. However, it remains up to the individual developer to decide whether an initiative will have the same relevance and effect on his project. Likewise, considerations related to how a tender should be prepared differently depending on which sustainability initiatives are decided to be implemented in a project. The issue of whether minimum requirements or criteria should be set in the tender, serves as a good example of the difficulty of securing sustainable development/inclusion in tenders, it depends highly on how they are used and how sustainability is included and to what extent. Minimum requirements ensure the inclusion of sustainability in projects and contribute to encouraging a sustainable transition at the contractor organisations, who are forced to incorporate sustainable solutions into the projects. On the other hand, minimum requirements in the tender will depend on developers' knowledge and ability to engage in an insightful market dialogue where other actors' knowledge can be retrieved. This can be considered to slow the innovative sustainable development, as sustainability is prevented from being a competitive parameter, but becomes a prerequisite to attend instead. Conversely, although minimum requirements can be considered limiting to the competition theorem, and thus limiting the sustainable innovation, it can facilitate knowledge sharing between entrepreneurs, which instead can be the prerequisite for sustainable innovation. Advantageously, both minimum requirements and criteria can be included in a tender to ensure a certain level of sustainability through minimum requirements, while the tender also allows contractors to think innovatively and compete to include sustainability further through criteria. However, criteria must be given a high weighting in the tender to get contractors to compete on sustainability.

9.2 Knowledge Sharing Across Organisations

In the transition towards sustainable development, the preparation of the catalogue of instruments in this project should only be considered a small contributor. Specifically, the catalogue of instruments can help Banedanmark, and other developers to whom it is sent, to get an overview of how other developers have integrated and worked with sustainable initiatives. Since the final edition of the catalogue covers only a limited number of initiatives and is only sent out to those developers who have asked to receive a copy of it, the knowledge sharing of this catalogue will be small. The catalogue can however kick-start an interest in knowledge sharing and collaboration between the developers that have been a part of the project and wish to receive the catalogue, which may be the foundation of a new joint practice. Nevertheless, greater sustainable acceleration in the industry requires that experience sharing can take place consistently and dynamically. Likewise, accessibility and quantity are important considerations because knowledge sharing should take place in one forum instead of many small forums for it to facilitate knowledge sharing that has relevance to many diverse types of projects, across different organisational priorities, and regulations, without becoming too complicated a practice for the developer. To ensure that these qualities can be included in Banedanmark's

further development of the catalogue, it should be digitalised and open for various developers to add and update it. Developers should be able to both describe new initiatives in the catalogue and also describe their experience with the initiatives that other developers have inscribed. As the empirical data in the project has shown, the possibilities and experience with initiatives can vary a lot depending on the regulations of different organisations. Aside from the assessment parameters already added in this project's catalogue of instruments, additional different risk assessment parameters should be added to the initiatives aimed at infrastructure construction, due to different risks that impact the decision of adaptation. However, risk assessment is, according to Banedanmark [Appendix A – Interview with Bech Nicolaisen, Banedanmark] difficult assessment parameters to make an objective assessment, because different risk assessments and requirements vary depending on the project and organisation. Therefore, an organisation will have different perceptions of what can be considered risks regarding an initiative.

As this project reflects, various concerns from various actors to whom the catalogue of instruments is addressed must be represented. Banedanmark as a facilitator of a newly developed catalogue of instruments, after the project group finish the project, may lead to problems concerning the fact that the organisation's special interest could quickly cause the catalogue to reflect only the organisation's concerns and initiatives that are outside the capacity of other organisations. As Banedanmark is one of the largest public developers in Denmark, they have other means at their disposal compared to smaller developers, and if the initiatives in the catalogue only reflect Banedanmark's concerns as well as initiatives that require greater capacity, the catalogue could become irrelevant to other developers, which will prevent knowledge sharing through it. Advantageously, the catalogue could be facilitated by an actor with no special interest in the content. These could, for example, be knowledge-sharing centres such as the Confederation of Danish Industry, the Centre for Public-Private Innovation or similar organisations, that already possess knowledge about the needs and challenges of various developers.

9.3 Internal Knowledge Sharing in Banedanmark

As mentioned earlier, research throughout this project has indicated that the organisational structure of Banedanmark is a challenge to create agility and make the company responsive to new methods and practices. According to Banedanmark itself [Appendix A – Interview with Bech Nicolaisen, Banedanmark] and their suppliers [Appendix F – Interview with Munck Group] (& section 6.2.2, Aarsleff Rail), there are some communicative problems in the organisation, that complicate horizontal communication between silos. As the silos depend on each other when projects are to be passed on from construction silos to operation silos, the need for communication and cooperation between them is important.

To combat these communicative problems within the organisation, a cross-cutting collaboration between the silos could be a step in the right direction. This could be accomplished through weekly meetings between the silos to support the exchange of knowledge across different communities of practice (Wenger, 1998). To strengthen such meetings, it should be mandatory to present an agenda for the meeting, a couple of days before, and make it a habit, that all participants provide a list of suggestions to what should be outlined under every single topic, under the agenda. Despite this adjustment only creating hori-

zontal communication in the organisation's hierarchical levels, it could strengthen the bottom of the hierarchy, and create an incentive for improved communication vertically, as ideas and initiatives would be thoroughly worked out and realistic, as they can be approved by all the silos. The collaboration across silos will establish a negotiation space where the inclusion of sustainable initiatives that have the potential to be implemented in the organisation, can be discussed. An action that could to some degree incorporate the vertical level, would be to invite some from the upper or lower level of the organisation, to participate and present their views regarding the agenda for the actual meeting.

Therefore, this cross-cutting collaboration could create a space for the inclusion of sustainability in projects if this priority is given the needed agency. To ensure that sustainability is a consideration in the collaboration between the silos, another beam across the silos could be included that only deals with the inclusion of sustainability in projects and initiatives of the remaining silos. As data collection has demonstrated, the enrolment of the sustainability in the projects must take place in the pre-phase, to create solutions that are sustainable at their core (See section, 5.2.1, Holstein, Roskilde Municipality). The sustainability beam can contribute with knowledge and solutions involving sustainability, that will furthermore help develop the communities-of-practices, by adding new aspects to the respective field. In this respect, learning becomes the bridge between working and innovating within each silo, as learning and working with sustainability will change their practices. The practices within the sustainability beam will relate to all the silos, and thus also create a common syntax, and agenda that the remaining silos need to agree upon. It is thus important that such cross-sectional groups are founded in management and at the top decision level, in their departments. This is to be sure that there is a decision power behind ideas developed and to ensure that the upper level of the organisation has a sense of involvement in and responsibility for the group. It is not a necessity to have top-level management participate in group meetings. It is sufficient that every detail of meetings is reported and accepted by the management level, before being converted to guidelines for the whole organisation.

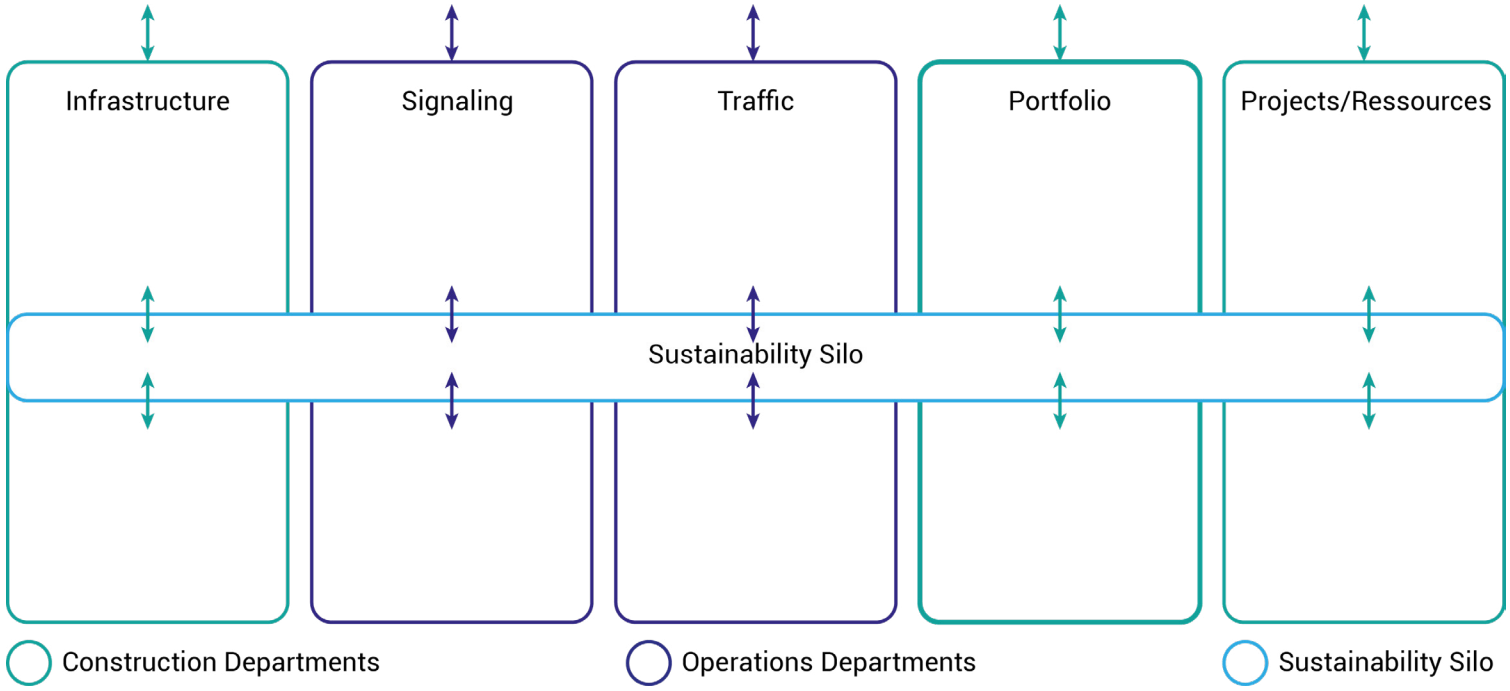

Figure 45: Author illustration of cross-functional collaboration across silos.

9.4 Market Dynamics

Besides looking into how a sustainable prioritization can be created in Banedanmark, as well as what it takes for the catalogue of instruments to have the specifications that allow a broad knowledge sharing, market dynamics also have a great influence on the sustainable acceleration. According to Ha-Joon Chang, the problem of free markets is that market actors are perceived as imperfect in the way they make decisions and limited in their understanding of the extent of market dynamics, as the market and the consequences of market decisions are unpredictive (Chang, 2012). Consequently, markets should be constructed as exchange arenas where the state can control which markets have success in relation to others, to ensure equality, growth, and stability (Chang, 2012). Today, the free market does not exist, it is only a matter of the degree of freedom, as all markets have regulations and restrictions (Chang, 2012).

In the procurement process for the market, regulations can be seen in the form of the Public Procurement Act, which sets up laws and regulations that ensure equal competition for all actors. The market is constructed in this way among other things, to ensure that the market does not become too polarized, and few large organisations dominate the entire market. However, in the market, there is still a lack of regulations that ensures a sustainable agenda, and therefore there are no requirements for either developers or contractors to include sustainability in construction projects. The closest thing to sustainability regulations from the state is the building regulations, which through quality assurances of constructions, encapsulate some sustainability parameters at the same time. The lack of regulations in the market makes sustainability in the market an interest-driven topic, and due to financial deficiencies and little knowledge of the field, sustainability is deprioritized. This acts as a clear example of how the free market can have unforeseen consequences due to the imperfect actions of actors and a lack of ability to anticipate the consequences of them. This indicates that the market is not constructed enough, as actors do not manage to prioritize sustainability themselves, which will have environmental consequences in the future. Sustainability regulations could push the market towards a sustainable transition as developers and contractors would be forced to meet certain sustainability requirements. However, sustainability requirements from the state will also require quantitative data on sustainability initiatives, as it will be required that initiatives financially, as well as environmentally, can be measured on their effect, and set an agenda for what actors in the market must deliver.

