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REDUCING EMISSIONS VIA SUPPLY CHAIN MANAGEMENT IN BUILDING CONSTRUCTION

Master's Thesis
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ABSTRACT

Elias Tuominen: Reducing Emissions via Supply Chain Management in Building Construction
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Climate change is on the agenda of most companies as they are preparing for the future. Tools such as Science Based Targets initiative are requiring companies to address not just their own emissions, but their value chain emissions as well. Within construction industry, these value chain emissions are a major challenge, as the actors have over time developed to function rather independently from any other participant along the chain. Reducing emissions tends to require a more systematic perspective, where actors have a mutual interest to solve these challenges. Shifting away from the traditional adversarial approaches to working together is a well-known and extensively researched issue but has not been widely researched from the emissions reduction perspective.

The study was conducted by focusing on a single large Finnish construction company and divided into three units of analysis. Tendering, procurement, and design management are the units that worked as the cases of the study. Life cycle projects were used as a context to make the data collection and sampling more manageable. A total of 9 qualitative thematic interviews were conducted, with a focus on internal processes, suppliers, and customers. Data was analysed thematically using an abductive approach. Theories used in the analysis related to supplier engagement, business ecosystems, and project-based supply chain management.

Results of the study suggest that a more centralized approach to procurement on the most strategic components in relation to emissions is required. As project-based construction companies make commitments to reduce their emissions, it can only happen with enough control over the key decisions. There are good reasons for remaining decentralized on many aspects of construction, as each project is unique, and many things cannot be standardized. However, on emission critical frame materials, strong support for the requirement of decentralization was not found. To gain the advantages of centralization on frame materials, quite large changes in the internal processes of the project-based businesses might be needed. But without them, ambitious climate goals will be very hard to reach.

Keywords: Supply chain management, emissions, construction, business ecosystem, project-based business

TIIVISTELMÄ

Elias Tuominen: Päästöjen vähentäminen toimitusketjun hallinnalla talonrakentamisessa
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Yritykset joutuvat kasvavassa määrin tulevaisuuteen valmistautuessaan miettimään ilmastonmuutosta. Science Based Targets -aloitteen kaltaisten työkalujen yleistyessä yritysten on kyettävä tiedostamaan omien päästöjensä lisäksi myös oman arvoketjunsa päästöt. Rakentamisessa tällainen vaatimus on vaikea, koska ajan saatossa alalla on totuttu toimimaan varsin itsenäisesti ilman riippuvuuksia ketjun muista toimijoista. Päästöjen vähentäminen tullee vaatimaan kokonaisvaltaisempaa lähestymistapaa, jossa ongelmia ratkotaan yhteisvoimin. Vastakkainasettelusta yhteistyöhön siirtyminen on laajalti tunnettu ja tutkittu kysymys alalla, mutta päästöjen näkökulmasta aihetta ei olla laajasti tutkittu.

Tutkimus suoritettiin keskittyen yhteen suureen suomalaiseen rakennusyhtiöön, jonka sisällä tutkittiin kolmea erillistä yksikköä. Nämä yksiköt olivat tarjoustoiminta, hankinta ja suunnittelun johtaminen, jotka yhdessä muodostivat kolmen tapauksen tapaustutkimuksen. Elinkaarihankkeita käytettiin työssä kontekstina, mikä helpotti tiedonkeruuta ja otannan muodostamista. Yhteensä suoritettiin yhdeksän laadullista teemahaastattelua, joissa keskityttiin sekä sisäisiin toimintatapoihin, toimittajiin, että asiakkaisiin. Datan analysointi suoritettiin teemoittain abduktiivisesti. Teorioina analyysin taustalla toimivat toimittajien osallistamiseen, liiketoimintaekosysteemeihin, sekä projektiliiketoiminnan toimitusketjun hallintaan liittyvät kokonaisuudet.

Työn tuloksena ehdotetaan päästöjen kannalta tärkeimpien rakennuskomponenttien hankinnan keskittämisen olevan tarpeen. Kun projektiliiketoimintaa tekevä rakennusyritys sitoutuu vähentämään päästöjään, sen on ensin kyettävä riittävällä tasolla kontrolloimaan päästöihin liittyviä kriittisimpiä päätöksiä. Hajautetusta päätöksenteosta rakennusprojekteilla on tunnistettavissa paljon hyötyjä rakennuskohteiden ainutlaatuisuuden ja vakioinnin vaikeuden vuoksi. Tästä huolimatta tulokset viittaavat siihen, että päästöjen kannalta kaikkein keskeisimpiin runkomateriaaleihin liittyvässä päätöksenteossa projekteille hajautettu päätöksenteko ei ole optimaalista. Runkoratkaisujen keskitetyn hankinnan etujen saavuttaminen tulisi kuitenkin vaatimaan varsin isoja muutoksia sisäisiin prosesseihin projektiyrityksissä. Ilman niitä kunnianhimoiset päästötavoitteet tulevat kuitenkin olemaan hyvin vaikeita saavuttaa.

Avainsanat: Toimitusketjun hallinta, päästöt, rakentaminen, liiketoimintaekosysteemi, projektiliiketoiminta

PREFACE

They say the more you learn, the more you realize how little you truly know. That is something I think I have come to realize over the past five years. Finishing this thesis marks an end of an era in my studying years, but honestly, I know it is only the beginning.

A big thank you for the focal company for the opportunity to do this thesis and to get to make a deep dive on a matter that I am truly interested in. Although at some point this topic seemed like a too big of a challenge, now I can happily say it was worth the struggle. A special thank you for the steering group for ideas and support. I also want to thank my examiners Leena and Aki for the comments and improvements you provided throughout the process.

I also would not be graduating without all the support from you Pinja, my family, and all the other great people I have had a change to get to know along the way. Luckily, I got to make a thesis about “decarb” so all of you did not have to listen to me talk about it as much.

Helsinki, 20th September 2022

Elias Tuominen

CONTENTS

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LIST OF ABBREVIATIONS

BFS	Blast furnace slag
BIM	Building information modelling
BP	Business Premises -segment
CAPEX	Capital expenditure
CHP	Combined heat and power
CLT	Cross laminated timber
D&B	Design and build
ESG	Environmental, social, governance
GHG	Greenhouse gas
GSCM	Green supply chain management
GSHP	Ground source heat pump
KPI	Key performance indicator
LCP	Life cycle project
LESCM	Low emission supply chain management
OPEX	Operational expenditure
RBV	Resource based view
SBTi	Science Based Targets initiative
SCM	Supply chain management
VRIN	Valuable, rare, inimitable, non-substitutable

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1. INTRODUCTION

1.1 Motivation and scope

Climate change is an issue on the agenda of almost every major company today. It is especially true for companies operating in the most emission heavy sectors, one of them being the construction industry. According to UN and IEA estimation (2018), building construction and operation is responsible for almost 40 % of all global greenhouse gas (GHG) emissions. As Finland has set an ambitious goal of reaching carbon neutrality by 2035 (Ympäristöministeriö, 2019), stakeholders around built environment will need to come up with rapid and impactful solutions for driving us towards those emission targets.

There are two main sources of emissions that make building construction and operations so crucial for the net-zero targets. These are so called embedded emissions, meaning emissions that originate from the manufacturing processes of turning natural raw materials into usable construction components, and use phase emissions (Röck et al., 2020). Use phase emissions from the built environment in Finland are mainly district heating, electricity, and fuel oils used in the buildings throughout their life cycle (Rakennusteollisuus, 2020). However, as electricity grids can be expected to decarbonize and building energy efficiency to keep improving, the role of the emissions embedded into the building materials will rise in significance (Röck et al., 2020).

As a growing portion of emissions are stemming from the building material suppliers, supply chain management (Mentzer et al., 2001) becomes an even more important issue than before. Environmental considerations have been widely combined to supply chains in earlier research (Sarkis et al., 2011; Tseng et al., 2019), but limiting the focus into emission reductions is less common (Plambeck, 2012). Additionally, more research is needed to combine these supply chain decarbonization efforts into business success factors as is suggested by Laari et al. (2017).

When looking at the investments, especially venture investments from the last decade or so, material manufacturing and building energy use have not been getting the attention they would deserve. According to a PwC analysis (2021) of the global climate technology environment, seen in figure 1, categories “Industry and Manufacturing and Resource Management” and “Built Environment” represent half of all the emissions globally. Despite this, these critical sectors get venture investments worth only 13 % of all climate

tech funding. This thesis explores why this is the case, and how could this issue be addressed from a perspective of a major Finnish construction company.

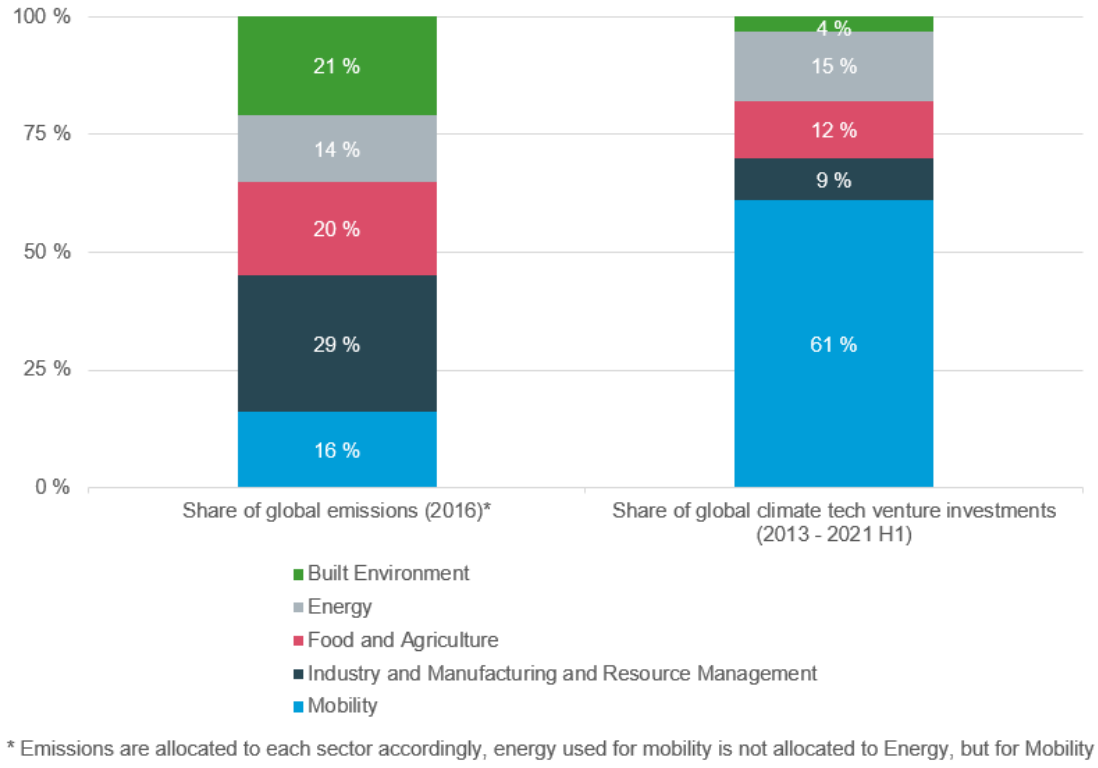

Figure 1. *Sources of global emissions and relative venture investment on each sector (adapted from PwC, 2021, p. 42)*

Category “Industry and Manufacturing and Resource Management” in the figure 1 includes the main emissions in the scope of this thesis, as well as plenty of emissions not in the focus. Three most important sources of heavy industry emissions are steel, cement, and chemicals manufacturing processes (Material Economics, 2019; Ritchie, 2020; World Economic Forum & BCG, 2021), of which in the construction industry cement, and its end product concrete, is the biggest single concern. This thesis tries to add understanding on why investments into heavy industry decarbonization, especially from the point of view of concrete, have not materialized in large scale, and if they could be a source of future competitiveness for the focal company.

Category “Built Environment” in figure 1 refers to the building use phase energy related emissions. These are not the core focus of this thesis but will be addressed whenever relevant. In Finland, the situation is already better than in most countries in Europe and globally, as we commonly keep our buildings warm with CHP-based district heating rather than less efficient methods, e.g. gas boilers (Rakennusteollisuus, 2020). The main tool to tackle use phase emissions, in addition to energy efficiency improvements, has

been recognized to be heat pumps (New Buildings Institute, 2022), but as mentioned, they will not be the main research target in this thesis.

1.2 Objectives and research questions

Aim of this study is to evaluate, how key internal functions of the focal company approach working together and collaborating with external actors, and how these processes could be improved from the perspective of decarbonization. The external actors here are limited to public sector as a buyer and material manufacturers as key suppliers, based on the scope of the empirical research in life cycle projects. This thesis also tries to add understanding of what achieving major emission reductions in residential and non-residential construction would mean, how achieving them might require changes to the traditional approach of one-off projects, and if the changes in the supply chain could be combined with better overall competitiveness.

For internal functions, procurement is naturally one of the most important ones but tendering phase, and especially design management, are similarly in an important role when it comes to reducing emissions. Supply chain management practices need to be flexible, while still supporting collaboration and long-term planning. Design phase of each project has a major role in defining the lifetime emissions of the end-product (Bragança et al., 2014), so a lot of pressure is there as well. Overall, tendering phase is where the communication with the customer happens, and customers are the final decision makers in the context of life cycle projects.

It has been identified that there are multiple reasons behind the challenges construction faces in reducing its environmental footprint. Many of these things are stemming from the project-based nature of the business, and the industry is known for its fragmented nature and being heavily based on one-off projects, as will be discussed later in the following chapters. This thesis tries to evaluate, can these characteristics somehow be combined to the ideas about modern supply chain management, as well as collaborative emission reduction practices.

As an overarching approach to both supply chain management and emission reductions, *business ecosystem* perspective is examined in this thesis. Ecosystems are defined around the idea that all participants of the network are working together for a common value proposition, and these ecosystems are competing against other ecosystems. As an additional perspective, term *low emission supply chain management* (LESCM) is de-

fined. LESCM is derived from the green and circular supply chain management literatures with a restricted focus on emission reduction. Together these two form a theoretical foundation on which the empirical research is then built on.

By analyzing relationships with a strategic ecosystem and LESCM approaches, the goal is to better understand the positive potential emission reductions can have for the focal company, and the key challenges stopping it from getting there. The common direction is already clear for everyone, emissions must start declining, so it might be possible for the focal company to gain some advantages by trying to benefit from being an early mover in this area. So, to conclude, the research questions for this thesis are formed as follows

RQ1: What are the key opportunities on a building construction project for improved supplier engagement to reach meaningful emission reductions?

RQ2: What are the main bottlenecks currently for tendering phase emission reduction commitments?

RQ3: How should the focal company change internally to be able to gain early mover advantages in the low emission construction ecosystem?

The literature review in the next chapter will already look at each of these questions. However, the case study focusing on *life cycle projects* (LCPs) and reductions in *scope 3 emissions* will offer more depth and context for the theory-based findings. LCPs are a project model based on design & build (D&B), meaning that the same actor is responsible for both the design and construction phases of the project. In addition, LCPs have liability period, typically of 20 years, where the D&B contractor is responsible for maintaining the functionality of the premises. Scope 3 emissions, on the other hand, refer to emissions stemming from the value chain of the construction, mainly material production and use phase energy consumption of heat and electricity. Scopes 1 and 2 are direct and indirect emissions from the construction phase. This way LCPs can be seen as a good project model for researching the scope 3 emissions, as the main contractor oversees the material selection as well as the use phase.

Next, chapter 2 offers a theoretical background by examining the relevant academic literature from supply chain management, especially from emission reduction and construction industry perspectives. Chapter 3 explains the qualitative methodology used for the research. Chapter 4 presents the results from the empirical findings for the three units of analysis of the case study. Chapter 5 analyses the meaning and importance of the results and summarizes the findings for each research question. Chapter 6 concludes

the research, offers theoretical and managerial implications, discusses limitations, and offers possibilities for future research.

2. TOWARDS LOWER EMISSIONS WITH SUPPLY CHAIN MANAGEMENT

2.1 Key terms and definitions

Using supply chain management (SCM) practices as a tool for improving environmental performance of a company is not a new idea. According to Sarkis et al. (2011), the concept of *green supply chain management* (GSCM) can be traced back to the 1960s environmental movement. However, combining environmental ideas with distinct business success factors such as logistics and purchasing, started later in the 1990s. As is explained by Tseng et al. (2019), this is a development that has continued ever since, because most of the environmental issues businesses have to deal with are related to their wider supply networks.

By now, there is a constantly growing number of research published every year on sustainable and green supply chain management (Tachizawa & Wong, 2014). Sustainability is often defined by triple bottom line (Elkington, 2013) of economic, environmental, and societal sustainability. In this thesis, although relevant, the term used will not be sustainability, or even GSCM, but rather low emission supply chain management (LESCM). Triple bottom line -based sustainability is a much wider issue, and even GSCM is too wide of a term, as the focus here is solely on the emission reductions.

There is still a lot of overlap between GSCM and LESCM, as reducing environmental impacts and emissions is strongly interlinked. Sarkis et al. (2011, p. 3) defined GSCM as "integrating environmental concerns into the inter-organizational practices of SCM including reverse logistics", which emphasizes the role of closing the material flow loops within the system. Of course, thinking about material flows to reduce usage of virgin natural resources (Engez et al., 2021; Ghisellini et al., 2016), one of the main issues within circular economy, is crucial for emissions in construction as well as in general. It will still not be in the main scope of this study, and therefore limited out of the LESCM.

Instead, this thesis will use Tseng et al. (2019) definition of GSCM and define LESCM as "*the integration of emission reductions into the supply chain process including collaboration with suppliers and customers to share information and knowledge with an aim to drive forward industry decarbonization*". Unlike Tseng et al. (2019), here logistics service providers are excluded from the definition, since in construction it generally has a limited

impact. Other than that, the definitions are quite similar, only difference is on the tighter scope of examination.

A wide variety of different organizational theories have been identified to be related to the GSCM literature (Sarkis et al., 2011), of which this thesis will discuss a few from LESCM perspective, such as innovation diffusion, social embeddedness, and agency theories. In addition, resource-based view (RBV) of competitive advantage (Barney, 1991) will be extended via business ecosystem approach (Adner, 2017). Instead of natural resource-based view (Hart, 1995), business ecosystem management is used in the thesis as an approach to combine the RBV-based ideas of competitive advantage with the supply network perspective of LESCM. This will be referred to as *ecosystem based LESCM*, discussed further in chapter 2.6.3.

This study is set out to estimate, can valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney, 1991) be created outside the focal company, while still maintaining a degree of control over them. This would happen by ecosystem approach of improved SCM that is based on a mutual value proposition across the system (Adner, 2017). What makes ecosystems different from the relational view of networks (Dyer & Singh, 1998) is further discussed in chapter 2.6. The linkages between different research areas are preliminarily presented in table 1.

Table 1. *Overview of the literature covered*

	Authors	Definition	Contribution
Low emission supply chain management	Plambeck (2012); Jira and Toffel (2013); Touboulic and Walker (2015); Laari (2017); Sancha et al. (2019)	The integration of emission reductions into the supply chain process including collaboration with suppliers and customers to share information and knowledge with an aim to drive forward industry decarbonization (Tseng et al., 2019)	The collaborative view of SCM to address emission related issues. Novel cleantech products include uncertainty; capacity management, contracting need to evolve
Business ecosystem management	Adner and Kapoor (2010); Adner (2017); Jacobides et al. (2018); Hannah and Eisenhardt (2018)	The alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize (Adner, 2017)	The strategic view of alignment, innovations and first mover advantage. LESCM could be reached by ecosystem approach, but getting there will require changes
Supply chain management in construction	Dubois and Gadde (2000, 2002); Cox and Ireland (2002); Cox (2008); Sheffer and Levitt (2010)	Buyer is proactively working with suppliers and the scope of collaboration reaches over the first tier of suppliers (Cox, 2008)	Sector specific issues that need to be acknowledged, if LESCM is the end goal. Arm's length relationships dominate, focus needed on building more stable networks

Terms *value chain*, *supply chain*, and *business ecosystem* will need to be more concretely separated from each other. All are dealing with a network of interrelated actors performing activities to produce value for the end customer. Value chains, defined by Porter (1985), are about positioning oneself within the chain in an optimal way to gain competitive advantage. The core focus is therefore on the focal company and its core activities. Supply chains on the other hand are defined as "*a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer*" (Mentzer et al., 2001, p. 4). Supply chains therefore already extend the examination more to suppliers and customers, but as will be presented later, Adner (2017) has defined why ecosystem perspective is needed as an additional framework to both supply and value chain approach on more complex issues.

A comparative look at the differences between supply chains, value chains and ecosystems is offered by Kapoor (2018). He defines supply chains as focusing on efficiency

and responsiveness, and not considering the demand side complementarities or interdependency structures. So, while supply chains focus on orchestrating the supply and demand flows of the focal product, they emphasize the supply-side interactions more. Kapoor (2018) explains the difference between value chains and ecosystems on the scope of the focus. Value chain focuses on the micro view of the company, on how internal actions within the focal company can bring competitive advantage, while ecosystem perspective will include every external factor that is needed for the focal value proposition. These definitions support the choices made above on how the terms are defined for this thesis. As the focus is on the upstream activities, supply chain perspective will be important, but will need to be supplemented especially by macro view ecosystem perspective on value proposition-based alignment of actors.