On the other hand, government regulations to push the market can also disrupt natural demands in the market, making the market less efficient. An example of how interference with market forces may produce inappropriate results is when the state's demands for the market are not realistic and do not reflect the real stage of development (section 5.2.3, Søren Hvilsted). In this case, the market cannot live up to the requirements that are set, which can result in organisations not being competitive and deliverable. In this way, the influence of the state can create a market that is inefficient and advantageously favours those organisations that are large enough to meet the sustainability requirements. Free market ideologies believe that the special interest of actors in a market, which stimulates free trade by allowing actors to produce and exchange goods freely, will promote greater prosperity than state regulations can (Smith, 1776). Through research in this project, concrete examples have emerged of state regulations creating complications in relation

to sustainable inclusion. This can be seen, for example, when the Public Procurement Act sets requirements for a developer to be receptive to contractors being able to document environmental considerations that correspond to eco-labels (See section, 5.2.1, Bollerup, Region of Northern Jutland, Bech, Metroselskabet, Holstein, Roskilde Municipality & section 5.2.3, Bödewadt Lauritzen, VILTOFT). This creates complications for the developer as they must deal with a lot of documentation work, instead of just checking that the product is eco-labelled. This results in developers boycotting eco-label requirements because there is too much work involved in the research of whether documentations are equivalent to an eco-label. Alternatively, a state interference that does not hamper the special interest of market actors, but instead stimulates special interest through market benefits, could potentially direct market actors to include sustainability themselves. Such market benefits could be of economic nature, where developers and contractors receive financial subsidies per CO2 savings, or similar.

10. Conclusion

10. Conclusion

The project presented in this thesis has sought to develop a catalogue of instruments that can facilitate knowledge sharing in the construction industry. For this, the project has focused on the catalogue reflecting developers across organizations' needs for knowledge sharing. Specifically, the aim of this thesis is described through the following research question, and sub-questions:

How can a catalogue of instruments be developed to circulate between actors in the construction industry and facilitate knowledge sharing of sustainable initiatives for public tendering, contributing to accumulating an experience base that accelerates sustainable development?

1). How can a catalogue of instruments represent knowledge that is relevant for actors across different organisational boundaries?

2). What is currently blocking sustainable development in the organisation of Banedanmark, and where exist a room for manoeuvring at the organisation that allows the inclusion of sustainable initiatives?

Through analysis of the actors that are part of the construction network, and their internal controversies, that arise in terms of implementing sustainability in projects, a common denominator for what could help resolve these controversies, was identified. This common denominator, which can contribute to sustainability becoming a major priority in the tender, was identified as the description of quantitative data concerning sustainable initiatives. This thesis incorporates some examples of which quantitative data actors have expressed that would be relevant for a catalogue of instruments to report. However, these should not be construed as the sole representative of the quantitative data the catalogue should include, but examples of this. The quantitative data that are described regarding initiatives in the catalogue, should represent a broad range of assessment parameters, prioritised by different developers. The initiatives included in the catalogue should also - as is the case with the prototype in this project – report initiatives that are relevant to different types of projects. Initiatives will inevitably vary in relevance for the individual developer, depending on their organisational backgrounds and the project type in question. However, for knowledge sharing to be facilitated most efficiently, developers should also access reports on initiatives that are unusual for their organisation, as it serves as inspiration for new solutions and ideas.

The empirical data presented in this thesis indicate that the organisational structure in Banedanmark, which can typically be found in large organisations, complicates the implementation of sustainable initiatives. Because sustainability is a dynamic field where change takes place constantly, it is difficult for an organization like Banedanmark to adjust to the sustainable transition, as its structure makes adaptation and change difficult. In the analysis, a space was identified where sustainability could be included to a greater extent if projects could be developed jointly between the silos in Banedanmark. This aims to solve the challenge that usually arises as a result of the silos' different approaches to implementing sustainability. The intention of this cross-disciplinary collaboration, and integration of each other's practices, is that sustainability initiatives in the future can be developed with an inherent consideration of the various silos' different concerns. In addition, to ensure that sustainable implementation in projects takes place, and is prioritized, a supplementary silo could be added, which the main objective should be to unite the other silos in a collaboration on a sustainable implementation. This silo could effectively have a distinct focus on acquiring knowledge about sustainability

from other organisations in Denmark and abroad and process this knowledge regarding how it fits into the organisation of Banedanmark. For this process, the catalogue of instruments that Banedanmark wishes to develop could use the empirical data and experience presented in this project. Such a catalogue will be able to function as an instrument to facilitate knowledge sharing and translate actors towards integrating sustainability in their tenders if it manages to align all actors and their knowledge. The mobilization of developers for the development and updating of the catalogue will accelerate sustainable development in the construction industry, through the accumulation of actors' knowledge and experience base.

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Appendix overview:

Appendix A – Interview Bech Nicolaisen, Banedanmark

Jacob Bech Nicolaisen Banedanmark meeting with prototype.* Appendix summarise.

Jacob is project manager within the construction department of Banedanmark. He has a managing role and is often in discussion with other mangers from the different apartments such as operation. In this meeting we discussed various aspects of how Banedanmark function as an organisation and how integration sustainability can be worked with within their current structure and the pros of cons of set structure.
This interview is an hour and 20 minutes long and conducted as semi structed interview and is hosted inside Banedanmark's offices. The following summary will be in short sensitive, however there are sensitive information in the interview which will not be displayed or mentioned.

First we talked about the current sustainability initiatives and recycling in Banedanmark, which is currently remarkably high. Currently their recycle amount is around 98 %.
There have been add a lot of initiatives towards recycling of steel and concrete, there is around 100% recycle of these elements. The steal is easy to reuse and are incorporated in their practices and tenders.

Next, we talked about use of lime stabilisation in earth, however, they cannot make it fit the calculation for it to last 100 years. They must know it will work 100 years, so we are very rick aware. This a conflict between construction and operation, Constuction wants this due to its being fast and quick however operation do not have the data they need.

Sustainability and economic gain can go hand in hand a long way, a lot of innovation in projects are more sustainable and cheaper.

We discussed how changes can occur inside Banedanmark, here they mentioned project forum and system forum. In these meeting people from all departments can propose changes. After this it can go to higher level and be discussed. This process has previously been very slow, because it can be hard to estimate risk, and this is a hard discussion premise. With the use from all outside actors and other advisers.
Its easy what to do when all the analysis are done, however to get to do all the require analysis is hard to get.

Corporation is hard the lower you go in the organisation structurer due to their increasing knowledge and skills within their field.

In talking about economics how they move money between the different part of the originations, here we talked how money can follow those who takes the risk.

They want to establish more focus in the marked dialogue regarding sustainability, they see there are potential where it does not have to cost extra right now. We talked about who takes the risk between Banedanmark and its partners. They are more willing if they take the risk, its easier for Banedanmark, then they might agree to work that into the tender.

we asked question how to define sustainability in tenders. They want to be better in meeting their partners, so they can't help them solve what hinders them from providing sustainable solutions. They could award actors who develop innovative solutions with setting them as demands in the

tender.
they want to support the dynamic of the marked to be completive on sustainability.

they have had trouble only weighting project on price and not include sustainability. Price is a huge factor, however creating the tender and the offer is also an art. They try to get the best quality for the best price.
They are hoping for solutions such as infralCA could support innovative solutions and weight them properly. They must have price and co2 to be measurable. This is lacking and they are hoping solutions will be easy after the arrival of infraLCA.

However, it's a very pushed marked, they have some tenders where we don't get offers, they can't further the demands if they don't even get any bidders.
They have a hard time enough getting people to bid, this is a larger problem for the entire industry.
They don't know exactly why it's a extremely pressured marked, however the current political situation with Ukrainen have pressured it even more, with a lack of resources, like high quality steel where there are high demands.
They cant be forced to do thing, that is not as sustainable as they wish but have to be done to secure the buildability of the project.
They have not received additional funds from the politician to fond the sustainable transition, they must find option which does not affect budget.
they are going to ask for more funding however this is larger process.

Next, we discussed how we have mostly seen initiatives towards improving the construction site, when it comes to infrastructure projects.
Concrete is a big place to find improving however also very hard to understand when the effect will take in place, while the initiatives on the construction site is easy measurable. They would like to control the formular for their concrete mixing due to the high demands to quality they have.
They are not going to be first mover on any area, however it's their duty to follow if anything have proven to work, in the condition they have. Other actors must drive the innovation, they will follow, when the technology is ready and tested. They fear future risk.

In 1989 we had a mistake in our production which resulted in a lot of extra work, since then we are not very adaptive to risk taking since it can have long last effect.
They are willing to try innovative project if what are doing have no relation to the function of the railway. They have some bridges where they were considered modular or design optimalisation however they are no direct evidence of the actual gain of doing so. However with the currently marked it's hard to bids on any offers.
they are hoping for others Maeby smaller actors' developers these solutions and bring them into the larger nations forums and can adapt from there. They are very engaging in these groups with other developers and follows them closely.

If this risk could endanger train transport it would slow the current sustainable movement in the public. However current gas prices might get people back to trains.

At this point we bring op our current initiation of the prototype, the third. We want to talk about the different initiatives.

We talked about lack of catalogue for the construction industry, right now there are mostly focus on buildings. We would like to help Banedanmark developer their own. A summary of this can be seen in the report prototype section.

He said there are some establish phases established by ABR18, we should follow and implement those to secure a common language. This can also avoid confusion, for a lot of developers.
ABr18 setup a lot of standardised for contractors and developers. You should highlight where the biggest possible gains are over the phases. You must think about all the phases in a construction project when establishing sustainability and therefore there is a gain in understanding and planning for theses phases. Their goal is to take the low hanging fruit now, and we should mark where that is.

What did you think of our overview and what would you like to see it contain we asked.

The overview should give more concrete data and specific about risk, and the different aspect of it. You can also spilt into scope 1 2 3, from LCA he suggested. To split it into categories. They need information regarding price and co2.
However risk is also very important here, what type of risk is is compared to possible gains.

Next we go to look at the different initiative we start with material stocks.

Banedanmark already have many materials stocks however it's a good and easy place to start for many developers. they could always use development in this area, and many are trying to sell them solutions for different tools regarding materials stocks.
We want to know if other actors with the same condition and us, how have they done or are doing it.

We talked about how our catalogue try to be neutral actor between developers and entrepreneurs, however we must be aware of the marked rules. However we are hoping we could corporate where both partners win.

We continue to talk about the different initiatives. We would you like to see how certification and such initiatives could contribute to Banedanmark?

DGNB is not their business, they are for buildings, however it is expensive. A lot of these certifications are expensive, it can hinder the sustainable development. DGNB add extra cost to advisers who solely focus on it.
They like the idea of certification and standardisation; however it is a trouble area. Some certifications are not properly handling their areas and need further development.
They would use certification to secure their work as a risk reducing factor, however most are not super concrete to use in their organisation. They believe Banedanmark should not be the main actors in a certification it has to be another actor. However, they could be laws implanted Aswell that could replace some certifications.
ABR-18 is a laws, we have a lot of legal advisers and help us secure certain aspect of our projects. Sustainability could be controlled by law and regulated as that, making it an even ground for all actors and place sustainability as necessary in many projects. All our contact with enterprises is also under legal surveillance for multiple reasons. They are all controlled by long legal processes however this works, despite the constrains it may give. Laws are the premised its not bendable however they give a clear direction of what to do and how problems are solved. The more sustainability is intergraded into law the easier it is for Banedanmark to uphold.

Now we would like to talk about electrified vehicles in construction. We have heard this a lot, and would it be possible for Banedanmark to intergrade into their tenders? Creating a demand for among entrepreneurs.

They know that there are some experiences in Norway, where they are pretty far, and give us some contacts. (However we later tried and didn't receive answer in time for them to participate). They have developed a machine for setting poles and other stabilisation, that works on electric only. However, this is far from being marked available technology, its takes years, and years to developed. Aswell as the concern regarding the price of development new initiatives, Banedanmark does not currently have those funds. They are also scared of creating expensive monopole for some entrepreneurs.
They hope that their entrepreneurs will bring it using the smaller electronic vehicles in their offers. Due to them having better knowledge of what possibilities is, Banedanmark could help them develop a way to charge the machine along the rails. However, there are still geographical issues related to electric machines. Banedanmark also have construction sites that worked 24/7 when replacing curtain railroads, therefore electronic machines must be able to do that as well. Marked dialog is essential in solving this problem, however it's a tricky situation which requires other actors as well.

after the interview we asked two questions via text, the questions and answers are seen below. .

1)What is the maneuverer room for each departments/silo, what can they do without involving the project forum?

The project forum is a possibility to bring the decision to attention, with people who can make it, due to their position in the organisation. When something in brought up in the project forum, its often due to the problem covering multiple silos, where the discission must made by a range of people. This can be difficult due to the negotiations and result must stimulate many areas at the same time. Each of these silos can have their own possible best solutions, depending on their view and field. This is a time-consuming process where the final solution is often found when all actors compromises, to find the least “bad” option.

“Det taler også ind i et filosofisk paradoks: Grundlæggende tror vi ikke på, at der er noget, der meningsfuldt kan være éns ansvar – til det er vores projekter, fagområder og grænseflader for komplekse. Men omvendt kan man heller ikke deles om ansvar (”hvis 2 eller flere deler ansvaret har de max 1 % hver”).
quote taken from text conversation between the group and Jacob.

” This is paradox, we do not believe it can be one person's responsibility for at project, it is our project, area of expertise and competence. However, you cannot split responsibility, (if two have the responsibility they often have 1% each max)”

Our answer to this paradox is a matrix organisation. Horizontal you have the areas of expertise, whom have responsibility for their own field in all projects. Them that are vertical in the organisation reasonability is to make sure that the project is delivered and that understanding between the different field of expertise and what is needed in the project.
There are clear definitions in what those vertical and those horizontal can do, however when there is disagreement, often regarding resources and economic, is escalated to project forum.

There can be situtiions where the project risk is biggger and you want to communicate it to higher up, due to the focus on risk. So, they can assist and lower the chance of the risk, Aswell as prepare measures if unsuccessful.

2) do you have any examples of decision of small characters that had to be escalated to project forum? Despite their positions to solve it them self's.

It’s a hard balance to find out when to escalate something. The participants in the different project forums will often first ask” have you talked to XX About the problem, and can you find a solution together”. Often the reason for escalation is that they have a problem they cannot solve, but it is often clear who they must talk to, they just did not have that knowledge themselves.
It's important to be clear on what you need for the project forum to decided, it happens that people can take the decision they just did not know due to lacking knowledge regarding the problem.

Appendix B – Survey Responses

Survey Respondants

Metroselskabet

Replaceable components on structures e.g., panels on the walls of stations

Repair of metro trains extends the estimated lifetime by ten years

Special permits for materials and substances that come into contact with the soil

Requirements for max CO2 emissions on steel and concrete

Crushed concrete used as a stability layer

Smaller machinery (<2,5 t) has to be electrified. Larger has to use certified HVO100

Every construction project have a long estimated life time +100 years

Aabenraa Municipality

Uses the Voluntary Sustainability Class to set requirements

Sustainability is the core of new building projects not just an addon

Vesthimmerland Municipality

Uses third parties for their sustainability initiatives i.e., RealDania

Implementation of sustainable urban drainage systems

Reuse of crushed concrete and tarmac

Hjørring Municipality

Implementation of sustainable urban drainage systems

Innovative urban areas

Surplus materials from construction is freely available for the citizens

Stabilising layers of roads consists of crushed concrete and slag from the local incineration plant

Correct renovation and disposal concerning materials from buildings

No harmful substances in new buildings

Greenery must be local wild species

Reuse of cobblestone, vinyl floors and windows

New use for old buildings

Requirements for labels and certifications e.g., ISO14001, FSC, all new buildings must be DGNB and no materials containing PVC

Fredensborg Municipality

Implemented a new green procurement strategy in 2020

Aarhus Municipality

Focus on sustainable transport, materials and circular economy

Uses project specific initiatives

All buildings must be based on the catalogue "Miljø og Energirigtigt Byggeri i Aarhus Kommune

Experimentations with construction workers using electric cars, bicycles and scooters

Rewards points for sustainability

Nyborg Municipality

Has developed a codex for Sustainable Buildings which focuses on materials, health, climate and more

DGNB certification in larger building projects, e.g., hospitals

Sees sustainability as a integral part of climate, indoor climate, functionality, operation and renovation

Uses LCA calculations on buildings

Roskilde Municipality

Uses DGNB and sustainable requirements as an integral part of building projects

They are considering to use "shadow prices"

Uses points to reward sustainable projects through the tender

Has a storage facility for recycling materials

Appendix C – Affinity Diagram

Appendix C – Affinity Diagram

Appendix D – Interview with Bjerre, Kammeradvokaten

Judicial Schisms in the Tender Process

Investigating the judicial perspective on the tender process, including the controversies that can emerge between parties, an interview was arranged with the tender lawyer Magnus Bjerre Clausen, from Paul Schmith/Kammeradvokaten who at the same time teaches at the University of Copenhagen. Bjerre's daily work concerns sorting out judicial disputes and arbitration cases that can happen during a tender process and supervising owners, contractors and technical advisors in the legislation around tender processes.

According to Bjerre, one of the biggest causes of controversy regarding sustainability in the tender process concerns the measurement of sustainability in the tender process. More specifically there is a difference between whether sustainability is verified in offers and how it is done to get data that constitute an equal base for comparison between the different submissions. A main issue is the criteria setting of the tender, and their degree of specificity, as they should create a measurable base for comparison. A criterion that defines the bid with the largest CO2 reduction as the winning bid, would not establish a fair base, as there is a lack of limitations on how much is included in the measurement. E.g. Does the measurement include CO2 emissions from steel, gypsum and concrete only or does it also involve CO2 emission savings on transport, bolts, screws, etc. One way to combat this issue as a tenderer, and to stimulate a sustainable innovation in the tender process, is to engage in an early market dialogue with submitters. A market dialogue can contribute to an equal understanding of the opportunities on a market, in relation to creating sustainable solutions. An early market dialogue should be a priority, as sustainability is more difficult to implement later in the process and should be considered in all phases of the project to create solutions that are sustainable in its core. As a final addition, Bjerre points out the importance of considering the relationship between price and CO2 reduction in a tender that aims to be more sustainable. The greater the CO2 reduction desired in a project, the more costly a project becomes.. This ratio follows an exponential curve, which results in CO2 reduction pr. krone being unmanageable the more the contractors try to reduce emissions. This relationship may create an incentive to be more focused on economy than on sustainability, as the current practice of choosing the winning bid mainly focuses on price.

Regarding sustainability in the construction industry, the biggest boon and source of many disputes, according to Magnus Bjerre, is the use of recycled materials. The contractors know that the use of recycled materials in most cases produce less CO2 emissions, compared to using virgin materials. The predicament and schism for the contractors and technical advisors lie in, who has the

responsibility if something goes wrong, e.g. structural failure, human accidents etc, due to the use of recycled materials in many cases these materials have not and cannot be tested as thoroughly as newly produced materials. The construction industry's' biggest concern is thinking about risk management and responsibilities. This causes an apprehension in the use of recycled materials, as there is a lack of clear ownership over the responsibility between the contractors and technical advisors. Consequently, to make the use of recycled materials more attractive and thus directly reduce CO2 emissions from the construction industry, the issues of responsibility must be resolved.

Appendix E – Interview with CO-PI

Center for public and private innovation

Center for public and private innovation (COPI, Former Coi). Was started in 2021, based on the former Center for offentlig inovation. The new organization focuses on the private sector inclusion in the innovation as well. Copi is knowledge centre and on of their task is to develop nye types of corporation between the public and private, and its important for them not to take the work of lawyers or other processing tenders.

The researchers contacted Copi to understand their roles and the connection between the public and private.
Copi stands help the corporation in invitation cases and promotes them, to actors on the public and private sector. They help in public innovation cases and describe their own three areas of focus to be:

“

- Teknologi til understøttelse af velfærd
- Klima, grøn omstilling og miljøforbedrende tiltag
- Bæredygtigt byggeri.

“

(https://co-pi.dk/om-co-pi/hvad-er-co-pi/)

We got in contact with a tendering consular from COPI. Their roles in not direct contact with the specific tender, but before actual tender is created. They are to collect both private partners such as Banedanmark, København kommunne, metro danmark, with private actors such as entreprenaurs, counlers and producers, to share knowledge about possible solutions. Here the exsampel of the task they help with before an tenderprocess in their new developed process called

INDSÆT Modellen for den der tværgående process:. https://co-pi.dk/media/53472/loes-problemet-sammen-offentlig-innovation-i-samarbejde-med-private-virksomheder-final-a.pdf

They mention the example to use electronic vehicles at sights, if it just a small innovation project that will require it, give no incentive for entrepreneurs to go out and invest in new electronic machines. however, if both BD, København Kommune and metro Denmark promise to include it in their tenders onwards, it gives a incentive and financial security for the entrepreneurs /machines owners to invest in new machines packages.
They mentioned the story of how it has been done it Norway, where they first focused on fossil free and later emission free constructions sides. The dialog has taken a couple of years, about not just what they want, but how to do it in the tendering process.
Copi roles in these dialogs in to make sure the private and public gains from these negotiations, so the public don’t set demands that could crate monopoles or can't be fulfilled. Here it's hard to know exactly how to insert the sustainability demands in the tendering, here it's important to view it case by case, and to make sure that doing it increasing the chance of getting the project. However its easier to start with to make small minimum requiring, and move slowly forward from there, however this requires a large, marked dialog before, which ensures many actors can live up to such demands.

Here marked certificate is helping a lot, however not ion the anlæg business, but many other areas, via fx nordic eco label. Standards and marked certificate are making it a lot easier for many in the tender process. This is certainly helping in katalog tendering like food or medical equipment, making it possible for each actors using this agreement to choose where they would like standard products.

However, there are lacking a space to talk innovation between partners. The public want to demand the newest solutions, however since they are not demanding it entrepreneurs don't want to finish the development before it is required, referencing to the hen and the egg.
there are tendering's processes like the invotaion partner and tenderings with forhandling.