2.2 SBTi perspective on reducing emissions

This thesis is based on focal company's initiation of a Science Based Targets initiative (SBTi) process. This process requires committing company to address not just their own direct and indirect emissions, but also the emissions from operations in the value chain (Greenhouse Gas Protocol, 2011). Value chain emissions are also known as scope 3 emissions, referring to the classification shown in figure 2. For most end products, such as buildings, value chain or scope 3 emissions are typically well over 80 % of the total emissions. World Economic Forum and BCG (2021) estimate that in construction scope 3 is responsible for 81 % of all sector emissions.

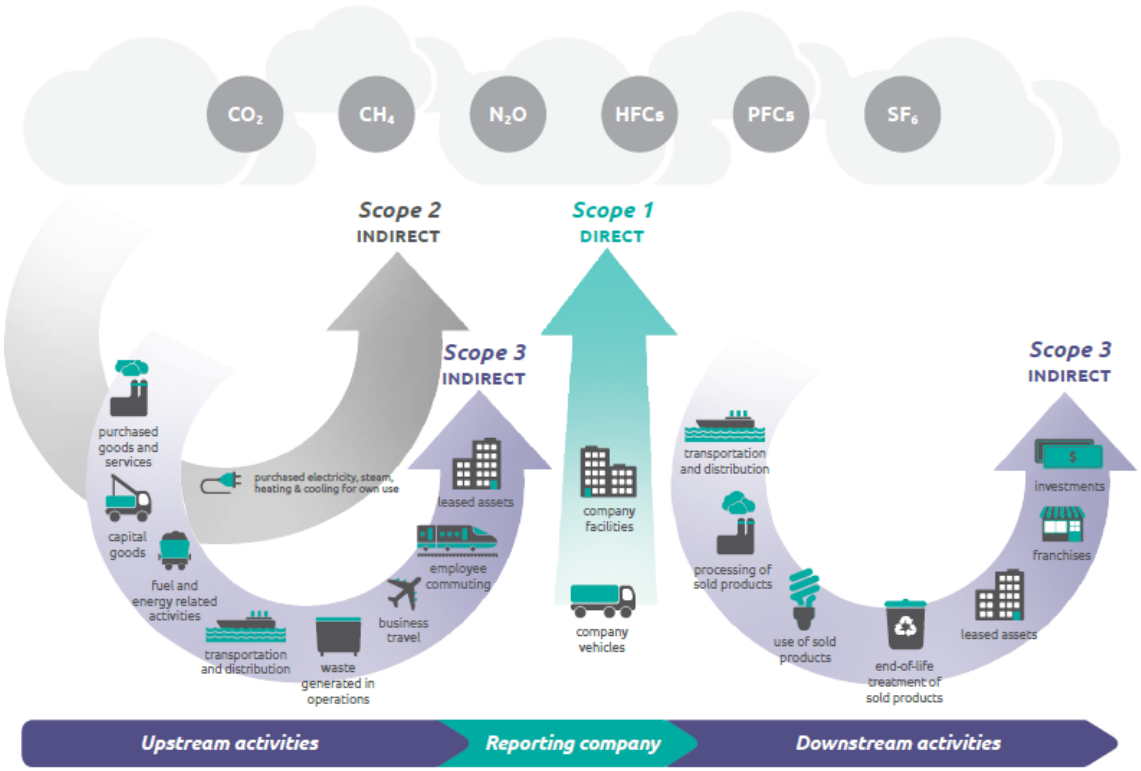

Figure 2. *Definitions of emissions scopes (Greenhouse Gas Protocol, 2011, p. 5)*

As was mentioned already, two of the most meaningful emissions categories for construction company developing value chain decarbonization strategy are embedded material and use phase energy use emissions. These are both scope 3 emissions, with embedded material related emissions being upstream and use phase being downstream. Scopes 1 and 2 are not part of this thesis, and from scope 3 the focus is on upstream.

There are obviously many possible approaches a construction company can take to start addressing its value chain emissions. For this thesis, the approach chosen is a mix of supply chain and business ecosystem management, with a focus on strategic long term and high impact decisions. As can be seen from figure 3, there are also short term and low impact actions that are required as well. The short-term actions are mainly about data collection from suppliers, a natural first step for improvement, while long term is more focused on strategic supplier collaboration and use phase impact reductions.

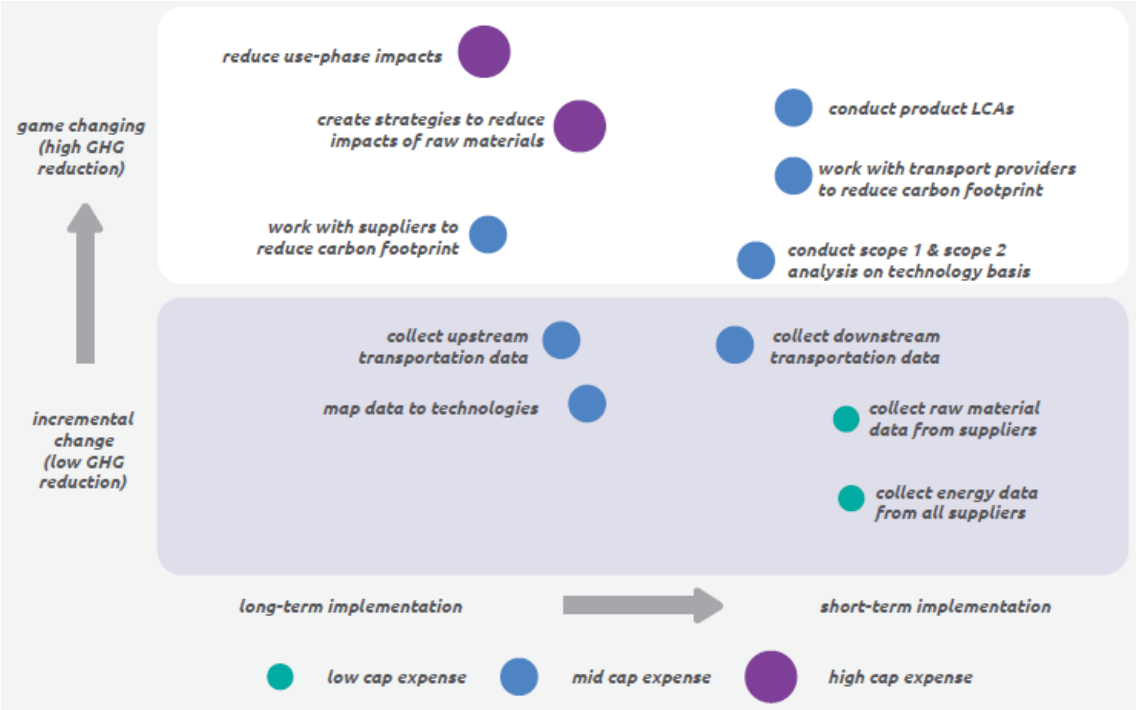

Figure 3. *Strategic carbon opportunity (Greenhouse Gas Protocol, 2011, p. 17)*

One important thing to point out about the GHG Protocol method presented here is the fact that emissions are counted multiple times when the process from figure 2 is applied to the value chain. When every downstream company counts things like the raw material extraction to their scope 3 emissions, it will mean that large part of the total emissions is counted multiple times (Greenhouse Gas Protocol, 2011). However, as is explained by Caro et al. (2011), only this kind of emission counting will guarantee results: If every member in the supply chain optimizes only their own operations emissions, the most emission-heavy sectors will get underinvested. Plambeck (2012) sees this as an example of the moral hazard in teams theory by Holmstrom (1982).

2.3 Life cycle projects

There are various project models typically used for construction of residential and non-residential buildings. LCP is one of them, it is a variation of D&B model. D&B means that the customer purchases both the construction and the design under the same contract. Unlike in traditional design-bid-build projects, D&B therefore gives better chance for creating innovative and collaborative solutions because design and construction are done together. This is also why it is typically used in larger projects where the potential for innovations is recognized.

What is special about LCPs compared to a regular D&B is that the contractor agrees to take care of the property for an extended period after the initial construction phase is

completed. This liability period is typically 20 years. The model has gained popularity in Finland in the last decade, especially for schools and other social, welfare, and healthcare buildings. Life cycle model offers a more collaborative way of working between customer, contractor, and the end-users, compared to the traditional competitive bidding used in typical public procurement projects. The chosen contractor has the normal responsibilities of a design and build project, but additionally use-phase services that include property management services, usability and conditions, energy efficiency, and transferability at the end of the liability period. The aim of this kind of project model is to guarantee predictability, security, and the overall most economical solution for the customer. Additionally, it has been identified that LCPs incentivize designing energy efficient and low carbon material buildings. (YIT, 2022)

Because of all these positive characteristics, Finnish Ministry of Environment (Kuittinen & le Roux, 2017) has in their criteria on public low-carbon procurement particularly guided on how to procure using LCP model. What is different on the presented criteria compared to traditional competitive bidding processes, is that the competition is not about prices or expenses only, but about the best price to quality ratio. The emphasis on the low-carbon quality criteria is on three things: energy, materials, and innovations. As can be seen from the figure 4, these quality grades will create a motive for the tendering participants to come up with new innovative solutions that reduce emissions, especially those stemming from the major scope 3 categories. As was already mentioned, this thesis will focus mainly on materials and innovations, and energy related emissions are acknowledged, but not emphasized.

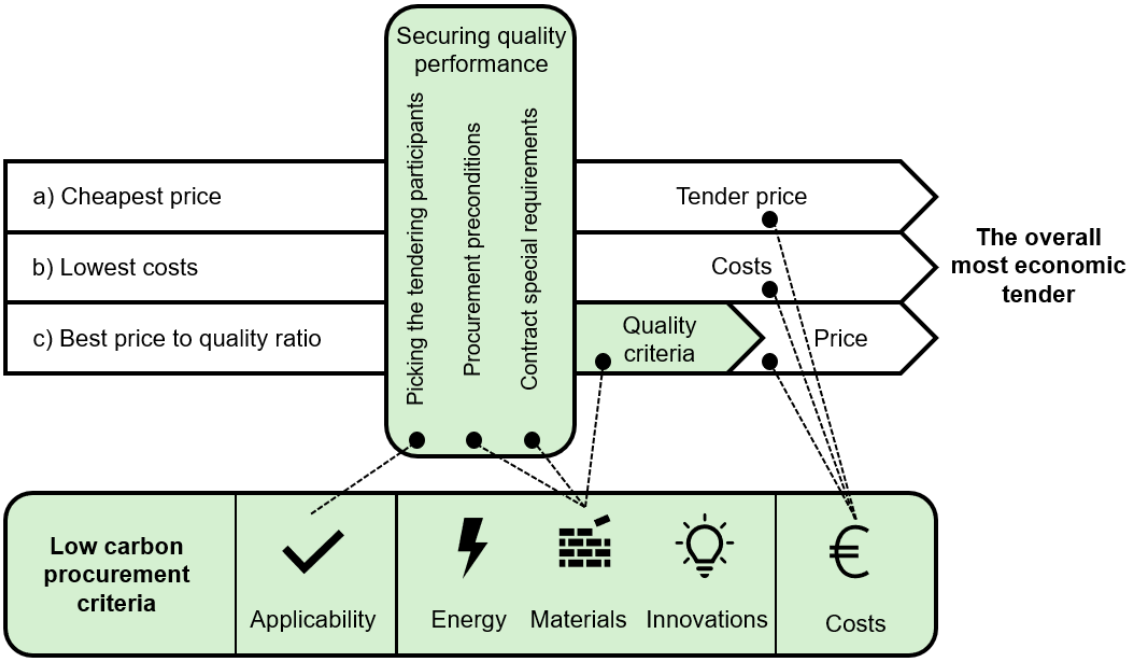

Figure 4. *Procurement criteria for low emission public construction (Kuittinen & le Roux, 2017, p. 28)*

The empirical case of this thesis will be based on LCPs and combining them with the scope 3 emissions reductions. There is no direct link between these two, as the focal company has set initial targets to start reducing its scope 3 emissions, not just for life cycle, but for any project type. However, as is explained by Ristimäki (2016), the lack of life cycle thinking is often a major reason behind urban development not being as sustainable as it could be. Key findings from that research are presented in figure 5.

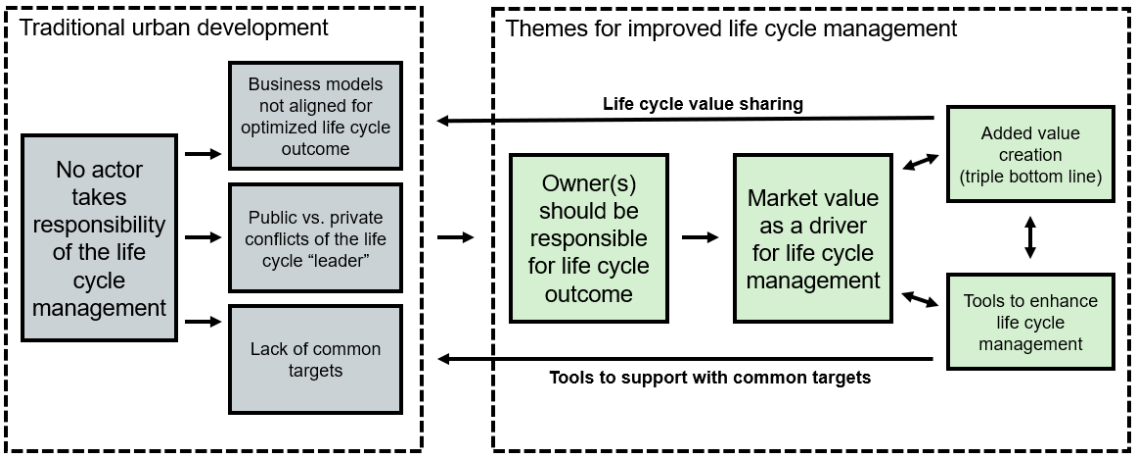

Figure 5. *Identified lack of life cycle thinking in construction (adapted from Ristimäki, 2016, p. 22)*

As can be seen from the figure, there is a clear need for better coordination of life cycle in construction (Ristimäki, 2016). LCPs are aiming to solve these issues in public pro-

curement, while producing additional value for the parties involved in the form of sustainability. Similar results have been identified elsewhere, Malacina et al. (2022) have found that everyone, the public buyer, users, and the suppliers are all gaining both internal and external added value in the form of sustainability, when the focus is shifted from short term cost optimization to the multiple dimensions of value creation.

Scoping the empirical research of scope 3 emissions on LCPs is a good way to add depth into the research case setting without losing too much breadth (Patton, 2002). In LCPs, the longer-term thinking is inherently included in the design decisions. The focal company is a market leading provider for LCPs, so good experiences and insights are known to be available. However, the quality gradings based on environmental criteria from figure 4 are a relatively new mode of operation for everyone, so this thesis can hopefully help add understanding on their meaning and possibilities better internally as well.

2.4 Business ecosystem management

When dealing with complex setting of network of companies collaborating to create value to end customer, recently a wide body of work has been written on ecosystems (Aarikka-Stenroos & Ritala, 2017). Ecosystem as a metaphor borrowed from the natural world to business was first used by Moore (1993), to explain the ongoing shift from traditional competition within an industry to an ecosystem-based competition. Already on this stage, business ecosystems were identified to be different in the way value propositions are defined, not by a single firm but rather focal company together with its key suppliers and customers.

Business ecosystem approach fits well to the topic of this thesis, as it is based on strategic management and determined to find best ways for interdependent companies to combine their unique resources and fulfill the focal value proposition with end customer (Jacobides et al., 2018). Even though recently most interest towards ecosystem approach has come from high tech industries such as smart phones (Jacobides et al., 2018) and semiconductors (Adner & Kapoor, 2010), Adner (2017) argues with his “Ecosystem as Structure” theory that most, if not all, industries have situation where ecosystem perspective will provide valuable new perspective in addition to more traditional network, project, or supplier management approaches. His example involves a car tire manufacturer, and other similar examples have come after, such as Hannah and Eisenhardt (2018), who apply business ecosystem approach to solar startups.

2.4.1 Defining the ecosystem

Definition of business ecosystem in this thesis will follow the one presented by Adner (2017):

> "*The ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*." (Adner, 2017, p. 42)

Alignment structure means that the end goal is shared between all the involved actors. *Multilateral* means that any individual relationship within the ecosystem cannot be examined alone. *Set of partners* means that membership is defined, and value proposition depends on these defined actors. *For focal value proposition to materialize* means that the focus of the ecosystem is on what is to be received by the end customer, not on the process of getting there. Key question here is on how much divergence from the focal value proposition within the ecosystem can be sustained. (Adner, 2017)

As can be seen, Adner's (2017) definition of an ecosystem is directly linked to the alignment of focal value proposition. What this means, is that instead of a typical definition, such as the original by Moore (1993), ecosystems are here defined by the activities, rather than by the actors. Instead of focusing on the links between focal company and its main partners, the focus is on the flow of activities taken by the actors in any position, directly linked to the focal company or not (Adner, 2017).

Jacobides et al. (2018) has somewhat similar definition to Adner's (2017) but emphasizes non-generic complementarities and the lack of full hierarchical control within the business ecosystem. The article goes even further than Adner and Kapoor (2010), discussed later, on contractual hazards and mitigating them. It argues that ecosystems go beyond fixed prices and quantities to attract customers to the focal value proposition. Instead of transaction costs and heavy contract risk management, ecosystems use modularity and various collaboration methods to create and capture value.

2.4.2 Ecosystem strategy

For ecosystem strategy, we use a definition by Adner (2017) as well:

> "*Ecosystem strategy is defined by the way in which a focal firm approaches the alignment of partners and secures its role in a competitive ecosystem*." (Adner, 2017, p. 47)

This definition has, again, many important implications. *A focal firm approaches* means that every company has their own understanding of what the ecosystem strategy is, and consistency makes convergent actions more likely. *The alignment of partners* means

recognizing gaps in the ecosystem and creating conditions to close these gaps. Gaps can be activity-based or structure-based. Activity includes co-innovation risks upstream and adoption chain risks downstream (Adner & Kapoor, 2010), while structure includes definitions of roles as in who hands off to who, and leader-follower roles. *Secures the role* means that leadership depends on focal firms' aspiration and requires willing followership. Leadership and followership can both become contestable. *In a competitive ecosystem* means that bargaining dynamics between buyers and suppliers is switched to partners who are a part of the value creation (and capture) but may not have a direct link to the focal company. From key resources the competition switches to aligning key partners and competing against other ecosystems. (Adner, 2017)

There is an interesting notion in the definition here, as Adner (2017) uses the term "gaps" with ecosystem alignment, while Hannah and Eisenhardt (2018) instead define "structural holes" as something that is only relevant in the network literature. These terms seem quite similar. Hannah and Eisenhardt (2018) explain that the term bottleneck, defined as the *technical challenges that hinder the growth or performance of the ecosystem* (Kapoor, 2018), is the term preferred to be used when referring to challenges within an ecosystem, as it emphasizes the activity over the structure of the ties in a network. This thesis will use the term bottleneck, but other than that will follow Adner's (2017) definition.

Hannah and Eisenhardt (2018) examine ecosystem strategies and find three distinct variations: bottleneck, system, and component strategy. These three strategies are based on the unique features that define ecosystem, which are *complementariness*, *bottlenecks*, and *co-operation vs. competition*. Complementariness is discussed next, in chapter 2.4.3. Bottlenecks are defined above. The third characteristic considers balancing the levels of value capture and creation. Co-operation-based value creation and competition-based value capture will be constantly measured against each other for the ecosystem participants, which has important implications. The Hannah and Eisenhardt (2018) article points out how literature on alliances has some conflicting findings on whether alliances can be built on both co-operation and competition simultaneously. It can be argued, that trying to do both is unsustainable, and alliance always shifts to one or another. But as Uzzi (1997) explains, it is often beneficial to maintain both arm's length price driven relationships, and deeper trust-based co-operative ones at the same time. Having a variety of different relationships for different situations can make the underlying network more resilient.

Different ecosystem strategies are based on bottleneck locations, and those can shift over time as ecosystems evolve and competitive environment advances (Hannah & Eisenhardt, 2018; Kapoor, 2018). The three strategies identified by Hannah and Eisenhardt

(2018) are distinct exactly in the way they handle these bottlenecks and shifts in them, in addition to the way they balance co-operation and competition. *System strategy* emphasizes competition, entering all components simultaneously and competing against rival ecosystems, so integrating vertically. *Component strategy* emphasizes collaboration, and value creation happens through mutual specialization, and value capture through innovation. *Bottleneck strategy* is more complex, mixing competition and co-operation by shifting focus constantly to the current identified bottleneck. (Hannah & Eisenhardt, 2018)

The key finding for the ecosystem strategy in the article by Hannah and Eisenhardt (2018) is the impact of bottleneck crowdedness. Bottleneck crowdedness measures the number of companies competing or collaborating around the key technical challenge within the ecosystem. In crowded bottlenecks innovations are crucial for standing out and attracting complementors, while uncrowded bottlenecks shift this balance towards barriers for entry, and therefore competition.

Overall, it can be said that these Adner (2017) and Hannah and Eisenhardt (2018) approaches to strategy in ecosystems are different. Adner (2017) emphasizes the meaning of the alignment, when Hannah and Eisenhardt (2018) stress the bottlenecks and their effect. In addition, other literature has plenty of good perspectives. Jacobides et al. (2018) add on the meaning of uniqueness, Kapoor (2018) on what separates ecosystems from strategic networks and alliances, and Adner and Kapoor (2010) on how aiming for the first mover advantage might or might not be worth it in ecosystem-based competition.

2.4.3 Innovating within an ecosystem

Understanding the effects of bottlenecks and the required innovativeness that is needed to overcome them is a crucial part of gaining advantages from improved SCM. Looking at the figure 6 from Adner and Kapoor (2010), there are two key sources outside the focal company, where these bottlenecks might be located. These are downstream suppliers who produce *components*, and upstream complementors who produce *complements*.

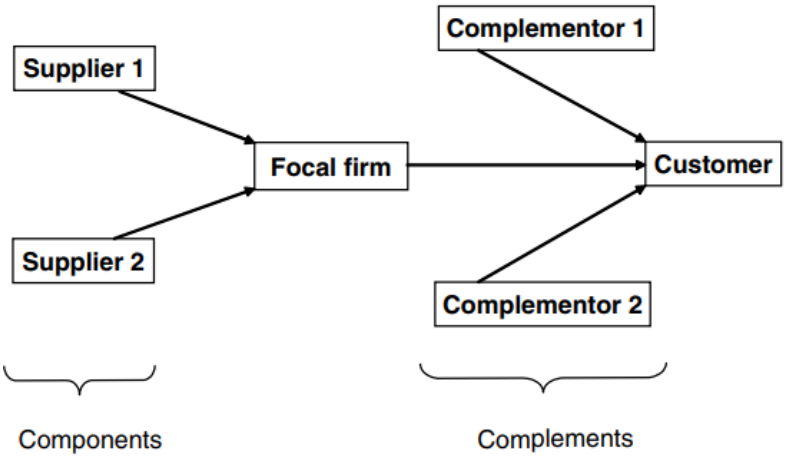

Figure 6. *Typical ecosystem formation (Adner & Kapoor, 2010, p. 309)*

The main argument relating to the innovation location within the value chain the Adner and Kapoor (2010) article makes is that bottleneck*s* will have different effect on the ecosystem depending on where they occur. Bottlenecks, discussed above from strategic perspective by Hannah and Eisenhardt (2018), can occur both upstream in components or downstream in complements, or even shift during ecosystem lifecycle (Kapoor, 2018). Either way, bottlenecks will potentially limit the value creation of the focal company: Component challenges are problematic for the production process, while complement challenges are problematic for customers using the focal firm's product (Adner & Kapoor, 2010). The article finds, however, that technology leaders or first movers are often benefitting from challenges in the components, depending on the level of modularity, learning curves, and imitation barriers. On the other hand, it might not be as beneficial being first mover or technology leader, when the challenges are in the complements, as this will cause delays on the market diffusion and gives laggards time to catch up.

In addition to the component and complement challenges, *vertical integration* is also assessed by Adner and Kapoor (2010). Vertical integration, relevant strategic option in any business ecosystem (Hannah & Eisenhardt, 2018), means that the focal company expands vertically to control up- or downstream activities. There might be various reasons for this choice, but often the reason is in reducing the level of uncertainty. There are two main sources of uncertainty, technological and behavioral, that can be addressed by vertical integration. Uncertainty stemming from supplier's technological challenges can reduce focal company's value creation, while opportunistic behavior will reduce the value capture. It can be concluded that vertical integration advantage increases as technology matures. For behavioral uncertainty, it is less clear, as more experience and interactions reduce uncertainty, but opportunism risks grow when supplier switching costs increase. (Adner & Kapoor, 2010)

We will return to ecosystems and innovations later, especially in the construction sector context in chapter 2.6. Project-based construction businesses are known to have hard time with building steady networks, as the projects switch around in different locations with different personnel each time (Gadde & Dubois, 2010), so combining the ideas presented here from the business ecosystems to that reality will be challenging. Further discussion on that will happen at the end of this literature review, in chapter 2.6.3.

2.5 LESCM opportunity

Returning to LESCM, let us start with SCM. SCM in construction sector is looked at in more detail in the next chapter, 2.6. In this thesis the definition of SCM will follow one presented by Cox (2008): Companies can fulfil demand by sourcing the required supplies internally via insourcing or a joint venture, or externally via *arm's length reactive ties* with supplier selection or supply chain sourcing, or *deeper collaborative ties* with supplier development or with SCM. What this definition means, is that only companies who extend their collaboration deeper into the supply chain and behave proactively are the ones using SCM in their sourcing. This definition is definitely quite restricted, but this is due the fact that SCM has been identified to be quite challenging in the construction sector due to the nature of the supply chains (Cox & Ireland, 2002; Sheffer & Levitt, 2010).

In addition to the traditional SCM-related challenges, a quote from Plambeck (2012, p. 570) can explain what LESCM will bring:

> "*A fundamental issue in supply chain management is to ensure that suppliers have adequate capacity. This is particularly difficult in nascent supply chains for 'zero'-emission sources of energy and other 'cleantech' products, because demand is potentially large but uncertain; reputations, relationships, and sources of capital are not yet established; and contracts may be difficult to enter and even more difficult to enforce*."

This is the key problem around which this whole thesis is built. It is complex enough that we can already assume that no single solution can tackle it alone. As mentioned, reaching SCM is hard for construction companies, compared to sectors like auto, IT, or retail where SCM practices are quite common (Cox, 2008). **Adding the new level of low emissions into this mix will only make things, at least initially, more complex**. It can be argued, however, that these two goals have synergies, as without SCM the emission reductions in scope 3 get much harder to manage. This will be further explained in the following chapters.

If we forget the construction sector specific challenges for a second, we can look at what has already been done elsewhere. Plambeck (2012) looks at what Walmart, one of the biggest retailers in the world, has done to successfully engage its supply chain to boost both economic and environmental performance. They have been able to (1) reduce costs through efficiency, (2) increase revenues through customers valuing environmental stewardship, (3) improve PR through robust climate strategy, and (4) attract talented people and gaining voice in public decision making by being seen as a climate leader. These steps are by no means straight-forward, but successfully implementing them will **not be a trade-off, but rather a win-win**. Plambeck (2012) also analyses other ways Walmart has reached emission reductions. They have, among other things, required suppliers to measure their emissions, committed to longer terms and larger quantities on purchasing orders, and collaborated with third parties to develop knowledge on sustainability issues.

2.5.1 Working with suppliers to reduce emissions

For this thesis, an important issue is the collaboration between buyers and suppliers. In the literature, it has been widely acknowledged that collaboration between buyers and suppliers is the best way of tackling environmental issues related to the supply chain (Ahmadi-Gh & Bello-Pintado, 2022; Sancha et al., 2019; Touboulic & Walker, 2015). Sancha et al. (2019) finds that when a buying company tries to address its environmental effects by supplier development, costly audits and other assessments are usually not very effective compared to a mutual collaborative effort. Of course, context always matters, and therefore formal mechanisms of contracting and financial incentives are always useful to support the more relational aspects of working together (Touboulic & Walker, 2015).

One requirement for suppliers in LESCM is to collect emissions data of their own operations and own supply chains. This is something Jira and Toffel (2013) have researched, trying to understand the dynamics of GHG data disclosures in buyer-supplier relationships. The article finds that voluntary emission related data disclosures are an information asymmetry problem, where the agent has access to information that the principal does not. This principal-agent problem is strongly present in the wider construction industry innovation context in general, as is stated by Sheffer and Levitt (2010) as well. Ahmadi-Gh and Bello-Pintado (2022) have also found similar results, and the outcome is often that the information asymmetry results in weak incentives for the supplier to achieve its climate-related goals. Like Sancha et al. (2019), the article finds collaborative ties to suppliers as the best solution for this.

For the supplier, the GHG disclosure will mean investments into analyzing regulatory effects of climate change, identifying the emission sources, collecting data on them, and developing a reporting system. Doing these investments will depend on the supplier's competitive position in the value chain. (Jira & Toffel, 2013) So, getting your suppliers aligned is by no means a straight-forward process for the buying company. What matters the most is a two-sided issue, as either buyers or suppliers can have different positions of power compared to each other. Buyers can have *breadth*, meaning that the issue at hand is a growing trend, not just single buyer asking about it, or *depth*, **meaning that the buyers seem committed to using the information when made available**. For suppliers, the important aspects are *profitability*, as more profitable industries are more likely to invest into GHG disclosures, *GHG intensity of the industry*, as stakeholder pressures will grow most in the heaviest polluting sectors, and *investment required for information sharing*, as country specific emission regulations will vary and therefore affect the competition in the market. (Jira & Toffel, 2013)

Investing into the emission reductions and into the disclosures of GHGs for the LESCM is always uncertain, as we see from the original quote above (Plambeck, 2012). Suppliers are not slowing the progress of the downstream actors because they want to be difficult or to avoid the risks completely, as could be figured from the Jira and Toffel (2013) findings. The fact just is, as Villena and Gioia (2018) point out, that **most of the reputational risks that the supply chain faces are on the downstream actors, who are facing the end-customer**. So, it is natural that especially lower-tier suppliers will require motivating for advancement to happen.

Another important issue in the Plambeck (2012) quote is the question about contracting. Within construction industry, like in many others as well, contracts are one of the most important tools for dealing with partnerships. Plambeck (2012) sees *relational contracting* as a potential solution in nascent cleantech product categories. Relational contracts (Taylor & Plambeck, 2007) are not court enforceable, but rather based on the relationships and reputations of the involved parties, who typically interact repeatedly. Instead of buyer and supplier agreeing on the prices and quantities beforehand, relational contracts only set the price. Quantities will be decided after the actual demand is better known. According to Taylor and Plambeck (2007), this kind of contracting could indeed motivate capacity investments better than strict buyer involvement with traditional contracts that might include audits or inflated order sizes.

Plambeck (2012) also suggest, that relational contracts and their effect on capacity expansion could be supported by making clear commitments to these key suppliers of nascent products. This could be done either via shared IT-systems that integrate the buyer

and supplier and allow faster and more detailed information sharing (Uzzi, 1997), or by consolidating all related business to single supplier. These actions are important for building trust (Kadefors, 2004) between the participants, however trust building is a slow process (Poppo et al., 2008). Touboulic and Walker (2015) have found similar results as well: Trust and relationship history between buyers and suppliers support in collaborative efforts to boost sustainability. The effect of trust and the social aspect of relationships is discussed in the next chapter in a bit more detail for construction.

In addition to relational contracts, buyers can motivate their suppliers to invest under uncertainty by *capacity leadership*. This means that the buying company convinces its key suppliers under the future demand uncertainty by making initial own capacity investments first. This is done to motivate the suppliers to offer complementing capacity. Taking the capacity leader approach can offer the buying company a way to make more credible relational contract offers for its suppliers, as the initial capacity has been already built. (Plambeck, 2012) In the context of this thesis, focal company's capacity leadership is harder to define than in traditional manufacturing business, as construction is strictly project-based. It could be seen as the depth mentioned by Jira and Toffel (2013), concrete evidence of meaningful actions taken in reducing emissions of operations.

Another thing to consider is these collaborative efforts to drive down emissions are often dealing with very varying sizes between companies, usually large buyers and smaller suppliers. In their research, Touboulic and Walker (2015) found that in these situations suppliers usually struggle when the buyer has an approach of unilateral one-way communication and lack of involvement, or the investment required is too much for the small supplier. Buyers on the other hand usually see the supplier's inability to change as the key issue. In these situations buyers, especially those using relational or capacity leadership methods to motivate investment, will also need to consider the risk of bankruptcy of the small supplier (Plambeck, 2012). These problems relate strongly with the questions of behavioral and technological uncertainty from the ecosystem innovations in chapter 2.4.3 (Adner & Kapoor, 2010). For the context of this research however, it is not always the case that suppliers are small, as the material suppliers can be multinational corporations as well.

To conclude, it can be said that emission reductions by working with suppliers can indeed be a competitive advantage. Firms working together can create something the open market would not be able to offer (Cox, 2008), so this might be a lucrative opportunity. However, as Laari et al. (2017) presents, this opportunity is real only, if there is a clear **alignment between the LESCM-strategy and overall competitive strategy**. If this is not the case, the article suggests that it makes more sense to move with the overall market

and not try to reach for early-mover advantages such as price premiums, new customers, and maximum time to adapt to future regulatory shifts.

2.5.2 Generic processes for getting to LESCM

There have been some attempts already to create a systematic process companies can follow to reach reduced environmental impacts trough better SCM, including many of the methods presented above. Let us take a look at two of them, one from academia created by Villena and Gioia (2018), and another from CDP made in collaboration with BCG (2022). Both these are wider, sustainability-based, processes, but we will look at them with the emission reduction focus of LESCM.

Villena and Gioia (2018) research focus is on the first and lower-tier suppliers and the risks they bring for the buying company. As was found by Jira and Toffel (2013) as well, risk of dismissing sustainability practices by suppliers is inflated if buyers lack breadth or depth in their requirements. Only if these factors are understood and present, does it make sense to even start engaging suppliers and building a systematic process for LESCM.

The process has four main phases: Firstly, *committing to sustainable supply network*, which means supportive organization structure, long-term goals for the firm and its suppliers, and incentivizing sustainability commitment for suppliers. Secondly, *building sustainability capability*, which means collaboration with key stakeholders for best practices, sustainability training for suppliers, setting and enforcing sustainability expectations in contracts, and collaborating to deal with surprises. Thirdly, *assessing sustainability practices*, which means conducting supplier assessments, managing supplier sustainability score cards, and closing corrective action plans. Fourthly, *managing sustainability risks and opportunities*, which means mapping the supply network, risk-assessment programs, and managing crisis. (Villena & Gioia, 2018) The process is visualized in the figure 7.

Figure 7. *Sustainable supply chain framework in manufacturing industry (Villena & Gioia, 2018, p. 81)*

For each step in the process, there are some concrete recommended action points. For the first step, these are things like setting a C-suite level sustainability executive, demanding suppliers to set own long term environmental goals and cascading them upstream while rewarding successful implementation by the suppliers. For the second step, company should select preferred suppliers for the environmental initiatives, and take these initiatives into consideration in supply contracts. For the third step, surveying suppliers for potential risk and opportunity factors and taking corrective actions based on audits is suggested. Finally, company should engage with its key strategic suppliers to better understand their situation within the supply network, as well as continuously update its risk assessments. (Villena & Gioia, 2018) There are nothing clearly contradicting in these actions compared to the other literature presented. The third step is, however, something that needs to be treated with care, as strict supplier assessments have been found to be ineffective by others, like Sancha et al. (2019).

Another process looked at here is a six-step guide by CDP made in collaboration with BCG (2022). The six key areas are strategy, people, supplier engagement, internal process, technology backbone, and communication, as can be seen from the figure 8. Looking at each of these areas, each one is explained in a time scale, where the first thing mentioned should be the starting point, and each following task is more advanced than the previous one. For each step there is also a suggested key performance indicator (KPI) to use. Let us go through the main points of each step next.

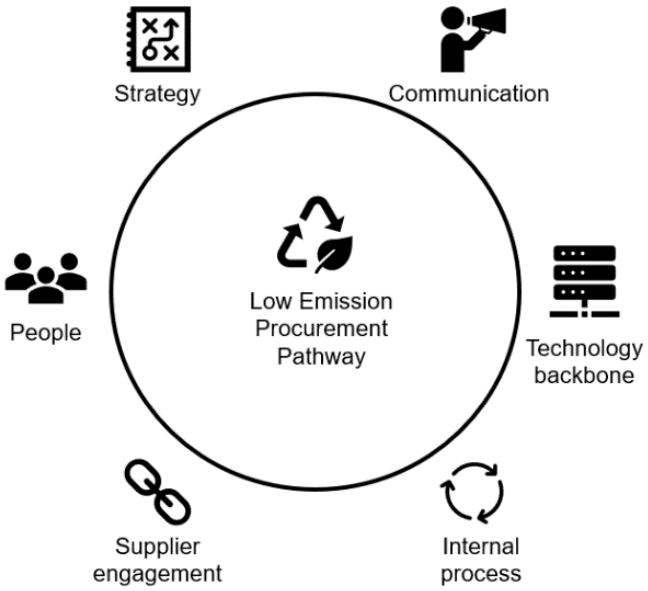

Figure 8. *Low emission procurement pathway (adapted from CDP & BCG, 2022, p. 23)*

For *strategy*, the starting point should be in agreeing to include environmental aspects into the procurement policy. From there, create links from procurement strategy to environmental and corporate strategies and try to recognize the potential of new technologies. Compare the procurement policy with industry best standards and communicate with stakeholders. KPI should be scope 3 reductions, with an end goal of 1,5-degree compliance. For *people*, training the procurement teams on environmental issues, and C-suite level KPIs on the procurement-related emissions are the first step. Incentive programs and advanced training for key personnel in procurement is required next. Finally, acknowledging and celebrating internal and external success in reducing scope 3 emissions. KPI here should be the %-level of staff trained (basic/advanced) on environmental issues and under the incentive program. (CDP & BCG, 2022)

For *supplier engagement*, identifying high impact suppliers and conducting spend analysis including buying power is the start. Engaging with identified suppliers and collaborating to create the procurement policy with senior management involvement is needed. After this, mapping key areas of the supply chain with two-way communication and incentives for suppliers. Finally, supplier development, environmental audit, and/or supply chain improvement programs are implemented, and successes and failures to reduce value chain emissions are rewarded and penalized accordingly. KPI should be the level of supplier engagement, with an end goal of >80 % of spend and emissions. For *internal processes*, key contracts need to be based on value for money and proper risk management, including environmental impacts as one of the key factors. After this, developing long-term plan for rewarding suppliers who make advancements in their environmental

criteria, and removing those who show no progress to support continuous development in the area, is required. KPI should be the level of procurement contracts with emission criteria, with an end goal of > 80 % of procurement spend. (CDP & BCG, 2022)

For *technology backbone*, starting with generic estimations of scope 3 emissions by multiplying procurement spend by generic emission factors is enough. After this, ad hoc annual data from key suppliers should be collected with development of supplier profiles. Data automation and systematic tracking of progress is the end-goal. KPI should be the number of days spent on carbon reporting and error rates, with an end-goal of 5 days spent on carbon reporting and a 5 % error rate. In the beginning the carbon reporting can take up to 60 days with a 50 % error rate, as it is known to be a challenge for companies. For *communication*, start by reporting annually via tools like SBTi. Suppliers and stakeholders should be updated on progress made, and when process evolves, benchmarking and independent audits should be conducted. KPI here could be the interval between results public release, with an end goal of quarterly reports and occasional independent audit reports. (CDP & BCG, 2022)

As we can see from the two processes presented above, there are plenty of similarities within them. C-suite involvement, strong supplier engagement, risk management perspective, and incentives for value chain actors to get involved are clear connecting elements. Acknowledging buying power of suppliers is only mentioned in the CDP and BCG (2022) process, which is interesting. This is something that will be discussed further in the following chapters, as it has been identified as a key issue within construction (Cox, 2008). Auditing suppliers was mentioned as an option by CDP and BCG (2022) as well as Villena and Gioia (2018), but as was explained above, taking this approach as the main tool has its risks.

Another important common theme between the two processes is the clear search for alignment between the environmental practices of the focal company and its identified key suppliers. This way it relates well to the ecosystem strategy definition presented by Adner (2017) from the chapter 2.4. The sustainability of competitive advantage that can be reached by LESCM is based on the level of alignment within the focal company's set of partners, and from the internal capabilities the focus shifts to relationships. These findings from ecosystem literature are clearly present in the processes presented here by Villena and Gioia (2018) and CDP and BCG (2022).

2.5.3 LESCM literature synthesis

This chapter has recognized multiple important findings from literature on what LESCM is or what it will require. It has been identified that supply chain decarbonization is a

collaborative effort where companies need to think outside the typical business boundaries. There is only a limited amount of project-based context in these studies, but the next chapter will focus on that. Findings are presented in the table 2.