Invention and sustainability is risk full, this there can be lack of understand of in the large public actors, this tendering process can mean a lot to small companies. They are not under the same stress to collect new fonds or job, like the companies are, the public funds source are secure. The private wants to be invovative however they have to secure a profit, and the need for constant work, is not understood by the public.
While the private seems to lack and understanding of the burecratic system behind them, since they are often in contact with only one person, they don't seem to understand the mechanimsen behind that person.

When they tried to work on "green concrete" they ran into problems regarding the long lasting ability of it. There is no evidence that green concrete loosing its abitlity, however there are noeviende that it doesn't. Since a lot of this project are ment to last over 50 years, they have to know the realiability of the used materials, this gives traditional concrete a marked advanges due to years of years of data collected related to concrete constructution.
When actors are consider using "green concrete" they have to find out who takes the responsibility in cases of a problem. Very few actors are willing to do this on larger projekt, since the responsibility could cost a lot.
This Is a problem herd a lot when it comes to implementing new technologies or materiels, since no can gurante their effect and ability 50 years in the future. Takeing the responsibility can be expensive due to the sheer sice of some project. With the ability uknow so far in the future it require more cheack up and perhaps danger to project, if abiltyes worses faster then expected.

Appendix F – Interview with Munck Group

Munch Gruppen interview regarding sustainable tenders.

Appendix

In this short phone interview with Munk Gruppen we want to explore various parts of sustainability in the construction sector. Munck Gruppen is large entrepreneur witch work with both building and construction. We talked with the marked leader, who is responsible for handling values related to sustainability, in their harbour and construction department.
This document is a summary of the 30-minute conversation.

First, we introduced us and our project. Then we asked how they believes sustainable certification can effete the construction industry?

Certificating is not used in construction project they have yet seen a reason to do so. Certification cost a lot and it is a hard case for them. The challenging regarding certification is like the challenges with sustainability, if there are no direct demands to live up, it's not moving the marked. They have seen a lot of fluffy demands, and not following up on sustainability demands.

They recently have had success with criteria, but this was due to their being a marketable case for it. There must be a gain for entrepreneurs as well, a lot of developers don't consider that. It can be a win-win.

We ask where the biggest potential was currently for sustainability in tenders. What changes do you see?

They advocate for a common CO2 measurement model to provide a data for the specific project, to reliable compare project. This model must influence on the weighting because now it the almost always the cheapest offer that win. If sustainability must be a thing, it cannot be the cheapest projects every time.

The changes in this are in what there is measured, they say there must have a standard model. A lot of times its different advice who makes the best cases scenarios to appear well in the tender material.

Next, we asked how a tender moved and is worked with in their organisation regarding sustainability.

When they see an interest sustainability project, which is mostly in our cases total enterprise. They establish a partnership with an adviser who also finds interest in the case, they must have the right competences for the project. They do not have enough sustainability adviser yet, so they must use external advisers.
They try to use their knowledge in corporation with the advisers to win the offers, if we do not win the case, it does not matter. If we do not win any cases we are done, we need the earnings. This is our premises; we need an income.

We asked them to tell a story where sustainability succeed.

They have an offer out in Lynnetteholmen, where the won a tender regarding the entranceway out

to it. The tender contains roads, dams, and bridges, a large project they are happy to get.
IN this project sustainability weighted 10%.

We asked what was weighted and included in this.

In this project there were 7 criteria from waste management, recycling, to c02 measurement.
They suggested to reuses old concrete elements, which they have decide with an adviser team they hired. They delivered 10 pages plus appendix regarding sustainability with the concrete ideas and project, witch contains a materials stock and an adviser following the project from start to end.

We asked if they felt that was work was worth the weighted 10%?

Currently the economics regarding the sustainability aspect of the tender, is expensive and compared to the low weighting gains from doing it. However, they were lucky to enough to win the bid, eels the lost would be large.
In this project there was a lot of demands, it is because By and Havn want to take sustainability seriously.

Was there demands or was it all criteria? We talked about demands regarding electric vehicles

It was mostly criteria in the Lynetteholmen.

They win a lot of offers in Copenhagen where they really want electric vehicles, however the needed infrastructure to support them with local recharging is not yet available.
They can deliver all machines electric if Copenhagen wish so, however this will result in all of them being driven in early in the morning and driven out later to recharge, result in a lot of transport via trucks in Copenhagen, eliminating the gain.
There is also the problem of them not being able to work constantly, witch increases the price.
The larger machines are still not available for the marked, its only the smaller once.
However, there must be a marked that is fair and competitive, and if developers set the bar too high it prevents innovation. Small companies cant go out and replace their whole machines park, like the larger have capabilities too.
They are a part of the munch group which gives us some capabilities and resources that smaller entrepreneurs would not have accesses to.

We asked what the learned regarding sustainability in the entranceway to Lynetteholmen project?

Every time they meet sustainability in tenders, they learn new things. Waste management is a good example, it's not something they have done before, however now they have developed a good approach to it.
They have learned a lot and developed their knowledge regarding the topic.
They will however only add it if the developer specifically asks for it, since they are not allowed to offer something not in the tender.
There is a time pressured on tenders, so they must focus on what the developer asks for.
They do not go for tenders far outside their comfort zone.

We asked what kind of knowledge they wish developers possess, or what information they think developers lack regarding how entrepreneurs work? Witch could be included in our catalogue.

Developers must have a better understanding of how sustainability and economy goes hand in hand, where can the get most for their money. Developers must know the conservancy of the demands, to obtain an optimal economic competition for themselves. Developers can set a lot of demands but if they do they get a small number of bids, which could increase the price of the project due to not having a completive marked.

There must be a understanding of the marked, its possible to nudge the marked in a direction. Like the demand for electronic machines, if they implement it would not reach it environmental potential and add a lot of extra cost. Sustainability is complex and cannot be solved by simple means.
They understand that they cannot just call developers with their innovative ideas, there must be some distance between to avoid unfair marked competition. It's also against the law.
IF developers do not ask the right questions, they cannot give them the right answers, there are rules for marked dialog.

We asked if he had any suggestions of demands that could be implemented now?

They suggest more total enterprise with could give the entrepreneurs more freedom to implement their solutions. If they have total enterprise, it allows them to rethink their entire solutions.
If they can use their competencies and be innovative, they are pleased.

However sometimes total enterprise is used to just move the responsibility from developers, and they do not bid on those.

However, a certain degree of freedom allows them to optimise their project, which total enterprise allows. It can be optimising of economics and sustainability; they can go hand in hand.
They see a large possibility to reduce CO2 and price creating win-win situations.
They will developer sustainable solutions if they money follows, if there are no earnings there are no gain for them.

Appendix G – Interview with Lendager

Lendager on developing sustainability in tenders

Magnus is team leader and project leader and have experience from other positions related to architecture.
Lendager is a innovative architect firm witch sometimes also bid on tender as developers.
They are a green company as a core and will not work with project who are standardised building projects. They developer project with focus on CO2 reduction and social sustainability.

This document is a summary of the 1 hour long online meeting. Some information is not represented in this summary due to it being confidential. This interview is a semi-structured interview the aims to understand the possibilities of sustainability in the construction industry and see if we can draw inspiration from the buildings industry witch Lendager focuses on.

We wanted to understand how they understood sustainability:

They are focusing on reduction on CO2 and a focus/core of the project they want to explore. This could be different variation from project to project, right now they focus recyclability in their latest project.
They try to use different tools such as LCA, to understand where to act. However, it depends on the core of the project which is mostly c02 and material recycling.
They often act as advisers for others in terms of circular architecture solutions, so they step in between roles and offer advising to both developers and entrepreneurs.
Often entrepreneurs want us to part of their tenders.

We ask them the effect of LCA or DGNB in archiving sustainable solutions.

They don’t see DGNB to achieve sustainability but away to achieve a quality for the house, and for the developers to have. However, they do not believe it’s the best for archiving innovative sustainable solutions.
LCA however often help them compare solutions and help them make decisions regarding material choices. They could have a couple of different solutions and understand where and how they affect the footprint and help them decide or communicate to their cooperating partners.
It's not always their decision, sometimes sustainability cost more and if it does so it is up the entrepreneurs or developers. However, they often have total enterprise, where they come with different solutions and different price levels and let them decide.’
They try to pressure the developers and entrepreneurs a lot in Lendager, to be innovative for the gain of both Lendager and the developers.

Next, we ask question regarding where the relations between actors in the construction industry creates ten that prevent sustainable integration.

They believe it's on the developers they set a lot of demands to price and time, which is hard to archive with new innovative sustainable solutions. There are often not enough resources to explore different alternatives, both for bidders and internally at the developers. Developers talk about sustainability however they do not weight them enough or give them the proper resources. They see

the challenges in Copenhagen to be the high prices of public grounds, developers must choose standard solutions to secure a profit. This is both a problem for both public and private developers.

Now we ask about a success story where they succeed in implementing sustainability in a project.

They had a project a bit outside Aarhus, and a demand was that it was supposed to be cheap due to developer being scared it would not be sold. It was a bit far away from Aarhus and not yet a very urban area.
Here they succeeded in creating a sustainable solution without extra price, due to the developer and entrepreneurs being willing to show and gain experience in how to make cheap and sustainable solutions. All partners working together in this project, this process have been time consuming compared to other projects, however ending in solutions all gain from.

We asked how they saw the most sustainable tenders and what they prefer in a tender?

When a tender is not just focused on price, this makes a major difference. Lendager are not willing to bid on offers where price is just in focus, and sustainability is just a sales factor. They are not interested in these projects. They want a degree of freedom and willingness from their partners to try innovative solutions.
They want to be involved as early as possible; this allows for greater possibilities. Sustainability will not be good if you try to add it in the middle of the process. Sustainability is supposed to be a core, sustainability cannot happen in silo thinking, it must intergrade from the start across the organisation.
If sustainability is add-on, it can easily be removed if the price goes to high, however if it is the core, it cannot be removed. Make sustainability a core element and it cannot be removed.
The current material prices are however strange now, making sustainable solutions suffer. However, the marked changes all the time.

We asked what knowledge they wish their cooperating's partners have?

They see Copenhagen as good developer with good ambitions and knowledge; however, a lot of the big entrepreneurs are not motivated yet. And even small entrepreneurs have a tough time due to them not having resources enough to incorporate sustainability.
The construction and building industry is a conversative business, which is dominated by rockwoll producers, concrete producers, and the more efficient building methods.
Sometimes it hard to be advisers if developers and entrepreneurs just want a low target price. However, Lendager only bid on project with resources for sustainability.

We want to know if he knew any low hanging fruit to add to a construction tender

There are not easy choices, it is always a negotiation. People want to do what they always do. There are some baby steps, which are easy to take, however they do not give a large effect.
They have seen a change, with a few entrepreneurs willing to listening and learn from Lendager. However, the responsibility discussion is hard, here public developers are showing the way and are good at taking the risks and reasonability.
They are have to show the risk to the developers and entreprenurs, the´more informationi the better the choice. Sometimes it has to be really simpel to explain.
They like to make a pro and cons list, to explain to their partners, this can be support by price and CO2 evaluation.

They have seen that adding recycled materials to buildingprojects decreases the time it takes to get renters and more happy renters. Susainbility can also be a sales points for their partners. They have had experience where the renters have become ambassadors for their building and telling the sustainability story.

We want to talk about the “story” of sustainbility.

A lot of new building projects looks the same, they focus on sustainbility being a trademark of the buildings they are creating.

We asked how him how they believe the future of sustainability in tenders will look?