Table 2. *LESCM literature overview*

Source	Methods and context	Main findings	Key insights for LESCM
Plambeck (2012)	Literature review on SCM and operations management literature that explicitly addresses climate change Experiences from a retailer via the biggest company in the world by revenue (Walmart), and a California-based construction sector start-up (Zeta)	There is limited research on the effects of climate change on SCM and operations management While many profitable ways to cut emissions do exist, strong climate policies will be needed to supplement them	LESCM will add complexity to SCM in short term Reducing emissions does not always require trade-offs in long-term profits Suppliers will be easier to get onboard when there is initial decarbonization investments made by buyer
Sancha et al. (2019)	Survey-based deductive study on Chinese manufacturing companies, a total of 129 company responses	Collaboration improves supplier performance, while assessments do not If supplier has leverage via dependency, environmental development will improve supplier's performance in collaborative relationships	Strict supplier audits are not as effective as more relational approaches Dependency structures are important in buyer-supplier relationships
Ahmadi-Gh & Bello-Pintado (2022)	Survey-based cross sectoral data from 263 manufacturing plants in 15 countries and three industries on sustainability and competitive advantage	Both internal sustainability practices and external collaborative efforts are important for sustainability Manufacturing sustainability performance is the most important aspect for increased competitiveness	Supplier has information advantage on emissions, with transactional relationship knowledge will not be transferred
Jira & Toffel (2013)	Survey-based empirical research via CDP (owner of SBTi) for thousands of suppliers in 49 countries on sharing emission related information with buyers	Buyers are most likely to receive emission data when emissions are widely accepted as a key measure, suppliers disclose better when the industry is profitable, and they are facing GHG regulation	Climate-related disclosures from suppliers will require the buyer to be seen as committed to emission reductions
Villena & Gioia (2018)	Inductive qualitative research on the riskiness of tier-one	Lower-tier suppliers address environmental issues more passively	Customer-facing buyer has much more risks than lower-tier suppliers

	and lower-tier suppliers on the environmental performance for three different industries' sustainability leaders	Supporting and training the tier-one suppliers well can promote learning upstream in the chain	Systematic processes to align the chain can be applied
Taylor & Plambeck (2007)	Quantitative game theory -based approach on buyer-supplier contracts	Relational contracts work best, when bargaining power is evenly distributed and investment costs are moderate	Relational contracting could work well on nascent low emission products
Touboulic & Walker (2015)	Case study on food sector multinational company working with its small suppliers on sustainability	With smaller suppliers, relationships will develop over time Buyers need to recognize the right level of involvement on each relationship	Smaller suppliers can get involved in LESCM, but will require more support initially
Laari et al. (2017)	Survey-based data set of 382 different firms on GSCM and its connection to competitive advantage	Sustainability leadership is more likely to be seen as a competitive advantage in firms that use it as a differentiative factor in their strategy	If LESCM is wanted to use in an ecosystem-based way, clear links between environmental and competitive goals need to be created in the supply chain

Multiple studies presented here discuss the difference between supplier collaboration and assessment (Ahmadi-Gh & Bello-Pintado, 2022; Laari et al., 2017; Sancha et al., 2019). When we move the focus more towards the construction industry, it has been identified widely, that arm's length relationships (Kadefors, 2004) with supplier assessments, and therefore high transactional costs (Laari et al., 2017), are the dominant form of supplier relationships. Therefore, a lot of research has been made on optimization models for construction companies to use in their procurement decisions, e.g., Keshavarz-Ghorabaee et al. (2020). This study will not focus on these approaches since the idea here is rather to find approaches where collaboration is suitable. Basically, this decision was made when ecosystem approach was chosen as the supplementing theory for LESCM. Transactional supplier relationships and ecosystem approach cannot be studied properly at the same time, based on the definition of ecosystem by Adner (2017).

2.6 Towards LESCM in the construction industry

Now that we have looked at the SCM literature from a more general sustainability/emission reduction perspective, it is important to understand the context of this thesis and focus therefore on construction specific issues. First, it is good to note that combining construction, SCM, and environmental issues is an extremely major issue, and it would

be impossible to cover all possible aspects in one thesis. The chosen approach could be to focus on prefabrication (Plambeck, 2012), building information modelling (BIM) (Kim & Kim, 2021), product-service systems (Fargnoli et al., 2019), life cycle assessments, material passports (Chen et al., 2022), lean construction (Bertelsen, 2016), certifications (Chen et al., 2022), or wood construction (Jussila et al., 2022). However, as was defined in the first chapter and the research questions, this thesis is not about any of these possibilities individually, but rather about identifying barriers of adoption and creating an environment for these solutions to move forward quicker in construction sector.

Returning to the discussions in the previous chapters, mostly on ecosystems, supply chains, and relationships between the different actors within them, is a good starting point for this chapter. Within ecosystems, one question might be, how does this new approach add value compared to the traditional approaches used in construction, such as project, alliance, and network management. Traditionally, competitive advantage has already been identified to stem from outside the focal company, from relationships (Dyer & Singh, 1998) and strategic networks (Gulati et al., 2000), so why is ecosystem perspective used for this thesis instead? As is explained by Kapoor (2018), in ecosystems the differentiating point is the focus on the value proposition of the focal offer, instead of dyadic voluntary ties between alliance members or the structures of these dyadic ties within strategic networks. Although questions about things like governance and sociological aspects are important within ecosystems as well, the focus here is on the value proposition of low emission construction. Similar definition is offered by Adner (2017) on what makes ecosystem perspective different from project management.

So, alignment for the common value proposition is the key to success in ecosystems. What does that mean for SCM, or even more specifically for LESCM? Kapoor (2018) mentions things like alliancing and setting of firm boundaries, complementary business models, and disclosures of some intellectual property during standard setting as general methods for reaching alignment. Tradeoffs are possible between performance and bottlenecks, as was discussed by Adner and Kapoor (2010). However, to bring this discussion back into its context, let us then move the focus into the construction industry specific issues.

In an influential paper about trust in project relationships, Kadefors (2004) argues that in construction industry, the behavior between buyers and suppliers in contracting and procurement practices is often very different compared to how one would expect a good partner to behave. As was discussed in the chapter 2.5.1, contracts should not be about enforcement but rather about relationships (Sancha et al., 2019; Taylor & Plambeck,

2007), which is exactly the opposite of how Kadefors (2004) sees the situation in construction. The article also finds that attempts at fixing this issue have been unsuccessful, because relational contracts often end up being compromises that bring up risks of opportunism. This has led to a circle of distrust, which should be tackled by setting clear economic incentives to work collaboratively, workshopping, continuous improvement practices, and so on. Of course, many of these ideas brought up by Kadefors (2004) are already well known within construction industry, but that does not mean they would be easy to fix, as is explained next.

2.6.1 The structure of power in construction

Construction is often referred to as an sector where productivity has not increased over time in similar fashion as it has on other sectors (Barbosa et al., 2017). The McKinsey research identifies the same issues already brought up in this thesis, such as weak levels of supply chain and life-cycle management, as the reasons behind the lack of productivity development, but does not go into detail on why these problems are so hard to solve. Cox (2001) takes a buyer and supplier power approach to define the issue. He explains, how the typical one fits all solution offered for SCM-related issues is the *integrated SCM*, or ISCM, which he identifies as a five-step process: (1) Focus on core competencies, (2) outsource the rest of activities to suppliers, (3) categorize supply inputs by spend, (4) focus on the chosen preferred suppliers, (5) improve performance through proactive supplier development. As great as this sounds, Cox (2001) argues that this kind of approach requires buyer to be in a position of power, either by structural *buyer dominance* or *interdependence*. What this means is that suppliers are not willingly sharing their power, so buyers need to have leverage on them to be able to have a say on their investment decisions, for example. Sancha et al. (2019) also found that in situations where buyer is dependent on the supplier, the gains from improved environmental performance might increasingly go to the suppliers.

The different positions of power are represented in the figure 9. The most important attributes for supplier/buyer dominance are things like ratio of available suppliers compared to interested buyers, buyer's market share of the supply, and the level of switching costs and supplier product commoditization (Cox, 2001). Interdependency, a situation where both buyers and suppliers are dependent on each other, is the optimal position for ecosystem-based approaches to form (Jacobides et al., 2018; Kapoor, 2018). In order for construction to become interdependent, it would mean, among other things, that both suppliers and buyers have limited options to choose from, switching costs are high for both parties, and buyer has a high market share of the suppliers products (Cox, 2001).

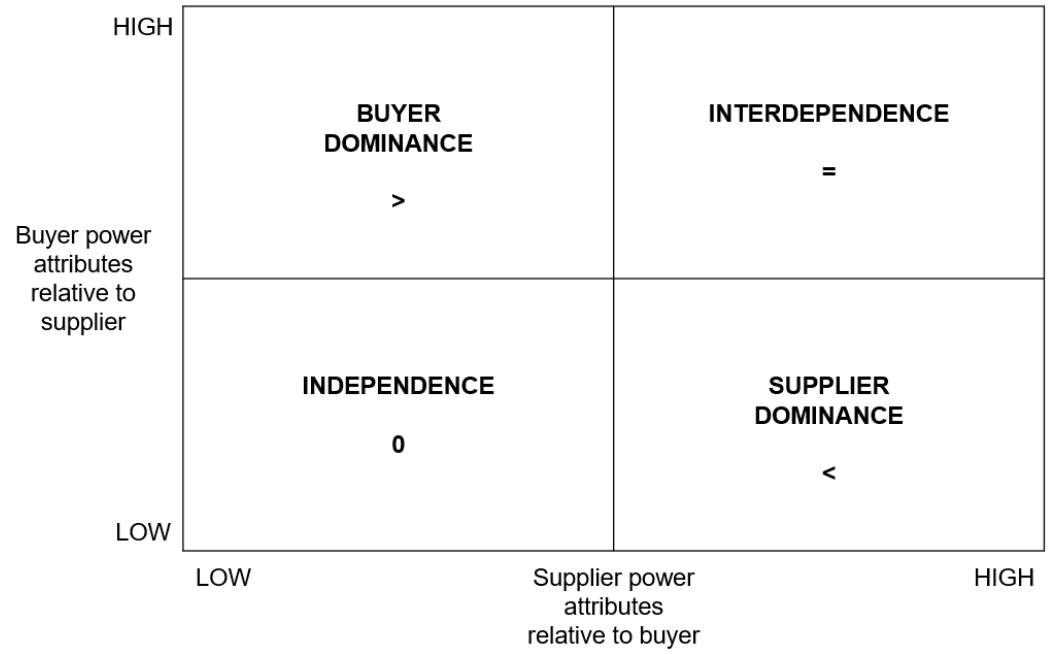

Figure 9. *The power matrix (Cox 2001, p. 13)*

Cox (2001), as well as Cox and Ireland (2002), continue by explaining the ideas behind lean manufacturing methods, and how they are often used to reach ISCM. When a production process is lean, the material suppliers are basically commoditized: Production happens in large volumes, low varieties, predictable environments, and supplier has basically no leverage on the buyer. As is widely known, this is not what most construction projects are like. So, what this means for the main contractor of a construction project, is that either they must accept their role as is, or start looking for more fundamental changes to achieve projects, where suppliers are needed for larger, more profitable, continuous workloads (Cox & Ireland, 2002).

It might then be valuable to address already here, how the power matrix and ISCM could behave very differently, when we consider the scope of this thesis, which is lowering emissions. Dubois and Gadde (2002) explain how the components of a typical project consist of similar and *independent* suppliers, in so called community of practice, which according to Powell (1998, p. 231) is problematic as “heterogeneity and interdependence are greater spurs to collaborative action than homogeneity and discipline”. This finding by Dubois and Gadde (2002) might be challenged, when the focus of the project shifts from doing a so-called typical project into low emission construction ecosystem with higher levels of interdependence. In other words, traditional construction component market is mature and concentrated, but in low emission exchanges the positions have yet to be defined.

To conclude the above discussion, we can refer to the definition of SCM from chapter 2.5 and the identified emission reduction processes from chapter 2.5.2. Moving from arm's length relationships to supplier development or SCM is extremely resource intensive, especially for construction companies (Cox, 2008), but both of the processes (CDP & BCG, 2022; Villena & Gioia, 2018) suggested that at least supplier development is required. According to Cox and Ireland (2002) and Cox (2008), the required win-win situations needed to reach meaningful supplier development are not typical within construction, **as the industry structure is inherently built to create tensions** between buyers and suppliers, and between different suppliers. What this means is that each supplier has to compete against other supply streams for the value they bring for the end-product (Cox & Ireland, 2002), while buyers and suppliers have tensions between their ultimate end-goals for participating in the exchange: In most cases, parties are happy with their situations, even if the one-off purchase does not split the value fairly between the buyer and supplier. For buyer, operationally the functionality – performance, quality, and on time delivery, matter most and commercially the total cost of ownership, while for the supplier, the main interest is often in the revenues and profits from selling to the buyer. (Cox, 2008) Of course, things like novel projects that could offer references for the supplier can reduce the tension here, linking this again with the possibilities of unique value propositions (Jacobides et al., 2018).

2.6.2 Innovations in the construction supply chains

So, collaborative efforts within supply chains are recommended to reduce emissions, but it has also been identified that this collaboration has been challenging to reach for construction sector companies. Let us next look into the reasons behind why collaborative innovations and continuous learning have been so hard, beyond just power structure. After all, meaningful emission reductions will require some innovative solutions within these supply chains. As the focus of this thesis is on the embedded material related upstream emissions, the innovations will most likely have to do with the way building materials are manufactured and used, whether the material in question is concrete, steel, wood, or a mixture of any of them. And as of today, there are already plenty of known technical solutions for these issues, that are just waiting to become commercially viable (Fennell et al., 2022).

Sheffer and Levitt (2010) discuss innovations within construction supply chains by dividing them into two categories, modular and integral. Modules, the components of modular innovations, are standardized and typically prefabricated singular units, while integral innovations deal with multiple distinct supply chains within the construction process.

Modular innovations can be plugged into the existing operations rather simply, and they therefore diffuse quickly. Integral innovations, on the other hand, require adaptations in multiple supply chains, which makes diffusion much harder. Emission reduction focused innovations are generally integral, as we can easily imagine: Substituting some of the cement in concrete with a substitute material, e.g. waste sludge (Plambeck, 2012), might require designers and on-site workers to take the change into account in their plans, and similarly implementing an intelligent software to optimize use-phase energy use will require multiple supply chains from labor to material to equipment to adapt as well (Sheffer & Levitt, 2010). These examples relate back to the chapter 2.4.3 about upstream components and downstream complements innovations (Adner & Kapoor, 2010), as some of the innovation required for meaningful emission reduction is within the components while some is within complements. And as was mentioned, this has clear consequences for things like reaching early mover advantages.

According to Sheffer and Levitt (2010), a lot of the difficulty with integral innovations comes down to the fact that construction is a mature industry, and with maturity comes fragmentation. When industry is young, single company typically operates all aspects of the product life cycle, but as time goes by, specialized firms emerge to perform single phases more effectively. Design, manufacturing, installations, and so on go from being part of one complex system into a higher volume operation by specialized firm operating on each individually. With fragmentation there are obvious advantages, as specialized firms gain economies of scale and accrue knowledge on their area of expertise. However, this also results in major challenges. Knowledge sharing among participants within the construction project is one of those challenges. Saini et al. (2019) recognize that this problem, among things like traditional way of doing business, is what mostly hinders knowledge-based management across construction sector. Additionally, the article finds that no single technical solution, like BIM, will solve the problem alone, as tacit knowledge will also need to be transferred. Overall, their findings suggest that understanding of the advantages of better information sharing for construction seems to be lacking for now.

Advantages of information sharing were already discussed with LESCM, but in addition one crucial construction specific point should be made. Sheffer and Levitt (2010) explain the principal-agent problem between customer and contractor in relation to the operational (OPEX) and capital costs (CAPEX) of the project. As Cox (2008) explains, CAPEX refers to the expenses from initial project management sourcing, whereas OPEX refers to the costs that accrue after the project has been completed. Improved energy efficiency is a good example of this trade-off in construction. Typically, innovations that result in

increased CAPEX, even with positive net present value from decreased OPEX, have low likelihood of being implemented, as the motivation is not there for the agent (Sheffer & Levitt, 2010). This can be addressed well with life cycle project model, as was mentioned in chapter 2.3. On the other hand, long liability periods can cause other kinds of problems, as the long-term technological risks from innovative solutions are uncertain, so the main contractor will be cautious to carry risk of doing things in a way with unknown long-term effects (Sheffer & Levitt, 2010).

Additionally, with project-based business in fragmented industry, Dubois and Gadde (2000) discuss the two layers of networks within construction projects: temporary and permanent. Temporary networks are based on each project individually and have coordination and interdependence-based learning happening within them, but learnings are typically not well transferred to the permanent networks. This is since most relationships are short-term and transactional. The article finds that the role of the permanent networks in construction is negligible compared to most other industries. However, one might then wonder, how do buildings get built at all, if the industry structure and networks are this unique? Dubois and Gadde (2002) explain, that **as an answer to the complexity within the industry, construction has turned to decentralization**. As projects deal with uncertainty of unique locations, lack uniformity of materials, work, teams, and so on, decisions cannot be made solely by a single central actor. Yet, within the temporal network, high number of different technologies sequence and overlap each other, which increases interdependence.

As Dubois and Gadde (2002) define this way of decentralization of complexity, they call it a construction community of practice. However, for this thesis, the term that represents it better is *tacit alignment of actors*, which was partly already defined for the ecosystem approach by Adner (2017). This kind of alignment basically means that there is a set of unspoken and informal rules that overlap the temporary and permanent construction industry networks. Every actor follows the rather strict written legal standards and contractual obligations of how things work, but beyond this the short-term relationships are supplemented by this tacit way of doing things “as usual”. (Dubois & Gadde, 2002) Basically, what this means is that construction industry is excellent at adapting to legal frameworks and clearly set standards, but for an individual firm to start reaching for innovative solutions that are not in accordance with the current tacit alignment of actors is going to be very challenging. As this is the case, rapid value chain emission reductions will most likely require strengthening and alignment within the permanent network even more than in the temporal one.

These findings by Dubois and Gadde (2002) have obviously effects for innovations, of which four are emphasized. Firstly, the focus on temporary project organizations with no guarantee of future collaboration between actors is problematic. As Uzzi (1997) explains, having a variety of shorter- and longer-term relationships is great for flexibility and adaptability, but relating too strongly on short term makes industry level learning really challenging. Secondly, the strongly decentralized structure of construction is great for producing ad hoc learning but fails in bringing same set of partners to future projects. Thirdly, uncertainty could be reduced by focusing on continuous interaction. As Poppo et al. (2008) also point out, for trust-based interactions to materialize, future expectations of interaction need to be present. Fourthly, the current tacit alignment of partners in the construction sector tends to make firms similar and independent. As was discussed above also by Sheffer and Levitt (2010) and even Jacobides et al. (2018), this is exactly the opposite of what interdependency-based integral innovations for unique value propositions require.

It has by now become clear, what kinds of things are slowing construction companies from reaching LESCM or improving innovation diffusion. As was mentioned already with the power structure in the previous chapter by Cox (2008), Dubois and Gadde (2000) also emphasize that no single one-fits-all solution exists to make construction more trust- and long-term-based industry. And in many cases that is not even possible. However, both articles, as well as Sheffer and Levitt (2010) and Gadde and Dubois (2010), suggest that moving towards a hybrid solution might be the best approach in many cases. In figure 10 we can see a spectrum, that tries to explain what the hybrid solution could look like. With ecosystems it was mentioned that vertical integration (Adner & Kapoor, 2010) is one of the tools to reduce uncertainty, however for solutions to reach LESCM it can be seen as the most aggressive approach.

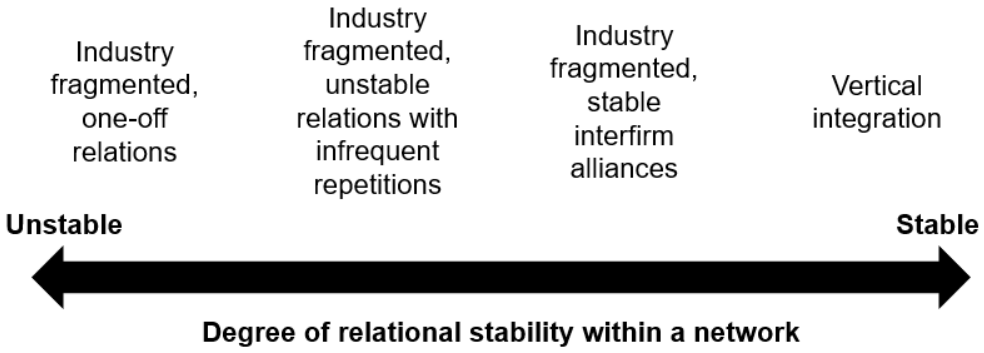

Figure 10. *Relational stability and industry fragmentation (adapted from Sheffer & Levitt, 2010, p. 16)*

Vertical integration poses clear challenges for a construction company, as it does not work well with demand fluctuations and required flexibility of the offering. Therefore, it

might make more sense to improve the current fragmented supply chains, at least initially, by stable alliances and joint ventures instead. This will reduce the risks for the focal company while still making the permanent network more meaningful, therefore helping with integral innovation diffusion. (Sheffer & Levitt, 2010) Similar ideas are also brought up by Gadde and Dubois (2010), who suggest that partnering can be divided based on local and central level partnerships. They claim that there might be solutions that **can achieve advantages from both sides by supporting the decentralized project management, while also reducing the number of short-term actors involved on an average project**. As Cox (2008) explains, this is still not a one-fits-all idea, and companies need to think carefully what kinds of projects are worth pursuing with these strategies. The article explains how multiple levels of relationships are always needed in certain situations. Labelling something "strategic" and moving forward with win-win and trust-based principles is not a shortcut to success. In some cases, it would be the exact opposite. However, reducing emissions can be seen as a such strong and unavoidable long-term trend, that these ideas about creating relational stability with preferred partners might make a lot of sense.