They believe there will be a larger focus on sustainability, and become increasingly intergraded into projects. It is going to be a fully circular project; it will include more end-of-life stages. However sometimes it hard to have the whole lifetime of the building in perspective, due to it being facilitated by one actor and created by other actors all within the same public actor. Public actors most be better at facilitating cooperation with operation and planning. They believe knowledge will transfer from project to project, so the tenders will develop.

Our last questions were about how they believe LCA will affect tenders.

It will have a big effect however it depends on the weighting. Best-case scenario is a CO2 price, however LCA’s have some limitation. There is some challenges ahead for LCA, so it's going to be developed and eventually play a larger role in the tender process.

Appendix H – Inger, Region Syddanmark

Phone interview with Inger from region syddanmark.

Date 22 February, 12:00-12:30

Inger is architect who is a project leader within the construction department of region Syddanmark which covers the south end of Jutland and Funen.
Here she focusses mostly on buildings projects, due to her experience as an architect. Here she is involved in creating tenders as well together with their procurement department.

Region Syddanmark have started been working with sustainable building for a long time and have developed several tools such as a regional demand for buildings. This process has help them gain more climate friendly solutions, however this have only been for buildings and not yet to included infrastructure construction.
One example where they had had great success in cooperating in different sustainable criteria in the tender materials where the recent expansion to an autist centre in Fredericia.
Here they have had several criteria regarding everything from material selection to construction site demands, in this project these criteria had a weighting of 20% of the total score.

This have been done using DGNB, which have been playing a key role increasing the sustainability in the building industry. Here region Syddanmark hope in the future to set demands to accomplish at least a silver DGNB rating in all future building projects.
They have also chosen certified and educated some of its personal, including Inger, where the goal is to be able to do their own DGNB certifications and as well as it being an integrated part of a new practices which includes sustainability via certification.

In an interesting following discussion, we talked about how they have tried to incorporate what they have learned related to DGNB in other projects which is not covered by DGNB. In a reason project they had to expand a parking building, they used some of the measurements and criteria from DGNB to increase sustainability in that project.
Some of DGNB criteria such as lighting levels or indoor climate are irrelevant for infrastructure projects related to roads, rails or parking.
They used criteria's from DGNB regarding construction site witch fits both buildings and constructions. In the parking project they used criteria regarding scaffolding and other construction site related criteria.
It was very inspiration to hear of this planed journey of trying to use DGNB to explore possible sustainable solutions outside it intended area.

Appendix I – Interview with Masana, Herning municipality

Sustainability in Herning municipality

Marc Masana is team leader for the tender department in Herning municipality. Along with four others, he is involved in almost all procurement for the municipality.

In Herning municipality, the employees are aware that the market is developing towards a more sustainable direction. Even though the municipality's recently described sustainability strategy is not directly affecting the tender process, an increased interest and focus on sustainability within the municipality is noticeable. Especially an interest for how sustainable initiatives is applied in other municipalities has increased, and the municipality is in general more responsive to adapt and invest money on similar initiatives.

Currently it is up to the individual administration which products they wish to purchase, however sometimes the municipality initiates a dialogue with the administration to affect the choice of product towards more sustainable alternatives. The only direct restriction on the purchasing assortment, is the political involvement. For example, political influence has led to the decision that plastic knives and forks should not be purchased in the municipality. However, it is rare for politicians to make direct demands on what can be purchased. Usually, political interference is just a matter of noncommittal requests like; the municipality might consider whether it can be avoided to purchase microplastics in a tender. Sometimes certain professions among the purchasers' requests which products Herning municipality should offer on their shopping portal, which is the online page from which Herning Municipality's purchasers choose their products. As a result, the selection of certain products is reduced, for example, the environmentally polluting alternatives to a product might be excluded from the online page.

To ensure a certain standard of the purchased products, label certifications are required. As a guideline, the Green Procurement Partnership has described various requirements and criteria that tenderers can include in their tender material, which is often related to which standards should be required for certain products. In addition, TCO (Total Cost of Ownership) is considered, where the relationship between emissions and price calculated. These calculations are performed by a sustainability adviser to assess what can be saved in terms of CO2 and price. Within the municipality, the current sustainability discussion concerns whether everything should be sustainable or concrete areas with a high sustainability potential, should be prioritized exclusively. To simplify these decisions, a sustainability strategy could be developed for certain areas where the price investment in a tender can measure up to the degree of sustainability in question. It would help Herning municipality to assess which focus areas provide the most sustainability for the money – which they consider very attractive. It is particularly relevant because the biggest obstacle to sustainability is

economics. Sustainability is expensive in most scenarios. In addition, there is also a lack of knowledge concerning degrees of sustainability. Masana gives an example; is it more sustainable to drive an electric car than a diesel car.

According to Masana, the market dialogue is the area of greatest potential for a sustainable change. The contractors are aware of what the market can deliver in terms of sustainable solutions, and there is no point in making demands they cannot accommodate. The traditional tender form applied in Herning municipality, is evaluation criteria that allows the supplier to describe what they can comply with. Tenders with negotiation are also used, as these establish a dialogue during the process and makes it possible to adjust the tender material after the offer has been completed. Minimum requirements are not a popular choice as this creates restriction on the tender. Specific requirements exclude other alternative solutions that the municipality could not have foreseen.

The municipality is a member of Com Tender, which is a procurement community consisting of 14 municipalities. Each quarter, all the purchasing managers from the various municipalities get together and discuss topics of relevance - such as specific projects, experiences, and sustainable initiatives. Knowledge sharing also sometimes takes place internally in the municipality, where various professionals contribute knowledge about how they think a tender should be structured if the tender is relevant to their profession. For example, it may be road workers giving advice on which kind of road salt is most efficient. However, trying out new products is not something that is easy to experiment with as each purchase has a binding contract. Only when the contract has expired, a reduction or increasement of the item can be made.

Appendix J – Interview with TMF of the Municipality of Copenhagen

The Technical and Environmental Administration of the Municipality of Copenhagen.

The Technical and Environmental Administration of the Municipality of Copenhagen's way of including sustainable initiatives in the tendering process is through criteria in the tendering material. They have two ways of doing so:

1. Through eligibility criteria on projects of a larger scale and,
2. through general criteria on almost all forms of tendering.

According to the Technical and Environmental Administration in the Municipality of Copenhagen, they themselves are very ambitious with the criteria they set as a part of their tendering material but see a space for them to be even more ambitious in the criteria they set. The two areas where the most focus lies within the construction sector in the municipality are recycling and reuse of a list of materials. Moving forward these two areas are where they see their focus be delegated to even more than they already do. Right now, these initiatives work within the layer of projects and smaller teams, where these initiatives already have been established, but in the future, this movement will be advanced and implemented through the administrational layer. These initiatives specifically concern materials such as granite, concrete, and tarmac. Granite is reused directly as is in other projects, i.e., curbs between roads and sidewalks or through their internal material recycling facility. Concrete and tarmac are recycled, where it is broken down and granulated, and used as a stability measure underneath the roads.

The communication between the municipality as a developer and the contractors has two faces; the administration as a whole is sufficient in having ongoing dialogues with the contractors on which criteria can be set and what room for manoeuvre, they must implement sustainable initiatives. But for project-specific dialogue, is more limited. This is due to the nature of the Technical and Environmental Administration as a developer, where they, themselves, develop a lot internally on these small-scale construction projects, so when the time comes to include the contractors in the market dialogue, the project is already too far along in the process to make major changes. But for larger-scale projects, where turn-key contracts are beneficial, contractors have more agency and say, where they are included early in the project. An example of an initiative stemming from a contractor is when constructing a new road, the top abrasive layer is scraped off and then directly reused as a new abrasive layer on the newly constructed road.

As to specific instruments to improve sustainability in the construction phase of projects, it is important to either not set specific enough criteria or set criteria that easily can be circumnavigated. In our catalogue of instruments, we had at this time included an instrument that stated: *Electrification of all vehicles/machines under 2,5 tons*. As a result of this formulation, a contractor can earn full marks in the evaluation, just by solely relying on and using machinery that is within weight classes above 2,5 tons. Instead, the criteria can be formulated as all machinery that has to fulfil a specific task, e.g., water pumps or machines for paving, must be electrical, and all other machinery that does not lie within these functions has to be Hydrotreated Vegetable Oil-driven (HVO).

"Den måde vi håndterer maskiner på, det er ved at bede om i alle vores udbud om at få en pris fra entreprenøren på at skulle lave arbejde for brolægning og afvanding med el maskiner. Alt øvrigt arbejde skal udføres med maskiner der drives af HVO."

"The way we handle machinery is by demanding a price from the contractors in all tenders, that tasks within paving and drainage must be done with electrified machinery. All other work must be done with machinery that is driven by HVO-fuel."

This is then brought to the contractor that then provides an estimated price for an electrified machine package. If the price is too high or not beneficial for the developer, the initiative is set aside, and shadow prices can be used instead. In general, the Technical and Environmental Administration does not meet the resistance of any significant level from the contractors, when evaluating these criteria, if the criteria are being formulated thoroughly enough and the contractors can feel assured that an even basis for evaluation is given on these criteria.

When handling waste materials from fractions common in the construction sector, such as tarmac and concrete, the Technical and Environmental Administration, has internalized the processes related to disposal, recycling, and reuse of these. This has been done to cut costs related to a scenario where contractors are responsible for handling waste material. By internalizing waste handling the administration also get more room for manoeuvre to reuse said materials directly in projects, although severely limited in most cases as the quality of EOL concrete and tarmac is lacking so as it stands now, there is no possible way to upcycle these materials into building grade concrete and can therefore only be downcycled into lower grade solutions where the quality of concrete is not a factor, e.g., stabilization of soil.

Appendix K – Catalogue of Instruments

Det Bæredygtige Udbud

Erfaringskatalog for anlæg

1. Udgave, XX Maj 2022

Udarbejdet til kandidatprojekt ved AAU

Af forfatterene:

Sigurd Hoffmann Buhl
Maria Dyremose
Jacob Toft Christensen

KØBENHAVN
AALBORG UNIVERSITET

Forord

I dette erfaringskatalog har vi, en gruppe specialestuderende, prøvet at skabe hvad vi tror er det første af mange kataloger for vidensdeling omkring bæredygtighed i anlægsbranchen. Bæredygtighed og klima bliver en større og større aktør i vores alles hverdag, mange brancher er allerede igang med den store omlægning, denne udvikling er nu kommet til anlægsbranchen. Byggebranchen har været foran, men vi ser et kæmpe potentiale for at anlægsbranchen kan komme foran og sætte eksempler for andre. Med store offentlige bygherrer som de største spillere kan vores alles fælles kamp for klimaet, blive forstærket og udtrykt gennem dem.

Vi tror at anlægsbranchen står over for store og spændende udfordringer og udviklingsmuligheder. Vi følger spændt med i udviklingen af Vejdirektoratets InfraLCA og de ændringer det medfører. Desværre er måleværktøjer som LCA ikke nok, der er brug for ildsjæle og frontrunners der kan skubbe branchen og udvikle sig som en helhed. Vi har mødt mange af dem gennem udviklingen af dette katalog, og de skal ikke stå med ansvaret alene. Derfor ser vi vidensdeling som et vigtigt redskab til at vi sammen kan løfte og løse de kommende klimaforandringer.

Som kommende bæredygtighedsingeniører håber vi på at bidrage til den grønne omstilling, vi vil derfor gerne invitere aktører der udvikler deres egne vidensdelings/erfarings kataloger til at kontakte os, så deler vi gerne begrundelser,erfaring og data der kan hjælpe.

Vi vil gerne takke Banedanmark for at sætte os på denne spændende opgave, samt at dele deres viden og netværk med os.