As a final note, it is important to acknowledge the role of the public buyer. As Plambeck (2012, p. 573) notes, "*the magnitude of profitable emissions reduction seems likely to be insufficient. I conclude that effective climate policy is needed to spur transformative supply chain coordination and innovation*." It is not realistic to suggest that all these required strategic changes to the industry structure would happen without the public sector taking a heavy initiative via policy. Luckily, as was presented in chapter 2.3 by Kuittinen and le Roux (2017), this issue has been identified in Finland and concrete actions are starting to happen. And for a construction company, fully understanding all these challenges can already be an advantage. Being open about them in collaborative negotiations and proactively trying to come up with solutions can already be beneficial. This is the basis for getting various actors aligned and working towards the common value proposition in an ecosystem for LESCM. Interest from end-customers towards reducing emissions across supply chains already helps the effort a lot (Sheffer & Levitt, 2010).

2.6.3 Combining LESCM, ecosystems, and project-based construction

To tie together this literature review, let us as a final point look at how could a project-based construction company start moving its operations towards the collaborative LESCM and eventually reach the principles of an ecosystem within its emission reductions. Engwall (2003) presents that project management needs to improve its ability to

take into account the context in which the project-based business is conducted, how the history and future projects effect or should effect the decisions of today. The article explains, how project management has been divided into two opposite streams: projects are either treated as fundamentally similar, or fundamentally unique.

For the ecosystem based LESCM to become reality, each construction project cannot be treated as a unique. Key suppliers, defined as suppliers who produce something strategically important (Holmen et al., 2013), need to be given continuous workloads to get them committed (Cox & Ireland, 2002). As material related embedded emissions raise in significance (Röck et al., 2020), these key suppliers from the emission perspective will mainly be frame structure component providers. It is reasonable to claim that each building construction project is similar when it comes to the frame structure materials. Concrete, steel, and wood are the three main materials used for every building, of which commonly used concrete is the most meaningful for emissions (Rakennusteollisuus, 2020). Even if each project was completely unique beyond this point, the main emission hotspot is already covered.

Managing rather independent construction projects' key material procurement in a more centralized fashion via LESCM poses a major challenge. As was identified in the previous chapters, not only is it resource intensive to proactively manage supply chains (Cox, 2008), it is also very different from the transactional relationships that are widely used in the current alignment of partners (Dubois & Gadde, 2002; Kadefors, 2004). LESCM would require both internal and external collaboration and information sharing about ongoing and future projects in a way that can probably only be reached by *project portfolio management* (Cooper et al., 1997). Without strong portfolio level management, it is hard to see how a project-based construction firm could ever get adequate capacity that it could promise upfront for its key suppliers of low-carbon materials.

Project portfolio management is defined by Cooper et al. (1997) as having three distinct goals: maximizing the value of the portfolio, finding the right mix of projects, and linking the portfolio with business strategy. Especially the last one is emphasized here, if lowering emissions is an actual part of the business strategy, key material related emissions will need to be managed on the portfolio level. As is explained by Meskendahl (2010), linking portfolio management to business strategy will start from choosing a strategic *orientation*, then *structuring* the project portfolio, which will only then lead to portfolio and business level *success*.

Meskendahl (2010) defines each one of these terms. Orientation can be analytical, risk-taking, or aggressive. Structuring means that the portfolio has consistency, integration,

formalization, and diligence. Portfolio success consists of average single project success, use of synergies, strategic fit, and portfolio balance. Business success means economic success and being prepared for future. For early mover advantages within emission reductions, it can be argued that at least some risk taking will be necessary.

This approach of emission reductions via project portfolio management is not something that has been widely studied. It will not be the main research topic here either, but this study suggests that it could be a promising approach to achieving the goals of ecosystem based LESCM. Additionally, as this kind of portfolio is trying to create change within a company and its external actors, change program management approach might offer some supportive insight as well. Miterev et al. (2016) has identified key skills that are required for a change management program, where the change towards an evolving strategic goal must happen during an ongoing business process (Pellegrinelli, 1997). The key skills for program managers in these kinds of situations are things like scenario planning, contextual awareness, political and networking skills, coordination, and courage.

In conclusion, to reach the benefits of having more stable permanent networks (Dubois & Gadde, 2002; Sheffer & Levitt, 2010), where knowledge is shared (Saini et al., 2019) and competitive advantage is created together with key suppliers through alignment (Adner, 2017), top-down management needs to be increased. Completely decentralized single-project focused approach to management will most likely not be possible if ecosystem based LESCM is the end-goal. The reason, why it might make sense to do such a radical change in approach, is explained via findings from Plambeck (2013), who studied a green cement producer. When these low-emission materials are developed for construction, the production processes will be heavily dependent on the alternative sources of raw materials, such as industrial by-products and green electricity, so ramping up production will require constantly finding new sources of these raw materials as well. In this kind of situation, being early mover might make the most sense, as these “waste” streams are only available for a limited number of actors. This could be a VRIN-resource, but decisions to make such commitments will need to come early, and from the top management.

3. RESEARCH METHODOLOGY

3.1 Research design

The research methodology used for this study is qualitative research with *interpretative* research philosophy. As is defined by Lewis et al. (2019, p. 149), purpose of this kind of approach is to create richer understanding of organizational contexts by looking at various distinct units within the organization and analyzing interactions based on these identified differences in perspectives. As the topic of the thesis is somewhat emerging and requires lots of communication and interpretation, this kind of approach is well suited to capture all the complexity and even uniqueness related to the issue.

Another way to look at the initial purpose of the research is to use a spectrum by Patton (2002, p. 213), where basic research aims for the most fundamental contributions to knowledge and theory, and action research is conducted solely to solve a specific problem. On this continuum from theory to action, in the middle there are two *evaluative* purposes, of which this study is *formative*. Formative evaluation is typically concerned with improving a certain program within an organization, as is the case for this thesis. As Patton (2002, p. 220) explains, findings are typically not aimed to be generalized, but are rather context specific. This way formative evaluations are quite close to action research, as the problem at hand brings the context to the study.

The problem was, however, quite vague at the start of the research process. Research started by acknowledging scope 3 up- and downstream emissions, and the realization that not much can be done to have direct control over them. This is especially difficult when the focal company is not in the role of a developer, as is the case for most of the projects in the Business Premises -segment (BP). Generic solutions had been identified for the scope 3, but the progress with them has been limited so far, mainly due to higher costs related with them. This level of understanding of the problem was reached by naturally occurring data (Speer, 2008), as the author was observing and discussing the issue before the start of the actual research process.

The start of the research process was extremely iterative. Research objectives and questions were not locked, and the desired end-result was not super clear. Because of this, the initial literature review was gathered from a variety of different perspectives to better understand the situation. Based on these findings from academic articles, and overlapping observation and brainstorming sessions, data was then collected via in-depth interviews. Although usually qualitative research, especially with interpretative approach, is

inductive (Lewis et al., 2019, p. 179), abduction was seen as the best fit for theory development. Main reason is that existing literature had a clear role in defining the research questions and aims of this thesis. Additionally, during the data collection, the interview guide (Patton, 2002, p. 343) was slightly updated based on the information received in the previous interviews. Therefore, unlike how it can look like in the figure 11 as straight forward process, the research process was rather iterative.

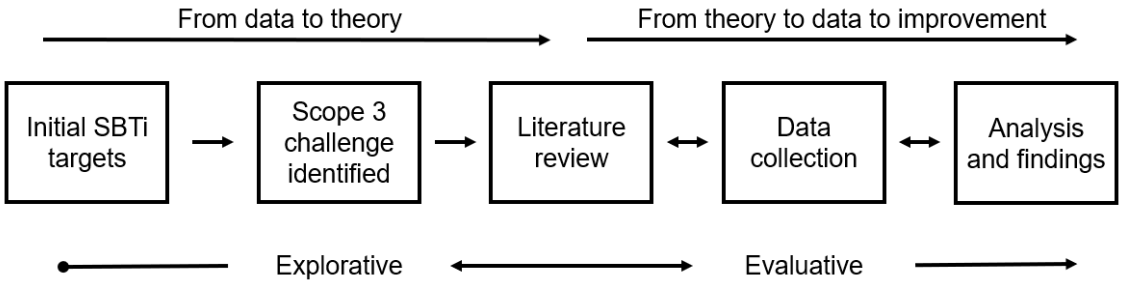

Figure 11. *Abductive research design*

As can be seen from the figure 11, the research design moved from explorative to evaluative as the research and understanding of the current situation evolved. Exploratory phase was mainly done by searching the literature, and some parts of the interviews were also used for exploratory open “what” and “how” questions. Later in the process, an evaluative approach was used to try to produce solution proposals for the focal company, as they are currently looking for rigid long-term plans to improve their environmental performance, without making too heavy sacrifices on their economic bottom-line. (Lewis et al., 2019, pp. 187–188)

3.2 Research strategy

Research is conducted by using a case study strategy (Voss et al., 2002), with a focus on not any particular project within the focal company, but three of its operational units. These were the units of analysis (Patton, 2002, p. 228) of the study. Based on the initial discussions, earlier research, experiences by the focal company, and the literature, three distinct processes within the focal company were selected: tendering, procurement, and design management. These are the three key operational processes that can most affect the scope 3 emissions going forward. It is still important to note, that the focus of the study is in SCM, so procurement-related issues are emphasized with each unit.

To make these three large units easier to examine, they were further reduced by limiting the sampling of interviewees to personnel with critical experiences from either LCPs or other low emission construction aspects. Therefore, purposeful sampling method of *operational construct sampling* was used. It is a sampling method, where the goal is to

study real world examples of the construct that is of interest (Patton, 2002, p. 239). As the key decisions of a typical D&B construction project are made in the tendering phase, it is natural to focus there. Interviewees were selected from within the focal company in LCP key personnel, cost estimation, procurement specialists, and one external emission consultant for design management used in LCP projects. More details about the interviewee groups are presented in the next chapter.

The focal company is a market leader in Finland on LCPs and has stated in its BP strategy that it wants to shift more focus on LCPs as well as D&B in general. In addition, the corporate strategy of the focal company includes the goal of reducing the scope 3 emissions. Overlapping these two development goals together is the case study scope of this thesis. This is presented in the figure 12.

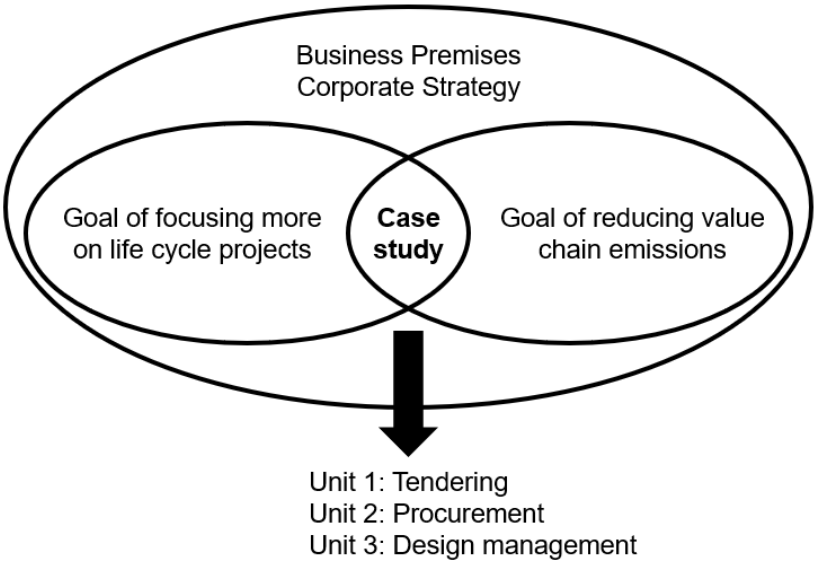

Figure 12. *Case study scoping with the three units of analysis*

As is defined by Patton (Patton, 2002, p. 447), cases are the units of analysis in a case study. So, the three operational units are used as the three cases. To go into more detail, the approach to case research in this this thesis is to use *emergent and embedded multiple case study*. First, the setting of the cases was emergent, as it was clear what the areas of interest and the context were, but throughout the process the focus evolved, and the insights gained from the data collected in various phases affected the direction of the research. This approach had therefore some clear similarities to grounded theory. (Lee & Saunders, 2017) Second, embedded case refers to the sampling and units of analysis discussed above. Instead of a holistic view of the focal company, the study is only focusing on the key processes between the key functional units. Third, a multiple case study was chosen as it gave an opportunity to examine each unit separately, and

then make cross comparisons to see if the operational units were similar in their outcomes and findings. (Yin, 2018)

Even though it is referred to as a multiple case study, the context of the research is solely focused on the focal company. The three units of analysis are not comprehensively researched, but rather they are examined in the light of the case study context: scope 3 emissions and LCPs. As all upstream scope 3 emissions are supplier-related, all three cases are then somewhat examined in relation to procurement of key components. Further definition of each case, and linkages of sampling to the case study are presented next.

3.2.1 Data collection by thematic specialist interviews

The main tool in data collection was to use one-to-one internet-mediated qualitative interviewing (Lewis et al., 2019, p. 443) with predetermined themes on the questions (Appendix A). One interview was done with two interviewees, and one was done over the phone, but other than that all were completed and recorded one-to-one in Microsoft Teams. All but one participant was employee in the focal company.

The interview themes worked as an *interview guide* (Patton, 2002, p. 343), but some parts of the interviews were quite informal and used even a conversational approach. This combination of two approaches supported the chosen emergent case strategy well, as each interviewee had a change to guide the conversation into areas that were not anticipated. Certain issues, such as identified bottlenecks currently stopping emission reductions, and opportunities to tackle them, were discussed systemically with each of the participants. Let us look at each of the units of analysis in more detail next. To maintain the anonymity of each participant, interviewees and their backgrounds relating to the case study are not explained in detail.

Tendering is not an actual function within the focal company, like design management and procurement are. Rather, it describes the phase of customer-led projects between deciding to take part into the competition, and the possible win or a loss. In D&B, during tendering phase the design gets already defined, as the final tender is for both design and the build, as well as for the 20-year liability period in LCPs. As this is the case, interviewees for this group were not focused to one process only: Building life cycle services, design and material cost estimation, and defining the customer value proposition were all relevant components. All three interviewees had plenty of LCP experience from recent quality graded competitions. Table 3 presents the tendering phase interviews.

Table 3. *Overview of the tendering case interviews*

Interview code	Organizational role	Duration (min)
T2	Use-phase services	83
T3	Cost estimation	60
T5	Life cycle projects	83

In **procurement**, the interviews were conducted on multiple levels within the focal company, and one of the participants was from Housing-segment. This was done to bring other segment's perspective on partnership development and emission reduction strategies into the study. Two of the interviews were solely based on the participants' LCP experience. In general, procurement personnel are a part of each projects white-collar staff, and their responsibility is to invite tenders and find the best suppliers for all required work and materials to complete the project. Some components, most commonly in Housing, have periodic contracts for them, which means that the project's procurement does not invite tenders on those purchases, as those supplies are predetermined to come from a certain supplier. Partnership development is naturally easier, when there is a periodic contract making the relationship commitments reach over single project limits. In this way, Housing segment's perspective and the higher-level development of periodic contracts were important to be included in the operational sample. Table 4 shows the procurement unit interviews.

Table 4. *Overview of the procurement case interviews*

Interview code	Organizational role	Duration (min)
P1	Engineer(s)	65
P6	Director	69
P7	Manager	67
P9	Vice President	60

Design management is the third case unit. As the construction sector is highly fragmented, this is also true for design. Design is typically done by specialized firms, and the focal company is only responsible for gathering the right designers and architects for each project and steering and managing these designers to the wanted outcomes. As this is the case, the focal company is outsourcing a lot of emission-related critical solutions to its designers, so having them under control is important. The design management responsibilities are typically on project managers in D&B, but in addition LCPs have a separate permanent resource for it, as well as a partnership with a consultancy that is used to help with more demanding design management decisions on emissions. These two permanent LCP resources were interviewed, as can be seen from table 5.

Table 5. *Overview of the design management case interviews*

Interview code	Organizational role	Duration (min)
D4	External consultant	75
D8	Life cycle projects	76

The order of the interviews can be seen from the number in the code on the first column of each of the three tables above. As the research was emergent and somewhat exploratory in nature, the order of the interviews was impactful for the findings. Before the first interview, the questions and themes were based solely on the literature review, secondary data, and author's observations that preceded the primary data collection process. As the interviews progressed, it was possible to keep asking constantly more detailed probing questions based on the data collected in the earlier interviews. Of course, there were scheduling limitations and things like that, which made it not possible to book all the interviews in any exact order, but that was the general idea behind why the order matters and is shown here.

3.2.2 The role of secondary data

A few sources of secondary data were also used for this research. Their role was mainly to help in creating an understanding of the bigger picture both on the emission sources within cement production, and on the industry structure in construction. Secondary data had more quantitative data in it than the primary data, but it was mainly used to support in the qualitative analysis. Data collection for the secondary data happened mainly before the interview process, but some overlapping happened as well. Overview of the secondary data used visible in the table 6 below.

Table 6. *Secondary data sources*

Source name	Source type	Data type	Role in the study
Roberts (2022)	Podcast	Qualitative and quantitative	Basics of the heavy industry decarbonization, especially steel and cement
Potter (2021)	Blog post	Qualitative and quantitative	Deep dive on construction value chain and various actors' typical profitability
Alarautalahti (2022)	Company presentation (Finnsementti)	Qualitative and quantitative	Decarbonization roadmap for Finland's only cement producer Finnsementti

3.3 Data analysis

Thematic analysis is a data analysis tool that fits well with the interpretative research philosophy and abductive research used for this study. With abductive approach, it was possible to take initial classifications from theory and then adjust them based on the data. The overall process was the following (Lewis et al., 2019, pp. 652–660):

1. Familiarizing with the data, transcriptions
2. Coding the data
3. Searching for themes and recognizing relationships
4. Refining themes and testing propositions

The initial data analysis began with coding the data with the interview guide as the starting level (Patton, 2002). As was explained above, the interview guide and therefore the overall data collection developed along with the process, so some of the initial codes were revised, supplemented and so on. Full set of the 20 final codes used for creating the themes and relationships can be seen in in Appendix B. For the coding and further analysis, ATLAS.ti program was used.

After all the data had been codified, themes started to emerge. To help in synthesizing, research questions were used. The questions discussed SCM (RQ1), tendering phase bottlenecks (RQ2), and ecosystem approach (RQ3). Based on the codes and these three key issues of the research, three main themes were identified: *Supplier engagement related issues*, *Customers and value propositions*, and *Internal processes hindering or enabling the ecosystem approach*. The approach is presented in the figure 13.

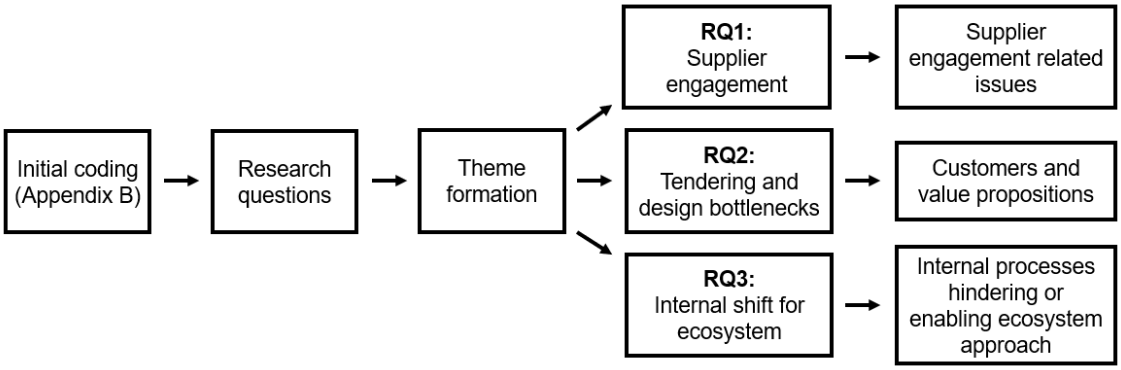

Figure 13. *Theme formation process*

Each theme was initially examined for each unit of analysis separately, and then finally across units. This was done to examine to what level the three units within the focal company have differences and similarities to between one another. As the research

questions and design suggests, the important sub-themes on each theme are identified *bottlenecks/challenges* to reach LESCM and the *solutions* participants saw as most promising to solve these challenges. For both the challenges and solutions, initial understanding was already created via the literature review and the observations made before the data collection. As new issues emerged during the interviews, they were immediately discussed in detail with participants, and in some cases tested with the following participants as well. This was done to get the best *evaluative* outcomes for all the suggestions and findings presented as the results of the study. This approach can be seen in the interview guide (Appendix A), as main discussion themes involve the suggestions for improvement as well as the main challenges. This made it easier to analyze the data and recognize most promising findings.

In this way, data collection and data analysis had clear overlap between them. Refining the themes and proposition testing, the fourth phase of the process presented above, was an ongoing process that was done throughout the data analysis phase. As was mentioned earlier, there were some elements of grounded theory involved, as the propositions were constantly tuned based on each interview. When an interviewee brought up something that conflicted with or was absent in the previous findings, it was immediately discussed and probed more deeply to find the most basic level of unity between participants and cases.

4. RESULTS

With the heavy fragmentation of the supply chains in construction industry, it can be quite challenging to pinpoint exactly what all things need to change, or should change, to make the entire chain less emission intensive. During the data collection, it became quite clear that both upstream and downstream from the main contractor can be expected to change. The responsibilities of each actor are much less clear.

As the cases have been defined to be the three units within the focal company, tendering, procurement, and design management, the internal relationships are in a way already examined by making comparisons between them. The three themes identified in chapter 3.3, based on the three research questions, are then used for systematically going through how the interviewees saw the situation from their unique perspectives. Trying to bring clarity to the responsibilities of customers and suppliers, and to the potential for internal proactiveness is the end-goal. These findings from the cases are then systematically compared to each other in chapter 4.4.

4.1 Tendering

Theme 1: Supplier engagement related issues

The number one issue making supplier engagement difficult, is the fact that BP projects are typically large and heterogenous. In two of the three interviews it was brought up that this type of business environment supports long-term supplier relationship building quite poorly. The idea of internal collaboration over segment limits was seen as a potential solution:

> "*The challenge is that this type of development can be applied much better to Housing. They can apply much stricter evaluations on the levels of capacity needed each year. BP lives from project to project, so the capacity switches year by year. So, how can we promise certain capacity, maybe by following Housing? However, Housing's product is quite thin in its requirements compared to BP. We can have huge shifts from steel to concrete to wood and their hybrids, which makes it tricky to promise a certain level of capacity upfront. Maybe we could use self-developed projects* as BP's leverage here?*" (T5)

*Self-developed projects are only a fraction of what BP builds yearly, whereas Housing produces mainly self-developed apartments. Self-developed means that the focal company works as a developer and therefore has control of all decision making, unlike in typical customer-led projects.

As the emissions mainly stem from the structural elements, that are typically similar, or can be designed to be similar with certain exceptions on heavily customer-led projects with design-bid-build, it was generally agreed in later interviews as well that this could be a possibility. An example from a customer-led LCP was brought up in interview T2, where the focal company had built a log-based campus and sheltered home. The motivation there was to order the structural components from a local log supplier that was preferred by the customer. As focal company was able to create a good relationship with this supplier quickly, it was part of the reason they won the tendering. This showcases, how project by project flexibility is still very much needed, even when proactive supplier engagement on capacity starts to happen.

Another important aspect that was recognized by all three interviewees was the time scale aspect. LCPs are inherently built to tackle the issue with the long liability periods, but the culture shift takes time. As the tendency is typically in favoring the short-term cost-based contracts with all suppliers and subcontractors, it is going to be extremely difficult to balance out the strategic components and their possible longer term contracting, and the flexibility and decentralization that remains on the project level. LCPs also mean that the willingness to try new products is reduced, for the exact risk aversion reasons that are natural with longer liability periods.

Theme 2: Customers and value propositions

In relation to the customers, the most important thing emphasized by all three interviewees was the always changing nature of the tendering process. It is going to be hard to try to create any type of standardized solutions when each customer and each building has unique special requirements. However, it is clear what the trend is for quality criteria. Proactively coming up with solutions that can reduce emissions cost-effectively will keep getting more important for competitiveness. In interview T3, it was mentioned how customers are already demanding more circularity-based solutions of reuse in their tenders. There the lack of existing ecosystem is even more strongly present than in low emission issues.

As was brought up in interview T5, the focal company has not widely branded its end products as differentiated on the low emission perspective. If it were to gain advantages

from increased customer interest with unique value propositions on these emission questions, it would require focusing more into the company brand on that matter. So far, focal company has done better the higher the quality criteria's emphasis has been, but if it does not commit more systematically to these emission questions, the success is not guaranteed with current procedure.

LCPs have also faced some issues with customers that stem from the fact that they are quite different from the traditional D&B. As focal company is the market leader and has built much more LCPs than its main competitors, the culture has already been rooted quite well on the liability periods between many of the customer and user groups in different municipalities. This is something, that could be tried to take advantage of with the ecosystem thinking. However, as noted in interview T2, currently the key personnel have limited resources for marketing of LCPs across Finland, but the opportunity has been already recognized: Pushing for more LCP adoption across Finland would be beneficial.

One thing that was found making it easier to work with LCPs, is that they have a very strictly defined use-cases as a public space. This makes some parts of the value proposition easier to define than in typical markets, especially during the life cycle phase. It is part of the explanation on why energy efficiency and renewable energy production have developed so well in LCPs, use phase does not have that much uncertainty for investments. In interview T2 this topic was discussed in more detail in the early days of LCPs, a major problem with the life cycle phase was how municipalities owned district heating production. Nowadays, ground source heat pumps (GSHPs) are already common in LCPs, as the emission reductions are valued more than the conflicting interests within municipalities on district heating. As benefits from the improved energy efficiency and own production are also shared, the economic and environmental motives are already well aligned.

Theme 3: Internal processes hindering or enabling ecosystem approach

Widely recognized issue is that the focal company rewards projects based on criteria that does not go well with the long-term thinking that is required for partnership building and emission reductions in general. Rewarding is based on individual projects' margins. Projects, and in some cases even units within the company, have limited collaboration or communication between them. As this was probed from the participants in later interviews, the reason seemed to be in the fact that the dominant mind set is that each project is fundamentally unique. Therefore, only limited advantages can be seen to be reached from increased communication across projects.

An important discussion within interview T5 happened on what should be done, if the focal company wants to be better at managing its emissions and systematically recognize opportunities in this area. Firstly, there should be an internal library of tried and tested design and material solutions. Currently, all updated data on solutions that are available comes to us via our designers, material suppliers, and so on. It is quite hard to start building unique value proposition from this situation. Second, more standardization from these internal improvements will mean more focus needed on managing those parts that are unique on each project. Instead of starting each project as unique, and identifying similarities later, it should be other way around. Third, as reorganization of the company has brought development lower, to segments and divisions, it has made these units very thin as well. There is no change of identifying potential long-term solutions when this is the case, and it might therefore require a separate unit. Overall, the need for better awareness and management to recognize the early opportunities in this space has been recognized.

As this discussion continued, it was concluded that scenario planning could be an important tool in making all of this happen. It will be crucial that this kind of solution happens on the right height within the organization. Initially it could be high-level, but it needs insights from segments and divisions as well. “It would have to still be about sharing insights and concepts, not ordering things to be done”. Current forums might already have something suitable. The timetable is, however, limited as was mentioned:

> “*In some years there will be no advantage to be reached, as you mentioned. At some point the processes will stabilize. We are making the leap to low emissions right now throughout the chain of construction*”. (T5)

With a systematic approach for scenarios, it might be easier to be equipped to react to changes in the competitive environment, just as well as be prepared. And it is always a possibility not to reach for these early advantages, of course. There is still a lot to be resolved:

> “*Information is fragmented. We talk about E-values, we talk about RTS-certification classifications, we talk about carbon footprints, carbon handprints, construction phases, use phases, and so on. There is information on these, but it is quite all over the place*”. (T5)

Important point is to link these ideas to the first theme above, where it was mentioned that there could be potential to do more collaboration over the segment and project type limits. If focal company could improve its foresight ability in this way, it would probably be extremely helpful in the proactive supplier engagement as well.

4.2 Procurement

Theme 1: Supplier engagement related issues

As was already identified, one defining factor of traditional contracting in construction is that each agreement is decided on lowest price. Short-term arm's length relationships dominate. In interview P1, where interviewees were procurement engineers from older, but still ongoing LCPs, this issue was discussed in more detail. As these projects had no quality gradings for emission related issues, and supplier relationships were the typical arm's length, time was mostly used on making contracts, and any environmental issues would feel like an extra burden to negotiate on each deal. This is how procurement operates on all customer-led price-driven projects. This was identified later as a key problem:

> "*Procurement has a limited toolbox in improving our performance in ESG* just like in work safety, quality, lead-times, and overall costs, as long as our focus is on making contracts and inviting tenders. That does not create value*." (P9)

*ESG is a term originating from the financial sector and is generally used for sustainability-related issues. For this study, it can be defined more tightly as just reducing emissions.

The issue with developing partnerships instead of making contracts relates to the problem already identified by the tendering interviews above. As Housing has a much better view on what it is going to build each year, it can define the material needs and therefore make proactive arrangements. This relates to the fact that almost all Housing projects are self-developed, the focal company has acquired the plots, the designs and so on. For BP, self-developed projects are the exception. Most projects come from the customer-led competitive tendering process, and you can never know for sure what kinds of orders and how many are going to be won next year. Basically, this is the reason, why periodic contracts are not used more in BP procurement.

However, it was mentioned in interview P1 that periodic contracts used to be common tool for procurement in BP back in the day. The reasons why the development of them had faded remained unclear. In later interviews, when this was bought up, it was mentioned that it related to the fact that design management is currently not that systematically organized. In history, the process had been that design management had a unit, whose responsibility was to collect and maintain the design solutions typically used in different types of buildings. As some reorganizations have happened within the focal company, at some point this responsibility has been lost. Standardization of design base levels have no longer been updated. In this situation, it is even more difficult than before

to make periodic contracts in BP on any component. This can be seen again as a question about what the level of uniqueness on an average project is. However, this is a controversial topic, as will be discussed in the design management chapter 4.3.

A good example of this came from interviews P6 and P7. In interview P6, contracts on elevator purchases were discussed. Unrelated to the study topic of emissions, it was just an example familiar to the interviewees. Housing has a deal with elevator supplier, that is used for all apartment blocks built by the focal company. Elevators are a clear modular product category, that is used both in apartment buildings and business premises. However, BP and Housing do not have a common contract for elevators, as BP's projects might have some unique special requirements, that are not included in the standard deal that Housing has. BP might need to pay double for their elevators, as the project-based deals are always more expensive.

There are good reasons for making some exceptions, that were mentioned in interview P7. If the focal company is participating to the project only as project management contractor, which is another typically used project model, it is required that all purchases are made via competition, so periodic contracts would not be accepted. But outside of these exceptions, in projects where BP is responsible for the design, meaning the self-developed and D&B-based projects, there are no good reasons why periodic contracts could not be applied. It would only require strengthening the portfolio-level management. Elevators are a good example, because of their similarity to the structure materials with the heaviest emissions: all buildings need them, and they can be designed to be similar in different kinds of buildings. And still, periodic contracts are currently not widely applied for these components. There would most likely be enough leverage on the focal company to negotiate its key suppliers to these longer-term lower-price deals, but the leverage is just not being used.

Periodic contracts are by no means an easy solution to fix all the problems. The problems were more thoroughly brought up in interview D8 and discussed later. The general idea with using per project deals is that it stops the focal company from over-committing and keeps things simple. As the end-products can vary, volumes can vary, prices can vary, it is just easier to be as independent from any single supplier as possible:

> "*There are pressures to constantly look for new suppliers from the market, which does not fit well with the partnership idea. Also, putting too many orders on one supplier is also seen as problematic.*" (P1)

This describes well the overall approach to interdependence. Instead of partnering, the competitive market is seen as the best source of innovations, and buyer is mainly responsible for creating demand. As the material supplier market keeps consolidating more to large, vertically integrated (Potter, 2021) material suppliers, this approach might not work too well in the long term. An example from interview P1 showed this: When the procurement teams in LCPs had found a good quality low-cost small supplier for a certain fragment of all typical school projects, this supplier got acquired by a larger supplier. Therefore, it could be argued, that as a large construction company, the key suppliers are good to have locked in and managed more systematically.

As Housing has a more standard construction process, and therefore uses periodic contracts, they have been able to start developing their roadmap for emission reductions on hollow core slabs, one of the heaviest emission components of a typical element-based apartment block. As a partner, they have used their second largest, over 20M € a year, concrete supplier. The key to the noticeable emission reduction in those slabs is in using blast furnace slag (BFS), a side stream from steel production, to replace extremely emission intensive cement. Without going too deep into the details, BFS has very similar properties than traditionally used Portland cement, it just requires a bit more time to harden (Alarautalahti, 2022).

So, with this partnership, Housing segment has been able to pilot and now start building larger volumes with these BFS-based slabs. Initially, the price of the slabs was 12 % higher than traditionally made, but the cost has been coming down quite quickly as volumes have started to grow. As the drying times are longer, full price parity cannot be reached, but overall, the price difference is already quite small and can reduce the total emissions of an apartment block by 6 %. However, things are not that straightforward. Half of Housing in Finland is building with a cast-in-place instead of element-based process. That means, that using high levels of BFS in the cement would mess up the schedule of the entire process, as the drying happens on site. So, cast-in-place is even harder to decarbonize, as elements cannot be pre-dried in the factory. Initial steps on reducing emissions have been taken on cast-in-place as well, but there the development is not a similar partnership as with the hollow core slabs.

Based on this, it is easy to understand how Housing can be seen as the driver of the entire emission reduction effort within the focal company. They have a clear process, self-developed projects that are easier to predict, quite standard product, high number of projects, partnership on key component, and so on. In interview P9, this approach was still criticized:

> "*It makes completely no sense that we have [Housing Helsinki] with its own green hollow core slab strategy, and right next to it we have a BP project site buying their own elements individually. Every project is asking tenders from basically the same set of suppliers and competing for the same key suppliers. We think that it guarantees the best prices when everything is tightly tendered. The fact might be that the suppliers make the decisions: They hand pick those orders that they see as the most profitable for them, and over-bid on those projects they do not want to win*". (P9)

This is suggesting the same solution, that was identified in interview T5 as well. More volume and steadier relationships with key suppliers could be reached with better internal coordination across project and segment limits. It also suggests the same thing that was concluded earlier, organizing a competition is not a guarantee of getting the best solutions out of the market, especially when the supplier field is concentrated.

In general, all the procurement interviewees agreed that periodic contracts, and the fact that they enable steadier relationships within the construction supply chain, is beneficial. With Housing, the partnership has made it possible to get moving much quicker with low emission components, than what it would have been within the open market. The advantages of sharing knowledge and learning that accrues as these new solutions are tried and tested can be shared fairly. The key issue right now has to do with the combination of emission reductions causing short term price increases, and with the current inflationary environment already putting pressure on margins. There is a need for a clear long-term vision, that reduces the focus put on the few initial lower margin projects that might be required.

As has been emphasized already, being early mover in situations like these is very challenging. Issues about LCPs being risk averse on new technologies and the challenges with wood construction being too expensive were also discussed. Overall, the best solution was found to be in building synergies between frame structure material demand across projects:

> "*We could, with our combined capacity, promise five key suppliers a certain baseload, e.g., 200k € every month, if we wanted to. They would lock that capacity proactively for us, and in return they would agree to reduce their products' emissions each year*." (P9)

It was identified, that taking this approach too far will cause more problems than the advantages of increased supplier engagement would bring. Therefore, this idea should not be applied to everything, but rather the most strategic supplier categories, of which

this study focuses on the heavily emitting frame structure materials. But for now, especially BP has absolutely no levers to demand anything from suppliers, as the supplier relationships are all arm's length.

Theme 2: Customers and value propositions

As the responsibilities between suppliers and contractors on emissions seems unclear, similar situation applies to the relationship between customers and contractor-developers. The important topics that were discussed on multiple interviews were marketing and values of buyers, and the difficulties of unique location-related demands customers might have on LCP schools. Both things are related to the value proposition, and how it needs to have enough flexibility to cater well enough to all the different customer segments that the focal company provides for.

In self-developed projects, especially in BP but on some Housing projects as well, a typical customer is an investor with strict ESG-standards. In recent years, these standards have been getting stricter. This is a clear reason behind why the SBTi-process has been initiated in the focal company, and one of the reasons for the increased interest in building from lower emission materials. In a similar way, public sector has its own emission reduction standards, as governments in Finland and around the world announce their climate pledges. For these customers, it is quite straight forward to explain that the highest emissions in a building come from certain materials and decarbonizing them will cost money, and this will increase the costs as well. But in B2C markets, which are clearly the biggest market in Housing, these values are much less clear:

> "*A typical home buyer does not care about how green the concrete is, they have other preferences*." (P7)

What this means, is that the value proposition needs to be framed a bit differently. As a solution marketing was seen as the main tool. Interviewees were not marketing specialists, so identifying the opportunities there is outside of the scope, but overall, the feeling was similar than the earlier mentioned from interview T5. As there is no systematic approach that would combine emissions to the competitive strategy, it is hard to initiate marketing efforts, either. And without a brand built around low emissions, it is hard to get people interested, which would be a requirement for the business case.

Then again, concrete is extremely cheap, low value-add product. This means that the increase in the end-prices from decarbonization of concrete is estimated to be only 0,5 % per building, even without counting the plots into the prices (Roberts, 2022). In this sense, the issue is only about how to share this extra cost fairly, as it is basically in everyone's interest to make sure this transition to low emission products happens. No

actor in the value chain is still willing to take this price increase alone into their own margins.

Returning to the LCPs, there the systematic approach to reducing emissions on key categories is partly interrupted via customer requirements on facades. Facades are an issue where the customers can have clear preferences, especially in areas where cityscape is cherished, such as Helsinki metropolitan area. As facades are emission-wise a second important category in addition to the structural elements, this can be a problem on that perspective, as well as in general:

> "*It kind of fades the original idea of the contractor agreeing to take care of the building for 20 years, as you would assume they then know what the best solutions are. If we have not that much to say on [facades] as users express their strong preferences, how can we then be held responsible?*" (P7)

This is an example of how the D&B-idea under LCPs is getting fuzzy in some aspects of the decision making. These competitive negotiations before each project have dialog, and all tendering participants have multiple rounds of discussions with the customer to make sure, everyone understands the rules of the competition clearly. Again, this explains why approach is different from project to project. And as focal company has the experience of going through all these discussions and understanding of how even chemistries on personal level can affect each individual projects' outcome, this is a clear advantage that should not be overruled.

However, as was mentioned in the interview P9, there might be opportunities for the more standardized approach even with customer-led projects. If focal company took a SCM-approach, meaning that it would have predetermined partners for low emission products, who are known well and are guaranteed to be cost-effective and low emission, in a lot of cases the customer would most likely approve this supplier. Maybe even for facades, but at least for the previously mentioned frame materials or elevators, there are not that many good reasons for the customer to demand invitations for tenders from the open market, if there is a good deal already in place, negotiated by the focal company with the leverage of higher volumes:

> "*The only nuances are in the decision-making, some things might require decisions to be approved, we might need to use certain partners, but that is completely fine. It might be that because of these restrictions we cannot use our familiar partners who we know would be cheaper on ESG issues and so on, but these are only the exceptions. There aren't that many of these, and a reasonable customer will accept our supplier when we explain its advantages in most cases*." (P9)

As was discussed in interview P7 and in D8 later, the quality gradings on emissions are moving towards open level of emission reductions. Instead of stating that one quality point will be awarded at -10 % reduction in emissions and second one at -30 %, customers are moving towards a model where participants can offer as low emission tender as they see reasonable in relation to the cost increases. In these kinds of situations, the pre-negotiated volume-based deals could be extremely valuable.

Theme 3: Internal processes hindering or enabling ecosystem approach

As has been already briefly mentioned, an important distinction to make is in what parts of a project are unique, and what are not. Two of the clearest opposing points of view were presented in interviews D8 and P9, but this topic was discussed with multiple procurement interviewees in some form. When every project is seen as fundamentally independent and unique, it makes the development of periodic contracts, proactive supplier development, and well-defined value propositions impossible. As the interviewees from procurement, except for P1, were all responsible in some way or another for the development of periodic contracts, it is easy to understand why these interviewees saw that shifting approach from uniqueness to similarity across projects is needed. The opposing point of view will be presented in the design management chapter 4.3.

For theme 1, it was already explained how key issue with the development of periodic contracts was found to be in the fragmentation of the design management. However, a more fundamental issue was also discussed in detail in interview P9:

> "*What the structural issue is, is that internally we frame everything in a way that every project is unique. We decide it, instead of deciding that each project is similar, except this and that thing. We should just identify the key issues that make each project different from a 'typical' one and find a way to deal with those early on. But we decide that it is primarily completely different*." (P9)

What this kind of approach then means, is that projects are treated as individuals. Each project decides, where they buy their concrete, steel, and other heavy emission components. When these decisions are always made project by project, it does not matter what the headquarters decide on emissions, as these decisions will have no impact on individual projects and their decisions. Then, this project individuality has led to project personnel having a large part of their salaries paid in per project bonuses. As each project's success is measured via its margins, every decision on project happens with these margins in mind. So, if emission reductions are seen as threat to margins, they will not be implemented, even if the pressure on margins would only last for a couple of projects,

as these low emission supply chains get built up. Rarely do people want to make personal sacrifices “for the greater good”. This is how current situation was described in interview P9.