Indholdsfortegnelse

Introduktion

Der er et stort potentiale i bygge- og anlægsbranchen for at skabe en miljømæssig forandring idet industrien samlet set er ansvarlig for 30% af CO2-udledningen i Danmark. I byggebranchen eksisterer både værktøjer til at kvalitetssikre bygningen, som kan stilles krav til i udbuddet og innovationssamarbejde mellem bygherrer med fokus på den bæredygtige udvikling, er der mangel på samme incitamenter i anlægsbranchen.
Trods der er stor interesse for bæredygtighed hos bygherrer i anlægsbranchen, og midlertidigt eksisterer enighed om at branchen bliver underlagt et politisk pres fremadrettet der kræver en hurtig omstilling, så er vidensdeling mellem aktører i anlægsbranchen minimal. Da bæredygtighed er et relativt nyt parameter der skal inkluderes i byggeprojekter i anlægsbranchen, er viden om hvordan det inddrages, hvilke tiltag der giver mest bæredygtighed for pengene, og hvad der er mere eller mindre bæredygtigt, indskrænket. For at igangsætte initiativer i branchen er der behov for at akkumulere viden, og bruge erfaringer fra øvrige anlægsprojekter som inspiration til hvordan udbudsmaterialet og designet kan planlægges.

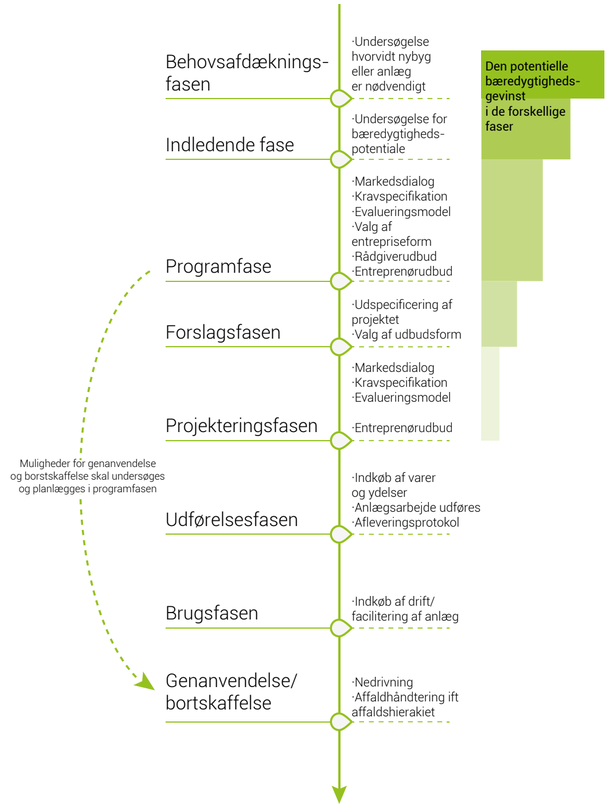
Dette katalog er udarbejdet som et erfaringskatalog hvor bygherrer kan inspireres til hvordan bæredygtighed i højere grad kan inddrages i de forskellige faser af byggeri. Idet det største bæredygtighedspotentiale ligger i de indledende faser af byggeri, vil flere af tiltagene tage udgangspunkt i at bæredygtighed inkluderes fra starten af et projekt. Kataloget henvender sig primært til bygherrer i anlægsbranchen, hvorfor tiltagene i kataloget primært er udvalgt ift. deres relevans for disse. De konkrete tiltag er dog fra aktører i både bygge- og anlægsbranchen da visse tiltag er relevante fra begge, og kataloget sigter anlægsbranchen inspireres af nogle af de initiativer der har skabt udvikling i byggebranchen. Kataloget er opdelt i forskellige kategorier med tiltag, og hvert enkelt tiltag vil give et indblik i bæredygtigheds-, pris- og risikoparametre som skal evalueres i forhold til det konkrete projekt.

Virkemidler	Pris:	Mulig CO2-besparelse:	Implementations ressourcer:	Skalerbarhed:	Risiko:
Indledende fase:					
Strukturering af det Bæredygtige Udbud	3	3	2	2	2
Projekteringsfasen:					
Certificering i Anlægsbranchen	3	2	3	2	1
Udførelsesfasen:					
Eldrevne Maskiner Under 2.5 ton	2	1	2	2	2
Delt Materialelager	3	1	2	1	3
Genanvendelse/ Bortskaffelse:					
End-of-Life Stage	3	2	3	3	1

Data i dette skema er ikke faktuelt, men blot til illustration

Behovsafdæksningsfasen

Til højre ser du en oversigt over de forskellige faser i et anlægningsprojekt. Disse er baseret på ABR18s opdeling af denne. Dertil har vi tiljøjet *behovafdækningsfasen* der omhandler de processer der sker allerede inden at projektet er sat i gang. Her undersøges det egentlige behov for nyt anlægsbyggeri, og det er også her man finder det største bæredygtighedspotentiale i form af; *Det mest bæredygtige byggeri er det der ikke bliver bygget*



Indledende fase

Strukturering af det Bæredygtige Udbud

Om

Følgende tiltag sigter at inspirere til hvordan bæredygtighed kan inkluderes i udbuddet. Idet tiltaget skal ramme bredt på tværs af forskellige projekter, vil de konkrete forslag være mere uspecifikke. Her kræves det at den enkelte bygherre tager stilling til om og hvordan eksemplerne kan inddrages i det enkelte projekt. Den store udfordring mellem bygherrer og entreprenører, ligger hovedsageligt i at skabe balance i udbuddet mellem innovation og kommunikation. Imens bygherrer oplever at bæredygtighed som del- og underkriterier i et udbud, skaber de bedste forudsætninger for at entreprenører kan inddrage deres viden og kompetencer, er oplevelsen hos entreprenøren at bæredygtighed som del- og underkriterie delvist ikke vægtes højt nok i udbuddet til at fremme den bæredygtige innovation, men delvist også kommunikeres uspecifikt og tvetydigt. Dette problematiserer tilbudsgivningen for entreprenøren da det bliver utydeligt hvad entreprenøren vægtes højt på i udbuddet. Følgende forslag bør derfor overvejes når udbuddet struktureres; Der bør i udbuddet sættes minimumskrav til bæredygtigheds data frem for minimumskrav til den konkrete løsning af opgaven. Det vil sige at udbudsgiveren bør sigte at stille krav til slutresultatet fremfor fremgangsmåden. F.eks. kan et minimumskrav konkretisere hvor meget CO2-udslip opgaven må indebære, eller sætte krav til EPDer på bygningsmaterialer. Det skal dog siges at EPDer i sig selv ikke er udtryk for hvorvidt et materiale er bæredygtigt eller ej, så specifikke krav til de individuelle miljøpåvirkningskategorier i EPDerne bør tages i brug. For at inddrage entreprenørernes viden og erfaringer i projektet og til hvordan den specifikke opgave kan løses, bør det overvejes om et udbud kan udbydes med totalentreprise med minimumskrav til bæredygtigheds data. Som et alternativ til minimumskrav bør bygherrer overveje om der kan skabes incitament for entreprenører til at inddrage bæredygtighed i løsningsforslag. Disse incitamenter kan involvere økonomiske fordele pr. bæredygtigheds dataenhed. Dette vil bidrage til at entreprenører i højere grad indtænker bæredygtighed i deres løsninger, og til den generelle bæredygtige omstilling hos entreprenører. For at repræsentere en, på nuværende tidspunkt, ikke eksisterende CO2-afgift i udbuddet, kan skyggepriser udarbejdes som fiktive CO2-afgifter. Dvs. at der tillægges en fiktiv merpris på de indkomne tilbud. Dette tiltag vil bidrage til at projekter vægtes prismæssigt i relation til deres konkrete klimabelastning. En Design for Drift/recycle/osv, tilgang vil kunne give muligheder til at opnå et større bæredygtighedspotentiale, her vil man specifikt vælge at et projekt skal være specifikt designet med henblik på nemme drift, genanvendelse m.v., hvis miljøbelastningen f.eks. findes inden for et af disse områder.

Mål

At hjælpe udbudsgivere med at planlægge udbud der;

1. Stimulerer leverandører til at indtænke bæredygtighed i byggeprojekter, og derfor opfordrer til en innovativ bæredygtigheds konkurrence
2. Bidrager til et klart og utvetydigt sprog imellem entreprenører og bygherrer som tydeliggør hvordan og hvor meget entreprenører vægtes på bæredygtighed i et udbud

Strukturering af det Bæredygtige Udbud

	Potentiel reduktion af CO_2e	Potentiel reduktion af partikelforurening	Merpris	Risiko
Krav om bæredygtige krav/kriterier i udbudsmaterialet	1-2% af total emissioner ~10.000 ton CO_2e	50% af totale lokale partikelemissioner	-300.000 kr – 500.000 kr	Lille risiko

Data i dette skema er ikke faktuelt, men blot til illustration

Miljø- og Klimapotentiale

Dette tiltag har svært ved at kvalificere en direkte miljøgevinst siden der ikke er et konkret forslag. Hvis bygherren ikke allerede overvejer bæredygtighed i anlæg er dette et godt sted at starte, siden bæredygtighedspotentialet er enormt. Anlægsbranchen bruger meget de samme få materialer og derfor er genbrug et oplagt sted at starte, Banedanmark genbruger 99% af de materialer i deres projekter, der kan bruges til nedknusning til ny beton eller endnu bedre direkte genbrug i andet projekt.

Forudsætninger/tekniske forhold:

Tydelig kravsætning

Det anbefales at minimumskrav til entreprenører er tydeligt beskrevet og specificeret. Det indebærer at udbudsgiver ikke blot er konkret ift. hvilke krav der sættes, men overvejer hvad der er essentielt for entreprenørernes tilbud, for at de kan sammenlignes. Sættes der eksempelvis minimumskrav til et CO2-niveau, bør udbudsgiver være specifik omkring hvordan CO2 skal beregnes, og hvad der skal inkluderes i beregningen, således at beregninger er ensrettede og sammenlignelige.

Vægtning

Det bør overvejes i forhold til det enkelte udbud om de bæredygtige elementer vægtes høj nok til at stimulere en bæredygtighedskonkurrence for entreprenører. Sættes vægtningen for lav på disse parametre vil bæredygtighed nedprioriteres.

Risiko

Hvis kriterier til bæredygtighed er fundet gennem markedsdialog og via forståelse for hvad entreprenører kan vil, den største risiko være en prisstigning. Hvis der sættes krav, som ingen entreprenører kan leve op til, dette kunne ske pga mangle forståelse for projekt og de bæredygtige tiltag eller dårlig markedsdialog, risikerer man at skulle lave udbuddet gå om, fordi ingen byder på det. Dette kan være tidskrævende.

Økonomi/Tidskrav

I nogle tilfælde kan der findes bæredygtige løsninger hvilket sparer bygherrer for penge, desværre er de ikke altid lige nemme at finde eller ikke eksisterende for det pågældende projekt. Derfor skal bygherre forberede sig på en prisstigning i forbindelse med større fokus på bæredygtighed i udbuddet.

Væsentlige kilder/erfaring

Københavns Kommune har arbejdet med bæredygtighed i udbud i længere tid. Deres erfaring rækker over mange områder, men erfaringen kan være lokalt og muligvis ikke have den samme effekt andre geografiske steder. Kontakt: https://www.kk.dk/om-kommunen/forvaltninger/teknik-og-miljoeforvaltningen

Indledende fase

Tilbudsgivers Egne Forslag

Om

Det kan være svært altid at danne sig et overblik over de muligheder der er for at opnå et grønnere projekt. Derfor kan det være oplagt at høre sine tilbudsgiver, hvorvidt der er mulighed for entreprenørerne at komme med forslag i form af en liste af mulige miljøforbedringer, som de kunne implementere i udbudsmaterialet og deres pris. Dette kunne være brug af HVO-drivmidler, genbrug af eksisterende materialer eller anden jordbalance. At bruge tilbudsgivere som ressource hjælper med at give forskellige bud på mulige tiltag der til det ene projekt. Samt senere at kunne anvendes i fremtidige anlægsprojekter for bygherren, som inspiration. .

Miljø- og Klimapotentiale

Afhænger af entreprenørs tiltag. Der kan efterfølgende laves en analyse af miljøtiltagende og deres pris, hvorefter beslutninger kan kvalificeres og tages.

Mål

At få entreprenørernes bæredygtige tiltag til anlægsprojektet, samt samlet pris for disse, for at danne et overskueligt beslutningsgrundlag.

Forudsætning/tekniske forhold

Disse er forskellige fra projekt til projekt, og ved at bruge tilbudsgivers erfaring og viden, kræver det mindre teknisk viden for udbudsgiveren. Det kan hjælpe aktører der ikke sidder inde med ekspertviden, at forbedre de bæredygtige aspekter i projektet.

Risiko

Lav risiko; projektet kan gennemføres som først planlagt, uden at tilkøbe ekstra løsninger. Der kan opstå ændringer i byggeplanen hvis der vælges at implementere nogle af der forskellige tiltag.

Økonomi/Tidskrav

Det kræver mulighed for at forstørre projektets originale budget hvis forslagene skal implementeres. Det kræver ressourcer for tilbudsgiver at sammensætte forslag, samt kræver mere tid til at behandle de forskellige tilbud.

Tilbudsgivers Egne Forslag

	Potentiel reduktion af CO_2e	Potentiel reduktion af partikelforurening	Merpris	Risiko
Krav om tilbudsgivers egne forslag	Varierer fra forslag til forslag	50% af totale lokale partikelemissioner	-300.000 kr – 500.000 kr	Lille risiko

Data i dette skema er ikke faktuelt, men blot til illustration

Væsentlige kilder/erfaring

Dette er benyttet til mange former for udbud også for andre produkter, hvor man spørger om tilkøb lister. Erfaring med dette behøver ikke stamme fra anlægsbranchen.

Projekteringsfasen

Certificering i Anlægsbranchen

Om

Byggebranchen er delvist mere veludviklet end anlægsbranchen hvad angår den bæredygtige omstilling. Dette gør sig eksempelvis gældende i forhold til at definere konkrete værktøjer såsom DGNB-certificeringer og Nordic Ecolabel, der kan stilles som krav til i udbuddet. Disse værktøjer bidrager til at konkretisere og inkludere bæredygtige tiltag I bygninger, og består af specifikke kriterier og underkriterier der kan inddrages i projekt byggeriet. På trods af at disse værktøjer er udviklet specifikt til byggebranchen, har flere af kriterierne og underkriterierne potentiale til at kunne inddrages i anlægsbyggeri. For at hjælpe anlægsbranchen med at forstå hvordan bæredygtighed kan inddrages i anlægsprojekter kan DGNB-certificering dermed fungere som inspirationskilde hertil og bidrage med konkrete metoder og krav der kan stilles i udbud.

Miljø- og Klimapotentiale

Det konkrete bæredygtighedspotentiale afhænger af hvilke kriterier og underkriterier fra DGNB-certificering der inddrages, og er derfor variabelt afhængigt af omfang og det individuelle projekts natur.

Mål

At genbruge erfaring fra byggebranchen til at opnå mere bæredygtige anlægsprojekter.

Forudsætning/tekniske forhold

Idet certificeringsordningen ikke er lavet til anlægsprojekter, er en del af underpunkterne, irrelevante for anlægsbyggeri. Det involverer blandt andet; krav om isolation, lysindfald og indeklima. De kriterier der kan have relevans for anlægsbyggeri involverer; byggepladsforhold, certificering af træ, støj forhold for byggepladsen og belysning

Risiko

Der er mulighed for at de krav der sættes ikke gør projekt mere bæredygtigt, f.eks, krav om at få EPDer siden de kun fortæller om produktionsforhold, men giver point i DGNB for at samle. Det kan give mere ressourcekrævende udbud og projekter.

Økonomi/Tidskrav

I tilfælde af at rette vedkommende har erfaring med DGNB-kriterierne kan der være ressourcebesparelser at opnå i forhold til at inkludere bæredygtige tiltag i anlægsprojekter. DGNB-certificerings kriterier ikke tager udgangspunkt i hvordan anlægsprojekt kan drage nytte af dem, kræver det gennemtænkning og udvikling af metoder til at anvende dem. Derfor anbefales det at der inddrages ekstern rådgivning, eller internt personale uddannes til formålet. Der kan dermed kræves ekstra ressourcer/tid i forbindelse med rekruttering eller uddannelse. Idet DGNB-certificering ikke kan bruges i anlægsbyggeri, skal det bemærkes at byggeriet ikke kan repræsenteres med certifikationen, men kun bruges som inspirationskilde

Certificering i Anlægsbranchen

	Potentiel reduktion af CO_2e	Potentiel reduktion af partikelforurening	Merpris	Risiko
Krav om certificering i anlægsbranchen	1-2% af total emissioner ~10.000 ton CO_2e	50% af totale lokale partikelemissioner	-300.000 kr – 500.000 kr	Lille risiko

Data i dette skema er ikke faktuelt, men blot til illustration

Eksempel med udbudstekst

Følgende eksempel er fra Green Building Council, Det Bæredygtige Udbud, side 18. Her ses hvordan DGNB-kriterier påvirker et byggeri, dog kan det nedenstående eksempel også anvendes I anlægsbranchen.

DGNB krav til stillads:
Det skal kunne dokumenteres at såfremt der benyttes træ/træprodukter, i forbindelse med stilladsarbejdet, skal dette kunne dokumenteres værende FSC-certificeret eller værende genbrugstræ.
Dokumentation for dette skal foreligge byggeledelsen digitalt inden udførelse af stilladsarbejder. Eksempelvis:

- Platforme, fodlister, knælister
- Overgange mellem stilladser og bygning
- Afdækning af åbninger i etagedæk
- Osv.

Kilde: Green Building Council

Et andet eksempel er fra Region Syddanmark, hvor man har krav til alle bygninger over en beløbsgrænse skal DGNB-certificeres. Hvis ikke det er muligt skal der drages inspiration fra andre sager (som DGNB-krav), til projektet. Dette tvinger nye udbud til at inkluderer bæredygtighed uanset type.

Nybyggerier og ombygninger over 2,5 mio. kr., hvor det er teknisk muligt, jf. kriterierne i DGNB, skal som minimum bæredygtighedscertificeres til DGNB guld. Ved certificeringen sikres en standardisering på et højt kvalitativt niveau, der medfører en grønnere bygningsprofil med en reduceret klima- og miljøbelastning og gør det komparativt med de øvrige regioners arbejde på området. Ved nybyggerier og ombygninger, der ikke bæredygtighedscertificeres, sikres stadig en højt niveau af bæredygtighed gennem de generelle klima- og bæredygtighedsvurderinger der udføres på alle sager.

Kilde: Region Syddanmark

Væsentlige kilder/erfaringer:

Det Grønne Udbud - Green Building Council

Regler for Byggeri i Region Syddanmark - Region Syddanmark

Bæredygtigt Byggeri - Region Syddanmark

Nordic Ecolabel

Udførelsesfasen

Eldrevne Maskiner til Specifikke Formål

Om

Dette initiativ fokuserer på anvendelsen af eldrevne maskiner til specifikke formål. I dag har de flere entreprenører mulighed for at stille med eldrevet maskinpakker for de mindre maskiner. Hvis denne udvikling fortsætter kan det også I fremtiden inkludere større maskiner samt skabe incitament for investering I fossilfri maskiner. Gevinsten ved at skifte til eldrevne maskiner, ses ikke kun via CO2 men også ved mindre lokal forurening samt støj på byggepladsen. Her ville initiativet kræve at maskiner til en specifik opgave skal være eldrevne, dette kunne f.eks. være maskineri til afvanding eller udgravning. Man kan skrive i udbudsmaterialet, at der er mulighed som entreprenør at søge dispensation, hvis opgaven ikke kan udføres med eldrevne maskiner.

Miljø- og klimapotentiale

1 til 2 % af den totale emission for et anlægsprojekt kommer fra byggepladsen, dette tiltag kan ikke reduceres det helt. Eldrevne maskiner udstøder ingen lokal skadelige stoffer samt larm fra byggeplads reduceres.

Mål

At alle maskiner på byggepladsen er drevet af bæredygtige drivmidler gennem efterfølgende krav, vil marked få incitament til at udvikle og anskaffe flere og større maskiner i el eller andre grønne alternativer.

Forudsætning/tekniske forhold

Hvis der ikke er mulighed for opladning ved byggeplads, eller andet lokalt, kan det give dagligt transport af maskiner mellem byggeplads og opladning, og dermed neutraliseres den miljømæssige gevinst. Dermed kræver det en forståelse for de lokale tilslutningsmuligheder.

Risiko

Hvis ikke udbudsmaterialet beskrives ordentligt kan entreprenører nemt komme uden om dette. F.eks. hvis der sættes krav til at alle maskiner under 2,5 ton skal være elektriske, kan entreprenøren anvende en 5 tons maskine til samme arbejde og derved stadig leve op til kravet i udbudsmaterialet.

Økonomi/Tidskrav

Det kræver ressourcer første gang kravene skal sættes, men efterfølgende kan det sætte standarden for kommende ydelser. Prisen for eldrevne maskiner er højere. Det kræver undersøgelse af tilslutningsmuligheder. Undersøg muligheden for hvad entreprenører kan levere i markedsdialogen.

Eldrevne Maskiner til Specifikke Formål

	Potentiel reduktion af CO_2e	Potentiel reduktion af partikelforurening	Merpris	Risiko
Krav om eldrevne maskiner til specifikke formål skal være elektrificerede	1-2% af total emissioner ~10.000 ton CO_2e	50% af totale lokale partikelemissioner	-300.000 kr – 500.000 kr	Lille risiko

Data i dette skema er ikke faktuelt, men blot til illustration

Væsentlige kilder/erfaring

Mange producenter såsom Volvo udvikler elektroniske maskiner og mange danske entreprenører og rådgivere kører forskellige forsøg. Kontakt dine mest brugte entreprenører og hør om muligheden.Læs mere om udviklingen af eldrevne maskinpakke hos Volvo: https://www.volvoce.com/danmark/da-dk/entreprenoermaskiner-as/about-us/revy/volvo-revy-nr-3-2019/volvo-eldrevne-kompakt-maskiner/

Udførelsesfasen

Delt Materialelager

Om

En fjerdedel af den samlede affaldsmængde i Danmark består af bygge- og anlægsaffald såsom beton, tegl, asfalt, træ og jord. For en stor del af dette affald er der stadig en restværdi der kan udnyttes, forudsat at byggematerialets tilstand testes. Her skal man være særlig opmærksom på stoffer som PCB, PVC, asbest, afhængig af hvilket byggemateriale der er tale om. Forudsat at byggematerialer testes grundigt kan de genanvendes på tværs af forskellige byggeprojekter, hos forskellige bygherrer. Da det varierer meget hvilke materialer der er i overskud hos bygherrer samt. hvilke materialer der er relevant for et konkret byggeprojekt, skabes der størst effektivitet og udnyttelse af materialer ved at bygherrer etablerer delte materiale lagere hvor overskuds materialer placeres. Forskellige bygherrer vil her kunne tilgå et sortiment af genbrugsmaterialer og vurdere hvilke der kan bruges det konkrete projekt. Ønskes der ikke et samarbejde mellem flere bygherrer kan et materialelager også faciliteres mellem bygherre og kommunens lokalbefolkning, hvor materialer kan frit afhentes. Da man typisk benytter et mindre udvalg af forskellige materialer i anlægsbyggeri, sammenlignet med byggebranchen, vil et materialelager være mere fordelagtigt på administrationsområdet, sammenlignet med et materialelager i byggebranchen.