Continuing with interview P9, the systematic process of construction was also discussed. The current situation is that Housing has a process, either the element-based, or the cast-in-place one, depending on where in Finland the construction takes place. Outside of that, no systematic process exists, due to the previously explained uniqueness. And even the Housing process can be seen as problematic, as it has been created during a time when no attention on emissions was required. Dividing walls are thick reinforced concrete, and so on. So, the next meaningful steps on the decarbonization path might require making major changes to the process, starting from the design, and that is very demanding. It is just so much easier to keep building the same way, and only piloting the green materials when they happen to fit into the schedules due to some exception. This makes it impossible for the low emission products to gain any meaningful volumes. Making the more radical changes to the product would require short-term pain on the margins, as Housing has the B2C-related issue of price inelasticity. In BP, the same inelasticity applies on the customer-led projects not using quality criteria, in the “traditional” project models.

In general, other procurement interviewees saw the situation similarly. All the easy emission reducing changes that can be reached without heavy redesigning of processes have been made. Now, the concrete pathway from the current state to the low emission state is required. In interview P1, engineers emphasized how they have not been trained on the low emission issues, so they could not push for it even if they wanted to. In interview P6, the low emission hollow core slabs were agreed to be well tested, working, and ready to go. All that is needed for taking the first step is to make the commitment for a periodic contract on all suitable project types to start using these low emission frame materials.

Making this commitment is challenging, as everyone is used to the project-by-project approach on everything. As was mentioned in the interview P7, making a shift to a centralized decision-making on any part of construction, and that decision then later turning out to be wrong, can be devastating. Even a large construction company could fail there. But then again, that is exactly why the shift would make sense to take place initially on the safer components with relatively low prices and high emissions. Additionally, these components have vast volumes, so getting them made from low emission waste streams such as BFS is very likely to become a bottleneck at some point. Following others will not be enough to secure the capacity, as was mentioned in interview P6.

To understand, what is required for this transition, an example from safety practices was raised in interview P9:

> "*Many do not realize this, but production sites do no longer get to decide if they are going to use helmets or not. No one talks about what it costs to buy helmets or other security equipment. When we have this, we have a structure for notifying about deviations, going through data about deviations, we look for the root causes […], we improve the process, we make changes.*" (P9)

Now, there might be a similar situation unfolding on emissions, as what has happened with safety earlier. As public and private sector are both demanding improvements, there is no other way than to create a centralized platform for making sure there is compliance on these issues. Safety has already reached this level, as there is a certain level of continuous improvement, process thinking, and discipline.

This relates to productivity. Emission reductions have a lot of common with productivity improvement, just like safety, as all require ability to manage material and information flows better across projects. When there is a lack a process of construction, it is impossible to be creative on continuous improvement. As was discussed in detail in interview P9, there is a huge demand for creativity in construction projects, but without a systematic process, there is nothing to target that creativity into. That is the limiting factor in overall productivity as well. Each project gets creative and solves their unique problems, but it does not transfer to the next project.

To start creating this process of construction, more stable relationships are needed. Being a first mover, starting to develop these emission-critical partnerships with periodic contracts now, would enable the focal company to hand-pick the best frame material suppliers. Housing has started this already, but this approach could be expanded for all relevant projects. However, especially on workloads bought by subcontractors, it is crucial that the productivity gains that become available, are shared:

> "*This is a trick that we cannot make alone: We do not build our buildings alone, we do not produce our own materials. So, the productivity leap will not happen for us alone. […] For our subcontractors, it is better to sell longer workloads on individual projects with a bit lower margin, as there is no certainty over future demand. Basically, the whole ecosystem is currently built against this kind of development*." (P9)

Every actor in the ecosystem is optimized to run its business with these short-term contracts. So, shifting away from them would require major strides in the beginning. While it is a major challenge, it is also an opportunity: Small-scale builders cannot offer the same

kind of continuity for their key suppliers, as a large company can. This could be focal company's window of opportunity. For the focal company, getting to pick the best partners and helping them to organically grow with it, could offer sustainable competitive advantages.

The focal company has been developing its takt production process, but that is too slow to scale for these emission issues, according to the interview P9. For emissions, even the "weirder", strongly customer-led projects, need to have an option to procure their heaviest emitting components with centrally negotiated deals. Currently, there are major issues in getting there. Most of them have been already explained, but one example is worth mentioning from the development of periodic contracts via category management on ready-mix concrete:

> "*This development failed, because the key personnel who would have had decent knowledge on both the concrete and its procurement, let me know that they are eager and happy to help, but they were already working on a project. If they spent too many hours on this outside-the-project work, they would not be getting their project-level bonuses after the project.*" (P9)

This is an extreme example of where the project individuality-based approach can lead. Internal development of long-term strategy might be blocked, because of how the project rewarding encourages personnel to commit only to one project at a time. As the solution suggested in the interview would strip some responsibility of decision making out of individual project's hands, then might be reasonable to suggest, that such a project individuality-approach might need to be changed on rewarding as well. As that is not in the scope of this thesis, it is rather just used here as a clear example of the difficulty of the current situation.

4.3 Design management

Theme 1: Supplier engagement related issues

In the two design management interviews, the most important outcome was the decision to focus on frame structures only. In interview D4, it became clear how from individual component categories most emissions are stemming from frame structures and facades, the two with the largest masses. As this is the case, reaching the typical maximum quality grading level of 30-40 % reduction in emissions used in a few of the recent competitions, it would require a lot of changes:

> "*It would require making the structures lighter, especially in frame structures and facades, also switching frames from concrete to wood, roofing to wood, and why not also low carbon products. CLT* used in load-bearing structures*." (D4)

*CLT means cross laminated timber, a versatile wood-based element that is currently not very competitive in price in Finland compared to concrete elements.

Making structures lighter is an approach that relates to material efficiency. Material efficiency, although not at the core of this study, is clearly an effective way of reducing emissions. Currently, concrete is quite cheap, whereas designer man-hours are not, so the incentives for spending money to get always optimal structures and minimal waste are not that strong (Roberts, 2022). However, as these quality gradings and other ways of pricing emissions start to rise in significance, there is plenty of potential there as well. Wood construction was also not at the core of this thesis and will not be further discussed here.

Development of low emission products, on the other hand, is a key issue for this study. As was mentioned already in interview P7, and later in interview D8, facades are a difficult category of products, as the LCP customers especially can have a variety of preferences. That was the main reason the focus is mainly directed towards frame structures only. However, outside of the Housing-led partnership with low emission concrete element producer, there is only a limited number of standard solutions that are currently used on most quality criteria projects to reduce the emission intensity of the building.

When this topic was discussed in interview D8, a lot of good points on the problems of more standardization were raised. As the focal company operates as a main contractor on a variety of different projects with unique requirements, on most components that are used, the volumes are negligible for the large multinational corporations that are producing them. These suppliers have no incentives for making periodic contracts with any single one construction company. Similar issue was presented by Potter (2021), shown in figure 14.

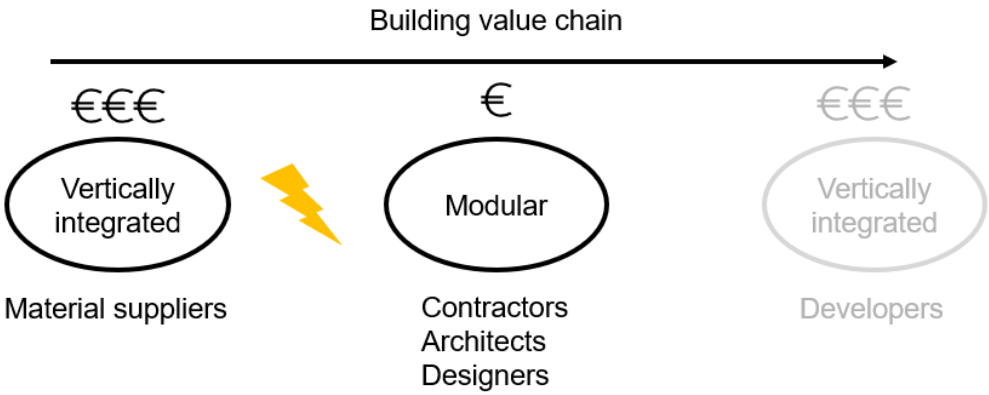

Figure 14. *In construction, profits tend to accrue more towards vertically integrated portions of the value chain over the highly competed modular ones (adapted from Potter, 2021)*

As a solution, in interview D8 it was presented that the focal company should only act as a mediator, as it gets growing demand for these low emission products from customers, it mediates this demand upstream to its suppliers. It was, however, seen as a benefit on frame structures to have proactive approach, as it can be seen as a product category where availability of the low emission products might become a limiting factor later. But taking the centralized approach too far outside of these selected strategic components was emphasized to be dangerous. This is the case since there is a lot of positive aspects in having flexibility project-by-project, as has been identified in previous interviews as well.

Theme 2: Customers and value propositions

Quality criteria was naturally the main topic of the interviews for design decisions with customers. In recent competitions, the criteria set up by the customer together with its consultants have been weird: Comparisons have not been emissions based but material based. What this means, is that the criteria have not been rewarding for the absolute lowest emissions, but instead for lowest emissions “relative to a typical building made from the same materials”. The reason has probably been in simplifying the competition process, as there just is not clear rules on counting emissions yet. Comparing to a similar building might be a bit easier and might leave less room for “creative counting”.

Both interviewees agreed that the use-phase emissions are a much easier issue than the embedded emissions from building materials, as those are built in for LCPs:

> “*Only way to build capacity for these low emission products is to accept that they are at least initially a bit more expensive, so the value judgement needs to happen in the ‘high end’ of the chain. We have already done this trick in the energy effi-*

> *ciency side, there are clear measurements, actors, and entire ecosystems for reducing these emissions, so now we just need to do the same on the materials side*." (D8)

Basically, these value judgements are clearly already starting to happen, as quality criteria are used more widely, especially on LCPs. As was mentioned in interview D4, emitting is still too cheap for the progress to start happening without these external value judgements. The best low carbon products cost about 0,20 € / kilogram, so it is still over double the price of what it would be to just use standard solutions and buy rights from EU emission trading at 100 € / ton of carbon dioxide.

For now, each customer is still defining their quality criteria so differently, that it makes it hard for the focal company to make any proactive decisions with its suppliers. As has been mentioned already multiple times, the direction is still quite clear, and absolute emission reductions are starting to be what is valued the most. There is just the fact that LCPs are not fit for testing demanding technical new ideas.

In addition to lower emissions, recent tenders have been giving value to circularity. As was brought up earlier in interview T3, this is a challenging topic to offer solutions for in LCPs. In interview D8, it was suggested that testing and developing these circular solutions should be the responsibility of these more profitable portions of the value chain (see figure 14). In LCPs, if some unexpected issue comes up with the reusing of old materials, it might destroy profitability not just for that one project, but of multiple projects afterwards. In this way, it is argued that these issues should not be construction company's responsibility.

Theme 3: Internal processes hindering or enabling ecosystem approach

It was mentioned with the tendering chapter, how a systematic approach to managing the opportunities on possible new ventures is currently lacking on emission reductions. One of these examples used was an innovation developed by the focal company's partner, where the GSHPs are used for heating already in the construction phase. These kinds of innovations might be great sources of competitive advantage if the focal company was involved in their development. As it is currently not involved, it lacks any type of exclusivity to use these innovations its partners are developing. In interview D4 this GSHP-based innovation was brought up as the single most impactful solution for the low emission quality criteria on a recent tender.

Additionally, in interview D8 the suggestion was that the focal company should not even try to engage in the development of more standardization and similarity of solutions

across projects, as that is not its core competence. Construction industry is just seen as such a fragmented and heterogenous industry, that it does not work:

> "*Our main know-how is that we can quickly and efficiently gather the currently available teams, materials and resources that are optimal for the current project's situation and preconditions. On the other hand, it would be great if we also were one of the first to find new ideas that have enough track record already from elsewhere.*" (D8)

So, instead of focusing on more stable networks that has been suggested earlier, in interview D8 the approach was instead to embrace the current situation and the flexibility it offers. This is an important perspective and should not be forgotten when reaching for the potential ecosystem advantages. As was already mentioned, frame structures are a potential exception, agreed even in interview D8, due to their strategic significance for emissions.

4.4 Comparison of the findings

As the study was partly carried out with an evaluative approach, clear distinction between things that are already working, and things that need to change, was present in the findings. Therefore, comparison of the findings is presented with enablers and barriers separated. Naturally, each unit, or even individual, had a bit different perspective on the issue, and now these differences will be looked at in more detail. Overview of the similarities and differences can be found in table 7.

Table 7. *Overview of the results by theme, divided to enablers and barriers*

		Tendering	**Procurement**	**Design management**
Supplier engagement related issues	Enablers	Collaboration over segment limits Flexibility to changing customer needs	Collaboration over segment limits between Housing and BP on capacity Periodic contracting for building supplier relationships	Quality criteria already demanding innovative solutions Focusing on frame structures initially to prepare for the possible bottleneck later
	Barriers	Capacity requirements are difficult to forecast Lack of long-term thinking in transactions	Finding the right balance between project similarity and uniqueness Design management fragmentation within BP segment	Volumes not large enough to make a difference for large suppliers
Customers and value propositions	Enablers	Use phase certain and ecosystem already in place	Reducing emissions can be expected to keep getting more valued by customers	Quality criteria makes it clearer what each customer values Portfolio management to identify strategic opportunities early on
	Barriers	Lack of a general definition for low emission buildings Brand image not aligned for low emission leader	Customers in B2B and B2C are different Value of cityscape is highly location-based	High variety on what customers value on each project
Internal processes hindering or enabling ecosystem approach	Enablers	Portfolio management for identifying opportunities over segment limits Scenario planning to support the shift to more proactive relationships	Safety as an example of the needed process-like approach Systematic process of construction enabling continuous improvement	-
	Barriers	Information on emissions is fragmented, no systematic approach Rewarding based on project-based profitability blocks key low emission initiatives	Project individuality, and resulting project-based profitability measures Key decisions on emissions happen on each project individually	Embracing modularity and minimal standardization has worked so far and is rooted into the culture

For **theme 1**, all three units generally agreed that a certain level of flexibility is required. All projects have special requirements, so it is by no means realistic to suggest that everything could be prepared for in advance with periodic contracting or partnerships. In tendering and procurement, collaboration over segment and project model limits was the key solution, and the barriers were mainly on making that happen. However, for design management, especially in interview D8, this approach was widely questioned. As the

supplier field has already seen heavy consolidation, it might be that the focal company does not have enough leverage to start making these key periodic contracts. In certain supply categories this could be true, but for frame structures a general agreement was reached that periodic contracting and that way development of a stable network can be seen as beneficial.

For **theme 2**, the key issue was on who should carry the risks of pushing the industry forward. Every actor across the chain knows that this is an ongoing shift that will require changes, but for focal company it is hard to commit to anything until it is guaranteed that the customers are always willing to pay for lowering emissions. No clear conflicts across units were found, except on the degree of ambition that should be taken. A few participants saw the situation more as starting with marketing and building a brand around these issues, in interview D8 no common value proposition was seen as needed due to project uniqueness, and in interview P9 proactive approach was seen as the only reasonable one.

For **theme 3**, there was a clear conflict between the answers from tendering and procurement, compared to the design management. Especially interviews T5 and P9 suggested, that a more centralized and top-down approach is needed for the next steps in meaningful emission reductions: Currently, all “painless” measures that can be easily applied without any larger changes to the core business activities have already been done, and the next steps would have to have an effect all the way to individual projects’ day to day operations. Mainly in interview D8, it was argued, that larger changes are not needed, as systematic and proactive measures do not work in construction industry due to the project-based business uniqueness. So, the key question is, how should these two very different points of view be balanced.

5. DISCUSSION

5.1 Supplier engagement and SCM

The first research question of this study deals with supply chain management and its linkage to emission reductions.

RQ1: What are the key opportunities on a building construction project for improved supplier engagement to reach meaningful emission reductions?

Based on the data collected and the literature reviewed, the approach of weak supplier engagement might lead to current emission reduction targets to not be reached. As each project is treated mostly like an individual, at worst it can lead to situations, where focal company's own projects are competing against each other for the same key suppliers. The industry is built around these short-term reactive relationships, so every contract is made with an intention to protect each actor's own self-interests. As was found by Sheffer and Levitt (2010) as well, this development is a result of the built-in risk averseness of a fragmented industry. It was clearly visible from the data collected, that construction is a cyclical industry and the limited visibility into the future demand makes this fragmentation an attractive option. But without a more systematic approach, the ambition set for SBTi or any business development goal that involves managing the supplier field, will be very difficult. The results here suggest that this shift is necessary, and if it is not done, a competing company might do it instead. This would result in the best possible partnerships to be already unavailable later.

Cox and Ireland (2002) have found that the key problem in the development of lean methods in construction is that it requires the buyer, the construction company, to be in a position of power over its suppliers. In standard manufacturing, the situation is often very different compared to construction. There suppliers are producing high numbers of components in a commoditized fashion for the same buyer. In construction, the situation shifts: Suppliers do produce high numbers of components, but they are shipped to a high variety of different sites, and no single customer has clear dominance. This was found to be the case in this study as well. For this to change, the focal company would need to come together with all its volume and make itself as attractive buyer to its key suppliers as possible. If it could start establishing longer-term supplier relationships, only then could it start to do SCM and that way LESCM. Naturally, these kinds of solutions do bring their own risks related to the increased interdependency.

Similar approach as that of Gadde and Dubois (2010) is therefore suggested. Projects and their partnering will need to be divided into more than one level. There cannot only be a local level management on each project, where all key decisions are made. This local level decision-making is extremely important, but for more strategic components, a central level partnership network is needed to create stability and improve SCM in a controlled manner. Without this kind of approach, it will be very difficult to build collaboration across segments and different project types, even on the basic components that are used in similar fashion in most buildings. As these basic components are often the ones with the heaviest emissions, this is the core outcome of this research. Decentralized decision-making on the most impactful supplier decisions will most likely not bring the desired outcomes.

The key to making this shift happen is in required change of attitude towards emission reductions. As was found by Plambeck (2012), when supplier field is engaged to the LESCM effort, after the short-term complexities, there can be a lot of improvements for the entire value chain available. Starting to use periodic contracts to categorically manage all frame material suppliers could be a sustainable competitive advantage. As suppliers get locked in longer term contracts where they agree to reduce their emissions, competing firms will have hard time getting similar deals later, especially locally in Finland. This is especially true for BFS-based elements, and similar products. As was mentioned by Plambeck (2013), there is a good change these tried and tested low emission products will at some point start attracting a lot of imitators, which makes securing capacity later constantly more challenging. BFS is, after all, only a waste stream from other processes, so availability can certainly at certain point become a bottleneck (Alarautalahti, 2022).

5.2 Customers, value proposition, and the low emission ecosystem

The second research question deals with the value proposition and the challenges currently faced in the communication with customers who want to reduce their emissions.

RQ2: What are the main bottlenecks currently for tendering phase emission reduction commitments?

For RQ2, the findings of the study are clear and linked to the RQ1. As one-off projects are the main way of construction, each competition is built modularly from the ground up with the available resources available on the given time in the given location. So, when the customers are inviting tenders with quality criteria on emissions, or even circularity, the solutions are underdeveloped, as the suppliers have no visibility downstream and

have optimized their offerings to match the typical price-driven tenders. Over time, as quality gradings get more common and emissions get a price, these supply chains will reorganize, but for now, there is no central actor taking the initiative to push the supplier field into this direction.

For the focal company, the main problem now is that the quality criteria are still in development, and each customer defines and values emissions in their own way, based on countless factors that are not possible to be predicted in advance. However, by taking advantage of focal company's size, it could reposition itself behind a common low emission value proposition, in which it would categorically focus its procurement on the most emission intensive products to certain suppliers, who it knows has the resources to develop these low emission products for different projects' needs. One of the important advantages of doing this kind of shift in approach would come from better information sharing and knowledge accruing that can only happen between more stable relationships (Ahmadi-Gh & Bello-Pintado, 2022; Saini et al., 2019).

Although not at the core focus of this study or RQ2, similar issues can be identified with other customer segments than just public buyers. As public buyers use quality criteria for their low emission commitments, private investors have ESG-criteria and B2C customers use personal value judgement. Without creating a comprehensive brand around being a sustainability leader with low emission construction materials categorically used in all projects, these customer segments might be difficult to get involved. For investors, the ESG-motives are already quite clear and growing in most cases, but especially on the B2C side the value proposition needs to be distinct.

The third research question deals with the low emission ecosystem, and internal issues that need to change to get there.

RQ3: How should the focal company change internally to be able to gain early mover advantages in the low emission construction ecosystem?

For RQ3, it is suggested that more is needed than just the partnership-building with key frame suppliers and a resulting value proposition that can be used for tendering. For identifying opportunities in the wider business ecosystem, a clear, more systematic top-down approach is needed to supplement the locally happening project management. For that, portfolio management was seen as a promising opportunity. As the project portfolio is clearly linked to the business success factors, and each individual project is measured against how it fits to the overall competitive strategy (Meskendahl, 2010), that is the way how ecosystem leadership could be built.

It became clear during the study, that the use-phase ecosystem is already well in place, and most remaining bottlenecks are upstream. Adner and Kapoor (2010) have found, that in a situation like this, it is typically more beneficial to be an early mover. By finding the right upstream suppliers, with whom the decarbonization effort can take place, the focal company could reach improved competitive position in its value chain. As the suppliers of key components are getting consolidated into large multinational entities, it is important to be able to create relationships with combined volumes of all applicable project types across all segments. That is suggested here to be the best way for more stable partnerships to form.

One key requirement of this kind of approach would be to gain better economies of scale in these key product categories, in this case mainly the frame materials. Currently, the main hindrance stopping this from happening, is that no similarities between different project types are recognized. Even as projects use similar structural components, made from concrete, steel, wood, and their hybrids, there is only a limited attention currently put on designing these components similarly across projects, so that they could be more easily purchased from the same suppliers as often as possible. The results of this study suggest that the main reason, why this kind of approach has not gained popularity, is in how BP segment is seen as unpredictable by nature. There is no guarantee on how many square meters the company is going to build, where these buildings are located, and what kinds of unique requirements these buildings will have on them. These buildings can be offices, schools, sport centers, and so on. But even as this is the case, the core materials, and this way the core upstream sources of emissions, remain the same, and to some level, forecastable.

Overall, it can be said that a heavily future-oriented approach is suggested in this study. For the focal company to be able to make itself an ecosystem leader, it would need to strengthen its internal resources on managing opportunities within the low emission construction ecosystem. Initially, it would need to identify the leading low emission frame material suppliers, who are convinced that the focal company is committed to making the leap to low emissions (Jira & Toffel, 2013). That will make it possible to start creating the stable relationships that are needed for managing the supplier field. Then, it would need to find internal resources for estimating the future demand on these frame structure materials and other strategic opportunities around the low emission ecosystem. As an example, focal company has not been involved in the development on an innovation that uses GSHPs already during the construction phase, reducing overall emissions significantly for the building. It would need to be more actively involved in these kinds of opportunities to be able to claim the ecosystem leadership position. This would require

scenario planning (Miterev et al., 2016) or similar approaches not currently widely applied. As the focal company has a high number of experts on various areas within the construction value chain, by organizing this resource around forming scenarios for future might be extremely valuable to remain ahead of competition on the path towards decarbonization.

The estimations of future demand from key material suppliers do not need to be exact, and they can be left with a safety margin. As is suggested by Taylor and Plambeck (2007), these kinds of contracts that aim at development of low emission production, should not be strict and court-enforceable, but rather relational. As the focal company can estimate exact numbers only on Housing and BP self-developed, these could be used as the bottom line. The key issue is not in getting the capacity estimations exactly right, as this can be negotiated with the suppliers in most cases, but rather in the fact that these contracts will need to protect the focal company from the possible price shifts these low emission materials can face as raw material availability, legislation, and countless other factors can shift the short-term market prices in the future. Additionally, these agreements are made to make sure, that the suppliers have a clear motivation to reduce their emissions at the promised rate.

5.3 Suggestion for the focal company

To summarize this chapter, an overall presentation of the findings and their meaning is presented. This study suggests that it does make sense for the focal company to make the commitment and organize around a low emission value proposition. The objective of this is to create an ecosystem, where it is strictly defined who are the suppliers of the key materials on all the buildings built within this value proposition. The value proposition would mainly focus on D&B (includes LCPs), self-developed, and Housing built buildings, as those are the ones where the focal company is fully responsible of the key design decisions. For other project models, especially project management contracting, this value proposition of low emissions would be applied when applicable. For customers, the value proposition remains unified, even as each project model typically serves customers with distinct interests. Figure 15 presents the overall idea.

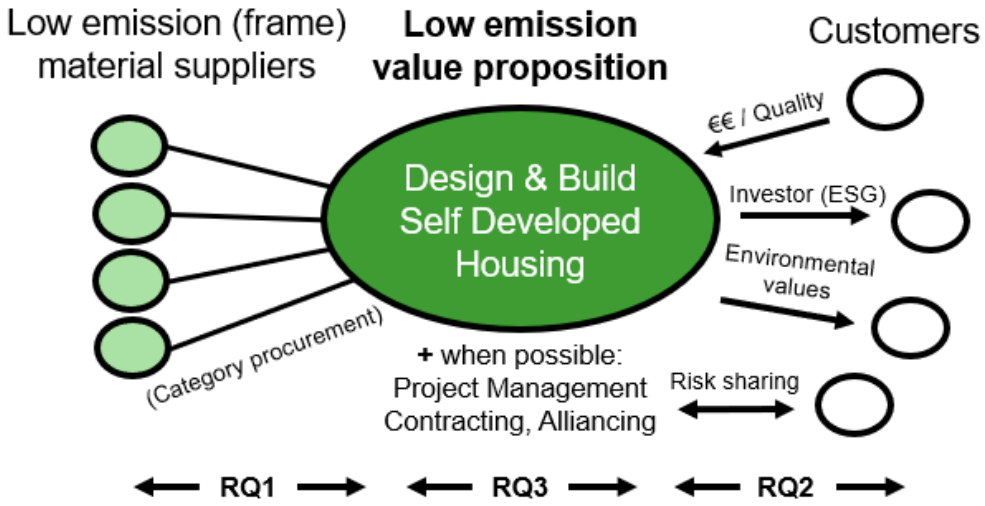

Figure 15. *Low emission value proposition that reaches over project model or segment limits*

Figure 15 includes many of the ideas from Adner (2017) on how ecosystems can include various functions from the focal company, all key actors are aligned based on the common value proposition, and the leadership is claimed by a central actor, here the focal company. Reaching this position will by no means be simple or easy, but this study suggests, it would be possible. The key difference compared to the current situation is in how emission reductions are in this approach deeply integrated into the overall business strategy of the company, and used as a source of differentiation (Laari et al., 2017).

6. CONCLUSIONS

6.1 Theoretical implications

This research has brought together three rather unlinked theoretical streams: business ecosystems, reducing emissions via LESCM, and SCM in project-based business. As construction industry is one of the biggest sources of GHG emissions, and a lot of research on SCM deals with manufacturing industries, some novel outcomes can be presented. A typical partnering approach divided into collaboration and assessment, presented in previous research (Sancha et al., 2019; Touboulic & Walker, 2015) does not apply well into construction sector. As typical relationships on project-based construction are arm's length (Kadefors, 2004), this study suggests that neither comprehensive supplier collaboration nor assessment takes place. As this is the case, a lot of untapped potential could be argued to be available from increased partnering in the supply chain. Long term business advantages (Plambeck, 2012), increased supplier information availability (Ahmadi-Gh & Bello-Pintado, 2022), and synergies between various business objectives (Laari et al., 2017) were all suggested in the literature, but none of them are currently present in practice.

However, this study finds a lot of support for the findings in the SCM literature for construction by Cox (2001), Cox and Ireland (2002), and Cox (2008). Claiming that increasing partnerships would be a universal solution is not accurate. Instead, there is an acute need for increasing the leverage a construction company has on its suppliers if it wants to have an actual say in the supplier's product development decisions. With the decentralized project management and tacit alignment of actors (Dubois & Gadde, 2002) used widely for construction, reaching this kind of leverage is going to be extremely difficult.

Therefore, this study presents similar results that have been found by Gadde and Dubois (2010), where the solution to this fragmentation and decentralization in construction is not to overhaul everything, as that is not even realistic. Rather, it is suggested to divide partnering in construction to two groups: one for strategic key components, and one for the rest. Sheffer and Levitt (2010) and Cox (2008) have presented similar ideas. According to the findings of this study, vertical integration might be a too aggressive of an approach but developing solutions with partners on key components in a stable business exchange on the key materials is realistic and doable. This study adds depth into the findings of both Cox (2008) and Gadde and Dubois (2010) by integrating the emission reduction considerations into the partnering decisions. From emissions perspective, the

frame material choices and design are strategic and important decisions, where larger volumes and more central decision making might be needed. This study suggests that the need for lowering emissions could be the required extra push to move the construction sector forward on these issues.

Processes created in the earlier literature, such as the one presented by Villena and Gioia (2018) in chapter 2.5.2, do not sufficiently address these extra difficulties faced by these project-based businesses. Based on the literature review conducted, the focus of previous research on this issue is on manufacturing companies, and situational uniqueness of project business gets overlooked. As strategic components are distinguished from the rest as was suggested above, a more generic approach for supplier engagement is then much more suitable. When strategic suppliers are known and relationships stable, capability development, assessments, and risks and opportunities are all much more systemically manageable.

Same is true for business ecosystems, as this study expands the focus there to project-based business management. As construction supply chains are currently built in a way where each actor is aiming to be as independent from any other actor as possible, ecosystem approach is presented to handle the increased complexity from the interdependence LESCM requires. Aligning the key actors of the supply chain under a common value proposition, as is suggested by Adner (2017), is the solution presented in this study. From ecosystem strategy, some support for the component strategy by Hannah and Eisenhardt (2018) is found: The focal company is in a situation, where it could enter the key component categories through partnerships and gain advantage from the mutual specialization. This could happen via shifting the focus to procuring and designing certain types of frame materials as widely as possible.

Similarly, as Adner and Kapoor (2010) have found earlier, upstream bottlenecks tend to support early movers. As clearly most of the problems of decarbonization are related to the materials, downstream complementors are much better developed. In this way results are linked to findings by Sheffer and Levitt (2010), as the empirical research was conducted in the context of non-commercial buildings, mainly schools, the energy efficiency and renewable energy related issues have developed much faster than the upstream. Use-phases are easier to manage, when the level of usage can be well estimated beforehand, and that way develop optimal solutions.

6.2 Managerial implications

For managers, this study finds that project-based businesses cannot make ambitious emission reduction commitments, if the key decisions related to those emissions are not centrally managed. Building schools, offices, or sports centers is not an industrial process, nor should it be treated as one, but the most meaningful emission sources are on the most basic level of components, primarily in the frame structures. When each project is individually responsible for making the procurement of these components, this study suggests that the outcome is not optimal. Especially, if a company wants to be seen as a low emission construction leader, a new level of more centralized decision-making is needed. Even as this is the case, managers should still be constantly aware of the advantages and needs for construction projects to have locally managed decentralized and flexible decision making, because shortly after the frame materials, each building often turns into something unique.

Starting to build more stable relationships with frame material suppliers will be challenging. More personnel will be needed for making estimations of future demand, maintaining these supplier relationships, creating scenarios of future opportunities, harmonizing technical requirements between frame materials typically used for different kinds of buildings, and so on. But without this kind of systematic approach to project portfolio management, the advantages are difficult to reach. Finding the right resources to do these tasks is going to be a major effort, but crucial for long-term competitiveness in this area.

The key outcome of this study is that collaboration and coordination need to happen across the three key units. Procurement has the best knowledge on the supplier field and on suppliers' capacities and capabilities. Tendering phase managers, and salespeople of other project types, have the best information on customer's stated and tacit needs and wishes. Design management would ideally then be then the unit where this supplier and customer knowledge is combined to a unique solution that is better than what the competitors can produce. Harmonizing certain standard design solutions for frame materials on each type of building and finding the best partners for supplying them is the key challenge, but as this study suggests, also a major opportunity.

6.3 Limitations

This study was done with qualitative interviews from a perspective of a single large Finnish construction company in a time span of about eight months. Only one researcher took part in creating the interview guides and conducting each of the interviews. Therefore, the results of the study are not to be fully generalized to other industries, and only

in limited scope to other project-based businesses. To increase research quality with these limitation in mind, triangulation of data sources and theories was used (Patton, 2002, pp. 555–563). For data sources, triangulation happened by reducing the unit of analysis into the smallest possible, three different operational units within the focal company. By this way, it was guaranteed that no single point of view gets over-emphasized in the results. If the focal company was used as a single case, it would have made any kind of perspective triangulation in the data analysis phase very challenging. Additionally, all new interview data was constantly compared to the previous interviews and observations made earlier. This way the data set was tried to make as unbiased as possible. Similarly, theory triangulation was used to reduce the previous literature from guiding the results into a certain outcome. As is mentioned by Patton (2002, p. 562), theory triangulation supports data source triangulation well.

Another limitation that should be mentioned relates to the author's objectivity (Lewis et al., 2019, p. 660). For the validity of the research, it is important to acknowledge that the topic was chosen by the author out of enthusiasm towards decarbonization issues. Therefore, a complete objectivity on all attitudes and assumptions is not possible to be reached, as some prejudice exists. However, the triangulation methods explained above, as well as the grounded approach to interviewing and analysis, can be seen as effective methods to tackle this issue as well.

6.4 Future research

Many issues that would have been interesting to investigate in more detail came up during the data collection but needed to be left out due to the resource limitations. Among others, the most interesting ones were the strictly project-based rewarding system, building use-phase ecosystem development, and circularity-based solutions demanded by the customers in recent tenders. This study initially suggests that rewarding projects based on individual project's profitability can be a major barrier for reaching the current emission reduction targets. Similarly, building use-phase and circular material solutions are interesting opportunities for creating new business models in the low emission construction, that should be further investigated.

An important, but here absent point of view relates to the EU Taxonomy. The European Union has been creating a comprehensive framework for sustainable finance within EU, and this framework will most likely be another reason for reaching for the low emission construction and SCM suggested in this study. Construction sector is a major part of the first phase of this new taxonomy, and the focal company is already working to find out what kinds of effects this will have on its business. It might be an interesting topic for

further research, as scope 3 emissions are an important part of the EU Taxonomy as well.

Finally, this study focused heavily on the focal company and its procurement and supplier relationships. Therefore, a similar study with a central focus on design management might be needed. Design management is such a large topic, that investigating it fully in the same study as procurement is not possible. Even as design management was a part of this study, there are a lot of details that should be investigated in more detail. Material efficiency, design for reusability, and the overall potential for standardization between D&B and self-developed to make collaborative approach possible are all extremely important issues, that were not deeply investigated in this study. In addition, the perspectives of other actors along the value chain, outside the focal company, should be further investigated. Public buyers, investors, material suppliers, designers, and architects are all important stakeholders with unique perspectives not widely researched here.

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APPENDIX A: INTERVIEW GUIDE

1. Esittelyt, tutkimuksen tarkoitus ja edistyminen toistaiseksi, luottamuksellisuus, lupa tallentaa haastattelu, teemojen nopea yhteenveto
2. Haastateltavan taustat lyhyesti, miten liittyy elinkaarihankkeisiin tai päästövähennysaiheisiin yleisemmin
3. Haastateltavan rooliin liittyvät erityispiirteet elinkaarihankkeiden ja vähäpäästöisyyden osalta

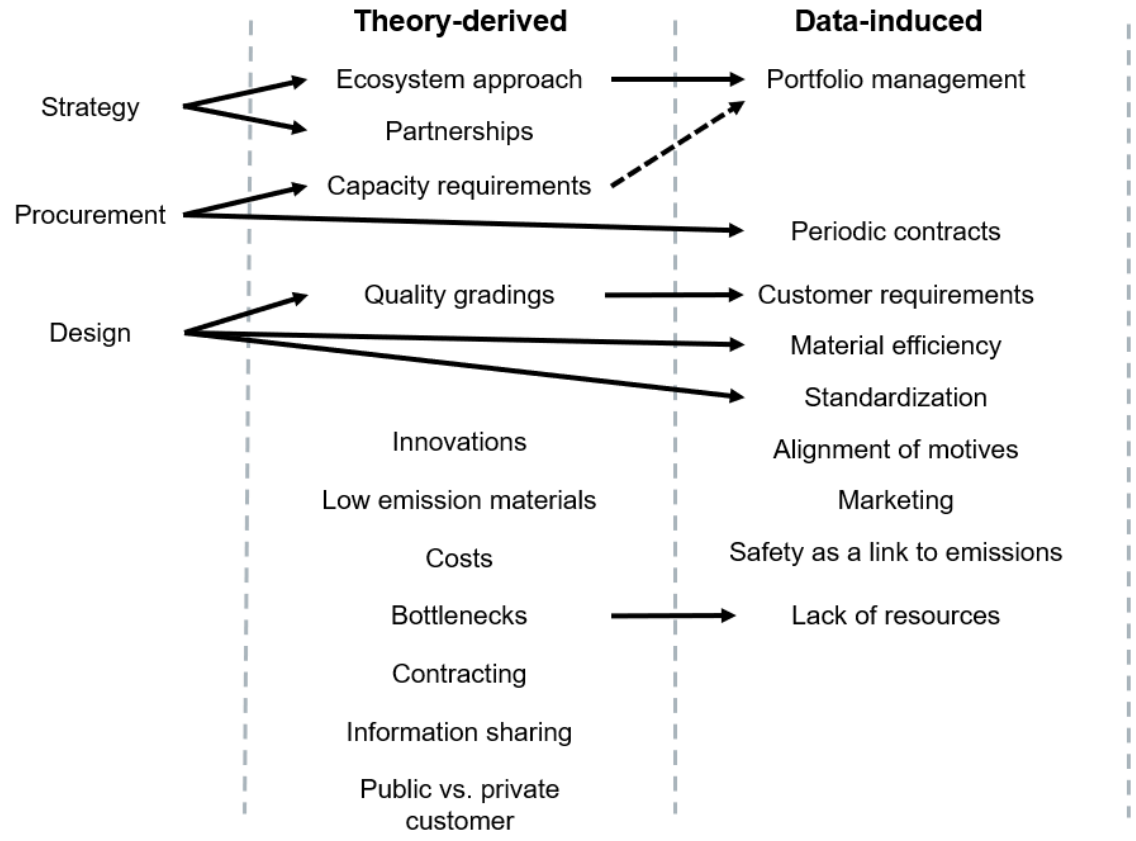
- **Hankinta**: Miten hankinta toimii tällä hetkellä, jos hankkeessa on laatukriteerinä saavuttaa tavallista vähäpäästöisemmät runkomateriaalit? (Asioita, joita voi nousta esille: kumppanuudet vs. satunnaisostot, vuosisopimukset, pienet volyymit, toimittajien kapasiteettien rajallisuus, innovaatiot, suunnittelusta tulevat rajoitteet …). Toimii, ei toimi? Miten tulisi ratkaista ongelmat, parantaa nykyisiä toimintatapoja hankinnan näkökulmasta tai ylemmälläkin tasolla?
- **SuJo**: Miten SuJo toimii tällä hetkellä, jos hankkeessa on laatukriteerinä saavuttaa tavallista vähäpäästöisemmät runkomateriaalit? Tai jos innovatiivisista suunnitteluratkaisuista on mahdollista saada merkittävästi lisäpisteitä kilpailussa? (Asioita, joita voi nousta esille: materiaalien kulutuksen vähentäminen suunnitteluratkaisuilla, puurakentaminen mahdollisuutena, ”vihreän” betonin käytön suunnittelu, hankinnalta saatavat kapasiteettirajoitteet suunnittelussa, …). Toimii, ei toimi? Miten tulisi ratkaista ongelmat, parantaa nykyisiä toimintatapoja suunnittelun näkökulmasta tai ylemmälläkin tasolla?
- **Tarjoustoiminta**: Miten asiakkaan kanssa käytävissä neuvotteluissa ja sisäisissä laskennoissa suhtaudutaan tiukkoihin laatukriteereihin scope 3 päästöihin liittyen? Koetaanko, että ne hyödyttävät kilpailussa suhteessa kilpailijoihin? (Asioita, joita voi nousta esille: Innovatiivisuus vaatii paljon, tunnistetut haasteet, onko helpompi perustella investointeja, kun kyseessä ei ole kaupallinen kohde, joka voi taloussyklien mukaan muuttua täysin, …) Toimii, ei toimi? Miten tulisi ratkaista ongelmat, parantaa nykyisiä toimintatapoja tarjoustoiminnan/laskennan näkökulmasta tai yleisemmälläkin tasolla?

4. Millaisia keskeisimpiä pullonkauloja tunnistettu päästöjen vähentämiseen liittyen?
5. Mistä tyypillisesti eniten käydään keskusteluja tarjousvaiheessa tilaajan kanssa ja toteutusvaiheessa materiaalitoimittajien kanssa? Sopimuskäytännöt?

6. Tiedon jakaminen sisäisesti, ulkoisesti toimitusketjussa? Kapasiteetista, kehityshankkeista, päästöistä, jne.
7. Vähäpäästöisuus arvolupauksena, ekosysteemiajattelu. Ensimmäisen toimijan etu vs. riskien minimoiminen etenemällä markkinan ja lainsäädännön mukana.
8. Julkisten hankkeiden scope 3 päästöihin liittyvät laatukriteerit, niiden yleistyminen
9. Jäikö haastattelussa jokin olennainen asia läpikäymättä, johon tulisi vielä palata?

APPENDIX B: ATLAS.TI CODES

There are 20 codes in total, split in two categories



View from ATLAS.ti with the most common codes