Mål

At reducere mængden af byggeaffald ved at udnytte materialers restværdi, og hjælpe bygherrer med at reducere omkostninger relateret til indkøb af materialer.

Miljø- og Klimapotentiale

Den konkrete CO2 besparelse afhænger af forskellige faktorer såsom mængden af materialer på lageret (lagerstørrelse), hvilke konkrete materialer der genanvendes på lageret, og hvilket materiale det substituerer. Nedenstående tabel giver en oversigt over potentialet for CO2 besparelse ved genanvendelse af forskellige byggematerialer.

Forudsætninger/tekniske forhold

Geografiske forhold

Det anbefales at de bygherrer som tilslutter sig et materiale lager, geografisk ligger indenfor en overskuelig afstand for at undgå at materialer fragtes over lange afstande. Fragt af materialer bidrager til øget CO2 udledning, og involverer som regel en merpris i fragtgebyr. Med henblik på placeringen af materialelageret, anbefales det at de involverede bygherrer i fællesskab lokaliserer uudnyttede bygninger med en beliggenhed der er fordelagtig for alle parter.

Delt Materialelager

	Potentiel reduktion af CO_2e	Potentiel reduktion af partikelforurening	Merpris	Risiko
Opførelse af et delt materialelager:	1-2% af total emissioner ~10.000 ton CO_2e	50% af totale lokale partikelemissioner	-300.000 kr – 500.000 kr	Lille risiko

Data i dette skema er ikke faktuelt, men blot til illustration

Screening af materialer

Forinden at materialer stilles på materialelageret bør tilstanden af materialet testes. Hvilke kvalitetssikringer der bør testes for afhænger af det konkrete materiale. Ønsker den enkelte bygherre ikke at være ansvarlig for materialets tilstand kan en ekstern virksomhed hyres til denne opgave.

Risiko

Projektet kræver en lokation hvor det er muligt at opbevarer materialerne, samt invistering i ressourcer til at starte og vedligeholde. Det kan være en risiko hvis projektet ikke lykkes, det kunne være fordi det ikke bliver udnyttet i fremtidige udbuds materialer.

Økonomi/Tidskrav

Der skal sættes penge af til lokation og bemanding. Materialerlagere kræver en længere tidshorisont, da materialer kan risikere at ligge i en lang periode før der findes behov for dem.

Væsentlige kilder/erfaring

I Hjørring Kommune har de erfaring med at bruge en ekstern virksomhed til at håndtere kvalitetssikringen af materialer. For yderligere information omkring dette, kontaktes

Jesper Heuck, E-mail; j.heuck@hjoerring.dk , Tlf: +4541937419

I Roskilde Kommune har de erfaring med at etablere en delt materialelager mellem kommunen og en privat bolig organisation. For yderligere information omkring de tekniske forhold kontaktes Sabina Holstein.

Sabina Holstein, E-mail: Sabinah@roskilde.dk, Tlf; +45 40 35 40 24

Københavns kommunes teknik og miljø forvaltning har også længere erfaring med genbrugsmaterialer i kommunen.

Genbrugsmursten	49,3	kg CO_2-ækv./m³ murværk	77 %
Genbrugte murstenselementer	38,9	kg CO_2-ækv./m³ murværk	61 %
Genbrugstagsten	14,2	kg CO_2-ækv./m² tagsten	98 %
Beton med 20 % genanvendt tilslag	0,91	kg CO_2-ækv./m³ beton	0,3 %
Genbrugte betonelementer/søjler/bjælker	295	kg CO_2-ækv./m³ beton	96 %
Genbrugte stålprofiler	2.240	kg CO_2-ækv./t stål	78 %
Facadebeklædning af genbrugte ventilationsrør	12,2	kg CO_2-ækv./m² stålfacade	56 %
Genbrugte aluminiumsplader	5.030	kg CO_2-ækv./t aluminiumsplader	81 %
Genbrugte bærende træbjælker og -stolper	28,2	kg CO_2-ækv./m³ massivt træ	77 %
Genbrugte gulvbrædder	0,62	kg CO_2-ækv./m² trægulv	78 %
Spånplade med 70 % genanvendt træ	15,2	kg CO_2-ækv./m³ spånplade	9.4 %
Gipsplader med 25 % genanvendt gips	0,11	kg CO_2-ækv./m² gips	10 %
Genbrugte indvendige døre	40,2	kg CO_2-ækv./m² dør	80 %
Kassevinduer af genbrugte termoruder	41,8	kg CO_2-ækv./m² vindue	95 %
Tagpap med 10 % genanvendt tagpap	5,07	kg CO_2-ækv./m² tagpap	69 %

Kilde: Videnscenter for Cirkulær Økonomi i Byggeriet

Genanvendelse / bortskafningsfasen
End-of-Life Stage

Om
I designfasen af et konkret byggeprojekt bør det indtænkes hvordan byggeriet kan indgå i en ny livscyklus og/eller hvordan restværdien af genbrugsmaterialer kan anvendes i nuværende eller fremtidige projekter. Det kan praktiseres på forskellig vis, og derfor bør det overvejes hvordan det enkelte projekt har et potentiale til genanvendelse. Ligeledes bør der indgå overvejelser omkring hvilke genbrugsmaterialer fra tidligere byggeri der kan anvendes. Følgende vil eksemplificere hvordan tidligere bygge- og anlægsprojekter har indtænkt genanvendelse i projektbyggeri:

I mange tilfælde kan jordstabilisering have økonomiske og miljømæssige fordele, fremfor at udskifte jorden. Miljømæssige fordele ved jordstabilisering indebærer reducerede transportomkostninger, reduceringer af emissioner (CO2e + partikler) fra køretøjer og forlængede naturressourcer. Det bør overvejes om komponenterne der indgår i byggeriet kan designes til at kunne adskilles, det giver større mulighed for at komponenter kan udskiftes og funktionelle komponenter kan genbruges ved byggeriets end-of-life stadie. Dette involverer også en overvejelse af hvilke materialer der anvendes idet komponenter i højere grad ville kunne skilles ad ved brug af nogle materialer frem for andre.

Mål
At inspirerer til hvordan der kan indtænkes bæredygtige løsninger i design- og planlægningsfasen.

Kan der indtænkes ny brug af materialer til byggeriet som har en mindre klimabelastning – det kunne eksempelvis involvere grøn beton, træ mm.
Kan designet af byggeriet gøres multifunktionelt således at anvendelsespotentialet for byggeriet forlænges. Affaldshierarkiet (se modstående side) bør indtænkes som en grundlæggende tankegang for at få den bedst mulige håndtering af materialer ved EOL. Mulighederne for lokal og direkte genbrug af materialer bør overvejes, da dette vil bidrage til en reducering af CO2 i form af kortere transport distancer, samt mindre grad af forarbejdning af materialet.

Miljø- og Klimapotentiale
hvis der diskuteres og arranges for end of life stages tidligt i processen, stiger den mulige miljøgevinst. For at opnå den største miljøgevinst kan man udnytte affaldshierarkiet for at se hvilket trin man kan indarbejde for sit specifikke projekt. I anlægsbranchen ser man ofte de samme materialer gå igen, derfor er der god potentiale for at kunne opnå en form for end of life use.

End-of-Life Stage

	Potentiel reduktion af CO_2e	Potentiel reduktion af partikelforurening	Merpris	Risiko
Krav om End-of-Life tiltag i udbudsmaterialet	1-2% af total emissioner ~10.000 ton CO_2e	50% af totale lokale partikelemissioner	-300.000 kr – 500.000 kr	Lille risiko

Data i dette skema er ikke faktuelt, men blot til illustration

Forudsætninger/tekniske forhold

Inddrag entreprenører og bæredygtighedsrådgivere i design fasen

Til at forstå potentialet for at anvende genbrugsmaterialer til det konkrete byggeprojekt bør entreprenører inddrages i designfasen af projektet. Her kan entreprenørernes viden bruges til at lave et design hvor byggematerialer med korrekte dimensioner der skaber et genanvendelsespotentiale anvendes, samt inddragelse af genbrugsmaterialer og alternative materialer. Bæredygtighedsrådgivere kan med nytte også involveres i designfasen for at sikre at byggeriet er fundamentalt bæredygtigt. Bæredygtighedsrådgivere kan give indsigt i hvor det største potentiale for bæredygtighed ligger i det konkrete projekt.

Hyppige statusmøder under hele processen

Det anbefales endvidere at alle aktører (entreprenører, bæredygtighedsrådgivere, bygherrer mm.) afholder hyppige statusmøder fra projektets start, til projektet er afviklet. Det vil fremme den bæredygtige udvikling idet nye bæredygtighedsmuligheder vil vise sig under byggeriet, som skal drøftes mellem aktørerne.

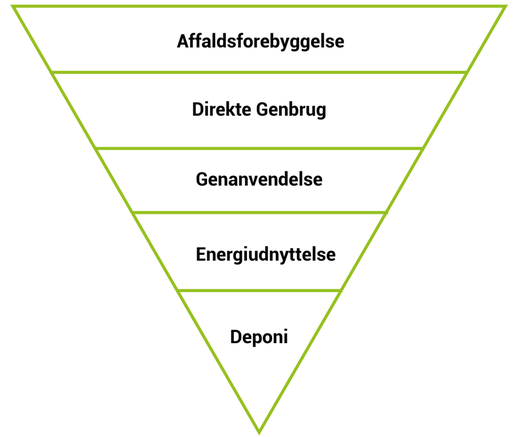
Risiko
Tiderne skifter og materialer der kan bruges i dag, kan måske ikke bruges i morgen. Det kan også være en risiko for at det gør projektet dyrere og mere tidskrævende, samt en yderligere sikkerhedsfaktor alt efter den ønskede funktion af genbrugsmaterialet.

Økonomi/Tidskrav
Ofte vil genanvendelse være en mere tidskrævende process end deponering eller afbrædning. Der skal derfor sættes ekstra ressourcer af til projekter. Der vil i nogle tilfælde være mulighed for at indhente besparelser ved at genbruge materialer, f.eks. genbrug af betonfliser.

Væsentlige kilder/erfaring
For yderligere information omkring multifunktionelt byggeri kan Søren Stoustrup kontaktes; Tlf.: 22 82 57 85, E-mail: ss@mangor-nagel.dk

For yderligere information omkring Musicon kan Andreas Høegh kontaktes; Tlf.: 46 31 68 68, E-mail: andreasbh@roskilde.dk

For ydeligere information omkring genbrug af materialer i anlæg kan Teknik- og Miljøforvaltningen i Københavns Kommune kontaktes.



Affaldshierakiet
Det største potentiale for bæredygtighed findes i modellens top, hvorefter potentialet aftager jo længere man bevæger sig ned.